



Entrepreneurial Impact: The Role of MIT

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Executive Summary

Economic Impact of MIT Alumni Entrepreneurs

Research- and technology-intensive universities, especially via their entrepreneurial spinoffs, have a dramatic impact on the economies of the United States and its fifty states. This report is an indepth case study, carried out during the past few years, of a single research/technology university, the Massachusetts Institute of Technology, and of the significant consequences it has helped to produce for the nation and the world via its broad-based entrepreneurial ecosystem. From our extensive data collection and analyses, we conclude that, if the active companies founded by MIT graduates formed an independent nation, conservative estimates indicate that their revenues would make that nation at least the seventeenth-largest economy in the world. A less-conservative direct extrapolation of the underlying survey data boosts the numbers to 25,800 currently active companies founded by MIT alumni that employ about 3.3 million people and generate annual world revenues of \$2 trillion, producing the equivalent of the eleventh-largest economy in the world.

The ultimate value of this study is to help us understand the economic impact of the entrepreneurial ventures of university graduates. We know that some universities play an important role in many economies through their core education, research and development, and other spillovers. But in order to support economic growth through entrepreneurship, universities must create programs

and a culture that make entrepreneurship widely accessible to students. While MIT's leadership in developing successful entrepreneurs has been evident anecdotally, this study—one of the largest surveys of entrepreneur alumni ever conducted—quantifies the significant impact of MIT's entrepreneurial ecosystem that supports firm startups. And, while MIT is more unique and unusual in the programs it offers and in its historical culture of entrepreneurship, MIT provides a benchmark by which other institutions can gauge the economic impact of their alumni entrepreneurs. The report also provides numerous examples of programs and practices that might be adopted, intact or modified as needed, by other universities that seek enhanced entrepreneurial development.

Our database is from a 2003 survey of all living MIT alumni¹, with additional detailed analyses, including recent verification and updating of revenue and employment figures from the 2006 records of Compustat (public companies) and Dun & Bradstreet (private companies). For further conservatism of our projections, we have deliberately excluded from our database companies in which the MIT alumnus founder had died by 2003, even if the company still survives, such as Hewlett-Packard or Intel. Even if the founder is still alive, we generally have excluded from our numbers those MIT alumni-founded companies that had merged with or been sold to other firms, such as Digital Equipment Corporation, which had peak employment of 140,000 people prior to its merger with Compaq in 1998. Nor do the database numbers include MIT alumni-founded firms that had

¹ Throughout the report we use the term “alumni” to include both male alumni and female alumnae.

closed prior to our 2003 survey. These estimates similarly ignore all companies founded by non-alumni MIT faculty or staff. Thus, we feel that our overall portrayal of MIT's entrepreneurial impact is quite conservative. Nor do we examine in addition to these entrepreneurial spinoffs the impact of MIT-generated science and technology on the overall innovation and competitiveness of government and industries that benefit from direct and indirect transfer of scientific know-how and discoveries emerging from MIT, its faculty, staff, and graduates.

While the economic estimates we present contain some degrees of uncertainty, the trends in the numbers are clear. More entrepreneurs emerge out of each successive MIT graduating class, and they are starting their first companies sooner and at earlier ages. Over time, the number of multiple companies founded per MIT entrepreneurial alumnus also has been increasing, therefore generating dramatically increased economic impact per graduate. MIT acts as a magnet for foreign students who wish to study advanced engineering, science, and management, and a large fraction of those students remains in the United States. Well over half of the firms created by foreign students who graduate from MIT are located in the United States, generating most of their economic impact in this country.

Thirty percent² of the jobs in the MIT alumni firms are in manufacturing (far greater than the 11 percent of manufacturing jobs in the United States overall) and a high percentage of their products are exported. In determining the location of a new business, entrepreneurs say the quality of life in their community, proximity to key markets, and access to skilled professionals were critical considerations, but almost all locate where they had been working or attending university, including near graduate schools other than MIT.

The study reveals that the states benefiting most from jobs created by MIT alumni are Massachusetts (for which we estimate just under one million jobs

worldwide for the entire population of more than 6,900 active MIT alumni-founded, Massachusetts-headquartered companies), California (estimated at 526,000 jobs from its current approximately 4,100 MIT alumni-founded firms), New York (estimated at 231,000 jobs), Texas (estimated at 184,000) and Virginia (estimated at 136,000). Fifteen other states are likely to have more than 10,000 jobs each and only eleven states seem to have fewer than 1,000 jobs from MIT alumni companies.

As a result of MIT, Massachusetts has for many years been dramatically "importing" company founders. The estimated 6,900 MIT alumni firms headquartered in Massachusetts generate worldwide sales of about \$164 billion. More than 38 percent of the software, biotech, and electronics companies founded by MIT graduates are located in Massachusetts, while less than 10 percent of arriving MIT freshmen are from the state. Not only do MIT alumni, drawn from all over the world, remain heavily in Massachusetts, but their entrepreneurial offshoots benefit the state and country significantly. Greater Boston, in particular, as well as northern California and the Northeast, broadly, are homes to the largest number of MIT alumni companies, but significant numbers of MIT alumni companies are also in the South, the Midwest, the Pacific Northwest, and in Europe. About 30 percent of MIT's foreign students form companies, of which at least half are located in the United States. Those estimated 2,340 firms located in the U.S. but formed by MIT foreign-student alumni employ about 101,500 people.

The Types of Companies MIT Graduates Create

MIT alumni companies are primarily knowledge-based companies in software, biotech, manufacturing (electronics, instruments, machinery), or consulting (architects, business consultants, engineers). These companies have a disproportionate importance to

2. We round off most numbers in this report to the nearest percent.

their local economies because they typically represent advanced technologies and usually sell to out-of-state and world markets. Their global revenues per employee are far greater than the revenues produced by the average American company. Furthermore, they employ higher-skilled as well as higher-paid employees. They also tend to have far lower pollution impact on their local environments.

An important subset of the MIT alumni companies is in software, electronics (including instruments, semiconductors, and computers), and biotech. These firms are at the cutting edge of what we think of as high technology and, correspondingly, are more likely to be planning future expansion than companies in other industries. They export a higher percentage of their products, hold one or more patents, and spend more of their revenues on research and development. (Machinery and advanced materials firms share many of these same characteristics but are not nearly as numerous as the electronics, software, and biotech companies.)

More than 900 new MIT alumni companies were founded each year during the decade of the 1990s. But the bulk of total MIT-generated employment results from the estimated 800 companies of 1,000 or more employees who have created nearly 85 percent of the jobs. Not surprisingly, most of the larger companies have been in existence for some time, but many younger entrepreneurs have built sizable companies in a short period of time. One in six of the companies founded by a graduate out of school fifteen years or less already has 100 or more employees.

The MIT Entrepreneurial Ecosystem

Rather than any single or narrow set of influences, the overall MIT entrepreneurial ecosystem, consisting of multiple education, research, and social network institutions and phenomena, contributes to this outstanding and growing entrepreneurial output. The ecosystem rests on a long MIT history since its 1861 founding and its evolved culture of “Mens et Manus,” or mind and hand. The tradition of valuing

useful work resulted in the development of strong ties with industry, including encouraging faculty consulting and even faculty entrepreneurship since before the beginning of the twentieth century. Over the years, the increasingly evident MIT entrepreneurial environment has attracted entrepreneurship-inclined students, staff, and faculty, leading to a strong positive feedback loop of ever-increasing entrepreneurial efforts.

Alumni initiatives in the 1970s appear to be the first direct institutional moves to encourage entrepreneurship, leading to the establishment of the now-worldwide MIT Enterprise Forum. Since its beginning, the Cambridge, Mass., chapter alone has helped nurture more than 700 young companies, with equivalent numbers across the rest of the country. Beginning in 1990, the MIT Entrepreneurship Center has crystallized these efforts by launching nearly thirty new entrepreneurship courses at MIT, and by assisting in the formation and growth of a large number of related student clubs. The resulting increase in networking among students, and between them and the surrounding entrepreneurship and venture capital community appears in survey results to be the primary MIT-related factor influencing the growth of new-company formation.

Classes taught by discipline-based academics and experienced, successful entrepreneurs and venture capitalists have generated an effective blend for learning both theory and practice. Mixed-team project classes, consisting of both management students and engineers and scientists, have had great impact on MIT students in their understanding of the entrepreneurial process, have initiated their exposure to and engagement with real-world new enterprises, and have influenced the subsequent founding of many new companies. Student-run activities such as the MIT \$100K Business Plan Competition have moved numerous students, often with faculty as team members, to develop their ideas to the point of public scrutiny. At least 120 companies have been started by participants in these student-run competitions.

The MIT Technology Licensing Office has consistently led the country's universities in licensing technology to startup firms, licensing to 224 new companies in just the past ten years. The TLO also has brought its experience and knowledge into active engagement with MIT students, faculty, and alumni.

In recent years, creation of formal MIT institutions focused on encouraging entrepreneurship has accelerated. In 2000, the Venture Mentoring Service was begun to help any MIT-related individual—student, staff, faculty, alumnus/a—who was contemplating a startup. It already has seen more than eighty-eight companies formed by those it has counseled.

The Deshpande Center for Technological Innovation was initiated in 2002 to provide small research grants to faculty whose ideas seemed especially likely to be able to be commercialized. In its first five years, the Deshpande Center has funded eighty faculty research projects. Fifteen spinout companies already have been formed from these projects.

In 2006, the MIT Sloan School of Management created a new Entrepreneurship & Innovation track within its MBA program to provide intensive opportunities for those students who seem dedicated to an entrepreneurial life. It is too soon to know what outcomes this focused approach will produce, but about 25 percent of incoming MBA candidates now are enrolling in this concentration and initial students already have engaged in numerous company-building activities and have won important university business plan competitions.

Beyond the MIT influences on firm formation, 85 percent of the alumni entrepreneurs reported in the survey data that association with MIT had significantly helped their credibility with suppliers and customers. Fifty-one percent of the entrepreneurs also felt that their association with MIT helped in acquiring funding.

All of these forces—from initial orientation and culture to all-encompassing clubs and activities to now-concentrated educational opportunities—

contribute to building and sustaining the MIT entrepreneurial ecosystem. That system has been uniquely productive in helping to create new firms that have had impressive economic impact.

The Role of MIT Alumni Companies in the U.S. Economy

For some time, anecdotes and research have indicated significant entrepreneurial impact from MIT. In 2003, along with professional staff from MIT, the authors set about to attempt to quantify through surveys and research the actual economic impact of entrepreneurship among MIT alumni. The results presented here—the first disclosure of this research—are supplemented with some detail on the history, institutions, and culture that have combined to influence entrepreneurship at MIT.

In 2001, MIT sent a survey to all 105,928 living alumni with addresses on record. MIT received 43,668 responses from alumni. Of these, 34,846 answered the question about whether or not they had been entrepreneurs. A total of 8,179 individuals (23.5 percent of the respondents) indicated that they had founded at least one company. In 2003, we developed and sent a survey instrument focused on the formation and operation of these firms to the 8,044 entrepreneur respondents for whom we had complete addresses. Of this group, 2,111 founders completed surveys. The database reported on in this report was created from these surveys, as well as additional detailed analyses, including verification and updating of revenue and employment figures from the 2006 records of Compustat (public companies) and Dun & Bradstreet (private companies). The Appendix provides further details on the survey and estimation methods.

Based on our extensive data collection and analyses, we conclude that, if the active companies founded by MIT graduates formed an independent nation, conservative estimates indicate that their revenues would make that nation at least the seventeenth-largest economy in the world. A less-conservative direct extrapolation of the underlying survey data boosts the numbers to some 33,600 total companies founded over the years by living MIT alumni, of which 25,800 (76 percent) still exist,

employing about 3.3 million people and generating annual worldwide revenues of \$2 trillion, the equivalent of the eleventh-largest economy in the world.

For conservatism of our projections, we have deliberately excluded from the database companies in which the MIT alumnus founder already had died, even if the company still survives, such as Hewlett-Packard or Intel. If the founder is still alive, we have excluded from our database those MIT alumni-founded companies that had merged with or been sold to other firms prior to 2003, such as Digital Equipment Corporation, which had peak employment of 140,000 people prior to its merger with Compaq in 1998. Nor do the numbers include MIT alumni-founded firms that had closed prior to our 2003 survey. These estimates similarly ignore all companies founded by non-alumni MIT faculty or staff. In addition, we do not examine the impact of MIT-generated science and technology on the overall innovation and competitiveness of government and industry beyond alumni-founded firms. Clearly, entrepreneurship likely has benefited from additional spillovers from the scientific and non-scientific advances emerging from MIT, its faculty, staff, and graduates. Thus, we attempt to portray only an aspect of MIT's entrepreneurial impact.

Companies founded by MIT alumni have a broad footprint on the United States (and the globe). While more than a quarter of these active companies (projected to be 6,900) have headquarters in Massachusetts, nearly 60 percent of the MIT alumni companies are located outside the Northeast. These companies have a major presence in the San Francisco Bay Area (Silicon Valley), southern California, the Washington-Baltimore-Philadelphia belt, the Pacific Northwest, the Chicago area, southern Florida, Dallas and Houston, and the industrial cities of Ohio, Michigan, and Pennsylvania.

Table 1
Estimated Employment and Sales Data for All Active MIT Alumni Companies

Jobs	Percent of Companies	Median Employees	Median Sales (Millions)	Estimated Total Employees	Estimated Total Sales (Millions)
More than 10,000	0.3%	15,000	1,523	1,339,361	1,389,075
1,000–10,000	1.8%	1,927	308	1,043,932	235,532
Less than 1,000	97.9%	39	<1	900,001	226,671
Total	100.0%	155	<1	3,283,294	1,851,278

As shown in Table 1, relatively few but larger companies account for a substantial proportion of the total sales and employment of MIT alumni-founded companies. We estimate that the 796 largest current MIT alumni companies (about 2 percent of the total estimated companies)—those with employment of 1,000 or more—account for more than 80 percent of total sales and 70 percent of employment of all the MIT alumni-founded firms. Most of these larger firms are quite old. But many young graduates have managed to build companies of impressive size in a short period of time. We estimate that 213 companies with a founder who graduated in the last thirty years (and fifteen with founders who graduated in the last fifteen years) have 500 or more employees. Of these 213 younger-but-larger companies, about 28 percent are in software, 10 percent are in telecommunications, and 21 percent are in electronics. Of the approximately 14,700 firms founded by MIT graduates from the last fifteen years, 10 percent already have 100 or more employees. This compares to 12 percent for founders out fifteen to thirty years, and 13 percent for founders out thirty to fifty years.

Two-thirds of the MIT alumni companies over the entire sixty-year span of our data have been co-founded, with the size of the founding group steadily increasing from 2.3 in the 1950s to 3.3 in the 2000s. We also have found consistency over all these years in the attributed sources of the ideas for these new enterprises. On average, two-thirds of the founders claim that the ideas for the firm came from industry

work experience, about 15 percent from networking, and about 10 percent from research.

Additional Trends over the Decades

Growth in Numbers

We estimate that 2,900 currently active companies were founded during the 1980s and as many as 9,950 companies were founded during the 1990s, of which 5,900 are still active. More than 5,800 companies were created between 2000 and 2006. For each decade (using our linear projection), Figure 1 shows the estimated yearly growth over the past fifty years of the number of “first firms”

Figure 1
Estimated Number of “First-Time” Firms Founded Each Decade by MIT Alumni

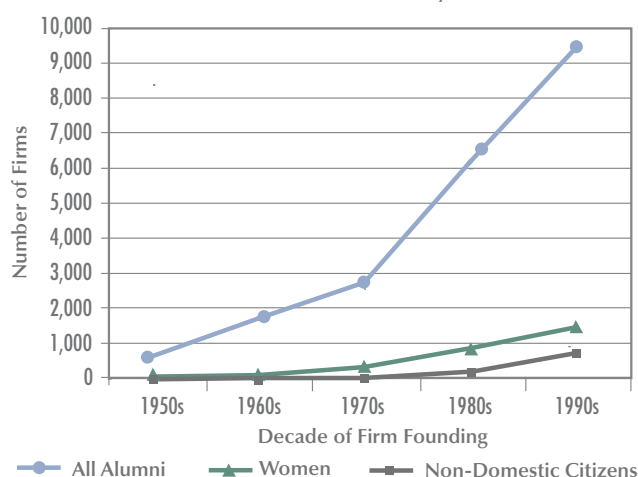
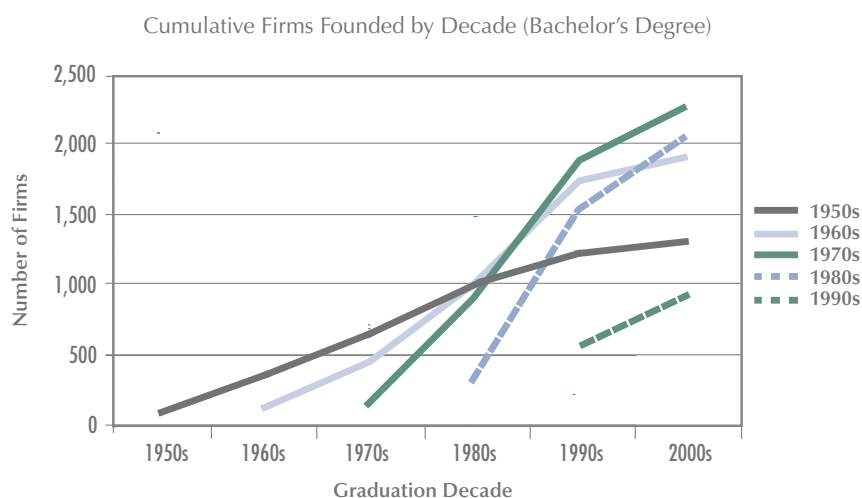


Figure 2
Cumulative Number of First Firms Founded by
Each Decade's Cohort of Alumni
(from limited sample only)



founded by all MIT alumni. **New company formation by MIT graduates is accelerating.** (We omit from this figure but will later present our evidence on the second, third, and more companies generated by many of the MIT alumni over their entrepreneurial careers.)

Further evidence on the acceleration of MIT alumni entrepreneurship through the past five decades is obvious in Figure 2, where we limit ourselves for consistency to just the Bachelor's degree recipients who responded to the limited survey of MIT alumni that was done in 2003. The figure shows clearly that the cohort of Bachelor's degree graduates from each successive decade has been forming more new first companies.³

More Diverse Entrepreneurs

We find evidence of significant shifts in demographics among MIT entrepreneurs, particularly on gender and citizenship. The numerical growth of women entrepreneurs appears to mirror the growth in number of women graduates from all levels at MIT, rising from just over ten female graduates per year (1 percent) in the 1930s to 43 percent of undergraduates and 30 percent of the graduate student population in 2006. Women alumnae lag their male classmates (but slowly are catching up) in the proportion that become entrepreneurs. Women founders start appearing in the 1950s and, as shown in Figure 1, grow to 6 percent of the reporting sample by the 1990s, and are up to 10 percent by the 2000s.

3. The MIT undergraduate class grew from about 900 per year in the 1950s to about 1,050 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. In many of our analyses, we took these size changes into account via normalization per 1,000 alumni at each decade. But these normalized analyses did not alter any of the underlying trends reported here.

Alumni who were not U.S. citizens when admitted to MIT founded companies at different (usually higher per capita) rates relative to their American counterparts, with at least as many remaining in the United States as are returning to their home countries. Figure 1 indicates that non-U.S. citizens begin slight visibility as entrepreneurs in the 1940s, grow steadily to 12 percent of the new firm formations during the decade of the 1990s, and are up to 17 percent by the 2000s.

About 30 percent of the foreign students who attend MIT found companies at some point in their lives. This is a much higher rate than for U.S. citizens who attend MIT. We assume (but do not have data that might support this) that foreign students are more inclined from the outset to become entrepreneurs, as they had to seek out and get admitted to a foreign university, taking on the added risks of leaving their families and their home countries to study abroad. (MIT has only its one campus in Cambridge, Mass., and, despite collaborations in many countries, does not operate any degree program outside of the United States.) We estimate that about 5,000 firms were started by MIT graduates who were not U.S. citizens when they were admitted to MIT. **Half of those companies created by “imported” entrepreneurs, 2,340 firms, are headquartered in the United States, generating their principal revenue (\$16 billion) and employment (101,500 people) benefits here.**

As shown in Table 2, an even higher fraction of the foreign student-founded manufacturing firms, which usually have the greatest economic impact, are located in the United States. The largest non-U.S. locations of alumni firms founded by foreign students are in Europe and Latin America. More than 775 MIT foreign-alumni businesses are in Europe, most of which are in software and consulting. The greatest numbers of these firms are in England, France, and Germany. Latin America has an estimated 500 firms, most of which are in Mexico, Brazil, and Venezuela. Asia has 342 firms, of which the largest numbers are in China, Japan, and India.

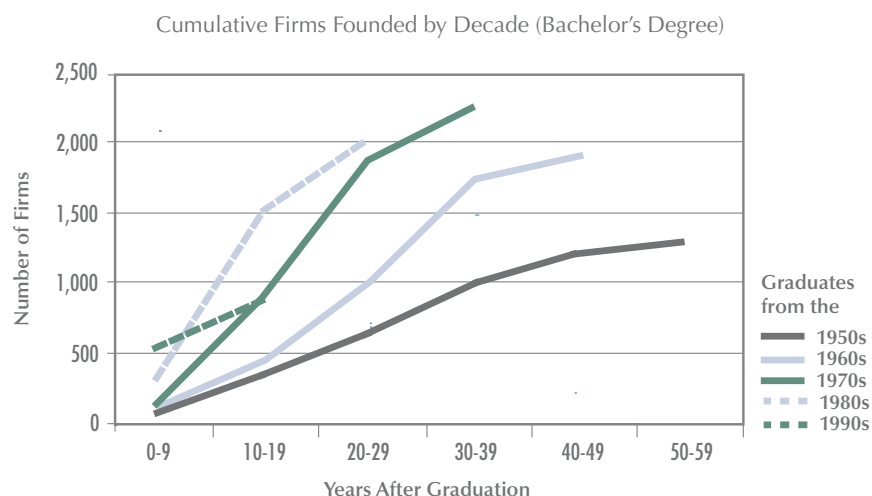
As is true of all the alumni-founded firms, many of these now are sizable businesses, but most are small; the median number of employees of those founded by foreign students in Europe and Asia is eighteen employees and the median revenues are a little more than \$1 million. Almost three-quarters of these businesses are started by alumni with MIT graduate degrees; not too surprising, as historically MIT has had few undergraduates from outside of the United States. About half of the American founders have advanced degrees from MIT.

Of the U.S.-located companies founded by MIT’s foreign students, 66 percent were started in the 1990s or 2000s. European alumni started 36 percent of the 2,340 U.S.-located firms and alumni from Asian countries started 28 percent of them. This

Table 2
Estimated Number of Companies
Founded by “Foreign” MIT Alumni

Location	Total	Manufacturing
United States	2,340	673
Europe	790	51
Latin America	495	63
Asia	342	43

Figure 3
Firms Founded by Years After Graduation for
Each Decade's Cohort of Alumni (from limited sample only)



geographic source distribution of foreign-alumni entrepreneurs will no doubt shift as Asians become a larger fraction of the MIT foreign-student population.

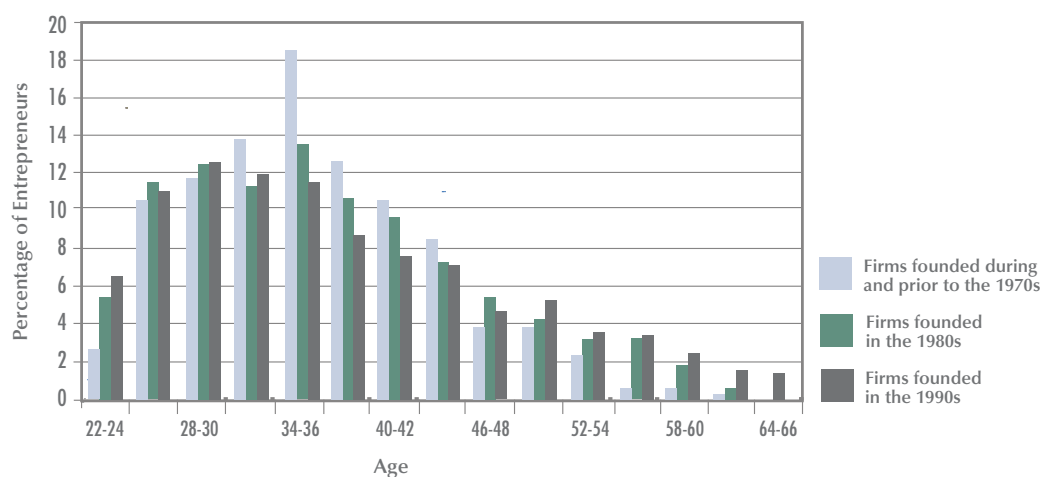
Younger Entrepreneurs

The tendencies shown in Figures 1 through 4 are clear: More entrepreneurs emerge out of each successive MIT graduating class, and they start their first companies sooner and at earlier ages. To illustrate this, in Figure 3 we display for Bachelor's degree graduates only how many companies were founded by each decade's cohort group as a function of the number of years following their MIT graduation. During each successive decade, the cohort of graduating alumni got started in its entrepreneurial behavior sooner (i.e., the cumulative number of companies rises much faster in terms of years after graduation) than the preceding decade's cohort.

Figure 4 shows three frequency distributions of the ages of MIT alumni first-time entrepreneurs for

firms founded during and prior to the 1970s, for those founded in the 1980s, and for those founded in the 1990s. Note the general shifts in the three curves over the years. The distributions show that the more recent entrepreneurs include many more from the younger age brackets, as well as slightly more from the late forties and fifties age brackets. During and prior to the 1970s, 24 percent of the first-time entrepreneurs were under thirty years of age; during the 1980s that number grew to 31 percent; in the 1990s that number grew to 36 percent of the founders were under thirty. During and prior to the 1970s, 30 percent of the first-time founders were older than forty years of age; during the 1980s, 28 percent were older than forty; and, in the 1990s, 35 percent were older than forty. More than half of all MIT alumni companies now are founded within ten years of the time the founder graduates from MIT; one-quarter of the companies are founded within six years of graduation. The median age of first-time entrepreneurs gradually has declined from about age forty (1950s) to about age thirty (1990s). Correspondingly, the average time lag

Figure 4
Age Distribution of Entrepreneurs at
Time of First Firm Founding



between graduation and first firm founding for alumni from the more recent decades dropped to as low as four years from graduation during the “Internet bubble” years of the 1990s.

To check on possible industry effects, we separated out those who had formed software companies. Figure 5 shows that the majority of software founders over all the decades of our study are age thirty or younger and the majority of non-software industry founders are below age thirty-five the year they found their first firms. But, not shown in this report, the increase in software entrepreneurship in recent years does not statistically account for the continuing decline in the average entrepreneurial age at time of first company formation.

We support the above arguments with the data in Table 3, demonstrating that the ages of first-time MIT alumni entrepreneurs have been getting younger each decade, whether male or female, U.S. or

Figure 5
Age of Founders: Software vs. Other Industries

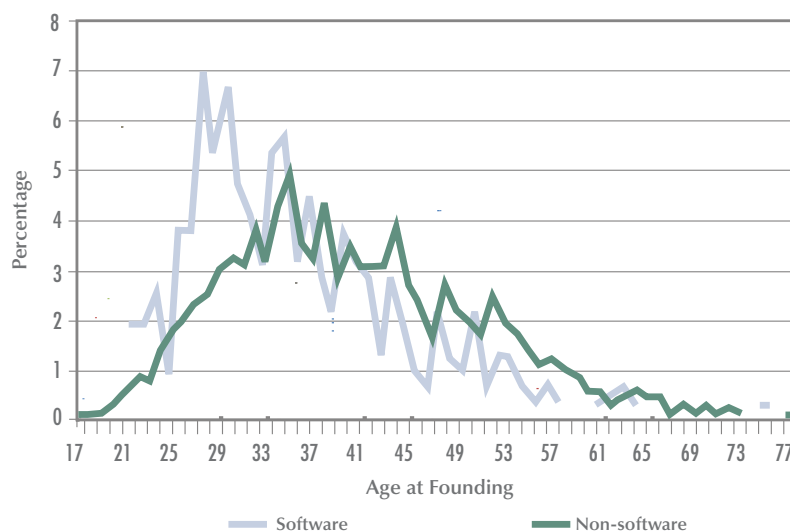


Table 3
Median Age of First Firm Founders

First Firm Founders	Decade of Graduation				
	1950s	1960s	1970s	1980s	1990s
All	40.5	39.0	35.0	32.0	28.0
Non-U.S. Citizens	38.0	35.5	36.5	32.0	29.0
Women	42.0	41.0	40.0	35.0	29.0

foreign citizen. (The big drop in the 1990s no doubt reflects the fact that many more graduates from the 1990s will form companies later, moving the average age upward to some extent.)

Serial Entrepreneurs

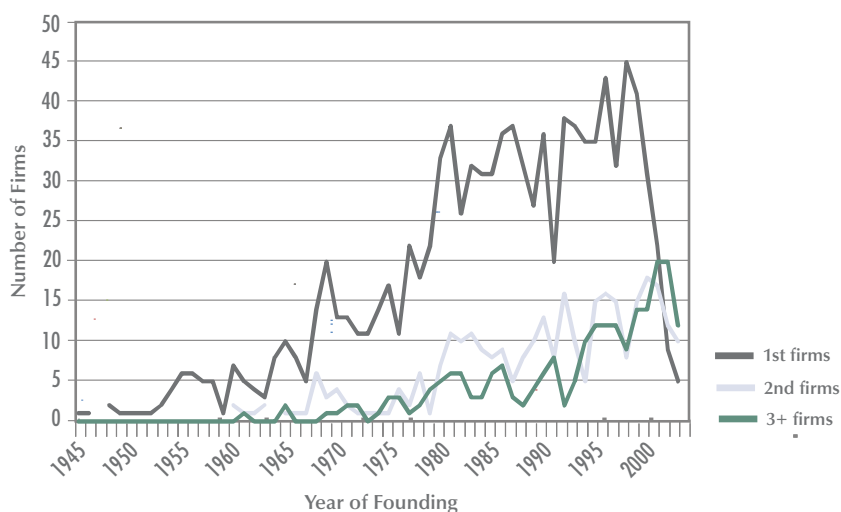
To this point, we have focused primarily on the vast number of MIT alumni who have founded their first enterprises. Yet the phenomenon of MIT graduates embarking on careers of repeat or “serial” entrepreneurship appears to be growing over time. Using only the limited data from the 2003 survey results, without any scaling adjustment, Figure 6 shows the number of first firms, second firms, and third (and more) firms by their founding year. By

definition, “first-time” firms are the most prevalent, and the number of first firms founded increases over the years. Separate from any other trends, we expect this increase due to the fact that each year adds another year of graduates with the potential for entering entrepreneurship. Table 4 presents, by their decade of graduation, the number of entrepreneurs founding one firm (the top line) up to five or more firms (the high in the database is eleven firms founded by an alumnus). The bottom row, labeled “Percent Repeat,” is the percentage of founders from each decade of MIT graduates who have started more than one firm. Across the decades, MIT alumni founders who have founded multiple startups have grown from 33 percent of those who graduated in

Table 4
One-Time and Repeat MIT Founders by Decade of Graduation (percent)

Total Number of Firms Founded	Decade							
	1930s	1940s	1950s	1960s	1970s	1980s	1990s	2000s
1	67%	61%	56%	54%	48%	57%	61%	59%
2	0%	11%	21%	20%	23%	22%	23%	28%
3	0%	9%	10%	11%	16%	11%	9%	9%
4	11%	8%	7%	7%	6%	5%	3%	3%
5+	22%	11%	7%	9%	7%	5%	4%	0%
Percent Repeat	33%	39%	44%	46%	52%	43%	39%	41%

Figure 6
Histogram of Repeat Founders Among MIT Alumni
Entrepreneurs (from limited sample only)



the 1930s to 52 percent of those who graduated in the 1970s.⁴ The decrease in the Table 4 entry percentage from the 1980s on is likely due to the fact that many of the more recent graduates have not yet had time to start a second (or more) firm but certainly may do so in the future.

The MIT alumni entrepreneurs who eventually found multiple companies differ substantially from “single-firm-only” entrepreneurs, and their companies are quite different, too. For example, proportionately more of the repeat founders are not U.S. citizens and a slightly higher proportion of the repeat entrepreneurs hold Master’s degrees. Relative to the repeat entrepreneurs, those who found only one company throughout their lives are older when they establish their sole company and have a longer lag from graduation to that founding. Repeat/serial entrepreneurs enter entrepreneurship much sooner,

which likely reflects their own strong entrepreneurial tendencies while also giving them more time to start subsequent firms.

Table 5, directly from our limited 2003 sample, contains economic impact indicators of the one-time and repeat entrepreneurs in terms of firms founded, revenues, and employees. The representative MIT alumni entrepreneur founds 2.07 companies over his lifetime. We see in Table 5 that repeat entrepreneurs have a substantial economic impact relative to the percentage of total entrepreneurs, accounting for about three times the total company revenues and employees as the single-firm founders. Thus, a third observed trend is that, over time, the number of multiple companies founded per MIT entrepreneurial alumnus has been increasing, with dramatically increased economic impact per graduate.

4. This statistic uses the total number of firms each entrepreneur claimed to have started. For the remainder of the analyses, we use the number of firms for which they listed the company names and founding dates in the 2003 survey. The listings are more reliable and conservative but were capped by the survey instrument at five.

Table 5.
Economic Impact of One-Time and Repeat Entrepreneurs (from limited sample only)

Category of Entrepreneur	One-Time Entrepreneurs	Repeat/Serial Entrepreneurs
Total Sales (in '000 \$2006)	\$9,876,900	\$29,190,000
Total Employment	111,915	344,208
Total # of Firms Founded	1,086	3,193
Total Founders in the Sample	1,086	981
Percentage of Entrepreneurs	52.5%	47.5%
Percentage of Firms	25.4%	74.6%
Percentage of Total Revenues	25.3%	74.7%
Percentage of Total Employment	24.5%	75.5%

MIT Founders and MIT Course Majors

More MIT founders—more than 20 percent of the total—come from the Institute’s electrical engineering and computer science programs (the two are linked in the same MIT department) than from any other department. Other programs heavily represented among the founders are management; mechanical, chemical, and civil engineering; architecture; physics; and aeronautics.

Over the years, an interesting shift has occurred, reflecting underlying change at MIT in the course majors taken by company founders. More than 65 percent of the founders who graduated more than fifty years ago were engineering majors. Only 44 percent of company founders who graduated in the last fifteen years are engineers, while 32 percent are from the social sciences/management departments. We estimate the total number of MIT alumni companies founded by living engineering majors as 17,090 compared with 9,100 companies founded by science majors and 6,860 companies by management majors, certainly affected by the relative sizes of the graduating populations.

Some correlation, but no predictable connection, exists between the founder’s major and the type of

company. For example, only 10 percent of alumni-created biotech and medical companies are founded by life-science graduates; 59 percent are founded by engineers. Social science and management graduates account for 9 percent of electronics firms, 10 percent of other manufacturing firms, and 20 percent of software companies, while engineering graduates account for 46 percent of the companies in finance and 45 percent of the management consulting firms. These differences reflect, in part, the additional degrees of the MIT alumni, whether from MIT or from other universities, and/or the backgrounds of their co-founders.

We normalized the number of entrepreneurs from each MIT school (MIT contains five schools), using the numbers graduating in each decade as our bases for normalization. Despite increased participation over time from science graduates, the percentage of them who become entrepreneurs is still the smallest of all study areas, over essentially the entire time studied. The data show that, proportionately, from 50 percent to 100 percent more MIT engineering graduates than science alumni eventually have become entrepreneurs. Management graduates overall seem to be at least as inclined proportionately to become entrepreneurs as are MIT

Table 6
Proportion of Founders from Three Selected Academic Areas of MIT
(percent of all MIT alumni companies founded during the decade)

First Firm Founders	Decade of First Firm Founding				
	1950s	1960s	1970s	1980s	1990s
EE and CS degrees	20.4%	26.5%	18.7%	25.4%	22.7%
Life Sciences degrees	0.0%	2.7%	4.0%	4.9%	4.7%
Management degrees	16.7%	14.3%	13.5%	13.8%	15.8%

engineering graduates. Architecture alumni are, on a proportional basis, perhaps surprisingly, the most likely among graduates of all the MIT schools to strike out on their own. But this no doubt reflects a dominant “industry” structure of large numbers of small architectural practices, with relatively frequent changes in partnerships (i.e., new “firms”).

Table 6 provides further details on the trends in three selected academic areas of MIT: electrical engineering and computer science (EECS), biology/life sciences, and management. EECS has, by tradition, been the largest MIT department 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 percent. The percentage of founders who are EECS majors

remains the highest at slightly more than 20 percent, and those with management degrees hover around 15 percent. Both EECS and management appear to be relatively stable in their proportionate supply of entrepreneurs over the decades.

Industry Composition and Effects

Table 7 shows an estimated industry breakdown of MIT alumni companies by number of firms, sales, and employment. MIT alumni found companies in a diverse array of industries, although they do tend to cluster in certain sectors. About 3,300 companies, employing an estimated total of 436,100 people, are in electronics, which (as used here loosely) includes computers, semiconductors, instruments, telecommunications equipment, and electrical machinery and appliances. These electronics firms make up 13 percent of the MIT alumni companies. All told, manufacturing firms make up 13 percent of the MIT alumni companies, 21 percent of total employment, and 6 percent of total sales.⁵ In the United States as a whole, manufacturing accounts for less than 11 percent of total employment. Naturally, company size varies according to industry. Although

5. Not all electronics firms are in manufacturing. Some, for example, are in IC design (computer companies and telecommunications also were grouped with electronics). The estimate depends on how we calculate what is truly manufacturing. The Standard Industrial Classification (SIC) codes (which are admittedly imperfect) of the companies indicate 13 percent with manufacturing codes. However, the entrepreneurs’ industry self-reports suggest that manufacturing constitutes as much as 31 percent. The truth is probably between these two estimates at around 20 percent, much higher than for the United States as a whole, as we would expect for graduates of a technical university.

Table 7
MIT Alumni Companies by Industry

Industry	# of Firms	Employment (Median)	Revenue (Median—in \$000s)
Aerospace	467	15	1,200
Architecture	1,209	5	265
Biomedical	500	27	2,000
Chemicals and Materials	742	25	1,275
Consumer Products	1,417	23	1,500
Management Consulting	2,239	2	200
Electronics	3,285	25	2,000
Energy and Utilities	789	8	507
Finance	1,111	7	1,800
Law and Accounting	1,046	8	450
Machinery	322	25	2,600
Publishing and Schools	564	12	1,200
Software	5,009	22	1,500
Telecommunications	902	5	143
Other Manufacturing	773	20	1,600
Other Services	5,395	30	1,750

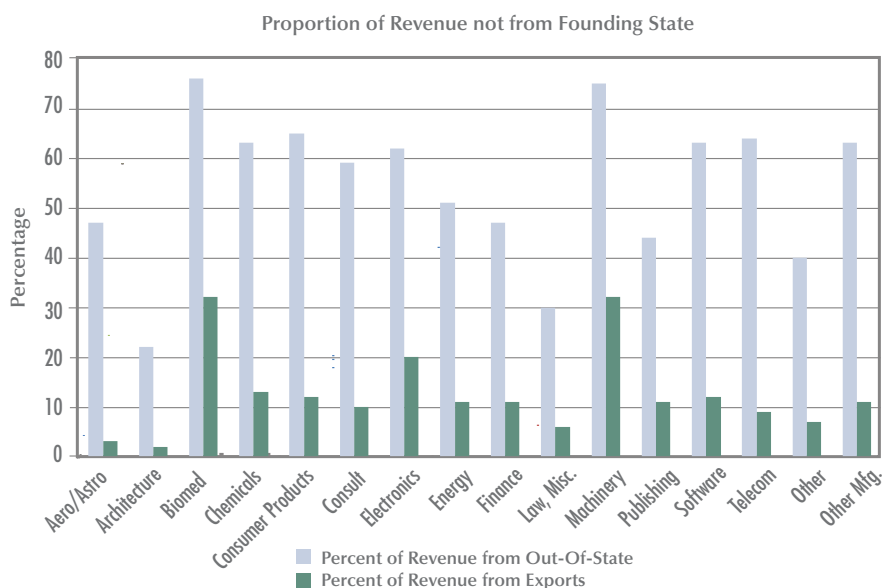
their cumulative impact is significant, the median size in every industry is quite small, reflecting the overall national experience and the large number of young firms.

Firms in software, electronics (including instruments, semiconductors, and computers), and biotech form a special subset of the MIT alumni companies. These high-technology firms (1) spend more of their revenues on research and development, (2) are more likely to hold one or more patents, and (3) tend to export a higher percentage of their products. They are more likely than companies in

other industries to provide the bases for long-term economic growth. Together, firms in these three industries account for one-third of the employment in all MIT alumni companies; electronics and instrument firms alone account for more than 13 percent.

The expansion plans of the companies we surveyed form an interesting “leading indicator,” pointing to growth prospects by industry. More than 30 percent of the firms in chemicals, aerospace, and biotech are planning to expand. They are followed closely by telecommunications and consumer products companies.

Figure 7
Sales of MIT Alumni Companies Out-of-State
and Exported Abroad



Global Markets

In any regional economy, firms that sell out-of-region play the major role in driving economic growth because, as these firms grow in total revenues, they also are growing in local employment, and they create markets for utilities, service firms, retailers, and other local-market businesses. MIT alumni companies have a disproportionate importance to their local economies because so many of them are manufacturing, biotech, and software firms (48 percent of the employment of MIT alumni companies) that tend to compete in and sell to national and world markets. Overall, 54 percent of company sales are to out-of-state markets; 13 percent of total sales come from goods or services sold by U.S. firms abroad. Figure 7 shows these percentages by industry. For electronics, chemical, machinery, biotech, software, and management consulting firms, 65 percent of sales are out-of-state. The only companies

that have in-state sales amounting to 50 percent or more of total revenues are architects, finance companies, publishing, and law firms.

Across all industries, exports (outside of the United States by U.S.-based firms) account for 13 percent of the sales revenues of MIT alumni companies. Exports are slightly higher for biomedical, machinery, and electronics firms (more than 20 percent). Companies in all other industries have an average export share of just under 10 percent. These high-tech, high-growth industries clearly depend on foreign as well as domestic markets.

Figures 8 and 9 present the distributions by industry of the 2003 survey responses. Among manufacturing industries, electronics has held its own for six decades as a major opportunity area for MIT alumni entrepreneurs. On the services side, software firms have grown strikingly as a percentage of firms founded since the 1950s. Also of note is the rapid

Figure 8
Changing Industry Mix of Manufacturing Startups
(percentage)

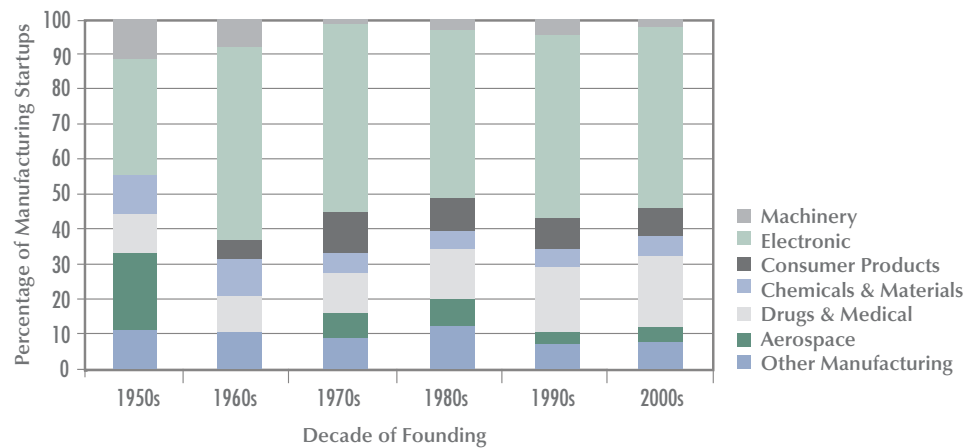
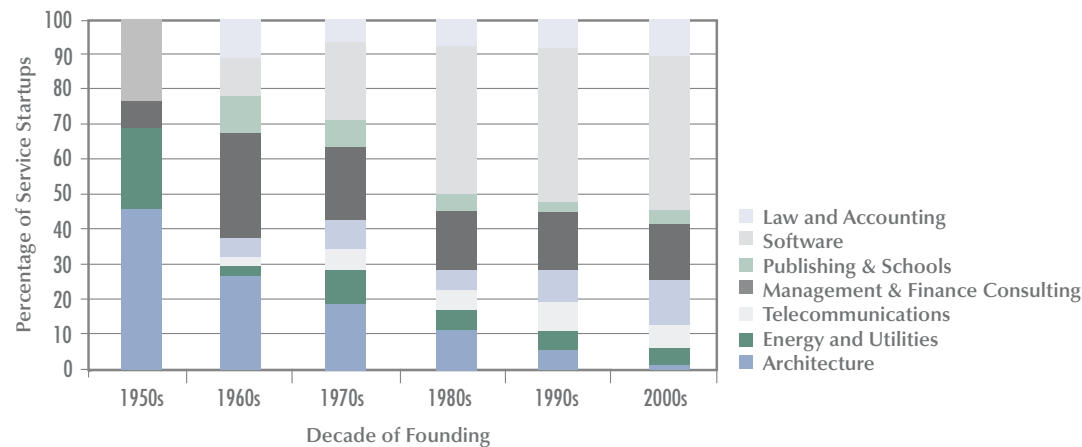


Figure 9
Changing Industry Mix of Services Startups
(percentage)



growth since the 1960s of ventures in financial services and management/financial consulting, no doubt reflecting both the market opportunities as well as the growth of the number of MIT Sloan Master's degree graduates during this period. Some of the trends may be attributable to changes in the size of certain departments relative to the rest of MIT (for example, architecture).

Figure 8 shows the trends over sixty years in the mix of new manufacturing companies being formed by MIT grads, the dominance of electronics firms, and an increase in drug and biomedical firms. Mirroring similar trends in the overall United States and world economies, the percentage of MIT alumni manufacturing firms has been slowly decreasing over

the decades, as shown in Figure 10. From a high of about 20 percent manufacturing firms in the 1950s, about 10 percent of the firms founded in the 1990s and 2000s were manufacturing firms. On average over the decades, 13 percent of the firms founded by MIT alumni are manufacturing firms. But they employ about 30 percent of the total employees of all MIT alumni firms. An interesting observation from Table 2 shown earlier in this report is that the U.S.-located companies founded by MIT foreign-student alumni include more than 28 percent in manufacturing. The overseas-located firms established by foreign alumni include less than 10 percent in manufacturing.

Figure 10
Steady Decline in Manufacturing
vs. Services Startups (percent)

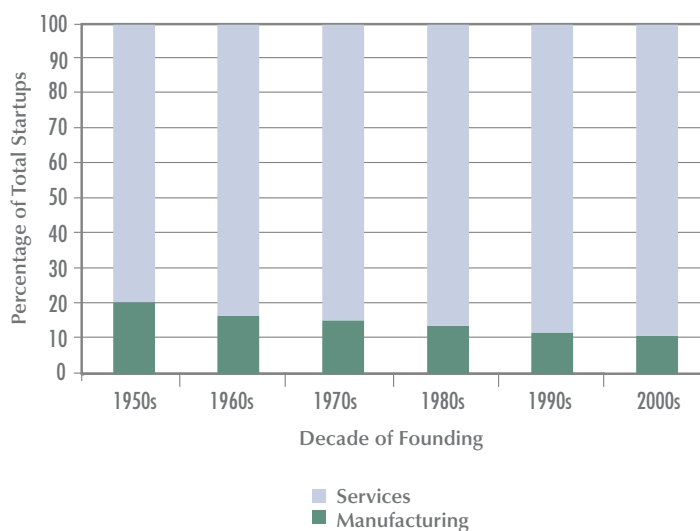
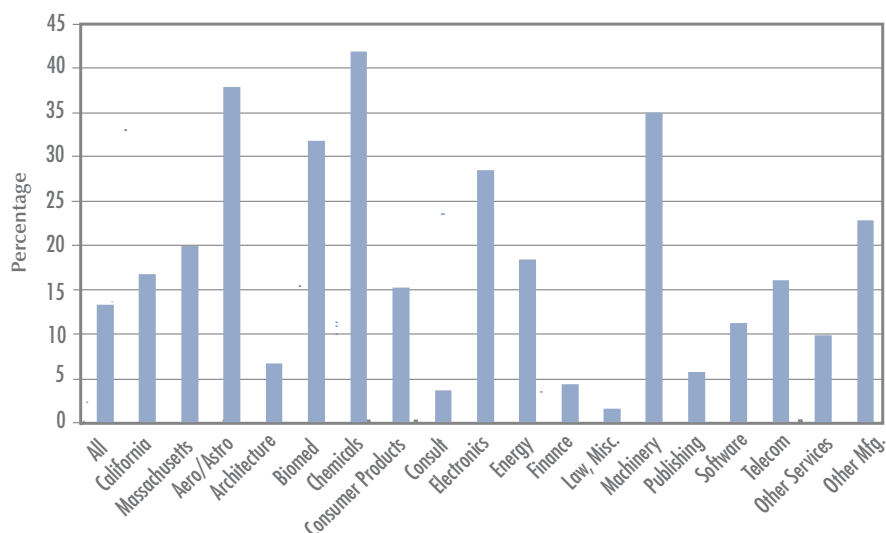


Figure 11
Percent of Surveyed Firms Holding One or More Patents



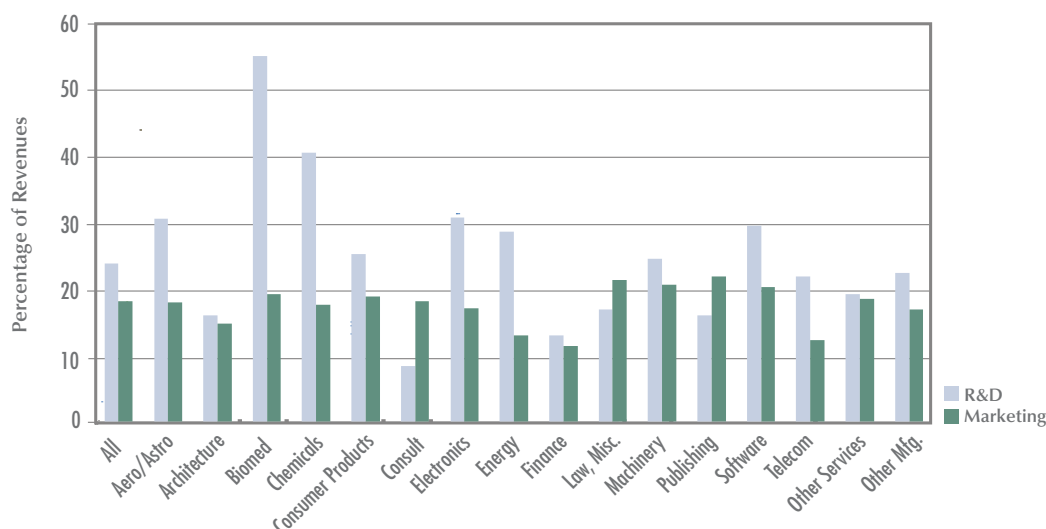
Patents and Research Expenditures

In all, between nearly 30 percent up to more than 40 percent of the surveyed firms in aero/astro, biomed, chemicals, electronics, and machinery hold at least one patent. Consistent with their reputations as the two premier technology locations in the country, as shown in Figure 11, California and Massachusetts firms are more likely to hold patents than are their colleagues in the same industries in other states. The companies that hold patents average around twenty-six patents each. Since larger companies are more likely to have had the time and legal resources to generate and protect intellectual property portfolios, larger companies are more likely to hold patents (59 percent of companies with 500 or more employees hold at least one patent, compared to only 16 percent of companies with fewer than fifty

employees). The larger companies also hold more patents (sixty-four per company for those with 500 or more employees versus only 0.78 for those with fewer than fifty workers).

Aerospace, biotech, electronics, chemicals, and software firms tend to report spending more on R&D, as shown in Figure 12. The average for all surveyed MIT alumni companies is 24 percent of total revenues spent on research and development, whereas software companies spend 29 percent. In contrast, the average R&D spending for all U.S. firms is estimated by the National Science Foundation to be 2.6 percent of GDP in 2006, demonstrating rather dramatically the extraordinary scientific and technological base of the MIT alumni firms. Average MIT companies' spending on marketing is 18 percent of revenue.

Figure 12
Spending on R&D and Marketing in MIT Alumni Companies



Competitive Edge, Obstacles to Success

The recent survey of MIT alumni entrepreneurs has generated some interesting insights into these knowledge-based companies and what gives them a competitive advantage. The survey listed competitive factors and asked respondents to rank each of them in importance. The most frequently cited factors perceived as vital to competitive advantage were: (1) superior performance, (2) customer service/responsiveness, (3) employee enthusiasm, (4) management expertise, and (5) innovation/new technology—all ahead of product price. Although price is not unimportant (it is hard for a company to compete if its price is unreasonable), if a startup has a cutting-edge product with outstanding performance and good customer service, it reasonably can charge a premium.

In the aerospace industry (where government is the major client), price is the second-most important factor (behind superior performance). Price is least important to finance and consulting firms. Time to market is particularly important in electronics and instruments, software, and aerospace, and least important in management consulting and finance. Innovation, new technology, and time to market are particularly important to founders who graduated in the last fifteen years.

Eighty-five percent of the alumni entrepreneurs reported association with MIT as having helped boost their credibility with suppliers and customers. Fifty-one percent of the entrepreneurs also felt that their association with MIT helped in acquiring funding. Had we studied alumni entrepreneurs from Stanford University, Cal Tech, or other research-intensive

universities, we no doubt would have found similar linkages between entrepreneur credibility and the reputation of the alma mater.

Government regulation mattered most to aerospace, chemical, and energy firms, reflecting the role of the government in defense procurement, environmental regulation, and utility regulation. Government regulation made much less difference to software and publishing companies and to company founders who graduated in the last fifteen years relative to their older counterparts.

Firm Location Decisions

Almost all founders (89 percent) started their companies in the general location in which they were living at the time. The largest fraction of these founders (65 percent) indicated that they were living there because this was where they had been employed, and 15 percent indicated that they were living there because that location was where they attended university, which often was MIT and, in other cases, another graduate school. When asked what factors influenced the location of their companies, the most common responses (in order) were: (1) where the founders lived, (2) network of

contacts, (3) quality of life, (4) proximity to major markets, and (5) access to skilled professional workers (engineers, technicians, and managers). Taxes and the regulatory environment were rated as less-important factors for most industries. High-tech startups are highly dependent on the availability of skilled professionals to build reliable, high-quality, innovative products. The companies locate where these professionals like to live.

Within the United States, the development of Silicon Valley and other entrepreneurial locations in California is shown in Figure 13 by the shift toward about 22 percent of MIT graduates starting their companies there, while still having about 26 percent locating in Massachusetts. New York and Texas are home to about 8 percent of the firms in total, slightly increasing over the years, leaving about 45 percent of the alumni-formed firms being located in the other forty-six states.

MIT alumni firms in the high-growth, high-tech industries (software, electronics, biotech) are particularly likely to locate in California or Massachusetts, especially in the premier technology regions of Silicon Valley and Greater Boston. These two states account for 66 percent of all MIT alumni

Figure 13
Location of MIT Alumni Firms in the United States

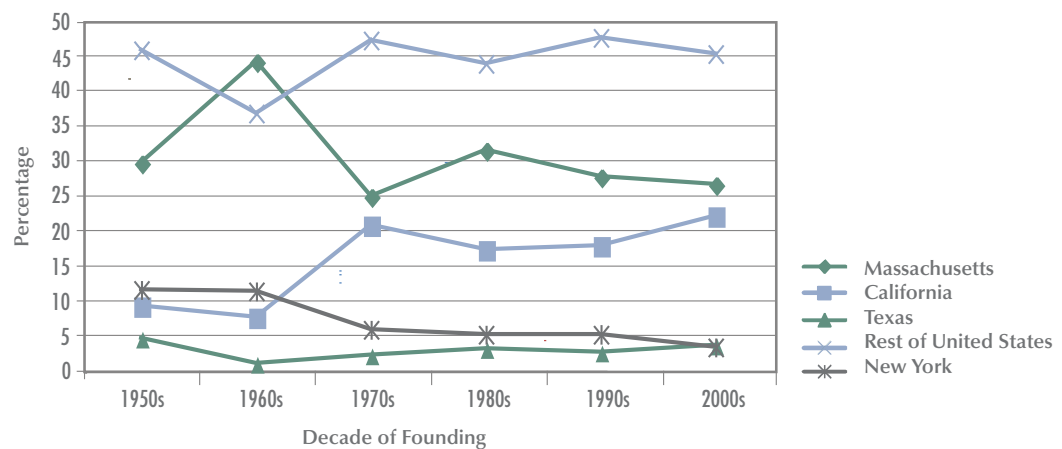
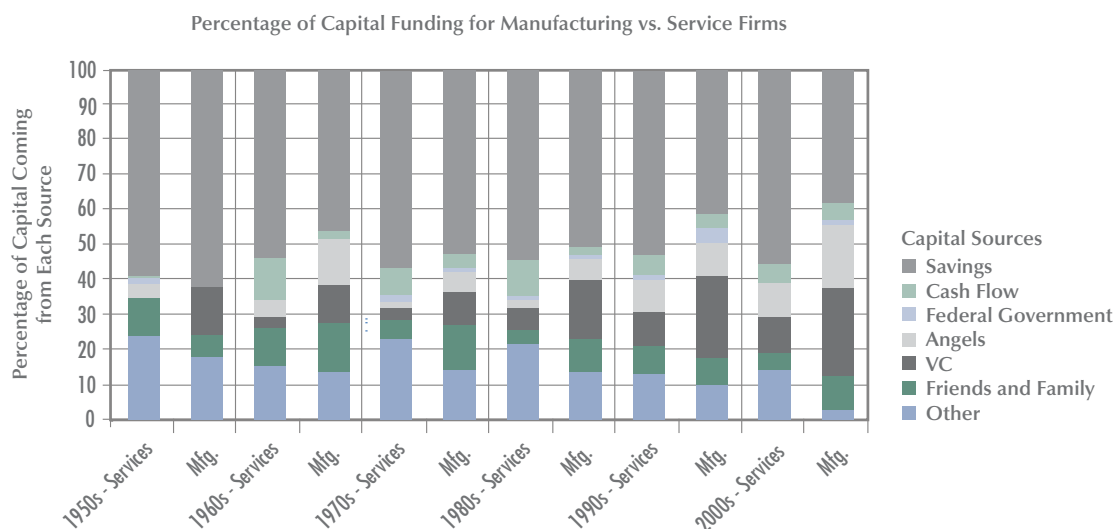


Figure 14
Startup Funding, MIT Alumni Companies (percentage)



electronics firms, 62 percent of software firms, and 62 percent of drug and medical firms. By contrast, they are host to only 36 percent of firms in all other industries.

Startup Capital

Most MIT alumni companies start with funds from the founder's personal savings or by re-investing cash flow, as shown in Figure 14. Personal savings was the primary source determined in earlier studies, as well (Roberts, 1991, pp.124–159). Little differences generally exist in the funding patterns across industries or regions of the country, with but a few interesting exceptions. Entrepreneurs' dependence on personal, family and friends, and informal investors is not just an MIT-related phenomenon, but seems to always have been true both in the United States and globally. Strategic corporate partners are important to electronics, machinery, and chemical firms. Venture capitalists are important to software, electronics, and biotech firms, as well as to chemicals and materials firms. In none of these cases, however, were these

alternate sources more important at the outset than the founders' own savings. Although venture capital was not a major source of initial or even later funding for smaller firms, it was important for companies that grew to fifty or more employees, and was even more significant for companies that achieved 500 or more workers.

Special Case: MIT Alumni Companies in California

We estimate that California has the head offices of 4,100 MIT alumni firms, which employ 526,000 people worldwide and have \$134 billion in sales. The 2,675 MIT alumni firms we project for northern California alone account for the greater part of the MIT presence in California—\$78 billion in worldwide sales and worldwide employment of 322,100. Total employment of MIT alumni companies in Silicon Valley alone is estimated at just over 260,000—about half of total California employment of MIT alumni companies. Of this number, some 135,200 work in manufacturing and 75,500 in electronics.

A 1990 study by the Chase Manhattan Bank identifies 176 MIT-founded companies just in northern California (the Silicon Valley area), employing more than 100,000 with aggregate sales topping \$20 billion. The growth over the fifteen years since that report has been impressive, perhaps attributable in part to a 1990 underestimation of the number and size of the MIT alumni firms. Chase Manhattan notes that 1924 MIT graduate Frederick Terman, former dean of engineering at Stanford University, has been acknowledged as the “father of Silicon Valley.” Other MIT figures in Silicon Valley’s past are William Shockley ’36, who co-invented the transistor, won the Nobel Prize, and founded Shockley Semiconductor Laboratory, which gave birth to the semiconductor industry; Intel co-founder Robert Noyce ’54, who devised the integrated circuit; William Hewlett, also a 1936 MIT graduate who co-founded Hewlett-Packard; and Robert Swanson ’69, who co-founded Genentech, the world’s first biotechnology company. Due to their deaths prior to 2003, none of these individuals or their firms was included in the survey database.

Well over half of the current sales and employment of California MIT alumni companies are in electronics and instruments, but more than \$1 billion in sales are estimated to be in software and biotech. The region’s largest MIT alumni firms include Hewlett-Packard, Intel, National Semiconductor, 3Com, Qualcomm, Tandem Computer, Raychem, Cirrus Logic, Lam Research, Genentech, and Symantec.

Special Case: MIT in Massachusetts

An estimated 6,900 MIT alumni companies are headquartered in Massachusetts. The estimated sales of these companies—\$164 billion—represent 26 percent of the sales of all Massachusetts companies. Worldwide employment of these 6,900 companies is nearly one million, with a substantial share of these jobs spread across the United States. MIT alumni companies in Massachusetts are located primarily throughout its eastern region.

However, these numbers understate the impact of MIT alumni companies on Massachusetts. In one industry after another, these companies represent cutting-edge technologies in their fields. Historical examples include Raytheon in missile and guidance systems; ThermoElectron in instruments and environmental technology; Lotus Development (now part of IBM, so not included in our impact estimates), Medical Information Technology, and Progress Software, all in software; Analog Devices and Analogics in integrated circuits and electronics devices; A123 Systems and American Superconductor in advanced materials; Teradyne in testing equipment for electronic components; M/A Com in microwave technology; BBN in electronics and networking; Genzyme, Biogen, and Alpha-Beta in biotechnology; Bose in acoustic systems; and AVID in video conferencing. Together, these leading companies provide a substantial part of Massachusetts’ high-tech environment, helping to attract highly skilled professionals and other firms to the state.

One reason MIT is so important to the Massachusetts economy is that, without MIT, most of these companies never would have been located in Massachusetts. Most of the MIT alumni companies in Massachusetts were founded by former students who came to the state to attend MIT, liked what they saw, settled down, and eventually started their companies in Massachusetts. Less than 10 percent of MIT undergraduates grew up in the state, but approximately 31 percent of all MIT alumni companies are located in Massachusetts. In the last five years, more than 37 percent of the newly founded MIT alumni companies in software, the Internet, biotech, and electronics have located in Massachusetts.

MIT attracts some of the brightest young people in the country (and the world); many of them like the Boston area and choose to stay there. As just one example, the late Alex d’Arbeloff ’49 came to MIT from Paris just after World War II. His first job after graduation was in New York, but he chose to come back to Boston, where eleven years later d’Arbeloff and his MIT undergraduate classmate Nick DeWolf

'49 started an electronic testing equipment company in DeWolf's home. When they outgrew the house, they rented space in downtown Boston because they liked living on Beacon Hill and wanted to walk to work. Today, Teradyne has more than a billion dollars in revenues and still is located in the Boston area. Another MIT founder located his company north of Boston so he could have easy access both to downtown and, on weekends, to the Maine coast and the New Hampshire mountains. These stories underscore the critical importance of the fact that scientifically oriented entrepreneurs like living in the Boston area. Absent the symphony, the parks, the ocean, MIT and other universities, the art museums, and the other cultural and sports attractions that make Boston unique, the city would likely fail to hold these entrepreneurs and the regional economy would grow more slowly or shrink.

Another advantage of locating in Massachusetts is the proximity to MIT and other Boston-Cambridge-area universities. When asked the importance of various location factors, Massachusetts firms ranked access to MIT and other universities ahead of low business cost; in every other region of the country, business cost was more important than contact with universities. (As indicated earlier, the most important location factors are quality of life and access to skilled professionals. These factors have average scores well above those for business cost and university access.)

Approximately 32 percent of the MIT alumni entrepreneurs report having or anticipate having an ongoing connection with MIT. Most frequently, this ongoing connection has taken the form of recruiting new employees, doing joint research, and/or having faculty advisors or directors. The companies of those who graduated more than thirty years ago are slightly less likely to maintain regular contacts than are the most recent graduates.

MIT—Its Unique History, Culture, and Entrepreneurial Ecosystem

Global pursuit of research- and technology-based industrial development has mushroomed in the past several decades. Greater Boston's Route 128 and California's Silicon Valley are the prototypes for other regions' and other nations' visions of their own futures. But what caused the original American Technopolis around Greater Boston to develop? What forces continue today to encourage young local scientists and engineers to follow entrepreneurial paths? This section of our report traces the evolution of MIT's and Boston's high-technology community, indicating the central role of MIT in building entrepreneurial practice and the supportive entrepreneurial environment or ecosystem. Our own takeoff from Webster defines an ecosystem as a complex community of living and nonliving things that are functioning together as a unit. We demonstrate here that such a system has been evolving for at least the 150 years since MIT's founding to make entrepreneurship so vibrant in and around MIT.

Overwhelming anecdotal data argue that the general environment of the Greater Boston area beginning during the post-World War II period and, in particular, the atmosphere at MIT have played strong roles in affecting "would-be" local entrepreneurs. The legitimacy of "useful work" from MIT's founding days was amplified and directed toward entrepreneurial expression by prominent early actions taken by administrative and academic leaders. Policies and examples that encouraged faculty and staff involvement with industry and, more important, their "moonlighting" participation in spinning off their ideas and developments into new companies were critical early foundation stones. MIT's tacit approval of entrepreneurship, to some extent even making it the norm, was, in our judgment, a dramatic, perhaps the defining, contribution to the Greater Boston entrepreneurial culture. Key individual

and institutional stimulants such as Stark Draper '26 and the MIT Enterprise Forum reinforced the potential entrepreneurial spinoffs that derived from a wide variety of advanced technology development projects in MIT labs as well as those of other local universities and medical centers, and in the region's high-tech industrial firms. These actions fed into a gradually developing positive feedback loop of productive interactions with the investment community that, in time, created vigorous entrepreneurial activity especially at MIT, and a vital Route 128 community and beyond.

Early Influences: The Heritage of World War II Science and Technology

The atomic bomb, inertial guided missiles and submarines, computer-based defense of North America, the race to the moon, and the complex of high-technology companies lining the Route 128 highway outside of Boston are phenomena that became prominent in the post-World War II years. This was a time marked by a plethora of scientific and technological advances. The war had identified technology as the critical element upon which the survival of the nation rested and brought scientists from the shelter of their labs into the confidence of those in the highest levels of government. And in the postwar years, their power and their products and by-products began to shape society, the economy, and the industrial landscape.

How had this started? The sudden need for war research in the early 1940s transformed universities like MIT into elite research and development centers where the best scientific and technological talent was mobilized for the development of specific practical devices for winning the war. Virtually whole universities redirected their efforts from pure scientific inquiry to the solving of critical problems. While many scientists

had to neglect their previous research in favor of war-related innovations, the scientists themselves were not neglected. Science and its offspring technology had become the property of the whole nation with an immediate relevance for all the people.

In addition to the urgent expansion and redirection of university research, the war made necessary the reorganization of research groups, the formation of new working coalitions among scientists and engineers, between these technologists and government officials, and between the universities and industry. These changes were especially noteworthy at MIT, which during the war had become the home of major technological efforts. For example, the MIT Radiation Laboratory, source of many of the major developments in wartime radar, evolved into the postwar MIT Research Laboratory for Electronics. The MIT Servomechanisms Lab, which contributed many advances in automatic control systems, started the research and development project that led to the Whirlwind Computer near the end of the war, created numerically controlled milling machines, and provided the intellectual base for undertaking the MIT Lincoln Laboratory in 1951. After the war, the Servo Lab became the Electronic Systems Lab and continues today as the MIT Laboratory for Information and Decision Systems. Lincoln Lab focused initially on creating a computer-based air defense system (SAGE) to cope with the perceived Soviet threat. To avoid continuing involvement in production and operations once the SAGE system was ready for implementation, MIT spun off a major group from Lincoln Lab to form the nonprofit MITRE Corporation, chartered to aid in the later stages of SAGE and to undertake systems analysis for the government. Lincoln then reaffirmed its R&D thrust on computers, communications, radar, and related technologies primarily for the U.S. Department of Defense. The MIT Instrumentation Lab, growing out of the wartime gun-sight work of Professor Charles Stark Draper, its founder and director throughout his career at MIT, continued its efforts on the R&D needed to create inertial guidance systems for aircraft, submarines, and missiles. It followed up with significant achievements in the race

to the moon with developments of the guidance and stellar navigation systems for the Apollo program. The former Instrumentation Lab now bears Draper's name in its spunoff-from-MIT nonprofit status. Draper testified as to the scope of these endeavors: "Personal satisfaction ... was greatest when projects included all essential phases, ranging from imaginative conception, through theoretical analysis and engineering, to documentation for manufacture, supervision of small-lot production, and, finally, monitoring of applications to operational situations." All these MIT labs were spawned during a period in which little debate existed about a university's appropriate response to national urgency. They have successfully fulfilled their defined missions, while also providing a base of advanced technology programs and people for other possible societal roles, importantly including significant entrepreneurial birthing.

Building on a Tradition

The World War II efforts and the immediate postwar involvements of MIT with major national problems built upon a much older tradition at MIT, enunciated by its founder William Barton Rogers in 1861 when he created an institution to "respect the dignity of useful work." MIT's slogan is "Mens et Manus," Latin for "mind and hand," and its logo shows the scholar and the craftsman in parallel positions. For a long time, MIT was seen as virtually alone as a university that embraced rather than shunned industry. Early alumni of "Boston Tech" (what MIT was "fondly" called before its move from Boston to Cambridge in 1910) pioneered new industries, such as automobiles. For example, Aurin Chase, MIT class of 1900, soon after in 1906 founded and ran Chase Motor Truck Company, a major truck and track vehicle supplier to the U.S. Army during World War I. From its start, MIT had developed close ties with technology-based industrialists, like Thomas Edison and Alexander Graham Bell, then later with its illustrious alumnus Alfred P. Sloan (MIT 1892) during his pioneering years at General Motors and with close ties to the growing U.S. petroleum industry. In the

1930s, MIT generated The Technology Plan to link industry with MIT in what became the first and is still the largest university-industry collaborative, the MIT Industrial Liaison Program.

These precedents were accelerated by the wartime leadership of MIT's distinguished president, Karl Taylor Compton, who brought MIT into intimacy with the war effort while he headed all national R&D coordination in Washington. In the immediate postwar years, Compton pioneered efforts toward commercial use of military developments, among other things helping to create the first institutionalized venture capital fund, American Research and Development.

"AR&D was, in part, the brainchild of Compton, then head of MIT. In discussions with Merrill Griswold, chairman of Massachusetts Investors Trust, and Senator Ralph Flanders of Vermont, then president of the Federal Reserve Bank of Boston, Compton pointed out that some of the A-bomb technology that had been bottled up for four years had important industrial applications. At the same time, it was apparent to Griswold and Flanders that much of New England's wealth was in the hands of insurance companies and trusts with no outlet to creative enterprises. Griswold and Flanders organized AR&D in June 1946 to supply new enterprise capital to New England entrepreneurs. [Compton became a board member, MIT became an initial investor, and a scientific advisory board was established that included three MIT department heads. General Georges] Doriot, who was professor of Industrial Management at Harvard, was later asked to become president" (Ziegler, 1982, p. 152). AR&D's first several investments were in MIT developments, and some of the emerging companies were housed initially in MIT facilities. For example, in 1947, AR&D invested in High Voltage Engineering Corporation, which was located in the so-called "back lot" of MIT to take advantage of Professor John Trump's Van de Graaf generator that stood there. AR&D also invested in Ionics Inc., which became the United States' preeminent water purification company, purchased by General Electric in 2004 for \$1.3 billion, but housed

initially in the basement of the MIT Chemical Engineering building. MIT provided the space, heat, and light, and AR&D paid for the staff and out-of-pocket R&D expenses. That kind of arrangement certainly was most unusual for its time, albeit quite entrepreneurial, and today would be seen at most universities, including MIT, as a source of controversy and potential conflict. Compton's successor as president of MIT, James Killian '26, furthered the encouragement of entrepreneurial efforts by MIT faculty and staff as well as close ties with both industry and government. At various times Killian served on the boards of both General Motors and IBM and as President Eisenhower's Science Advisor.

The traditions of MIT involvement with industry long since had been legitimized in its official "Rules and Regulations of the Faculty," encouraging active consulting by faculty members of about one day per week and, more impressive for its time, approving faculty part-time efforts in forming and building their own companies, a practice still questioned at many universities. Early faculty-founded companies include Arthur D. Little, Inc. (ADL), Edgerton Germeshausen and Grier (EG&G, Inc.), Bolt Beranek & Newman (BBN, Inc.), and many others. Initially, these were consulting firms that only later extended their domains into the realm of products. Faculty entrepreneurship, carried out over the years with continuing and occasionally heightened reservations about potential conflicts of interest, generally was extended to the research staff as well, who were thereby enabled to "moonlight" while being "full-time" employees of MIT labs and departments. The result is that a large fraction of all MIT spinoff enterprises, including essentially all faculty-initiated companies and many staff-founded firms, are started on a part-time basis, smoothing the way for many entrepreneurs to "test the waters" of high-tech entrepreneurship before making a full plunge. These companies are obvious candidates for most direct movement of laboratory technology into the broader markets not otherwise served by MIT. Few of the faculty founders, including Amar Bose '51, founder of Bose Corporation, or Robert Langer '74, a brilliant

biomaterials scientist who has co-founded more than a dozen companies, ever resigned their MIT positions, preferring to remain at MIT for years while turning over the full-time reins to their former graduate students and lab colleagues. George Hatsopoulos '49, founder of ThermoElectron Corporation; Jay Barger '50, co-founder with another faculty colleague of Dynatech; Alan Michaels '44, founder of Amicon; and Tom Gerrity '63, co-founder of Index Systems, are among the few faculty who left to pursue their entrepreneurial endeavors full-time, with great success achieved in all four cases.

Although today regional and national governments worldwide seek to emulate the Boston-area pattern of technological entrepreneurship, in the early years the MIT traditions spread to other institutions very slowly. The principal early disciple was Frederick Terman '24, who took his Cambridge experiences as an MIT PhD student back to Stanford University, forsaking a faculty offer by MIT, to eventually lead Stanford into technological excellence. From his earlier MIT studies, amplified by his WWII service in Cambridge, Terman gained first-hand exposure to the close ties between MIT and industry, made more important to him by his being mentored by Professor Vannevar Bush '16, later dean of engineering and then vice president of MIT, who participated in founding the predecessor of Raytheon Corporation. The attitudes he developed while at MIT led Terman to encourage and guide his former students, such as William Hewlett '36, David Packard, and the Varian brothers, to start their high-technology firms and eventually to locate them next to the university in the newly formed Stanford Research Park. While these efforts obviously helped found what has become known as "Silicon Valley," the resulting early proliferation of firms there came heavily from multiple spinoffs of other companies and did not follow the dominant Greater Boston pattern of direct fostering of new firms from MIT labs and departments. The MIT-Route 128 model still today remains unusual in its degree of regional entrepreneurial dependence upon one major academic institution.

The Neighboring Infrastructure

Yet, MIT has not been alone over the past several decades in nurturing the technology-based community of Boston, an entrepreneurial ecosystem now sprawling outward beyond Route 128 to the newer Route 495. Northeastern University, a large urban institution with heavy engineering enrollment and an active cooperative education program with industry, has educated many aspiring engineers who provide both support staff and entrepreneurs to the growing area. Wentworth Institute educates many of the technicians needed to support the development efforts at both the university labs as well as the spinoff companies. Boston University and Tufts University, both with strong science and engineering faculties, also play important roles. Even small liberal arts Brandeis University has participated, with Professor Orrie Friedman in 1961 starting Collaborative Research, Inc., forerunner of the much later biotechnology boom in the Greater Boston area. And that firm also illustrates the beginnings of cross-institutional ties among faculty entrepreneurs, with MIT Professor David Baltimore becoming the Chief Scientist of Collaborative while in his young thirties. Baltimore later became the founding director of the MIT Whitehead Institute, a major building block of the Cambridge biotech entrepreneurial cluster, and still later president of Rockefeller University, president of the California Institute of Technology, a Nobel Prize winner, and a co-founder of several companies.

Possibly surprising to readers from outside of the Boston area, Harvard University had not had a substantial role in entrepreneurial endeavors until the recent biotechnology revolution, in which Harvard Medical School and its affiliated teaching hospitals are playing a major role. In many ways over the years, Harvard has looked down its "classics" nose with disdain at the "crass commercialism" of its technological neighbor a few miles down the Charles River. An Wang, who worked at the Harvard Computation Laboratory before founding Wang Laboratories, Inc., is the most prominent exception to this rule. But change in regard to encouraging entrepreneurship has been in the wind over the past

two decades, even at Harvard. The outpouring of excellent research and discovery from Harvard's Chemistry and Biology Departments, as well as from the Harvard Medical School across the river in Boston, have caused Harvard faculty and staff recently to become much more active and successful participants in entrepreneurial startups, although not without voiced reluctance and controversy at the university. In fact, in a dramatic early attempted revolution of its policies, Harvard asked Professor of Biochemistry Mark Ptashne to start Genetics Institute in 1979, a company in which Harvard would hold 15 percent to 20 percent equity (something MIT has never done!). But protest by critics as to possible influence of such ownership caused Harvard to pull out. Ptashne went ahead and formed the company, while still remaining on the Harvard University faculty. In 1989, the Harvard Medical School took the far-reaching step of organizing a venture capital fund (discontinued a few years later) to invest in new companies whose founders relate to Harvard Medical, in some ways mimicking MIT's much earlier but less-direct activities in regard to AR&D, but nevertheless a pioneering step among academic institutions. And, recently, a group of Harvard Medical-affiliated hospitals (Partners Healthcare) has formed its own venture capital firm to invest in its potential commercial spinoffs.

Encouraged no doubt by the unique venture capitalist role of Professor Doriot, and separated by the Charles River from main campus influence, many Harvard Business School graduates joined alumni from the MIT undergraduate management program and, after its 1951 founding, from the MIT Sloan graduate school as well, in finding welcome homes in even the early high-tech company developments. These business school graduates got involved in startup teams initially as administrators and sales people, and in more recent years participating frequently as primary founders. Thus, Aaron Kleiner '69 from the MIT Sloan School of Management shares the founding of nine high-technology companies with his MIT computer science undergraduate roommate Raymond Kurzweil '70. And Robert Metcalfe '68 combined MIT educational

programs in both engineering and management prior to his launch of 3Com. The Greater Boston environment has become so tuned to entrepreneurship that even student projects with local companies, a part of routine course work in every local management school, have ended up helping to create numerous entrepreneurial launches. Several firms were generated from feasibility studies done as part of Doriot's famed "Manufacturing" course at the Harvard Business School. And *Inc.* magazine founder Bernard Goldhirsh '61 credited an MIT Sloan School marketing course with confirming for him the huge market potential for a magazine targeted toward entrepreneurs and small business managers.

Boston entrepreneurs also eventually benefited from understanding bankers and private investors, each group setting examples to be emulated later in other parts of the country. The First National Bank of Boston (later becoming BankBoston and now part of Bank of America) had begun in the 1950s to lend money to early-stage firms based on receivables from government R&D contracts, a move seen at the time as extremely risky even though the loans seemed to be entirely secured. Arthur Snyder, then vice president of commercial lending of the New England Merchants Bank (which became Bank of New England and later part of Citizens Bank), regularly took out full-page ads in the *Boston Globe* that showed himself with an aircraft or missile model in his hands, calling upon high-technology entrepreneurs to see him about their financial needs. Snyder even set up a venture capital unit at the bank (one of the first in the United States) to make small equity investments in high-tech companies to which he had loaned money. Several scions of old Boston Brahmin families became personally involved in venture investments even in the earliest time period. For example, in 1946, William Coolidge helped arrange the financing for Tracerlab, MIT's first nuclear-oriented spinoff company, eventually introducing William Barbour '33 of Tracerlab to AR&D, which carried out the needed investment (Ziegler, 1982, p. 151). Coolidge also invested in National Research Corporation (NRC), a company founded by MIT

alumnus Richard Morse '33 (later the first teacher of entrepreneurship at MIT) to exploit advances in low-temperature physics. NRC later created several companies from its labs, retaining partial ownership in each as they spun off, the most important being Minute Maid orange juice, later sold to Coca-Cola. NRC's former headquarters building, constructed adjacent to MIT on Memorial Drive in Cambridge, now houses the classrooms of the MIT Sloan School of Management. Incidentally, long before the construction of Route 128, Memorial Drive used to be called "Multi-Million Dollar Research Row" because of the several early high-technology firms next to MIT, including NRC, Arthur D. Little Inc., and Electronics Corporation of America. The comfortable and growing ties between Boston's worlds of academia and finance helped create bridges to the large Eastern family fortunes—the Rockefellers, Whitneys, and Mellons, among others—who also invested in early Boston startups. Although these funds existed, they were not available in generous amounts. Even in 1958, Ken Olsen '50 and Harlan Anderson '53 had to surrender more than 70 percent of startup Digital Equipment Corporation (DEC) for the \$70,000 they received from AR&D. Other aspects of the surrounding infrastructure also were slow in happening. By and large, lawyers were uninformed about high-tech deals, and general law firms had no specialists in intellectual property. As late as the early 1980s, the MIT and Harvard co-founders of Zero Stage Capital, Boston's first "seed capital" fund, eventually found Paul Brontas, the senior partner of Boston's then-leading law firm Hale & Dorr, to be among the only lawyers in town who knew how to set up the complex structure of a venture capital firm.

By the end of the 1940s, when space constraints in the inner cities of Boston and Cambridge might have begun to be burdensome for continuing growth of an emerging high-technology industrial base, the state highway department launched the building of Route 128, a circumferential highway (Europeans and Asians would call it a "ring road") around Boston through pig farms and small communities. Route 128 made suburban living more readily accessible and land

available in large quantities and at low prices. MIT Lincoln Lab's establishment in 1951 in Concord, previously known only as the site of the initial 1776 Lexington-Concord Revolutionary War battle with the British, "the shot heard round the world," or, to some, as the home of Thoreau's Walden Pond, helped bring advanced technology to the suburbs. Today Route 128, proudly labeled by Massachusetts as "America's Technology Highway," reflects the cumulative evidence of sixty years of industrial growth of electronics, computer, and software companies. Development planners in some foreign countries occasionally have been confused by consultants and/or state officials into believing that the once-convenient, now traffic-clogged Route 128 highway system actually caused the technological growth of the Greater Boston area. At best the Route 128 highway itself, later followed by the more distant Route 495 circumferential road, has been a moderate facilitator of the development of this high-technology region. More likely the so-called "Route 128 phenomenon" is a result and a beneficiary of the growth caused by the other influences identified earlier.

Throughout this period since World War II (and to a lesser extent prior to that time), the sometimes-overlooked but in reality quite vital formation of high-tech companies in the Greater Boston area, as well as in most other high-tech regions in the United States, has been aided powerfully, even if indirectly, by government research funding. One visible example at MIT and nearby was the foundation for the modern computer industry, which benefited from hundreds of millions of dollars of defense research into semiconductors and electronics, much of it spent in New England.

MIT depends on federal agencies for approximately 75 percent of its \$587.5 million of on-campus-sponsored research. Another \$636 million of research and development is at MIT Lincoln Laboratories, which MIT runs for the Air Force. (Ken Olsen, founder of Digital Equipment Corporation, worked on computer research and development there.) A very early (1964) study by Roberts documented forty-seven companies that

already had emerged from Lincoln Lab. On the occasion of its fiftieth anniversary in 2001, Lincoln Lab itself documented eighty-two companies that had been founded by former employees, many of whom were not MIT alumni.

On-campus research accounts for about 29 percent of the Institute's budget and, because of these research funds, the faculty is likely to be much larger than otherwise would be the case. In addition, more than \$52 million goes to hiring graduate students as research assistants. The flow of federal dollars thus helps to bring thousands of the brightest young students in the United States and from other countries to Boston, involves them in cutting-edge research projects, and helps pay for their graduate education. As we've seen, many of these students stay in the area and start companies, often with their faculty mentors.

Accelerating Upward from the Base: Positive Feedback

A critical influence on entrepreneurship in Greater Boston (and we assert in other regions as well, when they do indeed take off) is the effect of "positive feedback" arising from the early role models and successes. Entrepreneurship, especially when successful, begets more entrepreneurship. Schumpeter observed: "The greater the number of people who have already successfully founded new businesses, the less difficult it becomes to act as an entrepreneur. It is a matter of experience that successes in this sphere, as in all others, draw an ever-increasing number of people in their wake" (1936, p. 198). This certainly has been true at MIT.

The earliest faculty founders were senior faculty of high academic repute at the times they started their firms. Their initiatives as entrepreneurs were evidences for others at MIT and nearby that technical entrepreneurship was a legitimate activity to be undertaken by strong technologists and leaders. Karl Compton's unique role in co-founding AR&D while president of MIT furthered this image, as did the MIT faculty's efforts in bringing early-stage developments to AR&D's attention. Obviously, "if they can do it, then so can I" might well have been a rallying cry for junior faculty and staff, as well as for engineers in local large firms. Our comparative study years ago of Swedish and Massachusetts technological entrepreneurs found that, on average, the U.S. entrepreneurs could name about ten other new companies before they started their own, three or four of which were in the same general area of high- technology business. Few of the Swedish entrepreneurs could name even one or two others like them. A prospective entrepreneur gains comfort from having visibility of others like herself or himself; this evidence is more likely if local entrepreneurship has a critical mass, making the individual's break from conventional employment less threatening.

The positive feedback loop affecting MIT's entrepreneurial output is no doubt most affected by the increasing attraction of the Institute to students, staff, and faculty who are entrepreneurially inclined even before they arrive. The more entrepreneurial MIT appears to be, the more potential entrepreneurs want to be there. Table 8 indicates the responses from those MIT alumni entrepreneurs who completed the 2003 survey. Clearly, for more than fifty years, MIT has been attractive to those who later

Table 8.
Role of MIT's Positive Feedback Loop in Venture Funding (from limited sample only)

Proportion of Founders Choosing MIT for the Entrepreneurial Environment (percentage)					
Graduation Decade	1950s (N=207)	1960s (N=313)	1970s (N=373)	1980s (N=315)	1990s (N=214)
Chose MIT for its Entrepreneurial Reputation	17%	12%	19%	26%	42%

form new companies. But the table shows an amazing escalation over the past thirty years. Indeed, 42 percent of those 1990s graduates who already have formed companies within their very first decade out of MIT claim they were attracted to MIT originally by its reputed entrepreneurial environment. The more entrepreneurs MIT produces, the stronger the entrepreneurial environment and reputation, the more likely entrepreneurs, both students and faculty, are attracted to come to MIT!

The growing early entrepreneurial developments at MIT and, more broadly, in the Greater Boston area also encouraged their brave investors and brought other wealthy individuals forward to participate. As an example of the spiraling growth of new firms, even in the early days, Ziegler (1982) shows the proliferation of thirteen nuclear-related companies ‘fissioning’ within fifteen years from Tracerlab’s 1946 founding, including Industrial Nucleonics (which became Accuray), Tech Ops, and New England Nuclear (purchased by DuPont). Inevitably, that led not only to more new firms but to a technological cluster of companies that interacted with each other to the benefit of all. With now more than fifty years of intensive regional entrepreneurial activity in the Boston area, a positive feedback loop of new company formation has generated significant outcomes, even if the initial rate of growth was slow. In the mid-1960s, through dramatic proliferation of spinoff companies, Fairchild Semiconductor (co-founded by MIT alumnus Robert Noyce ‘53 before he left to co-found Intel) gave birth to similar and rapid positive feedback that launched the semiconductor industry in Silicon Valley. And Tracor, Inc., provided a comparable impetus to new-company formation, especially in military electronics, in Austin, Tex.

A side benefit of this growth, also feeding back to help it along, is the development of supporting infrastructure in the region—technical, legal, accounting, banking, and real estate, all better understanding how to serve the needs of young technological firms. In Nancy Dorfman’s early (1983) assessment of the economic impact of the Boston-area developments, she observes “a network of job

shoppers that supply made-to-order circuit boards, precision machinery, metal parts, and sub-assemblies, as well as electronic components, all particularly critical to new startups that are developing prototypes and to manufacturers of customized equipment for small markets. In addition, dozens if not hundreds of consulting firms, specializing in hardware and software, populate the region to serve new firms and old.” Of course, this massive network is itself made up of many of the entrepreneurial firms we have been investigating. Within this infrastructure in the Boston area are now “not-so-new” “networking” organizations, like the MIT Enterprise Forum (to be discussed later) and the 128 Venture Group, which bring together on a monthly or even more frequent basis entrepreneurs, investors, and other participants in the entrepreneurial community, contributing further positive loop gain.

Technology Clusters

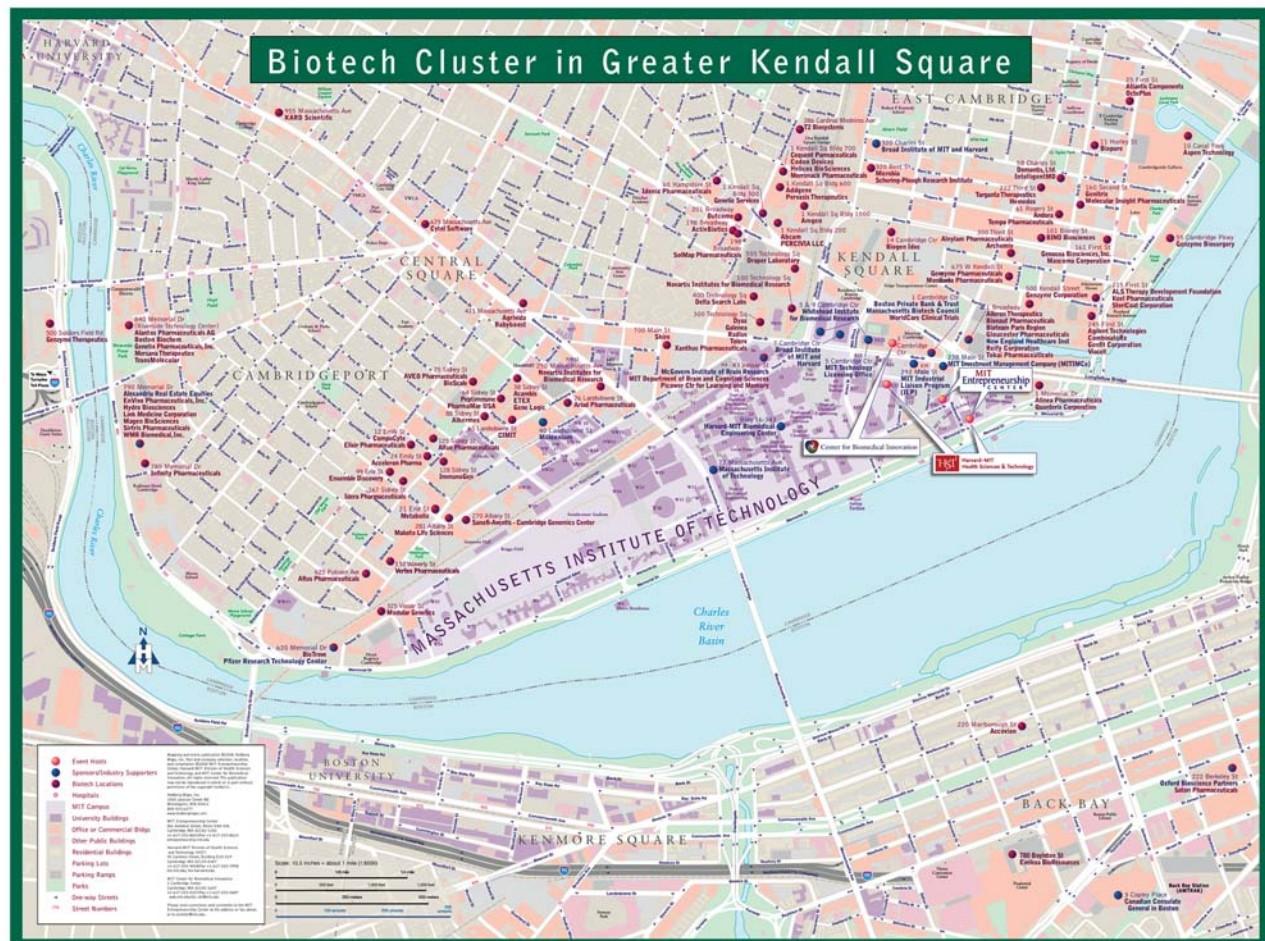
This positive feedback effect certainly occurred in the Greater Boston region as a whole and, as illustrated by the Tracerlab and Fairchild examples, also frequently occurs in many places at the single organizational level. As one individual or group departs a given lab or company to form a new enterprise, the entrepreneurial phenomenon may mushroom and tend to perpetuate itself among others who learn about the spinoff and also get the idea of leaving. Sometimes one group of potential entrepreneurs feels it is better suited than its predecessors to exploit a particular idea or technology, stimulating the second group to follow quickly. Five groups left the Draper Lab over a two-year period to establish new companies based on the lab’s advances in micro-electronics. The “outside environment” can help this process by becoming more conducive to additional new enterprise formation. In particular, venture capitalists, learning more about a “source organization” of new ideas and/or key people from the organization’s earlier spinoffs, may actively seek to encourage further spinoffs from the same source. This certainly played an important role in the 1980s’ beginning of the still-

continuing proliferation of biotechnology spinoffs from MIT and Harvard academic departments and medical centers. Sometimes a “keystone” company assists many others to be formed, as was done by BioInformation Associates, a company formed by eight MIT professors, including Anthony Sinskey ’67 and Charles Cooney ’70, to provide technical and strategic assistance to others interested in starting new firms. It provided major help in the creation and development of Genzyme Corporation, among others. And the increasing critical mass of companies and their skilled scientists and engineers attract other

companies, even very large global firms like Novartis, to locate laboratories and other facilities in the midst of the clusters, enhancing the availability of scientists and engineers, and further strengthening the relevant infrastructure.

As evidences of the results that come from this positive feedback effect within a given industry, we show two local maps of the area near MIT. The first, Figure 15, indicates the recent status of the biotechnology cluster in and around Kendall Square, Cambridge, within blocks of MIT. Ninety-five biotech

Figure 15
Biotech Companies Clustered in Greater Kendall Square, Cambridge, Mass.



companies had been documented by early 2008 as located within this complex, compared with fifty-five just three years prior. Thirteen of the Kendall Square life sciences companies accounted for two-thirds of the \$1.8 billion Massachusetts companies spent on R&D in 2000. By the year 2001, twenty-one of the Kendall Square companies either were founded by MIT alumni or faculty, or had MIT-licensed technology; their revenues were \$2.5 billion.

Since 2001, the biotech numbers have continued to grow substantially. In ongoing research on the MIT-related life sciences complex in Cambridge, Professor Fiona Murray of MIT Sloan now finds that sixty-six of the 493 MIT “life scientists” (including those at the affiliated Broad and Whitehead Institutes) have founded or served on the boards of directors of at least one venture-funded company, totaling 134 companies in all. Eighteen of these faculty or staff have founded or been board members of at least three companies each, with one MIT faculty member having twenty such relationships. Fifty additional MIT “life science” people serve as science advisory board members of an additional 108 companies, bringing a total of at least 242 life-science companies into strong ties with the MIT community. These ties are both cause and result of the interconnections between MIT and the entrepreneurial and industrial community. A large fraction of these life sciences faculty, post-docs, and staff do not have MIT degrees, and therefore are not counted among the MIT alumni entrepreneurship firms discussed in the earlier part of this report. Therefore, the economic and technological impact of these companies, by and large, supplement the data presented in the beginning of this report.

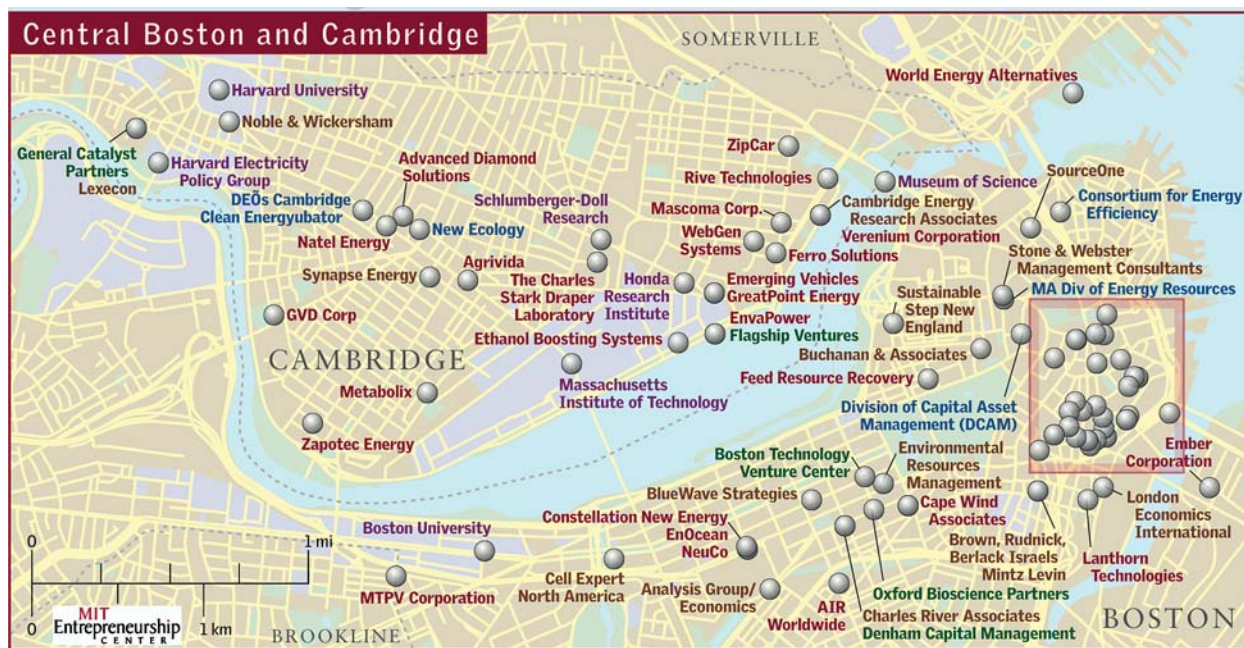
Another sign of linkage of this cluster to MIT is the record of biotech/biomedical winners and runners-up in the MIT \$50K Competition, the student-run business plan competition that will be discussed in greater depth later in this report. Data compiled by the MIT Entrepreneurship Center, listed in Table 9, shows fourteen bio-related companies in the last decade, several of which became real companies following their MIT \$50K successes.

Table 9
Recent Biotech/Biomed MIT \$50K Leaders

Company	Year	Outcome
SteriCoat	2006	Winner
Balico	2005	Winner
Active Joint Brace	2004	Winner
SmartCells	2003	Winner
Ancora Pharmaceuticals	2002	Finalist
Crosslink Medical	2002	Finalist
Angstrom Medical	2001	Winner
Iptyx	2001	Finalist
SiteSpecific Pharma	2001	Finalist
SmartCure	2001	Finalist
EyeGen	2000	Winner
MolecularWare	1999	Winner
Virtmed	1998	Finalist
Actuality Systems	1997	Winner

A second cluster has formed rapidly in the energy field. Over the past five decades, 3 percent of MIT entrepreneurs classified their firms as being in the energy sector. We now estimate that MIT alumni are creating thirty to thirty-five new energy-focused firms every year. Several hundred companies are in the New England energy cluster, with 263 in Massachusetts alone by early 2008. In Figure 16, we show the Boston metropolitan portion, containing twenty-two energy companies in Cambridge and twenty-five more in Boston. The broad geographic distribution of the energy firms, relative to the biotech companies shown in Figure 15, reflect the large number of source organizations of the energy companies, their wide diversity of technological bases, and their need for somewhat greater physical space than is readily available in central Cambridge. A high percentage of the new energy firms are MIT-related in terms of their founders and/or technology sources.

Figure 16
The Emerging Energy Cluster in Greater Boston



Other “Pulls” on Potential Entrepreneurs

In addition to the general environmental encouragements on technological entrepreneurship in MIT’s surroundings, specific “pulls” are at work on some of the people, making entrepreneurship an attractive goal to attain. Such influences may inhere in the general atmosphere of a particular organization, making it more conducive to the new enterprise spinoff process. For example, until his recent death, Stark Draper ’26, visionary leader of the MIT Instrumentation Laboratory (later renamed the Draper Lab), was a key source of encouragement to anyone who came in contact with him. No wonder that the National Academy of Engineering established the Draper Prize to be the equivalent in engineering of the Nobel Prizes in science. Having had the good

fortune to fly coast-to-coast with Draper one night on a “red eye” from Los Angeles, one of our co-authors learned much about Draper’s unique attitudes toward developing young technologists.

“I try to assign project managers who are just a bit shy of being ready for the job,” Draper said. “That keeps them really hopping when the work gets underway, although the government officials usually want to wring my neck.

“I break up successful teams once they’ve received their honors. That way every one remembers them for their success, rather than for some later failure. Also, this causes every young person in the Lab to be sitting within one hundred feet of someone who’s had his hand shaken by the President of the United States.

“The Lab is a place for young people to learn. Then they can go someplace else to succeed.

“When I give speeches, I single out those who have already left the Lab—to become professors elsewhere, VPs of Engineering in industry, or founders of their own companies. Staying behind in the lab is just for a few old ‘beezer’ like me who have no place else to go!”

Draper’s organizational environment was one of high achievement, but with negative incentives for remaining too long. Salaries flattened out quickly, causing the income gap between staying and leaving to grow rapidly as an engineer gained experience. Engineers completing a project had a sharp breakpoint, a good time for someone confident from the success of his or her project to spin off. In retrospect, Stark Draper clearly consciously tried to encourage spinoffs of all sorts from his laboratory, perhaps the highest attainment achievable by an academic scientist.

No questions were asked if Instrumentation Lab employees wanted to borrow equipment to take home over the weekend, and many of them began their new companies “moonlighting” with this kind of undisguised blessing. Draper wanted reasonably high levels of turnover and constant introduction to the Lab of bright, eager, young people. Over a fifteen-year period, during which we traced Lab performance, the average age of Instrumentation Laboratory employees remained at thirty-three years, plus or minus six months. This young-age stability, maintaining the lab’s vitality and fighting off technological obsolescence, was not true at most of the other MIT labs we studied.

Draper apparently produced similar effects in his teaching activities at MIT. Tom Gerrity ’63, founder of Index Systems, which, in turn, later created Index Technology and Applied Expert Systems as sponsored spinouts, reports that Draper’s undergraduate elective subject showed him the importance of being able to put together lots of different skills and disciplines to produce a result. Gerrity adopted this systems point of view in co-founding Index several years later, after

three MIT degrees and a stint as a faculty member in the MIT Sloan School of Management. Still later, Gerrity became dean of the Wharton School of the University of Pennsylvania.

Some other MIT laboratory directors followed similar patterns of entrepreneurial “sponsorship” in smaller, less-well-known labs. For example, the head of the Aero-elastic and Structures Laboratory of the MIT Department of Aeronautics and Astronautics had the attitude that the lab provided an internship type of position and that staff members were more or less expected to move on after a reasonable period. In other labs, the environment just seemed to breed entrepreneurship. Douglas Ross ’54, who left the Electronics Systems Lab with Jorge Rodriguez ’60 to found SofTech, Inc., commented: “The entrepreneurial culture is absolutely central to MIT. The same mix of interests, drives, and activities that makes a [Route] 128-type environment is the very life blood of MIT itself. No other place has the same flavor.” Ross epitomizes this “life blood” quality. When SofTech was established, MIT took the exceptional step for that time of making a small direct equity investment in his ground-zero company, joining a large number of friends and associates who shared great confidence in Ross’s vision.

Indeed, the challenging projects underway at most of the labs create a psychological “let-down” for their participants when the projects end. Many of the entrepreneurs indicate that they became so involved with their work on a given project that, when these projects were completed, they felt that their work, too, was completed. Several of the entrepreneurs attest that their sense of identification with their lab began to wane as the project neared completion. Only through the challenge of starting their own enterprises did they think they could recapture the feelings that they were doing something important.

Beyond the labs themselves, other activities at MIT have over the years encouraged entrepreneurship. The MIT Alumni Association undertook special efforts to encourage

entrepreneurship among its members, which will be discussed indepth later. All of these efforts have spread the word, legitimized the activities of entrepreneurship, and produced significant results.

New policies instituted by John Preston and strengthened by Lita Nelsen '64, successive directors of MIT's Technology Licensing Office (to be discussed in more detail), further encouraged entrepreneurship, especially by faculty and research staff. In addition to conventional technology licensing to mainly large corporations for fees, the TLO actively licenses MIT-originated technology in exchange for founder stock in a new enterprise based on that technology. In the first year of this new practice, 1988, six new companies were born based on licensed MIT technology, with sixteen firms started in the second year of policy implementation. Complete, more recent TLO spinoff data are shown later.

A Unique Culture

History, tradition, and accelerating forces contribute over time to creating a culture. Our studies of MIT alumni entrepreneurs also draw on a series of telephone interviews with MIT founders. We asked these founders whether and how their stay at MIT had played a role in their decision to start their own companies and, if it had, how it had done so. All agreed that MIT had encouraged them to become risk-takers. One founder sees it this way: "Let me try to give you my personal perspective about 'risk-taking.' I think it is a combination of several different factors. I knew I was not going to work for big companies when I was about to leave MIT. I would rather take the risk of failure than the risk of becoming nobody. There must be many alumni who felt the same way I did. MIT offers great mentors [professors] and more opportunities [professors' consulting/research activities] for students to test the water in establishing their own businesses. MIT exposes students to cutting-edge technologies and new ideas. It probably is easier to explore business potential of these new ideas and technologies as entrepreneurs. It seems to be quite natural that MIT becomes a cradle of entrepreneurs."

Respondents indicated that being an MIT student not only encourages individuals to become entrepreneurs, but also facilitates social interaction, enhances their reputations [association with MIT], and trains them to solve problems—all of which are valuable inputs to new-venture development. One surveyed alumnus 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."

Another founder says that MIT instills the entrepreneurial spirit in its graduates. "You know that lots of people [students and professors] start their own companies." Many of this former student's classmates started businesses while in school. This founder combined an electrical engineering degree with a management degree from the MIT Sloan School, where he learned that high risk could lead to high return. After graduation, he passed up a safer job with a large company to take a senior position in a startup.

Until his recent death, Teradyne co-founder/CEO Alex d'Arbeloff taught a graduate class at MIT Sloan. Having the entrepreneur who founded and built a billion-dollar high-tech company as a course instructor must have been a powerful role model for his students. Amar Bose, founder/CEO of Bose Corporation, still teaches acoustics classes at MIT. Several founders observed that enrollment at MIT was the first time they realized they were not the "smartest person in the world." One founder felt that this teaches humility, critical to CEOs who must learn to listen to customers and to respect the opinions of their employees. On the other hand, successful completion of an MIT education instills the confidence that bright people working together can solve problems.

"It's a 'hands-on' place; if there's a problem, students are encouraged to go down to the basement, build the appropriate equipment and develop a solution," said Ray Stata '57, co-founder and long-time CEO of Analog Devices (fiscal 2008 revenues of \$2.6 billion). He asserted that MIT taught him that no

problem was too difficult to solve. It was just a question of how hard and how long you were willing to work.

Along the same lines, another founder said that, because of the research and industrial ties of the faculty, MIT students get to work on “real stuff.” Students are “right in the middle of something big”—topics being argued about and worked on at that moment in the industrial world. Professors don’t hesitate to work on real-world industrial and global problems. Founders point out that anyone who’s at MIT for a few years knows the state of the art in his or her field. Other founders mentioned the importance of ties forged at MIT with fellow students who later become customers or co-founders: “The ‘brass rat’ [MIT’s unique and long-time traditional graduation ring that features a beaver] opens lots of doors.”

“Pushes” on Entrepreneurship

Some environmental forces affecting the “would-be” entrepreneur are the “negatives” about his or her present employer, rather than the “positives” of going into business. The uncertainties due to the ups and downs of major projects often have been cited as a source of grief, and sometimes even have led to expulsion of individuals into a reluctant entrepreneurial path. The evidence suggests that a stable work environment probably would produce far fewer entrepreneurial spinoffs than one marked by some instability. For example, the entrepreneurs who emerged from one large diversified technological firm most frequently rank “changes in work assignment” as the circumstance that precipitated formation of their companies, followed by “frustration in job.” One-fourth of the companies from that firm were founded during the three years that the firm suffered some contract overruns and laid off some technical people, although none of those actually laid off from this firm became entrepreneurs. The “worry about layoff” and seeing the parent firm in a terrible state are cited by many of that period’s spinoffs. Even at the Draper Lab, staff was cut by about 15 percent through layoff and attrition after the completion of

the Apollo lunar program, stimulating a number of new firms. Ninety-two percent of the spinoffs from the MIT Electronic Systems Lab (ESL) occurred during an eight-year period, when only 28 percent would have been expected if spinoffs occurred randomly over time as a function only of total employment. The large number of ESL projects completed during that period is one explanation for the “lumpiness” of new company creation.

Frustration with the noncommercial environment in the MIT labs and academic departments bothered some of the potential entrepreneurs. Margaret Hamilton, founder of Higher Order Software, exclaims: “The Draper nonprofit charter was frustrating, especially if you wanted to get into something exciting. There was always the sense of living in a no-man’s land.” Many of the entrepreneurs wanted to market specific devices or techniques. Others had no definite products in mind but saw clear prospects for further applications of the technology or skills they had learned at their current organizations. The prospective entrepreneurs usually felt they could not exploit these possibilities at MIT labs, because the labs concentrated on developing new technology rather than finding applications for existing technology. Unfortunately for their industrial employers, many of the spinoffs from industrial companies report the same frustration, despite the not unreasonable presumption that their large-firm employers should welcome at least some of these new ideas. In Silicon Valley, too, Cooper (1986) found that 56 percent of the new company founders had been frustrated in their previous jobs. Yet frustration should manifest itself more reasonably with just job-changing, not company-creating, behavior. Clearly, the overall environment promoting entrepreneurship in Greater Boston, and in Silicon Valley as well, makes the new-company option an active choice if other conditions are right.

As evidence of the significant historic flow of MIT alumni-founded firms, we show in Table 10 a small selection of prominent firms founded by MIT graduates. (Many other companies in a wide diversity of fields could be added to this list, such as Campbell

Table 10
Examples of Important MIT Alumni-Founded Companies (ordered by \$ sales)*

Company	Location	Employment (thousands)	Sales* (millions)	MIT Founder	MIT Class	Year Founded
Koch Industries	Wichita, Kan.	80	110,000	Charles Koch David Koch	1957 1962	1967 consolidation
Intel Corporation	Santa Clara, Calif.	86	38,300	Robert Noyce	1954	1968
Hewlett-Packard	Palo Alto, Calif.	156	22,600	William Hewlett	1936	1939
Raytheon Co.	Lexington, Mass.	72	21,300	Vannevar Bush	1916	1922
McDonnell Douglas	St. Louis, Mo.	70	14,470	James McDonnell, Jr.	1925	1939
Texas Instruments	Dallas, Tex.	30	13,830	Cecil Green	1923	1930
Digital Equipment Corp. (DEC) (acquired by Compaq/HP)	Maynard, Mass.	140	13,000 (in 1997)	Kenneth Olsen Harlan Anderson	1950 1953	1957
Genentech	San Francisco, Calif.	12	11,724	Robert Swanson	1970	1976
Qualcomm Inc.	San Diego, Calif.	13	9,800	Irwin Jacobs	1959	1985
ThermoElectron	Waltham, Mass.	30	9,000	George Hatsopoulos	1949	1956
America Online	Dulles, Va.	15	6,110	Marc Seriff	1973	2001
Symantec Corp.	Cupertino, Calif.	16	4,143	Denis Coleman	1968	1982
Analog Devices	Norwood, Mass.	9	2,570	Ray Stata, Matthew Lorber	1957	1965
Gillette	Boston, Mass.	29	2,250 (in 2003)	William Emery Nickerson	1876	1901
Bose Corp.	Framingham, Mass.	10	2,000	Amar Bose	1956	1964
Teradyne	Boston, Mass.	4	1,600	Alex d'Arbeloff, Nick DeWolf	1949	1960
International Data Group (IDG)	Boston, Mass.	13	1,520	Patrick McGovern	1959	1964
E*Trade Group	New York, N.Y.	4	1,400	William Porter	1967	1991
3Com Corporation	Marlborough, Mass.	6	1,300	Robert Metcalfe	1969	1979
Sepracor	Marlborough, Mass.	2	1.225	Robert Bratzler	1975	1984
Avid Technology	Tewksbury, Mass.	1	930	Bill Warner	1980	1987
Millennium Pharmaceuticals	Cambridge, Mass.	1	527	Eric Lander	1986	1993
Medical Information Technology	Westwood, Mass.	3	400	Neil Pappalardo Edward Roberts Curtis Marble Jerome Grossman	1961 1957 1961 1962	1969
The Math Works	Natick, Mass.	2	230	Jack Little	1978	1984

*All sales and employment data are from 2006 or the most recent year available, and are rounded off to the nearest whole number.

Soup Company; AMP—\$5.5 billion in revenues when acquired by Tyco International; EG&G—acquired by Perkin-Elmer; Kota Microcircuits—acquired by Fairchild Semiconductor; or Minute Maid Corporation—acquired by Coca-Cola.) As we have pointed out before, because of founder deaths or company mergers, most of the firms shown here are conservatively omitted from the economic impact projections in our study.) In Table 11, we show a similar small selected list of more recently created,

growing MIT alumni companies, which also may spawn giants in future years. (Due to the young age and small size of this group, we are aware disproportionately about firms near MIT. Over time, we assume that most alumni-founded companies will be located outside of Massachusetts, as we demonstrated earlier in this report.) The combination of large and small, old and young, mature and rapidly growing, always has characterized the mix of MIT alumni-founded enterprises.

Table 11
Some Examples of Younger, Fast-Growth Companies Founded by MIT Alumni*

Company	Location	Employment	Sales* (millions)	MIT Founder	MIT Class	Year Founded
A123 Systems	Watertown, Mass.	1,800	41	Ric Fulop Yet-Ming Chiang	2006 1980	2001
Akamai	Cambridge, Mass.	1,300	636	Tom Leighton Jonathan Seelig Preetish Nijhawan	1981 1998 1998	1998
Brontes Technologies	Lexington, Mass.	32	3	Douglas P. Hart	1985	2006
Codon Devices	Cambridge, Mass.	41	3	Joseph Jacobson, Drew Endy	1992	2004
E-Ink	Cambridge, Mass.	55	4	Joseph Jacobson	1992	1997
iRobot Corporation	Burlington, Mass.	75	249	Colin Angle	1989	1990
Lilliputian Systems	Wilmington, Mass.	54	3	Samuel Schaevitz, Aleks Franz	2000	2001
LS9, Inc.	San Francisco, Calif.	33	----	Noubar Afeyan David Berry	1987 2000	2005
Momenta Pharmaceuticals	Cambridge, Mass.	163	4	Robert Langer	1974	2001
Rive Technology	Ochelata, Okla.	2	----	Javier Garcia Martinez	2004	2006
Svaya Nanotechnologies	Los Angeles, Calif.	5	----	Benjamin Wang Erik Allen Kevin Krogman	2007 2008 2009	2008
Visible Measures	Cambridge, Mass.	40	----	Brian Shin	2006	2005
Zipcar	Cambridge, Mass.	16	3	Robin Chase	1986	2000

*All sales and employment data are from 2006 or the most recent year available, and are rounded off to the nearest whole number.

An Evolving MIT Internal Entrepreneurial Ecosystem

As indicated above, the history and unique culture of MIT began even before its founding in 1861 with the stated vision of William Barton Rogers for creating an institution dedicated to useful knowledge. But institutional elements in support of this culture, both within and surrounding MIT, were slow in coming until about thirty-five years ago. In 1964, when Edward Roberts started his first research project to study entrepreneurial spinoff companies from MIT labs and departments, he was able to find many companies previously formed, some of which already were quite successful (Roberts, 1991). But only one subject in entrepreneurship was being taught at MIT (begun in 1961, 100 years after MIT's birth) and no student clubs existed to encourage potential or would-be entrepreneurs.

Alumni Initiatives: Seminars and the MIT Enterprise Forum

In 1969, a small volunteer group of the MIT Alumni Association organized the MIT Alumni Entrepreneurship Seminar Program, hoping to attract at least thirty New England alumni from the classes of 1953-1963 to a day-and-a-half weekend session at MIT on "Starting and Building Your Own Company." All sessions on topics such as organizing, financing, marketing, and legal issues were to be run by Greater Boston MIT alumni. When advance registration passed 300, the committee cut off enrollment (330 actually attended on October 4-5, 1969), scheduled a second seminar at MIT for six months later, and began planning a nationwide rollout. Over the next three years, the committee conducted seminars in eight cities across the United States, using local MIT alumni to run the sessions, with a total of more than 3,000 MIT alumni in attendance, the largest attendance ever generated by the MIT Alumni

Association for any program before or since. As far as we know, this was the first effort by any part of MIT to promote entrepreneurial activity.

One of the authors of this report recalls that, over the years, many entrepreneurs have introduced themselves, saying they remember hearing his talks at various MIT Alumni Entrepreneurship Seminars across the country. His first meeting with Neil Pappalardo '64, with whom he later co-founded Medical Information Technology, Inc. (known as Meditech, but note that the initials are MIT, arising from having four MIT alumni co-founders, plus one from Northeastern University), occurred at an early MIT alumni seminar. Our survey generated many other unexpected testimonials to the direct effects of those and similar, later seminars. Bob Metcalfe '69, the principal inventor of the Ethernet and later the founder of 3Com, a great success in the computer networking market, reports that after attending an MIT alumni luncheon on starting your own business, he resigned from Xerox's Palo Alto Research Center, returned to Boston, and established his company with two other engineers. Similarly, the founders of Applicon, now the CAD division of Schlumberger, decided to create their firm after listening to a seminar at MIT Lincoln Lab that reported on the characteristics of the previous Lincoln spinoff entrepreneurs.

The seminars stimulated a variety of responses by local MIT alumni clubs. The parent committee itself organized and distributed directories of alumni who had attended the seminars and who wished to become visible to other MIT would-be entrepreneurs. "Networking" was beginning even before the term was used for that meaning! To continue its mission of encouraging entrepreneurship by MIT alumni and others, the committee also organized and authored a book published in 1974, *How to Start Your Own Business*, edited by William Putt '59.

The first significant local follow-on effort was the New York MIT Venture Clinic, which invited early-stage entrepreneurs to present their business plans and progress in an open diagnostic session of club members, aimed at providing feedback and suggesting ideas for improvement to the participating entrepreneurs. A New York alumnus who was spending the year in Boston transferred the clinic approach to a group of eight MIT alumni who were active members of the MIT Club of Boston. The resulting MIT Enterprise Forum of Cambridge flourished from its 1978 founding and still continues with its monthly entrepreneur presentations, with three panelist reviewers per company, to an actively engaged audience of two to three hundred persons at each meeting. Early on, non-MIT alumni were invited to join, creating the opportunity for all relevant elements of the interested Greater Boston entrepreneurial population to commingle and become involved—lawyers, venture capitalists, angel investors, and experienced entrepreneurs, as well as “wannabes.” Periodic major events, such as conferences focused on key emerging technologies or on major issues facing startups and growing companies, supplemented the monthly meetings and enlarged the community. The Cambridge chapter’s events calendar for January 2008 illustrates the scope of current activities: January 9, Startup Clinic, featuring two brand-new companies; 10, Get Smart, educational session on term sheets; 17, Concept Clinic, covering issues related to technology commercialization; 21, Special Interest Group on Software Entrepreneurship; 23, Special Interest Group on Digital Media; 24, Start Smart, educational session on Choosing the Right VC. This level of nurturing and networking must be contributing enormously to MIT (and nearby) entrepreneurship.

In 1982, the Cambridge group initiated its Startup Clinic, following a format similar to the big monthly meeting, but focused on very early-stage entrepreneurs who might not be ready to handle a large audience presentation. That monthly Startup session was held in an informal dinner at the MIT Faculty Club, limited to a rotating audience of forty

to fifty attendees. In that same year, the first entrepreneurship course offered during MIT’s “open” January Independent Activities Period, “Starting and Running a High-Technology Company,” was organized by the Cambridge Enterprise Forum. Since 1989, that course has been led by Joe Hadzima ’73, an active participant in the Cambridge Enterprise Forum and recent president and chair of the global MIT Enterprise Forum organization. In January 2008, that continuing course drew about 200 MIT undergraduate and graduate students and staff to daily sessions for one week.

The Startup Clinic’s work with early hesitant entrepreneurs has been very rewarding to all who participate. For example, Bill Warner ’80 was very discouraged and about to pull the plug on his new company, Avid Technology, until he presented at the Cambridge Startup Clinic. After attendees there kicked around and were enthusiastic about his ideas, Warner decided to continue his efforts. Avid went on to change the way film is edited, has won an Oscar and numerous other awards, and has grown to 2007 revenues of \$930 million. Eric Giler, a Harvard graduate, was struggling with the beginnings of Brooktrout Technologies when he appeared at the Startup Clinic. He says that the help he received led him to key customers and employees, and new ideas for forging ahead. He later presented at the regular Enterprise Forum meeting, hired a senior management team of MIT alumni, went public, then merged with Cantata Technologies, and eventually sold to Excel.

Stan Rich, then chair of the MIT Enterprise Forum of Cambridge, in 1985 assembled and published materials derived from the sessions to that point in time, “Business Plans that Win \$\$\$: Lessons from the MIT Enterprise Forum,” to provide guidance to nascent entrepreneurs and to further stimulate entrepreneurial activities.

After the mid-’70s, local MIT alumni in other cities began to mimic the Cambridge and New York activities for new and early-stage enterprises, usually with non-MIT participants as well, sometimes co-

sponsored with alumni groups of other universities, such as Cal Tech and Stanford. This movement led to the MIT Alumni/ae Association organizing the nationwide (and now global) MIT Enterprise Forum, Inc., in 1985, now numbering twenty-four chapters, including six in other countries. The national office, housed at MIT, creates frequent televised panel discussions on major trends and topics of interest to entrepreneurs. For example, the January 2004 program, "Innovation at the Interface: Technological Fusion at MIT," featuring MIT professors and serial entrepreneurs Robert Langer '74 (biomaterials) and Rodney Brooks (robotics), had a live audience at MIT of 630, with simultaneous satellite-fed live audiences of an additional 700 in twenty-five cities, and many additional copies downloaded for later replay by local chapters. As an example of the diversity of topics, the September 2008 global forum program focused on the issues affecting female entrepreneurship. Typically, 80 percent of the viewing audience is not MIT alumni, indicating the manner by which the MIT Enterprise Forum is encouraging entrepreneurship all across the country by MIT alumni and many others. Antoinette Muller, director of the national office, indicates that the Association's 2007 telecast audience was 5,500 people.

There is no way to know precisely how many companies have presented over the years, nor what successes have been fostered by MIT Enterprise Forum endeavors. Well-documented anecdotes abound, including that Michael Dell presented to the Houston chapter while he was still a student at the University of Texas. The MIT Enterprise Forum of

Cambridge did an intensive job of trying to assemble its history on the occasion of its twenty-fifth anniversary in early 2003 and was able to document 234 company presentations to its regular monthly meeting from 1981 (prior years' data are lost). Trish Fleming, director of the Cambridge chapter, estimates that, over the years from 1978 until now, some 700 companies presented to and were helped by the MIT Enterprise Forum of Cambridge alone in its regular sessions or supplemental clinics. The records document a large number of later acquisitions of and public offerings by these companies. On average, about 5,000 total attendees participate annually in the Cambridge meetings. Perhaps an additional 700 startups received support and assistance in the other Enterprise Forum chapters. We have no idea how many of these companies were founded by MIT alumni, MIT-related persons, or others, as today all of the chapters are open in membership to all interested participants, with or without MIT connections.

In the responses from MIT's limited 2003 alumni survey, we find indications of what aspects of MIT played a role in the entrepreneurs' founding of their companies. Table 12 shows just those responses that are linked to alumni activities. As we have indicated, the Alumni Regional Clubs were the first MIT channel for presenting to alumni the series of educational seminars on starting a new company. The graduation years of those affected, as shown in the table, nicely correspond to the beginnings of the alumni entrepreneurship programs aimed at earlier graduates as described above, and their continuations in various forms in different alumni regions. Further, as

Table 12
Alumni Organization Influences on Alumni Entrepreneurship (from limited sample only)

Proportion Rating Alumni Factors as Important in Venture Founding* (percentage)					
Graduation Decade	1950s (N=73)	1960s (N=111)	1970s (N=147)	1980s (N=144)	1990s (N=145)
Alumni Regional Clubs	5%	5%	3%	12%	3%
MIT Enterprise Forum	7%	16%	15%	22%	9%

*Respondents could check all relevant categories

documented above, these programs then led to the founding of the MIT Enterprise Forum in 1978, which, over time, grew dramatically and spread geographically, attracting participation from alumni of many classes, as well as many non-MIT participants. (The drop-off in Table 12 in the most recent decade merely reflects the need for more time to elapse before full impact on recent graduates is measurable.) In recent years, current MIT students actively have attended the MIT Enterprise Forum's Cambridge chapter meetings, suggesting that the future impact of the Enterprise Forum is likely to come sooner and also will increase in magnitude.

Case Example: Brontes Technology

We end this section by describing some of the dynamics associated with Brontes Technology, an example of a successful outcome from the MIT Enterprise Forum, but clearly one that illustrates the interplay among multiple parts of the MIT entrepreneurial ecosystem, some of which we describe later in this report. The Brontes single-lens 3D imaging technology derived from MIT Deshpande Center research funding to Professor Douglas Hart '85, which the MIT Technology Licensing Office licensed to Brontes at its formal company startup stage in 2003. Professor Hart was a reluctant entrepreneur who had thought the principal market application would be facial recognition for security.

"I came from an era where your job was to be a faculty member and teacher, not to spin out companies," he said. But, encouraged by the Deshpande Center's executive director, he attended a 2002 MIT \$50K networking event and met the two graduate students who eventually became his company co-founders. They all presented their preliminary ideas to the Cambridge Enterprise Forum Concept Clinic to discuss the commercialization alternatives they were evaluating for the 3D technology. That helped them formulate their business plan for the \$50K competition, where they were selected as the runner-up. As the team developed a prototype system, they explored the market opportunities and discovered a large need in

dental imaging. After forming the actual spinout company, they returned to present at the Enterprise Forum Startup Clinic, and then received two rounds of seed capital, followed by venture capital funding in 2004. Brontes was scheduled a case presentation to the regular Enterprise Forum when it was purchased by 3M in 2006 for \$93 million.

In appraising the impact of the MIT Enterprise Forum, Trish Fleming, director of the Cambridge chapter, observes: "The VCs, the lawyers, the CEOs, the management types all got used to coming here, to learning about technology, to making connections, to finding employees, to providing mentoring to students and new startups through the Forum. As the MIT entrepreneurial ecosystem grew, those relationships were able to grow, too." The MIT Enterprise Forum, with thirty years of life and now twenty-four chapters nation- and worldwide, inevitably has strongly influenced the culture and entrepreneurial environment not just of MIT, Cambridge, Greater Boston, and beyond, but also has had untold vast effects elsewhere, influencing MIT alumni and many others to form and build new companies.

The MIT Entrepreneurship Center

In 1990, Professor Edward Roberts '57 proposed to Lester Thurow, then dean of the MIT Sloan School of Management, that he support the formation of an MIT-wide entrepreneurship program to serve not just MIT Sloan, but the rest of MIT as well. Its goal would be to educate and develop those who will create, build and lead tomorrow's successful high-tech ventures. It also planned to increase dramatically, and then provide central coordination and integration of, MIT entrepreneurship classes and student activities. But, unlike nearly all other university entrepreneurship programs, which rested primarily on experience-sharing by entrepreneurs and investors, the proposed Entrepreneurship Center would follow the MIT tradition of "Mens et Manus." It had to connect rigorous scholarly pursuit of knowledge underlying entrepreneurial success with effective transfer of that

knowledge into practice. Thus, Roberts proposed a “dual-track faculty” of “tenure-track” academics and adjunct practitioners, linking entrepreneurial researchers with successful entrepreneurs and venture capitalists, building an ambitious teaching program accompanied by direct coaching and mentoring of student would-be entrepreneurs. Academic faculty whose primary thrust is entrepreneurship but whose discipline base is marketing, or finance, or human resources, for example, would be jointly appointed to their underlying discipline group as well as to the Technological Innovation & Entrepreneurship (TIE) faculty group at MIT Sloan, which would provide overall program coordination. In the past eighteen years, almost all of the leading business schools have adopted this dual-track model for managing their entrepreneurship programs.

With co-sponsorship by MIT Sloan faculty across multiple disciplines, the MIT Entrepreneurship Center (E-Center) was launched with an advisory board consisting of prominent MIT entrepreneurial alumni, including Amar Bose '51 of Bose Corp., Ken Germeshausen '31 of EG&G, Bernard Goldhirsh '61 of *Inc.* magazine, George Hatsopoulos '49 of ThermoElectron, Patrick McGovern '59 of International Data Group, and Ken Olsen '50 of Digital Equipment Corp. At that time, MIT still offered only one related class, “New Enterprises,” and had only one faculty member doing research in the field.

In 1996, Kenneth Morse '68 became the first full-time managing director of the MIT E-Center, which then was given a small amount of space near the MIT Sloan classrooms. Filled with cubicles, desks, and filing cabinets, the physical space provided a wonderful home base for housing and nurturing a wide array of entrepreneurship-related clubs and activities, with immediate access to adult coaching and guidance, frequently including an entrepreneur-in-residence in addition to Morse and staff. Over time, the MIT E-Center label has come to represent to many—at and outside of MIT—both that physical space and the broad-based MIT program of education and activities. The rapidly expanding MIT entrepreneurial program has contributed to a

dramatic increase in the number and ambition of classes, clubs, conferences, and the resulting breadth and depth of content and contacts that facilitate entrepreneurial behavior. Some have called it a frenzy of entrepreneurship!

Classes

Once the E-Center was underway, its leaders began to create new subjects, attracted existing MIT Sloan faculty to teach them and, when authorized, recruited and hired both practitioners (senior lecturers) and academics (assistant professors and above) into the program. The sole original “New Enterprises” class gradually was expanded into two sections and then doubled again as student interest in entrepreneurship grew across the Institute. While never tabulated, the number of new companies produced by that subject's MIT alumni is very high, including as examples such companies and graduates as MAST Industries, founded by Martin Trust '58, and Genentech, co-founded by Robert Swanson '69. Jon Hirschtick '83 and his roommate Axel Bichara '88 both took “New Enterprises;” later they co-founded and sold a CAD company. Hirschtick went on to found SolidWorks, a pioneering company later sold to Dassault.

In 1993, the first new full-time academic faculty member was hired into the Entrepreneurship Program, kicking off the dual-track design and beginning to expand course offerings. In 1994, the MIT Sloan School launched a series of educational-career “tracks” within its Master's degree program. The MIT Entrepreneurship Center, collaborating closely with the school's TIE and Marketing faculties, created the New Product & Venture Development Track. NPVD, known by the students as the “Entrepreneurship Track,” quickly became the most popular track for MIT Sloan graduate students, demonstrating the strong, rapidly growing interest in entrepreneurial studies and career paths. All of these “tracks” were dropped a few years later when a major change occurred in the MBA curriculum and were not reinstated until 2006 with the birth of the “Entrepreneurship & Innovation Track” (to be discussed later).

Soon, additional entrepreneurship-focused tenure-track faculty were hired into various MIT Sloan groups, such as international, human resources, technology and innovation, finance, and marketing, with central coordination provided by the TIE group as earlier described. Additional senior faculty from within MIT Sloan and from other MIT departments associated themselves with the growing entrepreneurship educational efforts. A significant number of adjunct faculty, all successful entrepreneurs and/or venture capitalists, also were recruited to bolster the dual-track elaboration, usually as unpaid volunteers eager to share their insights and enthusiasm with the younger entrepreneurial aspirants. By 2001, the number of entrepreneurship subject offerings had grown rapidly to twenty-one and the number of student registrants from all MIT departments had jumped to almost 1,500. Now students across MIT enroll in more than thirty entrepreneurship classes of all sorts, albeit 76 percent of the enrollments are from MIT Sloan, with 16 percent from the MIT School of Engineering.

Academic Classes in Entrepreneurship

Over the years, regular MIT “tenure track” faculty have developed and taught several new subjects, focusing on their own PhD training and scholarly research. These classes include such titles as: “Designing & Leading the Entrepreneurial Organization;” “Entrepreneurial Finance;” “Managing Technological Innovation & Entrepreneurship;” “Corporate Entrepreneurship;” “The Software Business;” “Strategic Decision-Making in the Biomedical Business;” “Entrepreneurship without Borders;” and “Competition in Telecommunications.” Each of these subjects provides an underlying disciplinary basis for entrepreneurial actions in a given area. Other subjects also fall into this category.

Practitioner Classes in Entrepreneurship

Many of the new subjects that have been developed depend entirely upon the experience of successful entrepreneurs and venture capitalists.

These expert practitioners share their real-world insights, built up over years of work, in aspects of entrepreneurship that lack much academic theory. Some of the subjects taught by our extensive part-time practitioner faculty members include: “New Enterprises,” the first course previously described that lays the groundwork for business plan development for new companies; “Technology Sales and Sales Management;” “Early Stage Capital;” and “Social Entrepreneurship” and “Developmental Entrepreneurship,” two subjects that parallel “New Enterprises,” but with a focus, respectively, on the firm motivated by social problem-solving or the context of developing countries. Other subjects also fall into this category.

Mixed-Team Project Classes

No doubt both the theory and practice-oriented subjects in entrepreneurship have had great influence on their students, as we have discussed. But, intuitively, we believe the strongest impacts have derived from a cluster of project-oriented efforts, the third category of subjects that we have created over the years since the MIT E-Center began. In these classes, the students organize in teams of four or five, preferably including participants from management and science, and engineering, to tackle real problems in real entrepreneurial organizations. Three subjects constitute the entrepreneurship program’s base in this domain, but we seem to be adding to the entrepreneurship curriculum one or more new subjects of this type every year. Our earliest subject here was “Entrepreneurship Laboratory,” or E-Lab, as it is well-known. Students select from the problems presented by companies that usually are quite young and in the Greater Boston area, although we have violated the distance constraint on many occasions. The intent is to work on “a problem that keeps the CEO up late at night!” With the emerging company CEO as the “client,” the team devotes heavy time for the duration of a semester working on her or his issue, with class time spent on communicating general principles of team management, project analysis, client relationships, some commonly used

tools of market research, and sharing progress reports with each other. The students learn much about teamwork and the issues facing early-stage, technology-based companies. Summer internships and, later, full-time jobs often result from the E-Lab projects. By the way, far more company projects are volunteered than we can accommodate in a single class, indicating the strength of the local network.

Two innovative entrepreneurship faculty members who had been teaching “Entrepreneurship without Borders” developed an approach for globalizing E-Lab. They introduced “Global Entrepreneurship Laboratory,” or G-Lab, in 2000, with the instructional and preparatory parts of the class, including team and company selection, taking place during the latter half of the fall term. During November and December, the teams work with company management to define precise, deliverable objectives and begin substantial background research while on campus. Then, during MIT’s “open” January Independent Activities Period, the teams go off to every part of the world (outside of the U.S.) to work with their chosen companies in three-week “team internship” projects. Finishing up of the projects and evaluation by both company and class occur during February and March. This global entrepreneurial subject rapidly has grown to be the most popular elective course in the MIT Sloan School, with half of the MBA class participating, providing them with a non-U.S. entrepreneurial work experience. In seven years, 185 host companies in eighteen countries have “employed” 810 MIT students in G-Lab projects, including 160 students during the past year. Professor Richard Locke, who co-created and runs G-Lab, says: “Only at MIT Sloan could we move from brainstorming to in-the-field implementation in a few short months. The student teams have offered exciting, imaginative, and—perhaps most important—effective changes in the way startups around the globe conduct business.”

The third mixed-team, real-world project class is “Innovation Teams,” or I-Teams (everything must have a short name!), a “hands-on” team project subject focused on developing commercialization

plans for carefully selected MIT faculty research efforts. The idea was conceived at the time MIT launched the Deshpande Center for Technological Innovation (to be discussed later) in the School of Engineering. Each team of business and technical students deconstructs the features of the technology, learns about the intellectual property issues in cooperation with the MIT Technology Licensing Office, scans the potential markets, interviews prospective customers and industry experts, and performs a go-to-market analysis in which it recommends a course of action (e.g., startup, partnership, licensing to industry, further research in the lab). Every team is coached by a seasoned entrepreneur from the Greater Boston community and works closely with the MIT faculty principal investigator of the underlying research project.

Case Example: SaafWater

During I-Teams’ very few years of operation, some of the varied companies that already have emerged following the teams’ class assistance are Avanti Titanium, Hydrophobic Nanomaterials, Myomo, SaafWater, and Vertica Systems. Myomo is discussed in the later section on the Deshpande Center. One of the other projects, SaafWater, built on the research work of Amy Smith ’84, senior lecturer and recipient of a MacArthur Fellowship, who created MIT’s Development Lab program for carrying forward engineering design and devising appropriate technologies for developing countries. The Deshpande Center had funded Smith’s hiring of Sarah Bird ’03 to advance the phase-change incubator research project that would indicate the level of bacterial contamination in village wells. The I-Teams student group developed detailed insights to possible distribution channels worldwide and assisted the principal researchers to enter the 2007 \$100K competition. The project reached the finals of the new “development track” and attracted venture capital investment. SaafWater was quickly incorporated and has been operating its first pilot plant in Pakistan since June 2007.

The I-Teams model, initiated by Ken Zolot '95 as its instructor, has caught on with many students and faculty across MIT. New variations of I-Teams have been encouraged by the MIT E-Center leadership. In collaboration with the MIT Media Lab, "Digital Innovations" was created as a mixed-team projects course to develop and experiment with mobile devices that might impact various markets in developing countries such as Chile. Last year, the E-Center started "Energy Ventures" as another mixed-team, real-world projects subject to encourage the growing student interest in entrepreneurship based on sustainable technologies, with energy ideas and new technologies coming from MIT faculty laboratories and graduate students. In parallel, a coordinated academic subject called "Energy Strategies" was launched to enable a student to build a thorough understanding of energy markets, technologies, competition, and regulatory aspects. "Strategies" and "Ventures" have back-to-back class schedules, so students can do the theory and the practice together. This year, the same model has been applied in a new subject called "The X-Prize," to bring the excitement of competing in the national X-Prize efforts to solve major problems into a campus-level pursuit of entrepreneurial beginnings. All of these classes involve mixed business-technical student teams in commercialization planning and implementation for state-of-the-art technologies. These classes are also feeding grounds for team business plan proposals for the MIT \$100K Competition.

A number of short-but-intense courses relating to entrepreneurship are offered during MIT's January Independent Activities Period. In 2008, the "Starting and Building the High Technology Firm" course brought about 200 students, mostly from science and engineering, into the MIT Sloan Wong Auditorium daily for one week. Two years ago, we started our first entrepreneurship class restricted to undergraduates. And, this past year, Ken Morse joined with the faculty of the EECS Department to launch the first subject aimed at entrepreneurship for just EECS students. The Neurosciences Department has just started another entrepreneurship subject; another major effort, the

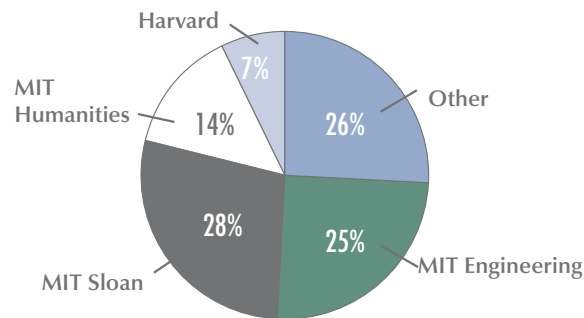
Biomedical Enterprise Program, ties together the MIT Sloan School with the Harvard-MIT Health Sciences and Technology Program to encourage students to combine intensive training in clinical medicine with entrepreneurial orientation and subjects. The entrepreneurship education boom at MIT seems to be continuing and accelerating, exposing more and more students to the examples and lessons underlying new-company creation and development.

Clubs

From \$10K to \$100K and Beyond

The premier student organization at the outset of the MIT E-Center's existence was the \$10K Business Plan Competition, created in 1990 by the MIT Entrepreneurs Club (largely engineers) and the MIT Sloan School's New Ventures Association. Its purpose was to encourage students and researchers in the MIT community to act on their talents, ideas, and energy to create tomorrow's leading firms. Fifty-four teams competed in the first competition; the winner received \$10,000 and the runners-up received \$3,000 and \$2,000 respectively. As an illustration of the MIT entrepreneurial ecosystem at work even in these early days, the finals that first year were conducted as one of the monthly programs of the MIT Enterprise Forum of Cambridge! That practice continued for ten years as the Cambridge Enterprise Forum had the only large audience and community linked to entrepreneurship on the MIT campus. An early achievement of the new E-Center was to secure several years of funding of the grand prize from a generous MIT alumnus and venture capitalist, David Morgenthaler '40. His gift freed up the students' time and energies for building the scale and quality of the \$10K competition. With rapid growth occurring, the activity further benefited in 1996 by the memorial gift from the family of the late Robert Goldberg '65, a successful serial entrepreneur who had returned to MIT to teach part-time. That gift elevated the competition to become the \$50K, with \$30,000 going to the first-place winner and two \$10,000 prizes to the runners-up.

Figure 17
MIT \$10K-\$50K-\$100K Competition
Individual Entrants



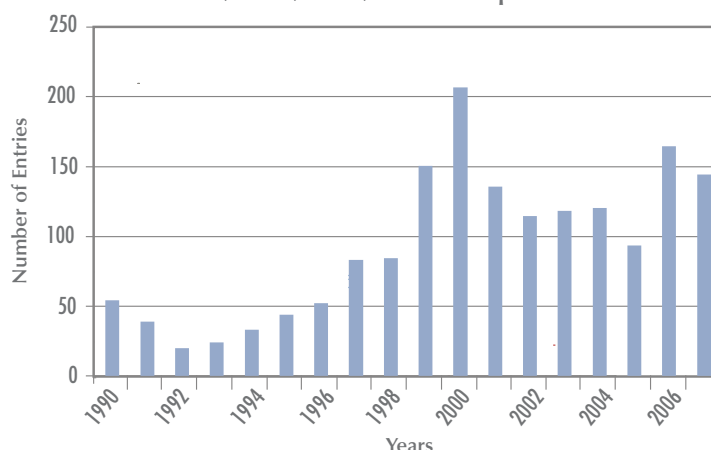
Undergraduate and graduate students from all five MIT Schools and twenty-seven departments and labs have successfully entered the MIT business plan competitions over its eighteen years. Figure 17 shows the sources of entrants to the competitions over these years, with MIT Engineering and MIT Sloan accounting for the majority. Students from Harvard and other local schools, as well as non-students, participate, but each team must include at least one MIT student. Multi-disciplinary teams of technical and business students have proven to be the most successful competitors. These teams bring together the skills necessary for making the bridge between technology and the marketplace, the same lesson taught in a variety of the classes, clubs, and programs throughout the MIT entrepreneurial ecosystem. Panels of experienced entrepreneurs, venture capitalists, and legal professionals judge the business plans.

Tracking alumni companies has been one of the \$100K organization's greatest challenges, even in terms of how many teams competed and who their members were, but especially what happened to them following the competition. We now know that more than 1,500 plans have been submitted over the years by more than 7,500 individuals. Figure 18 shows the number of teams that entered the competition

annually, reflecting significant growth of numbers over time, but also reflecting the cyclical effects of the Internet boom and bust.

The refinement process of the competition, its network of mentors, investors, and potential partners, and the cash prizes awarded have helped many of these teams to act on their dreams, and build their own companies and fortunes. Although records are incomplete and tracking is difficult once the students are gone, Karina Drees '07, lead organizer of the 2006 \$100K, was able to document 105 companies formed through the \$100K process, of which 22.8 percent already had successfully exited via IPOs or acquisitions of the firms, 23.8 percent are still in business as private companies, 20 percent are no longer in business, and 34 percent have unknown status due to lack of information. Even if we assume total failure of the unknowns, the 46.6 percent (or more) of the companies that have survived or been acquired provide a remarkable success story compared with companies formed nationwide. The \$100K companies have received more than \$700 million in venture capital funding. At least twenty-four firms have been acquired, of which the seven for which we have figures sold for more than \$2.4 billion. The transaction amount was not disclosed in the other cases.

Figure 18
Teams Entered into the MIT
\$10K-\$50K-\$100K Competition



We show in Table 13 the acquisition or IPO exit values of those firms formed out of MIT \$100K competitors for which we have reliable data. Testimony from the entrepreneurs indicates that many of the successful companies were based on technologies licensed from MIT. Also, they recognized the importance of the support they received from the vast MIT entrepreneurial ecosystem and, in many cases, had found key people to commercialize their technology through the \$100K efforts.

The public data of Table 13 document a value capture for the nine companies of \$2.4 billion. This amount, a dramatic underestimation of exit value of all the \$100K firms due to our lack of more complete information, represents more than a 550X return on investment on the historical MIT \$100K budget and a \$150 million per year average return over the life of the student \$100K undertaking. At least 2,500 new jobs (no doubt many more) have been created as a result of the MIT student competitions.

We also found three \$100K companies that completed successful public offerings, generating more than \$350 million at the time of their IPOs. But, by itself, the one company that is still public (the other two were acquired post-IPO) is Akamai

Table 13
Exit Value of Select MIT \$100K Competitors

Company	\$10K-\$50K-\$100K Date	Valuation at Exit (\$ millions)
Silicon Spice (acquired by Broadcom)	1995	1,200
Direct Hit (acquired by Ask Jeeves)	1998	517
Webline (acquired by Cisco)	1996	325
Harmonix (acquired by MTV)	1995	175
Brontes Technologies (acquired by 3M)	2003	95
C-Bridge Internet Solutions (acquired by Excelon)	1996	64
NetGenesis (acquired by SPSS)	1995	44
Firefly Networks (acquired by Microsoft)	1995	40
Stylus Innovation	1991	13
Lexicus (acquired by Motorola)	1991	Not disclosed
Flash Communications (acquired by Microsoft)	1997	Not disclosed

Technologies, which lost in the 1998 \$100K to Direct Hit. It was a \$50K finalist founded by MIT faculty and students, based on licensed MIT technology (see later discussion of the Technology Licensing Office) that had market capitalization as of June 18, 2008, of \$6.03 billion.

In 1998, the student leaders of the MIT organization created an annual MIT \$100K Global Startup Workshop located in a different country each year, in which MIT students bring the lessons they have learned about student team-based entrepreneurship to academic institutions from all over the world. The workshops have been held in Boston, Singapore, Spain, Australia, Italy, China, the United Kingdom, Abu Dhabi, Buenos Aires, and Madrid, heavily attended by campus representatives seeking to replicate the MIT experiences. This student-initiated and -run effort has helped to create competitions worldwide modeled after the MIT activities. Despite this, *Inc.* magazine said that “[the MIT \$100K] is more equal than all the others!” To illustrate, last year’s winning MIT team, SteriCoat, consisting of a 2006 MIT Sloan Fellow alumnus and his teammates, entered various business plan competitions as a way of raising additional funds to launch their business. In addition to winning the MIT \$100K, the team took first place in the Oxford University Competition and the Harvard Biotechnology Competition, and second place in the Rice Business Plan Competition.

New MIT entrepreneurial endeavors that are linked to the \$100K continue to be born. In 2005, the Cambridge MIT Enterprise Forum chapter launched its Ignite Clean Energy Business Plan Competition, founded and chaired by two MIT alumni. For the first two years, nearly all of its events were held on the MIT campus. In 2006, an alumnus who had volunteered for that competition took the concept with him when he moved to the Bay Area of California and founded the California Clean Tech Open, with the MIT Club of Northern California and the MIT Enterprise Forum of the Bay Area as the sponsors. In 2007, a spectacular advance occurred with an additional prize of \$200,000 provided by the

U.S. Department of Energy and NSTAR for winning business plans focused on “clean energy,” but now administered by the MIT \$100K.

In spring 2006, the competition incorporated the Entrepreneurship for Development Competition (plans for new businesses aimed at solving socio-economic problems in developing countries) under its umbrella. This action inspired the student organizers to re-brand from the previous MIT \$50K title to the MIT \$100K, offering two grand-prize winners \$30,000 each and the four runners-up \$10,000 each. A new \$10,000 prize has just been established for the best plan submitted in aero-astro, new prizes are expected for the life sciences competitive track, and inevitably, additional targeted entrepreneurial competitions will happen in the future, further stimulating campus-wide initiatives. The 2008–2009 competition was run with seven parallel tracks, with major prizes to be awarded for the winners of each track.

Lots of Clubs

The array of clubs tied to entrepreneurship is impressive, and forms a key part of the MIT entrepreneurial ecosystem. Students at all levels, from undergrad to PhD and post-doctoral, across all MIT departments, actively participate. They contribute immeasurably to creating the unique “passion for entrepreneurship” that now seems apparent throughout MIT. Many of these clubs are housed in small spaces within the MIT E-Center; others just use the mailing lists, and get advice and help there. The clubs often represent interest groups around particular areas of technology, such as the Astropreneurs Club, BioPharma Business Club, Energy Club, Mobile Media Club, NeuroTech Club, and the NanoTech and TinyTech Clubs. All of them have speaker programs with venture capitalists, MIT faculty, and related entrepreneurs helping to educate and connect the members to early-stage firms and to new ideas in their fields. Frequently they organize major meetings and colloquia.

Other clubs are more focused on stimulating entrepreneurship per se, or providing connections for prospective entrepreneurs. For example, Sloan

Entrepreneurs promotes networking events within the MIT Sloan School, with the Greater Boston community, other local MBA programs, and established Boston organizations. Tech Link started in 1999 as a joint venture between the MIT Sloan Senate and the MIT Graduate Student Council to generate social interaction across school and departmental lines for personal and professional development. With 1,200 members, it has become the largest student organization at MIT. It organizes many major events each year, including “treks” to visit early-stage companies in different technological fields. The MIT Innovation Club centers its activities on helping its members to generate new ideas and commercialize new technologies. And there are many others.

One of the most vital and successful student activities is the Venture Capital/Private Equity Club. Evolving from a small interest group with local speakers, the group now organizes and runs two major nationwide conferences, the MIT Venture Capital Conference in the fall and the MIT Private Equity Conference in the spring, wholly managed by MIT students. The hundreds of attendees from the professional community, as well as MIT students, make invaluable contacts for their entrepreneurial ventures and for recruiting opportunities.

Conferences

In addition to facilitating the major conferences of the VC/PE Club, the E-Center goes outside of MIT’s boundaries to produce several key conferences that further enhance the environment for new-firm formation. Its most visible Cambridge event is the annual so-called “Bio Bash,” more formally known as the “Celebration of Biotechnology in Kendall Square.” Last year, more than 850 registered for the event, including 150 founders, CEOs, and board members. As with the many other seminars and receptions organized by the MIT E-Center, the purpose is to bring together students, entrepreneurs, venture capitalists, and others who will enhance networking and communications that might stimulate

additional entrepreneurship. With MIT in the center of an intensive biotechnology cluster, including the MIT-related Whitehead and Broad Institutes, creating the Bio Bash was a natural opportunity. In recent years, the program has started with a professional colloquium on some major topic of importance to the biotech community, providing a “legitimate” excuse for some executives to travel to Cambridge from Europe or the West Coast just for the day.

Each semester, the E-Center organizes a major networking reception in the MIT Faculty Club to honor the CEOs of past and present “E-Lab companies,” i.e., those that have hosted student teams from the Entrepreneurship Lab classes. The current students always are given prominence at this event to try to promote summer internships and permanent jobs with the heads of the high-tech companies and their many venture capital investors who regularly attend the reception. For the past three years, the spring “E-Lab Bash” has featured the award of the Adolf Monosson ’48 Prize for Entrepreneurship Mentoring, given to recognize a person or group who has been outstanding over the years in nurturing and assisting young entrepreneurs.

Over several recent years, MIT had a partnership with the United Kingdom called the Cambridge MIT Initiative. The transfer to British universities of insights from the MIT E-Center and the \$100K were key components of the relationship. Annually in London, the E-Center organized a black-tie networking event that drew 500 people to build entrepreneurial ties. Attendees included the student leadership and the year’s winning team of the MIT \$100K competition. Even the Brits were surprised at their own enthusiasm for such rousing get-togethers. Observers at any of these conferences/receptions/parties could see that the real benefits were in the numerous one-on-one conversations that were happening between job seekers and job providers, between enterprises looking for money and investors searching for good targets, and between those with new ideas and those with previously developed skills wanting their next chance.

Impact of the MIT Entrepreneurship Center and Network

Our 2003 MIT alumni survey sought measures of MIT-related factors that influenced the founding of the new companies. In Table 14, we show several dimensions that directly link to E-Center efforts. Clearly, MIT’s entrepreneurial network was seen as a critical influencing force even fifty years ago, but its strength has grown dramatically to the point that half of the most recent entrepreneurs see the network as a key factor in the founding of their companies. Appropriately, the MIT E-Center itself and the \$10K-\$50K-\$100K Business Plan Competition have had essentially no perceived influence on alumni entrepreneurs until the past decade or so, when alumni have had the opportunity to engage with them. Prior to the founding of these two entities, only a few graduates of MIT classes had become connected with the E-Center, perhaps as E-Lab company CEOs or as \$100K judges. But, during their relatively short lives, both the E-Center and the \$100K have jumped into prominence as influences on those students who later became company founders. Other survey results indicate that the more recent alumni entrepreneurs, in particular, see extracurricular and social activities as accounting for the team formation of about 60 percent of the new firms, with an increase in the percentage of the startup ideas also coming from networking. The growth of classes, clubs, conferences, and their informal spinoffs has

altered the internal environment of MIT relating to these entrepreneurial movements.

Bob Metcalfe ‘68, Ethernet inventor, founder of 3Com, and now a partner in Polaris Ventures, is a constant observer of MIT. “It’s not just that MIT’s entrepreneurial environment flourishes under its institutional commitment to technology transfer,” he said. “It’s also that MIT includes both ‘nerds’ and ‘suits.’ Divergent life forms, yes, but necessary to and working together at MIT on entrepreneurial innovation. And what keeps MIT’s entrepreneurial ecosystem accelerating is that nobody is in charge. There are at least twenty groups at MIT competing to be *the* group on entrepreneurship. All of them are winning.” Testimony supporting this effect also is presented by the 2003 results shown in Table 15. There we see that, over five decades, the importance of faculty and research to new enterprise creation has been vital, but more or less constant, whereas the perceived influence of other students on venture founding has grown enormously, to the point that it is the dominant single perceived influencing factor found in our studies. The internal network of relationships, especially student-to-student, has become king!

Technology Licensing Office

The history of the MIT Technology Licensing Office traces the evolution of the MIT entrepreneurial culture and ecosystem. In 1932, the MIT Committee

Table 14
Entrepreneurship Center Factors Important to Venture Founding (from limited sample only)

Proportion Rating University Factors as Important in Venture Founding* (percentage)					
Graduation Decade	1950s (N=73)	1960s (N=111)	1970s (N=147)	1980s (N=144)	1990s (N=145)
MIT Business Plan Competition	0%	1%	0%	3%	30%
MIT Entrepreneurship Center	3%	1%	2%	1%	12%
MIT’s Entrepreneurial Network	26%	25%	32%	40%	50%

*Respondents could check all relevant categories

Table 15
MIT Factors Important to Venture Founding (from limited sample only)

Proportion Rating University Factors as Important in Venture Founding* (percentage)					
Graduation Decade	1950s (N=73)	1960s (N=111)	1970s (N=147)	1980s (N=144)	1990s (N=145)
Students	26%	24%	38%	50%	66%
Faculty	48%	42%	37%	28%	37%
Research	32%	32%	30%	26%	33%

*Respondents could check all relevant categories

on Patent Policy was formed to address issues of ownership of inventions and discoveries stemming from research done at the Institute. In 1945, the Patent, Copyright and Licensing Office was established as part of the MIT Division of Sponsored Research, one of the earliest university efforts of its type in America. It became a separate entity and was renamed the Technology Licensing Office in 1985. As its formal function had been to facilitate patent applications, and to execute copyright and patent licenses with industry, government agencies, and other research institutions, the Patents office had been dominated by lawyers. With the 1985 entry of John Preston as director and Lita Nelsen '66 as associate director, the lawyers were ousted and the TLO dramatically reoriented toward playing a far more active role in technology transfer. In that initial TLO year, the office put together eight to ten agreements with industry and registered approximately 120 invention disclosures. The latest figures average eighty to 100 agreements and about 500 disclosures per year, now under Nelsen's directorship for many years. The current TLO Web site describes its mission as "to benefit the public by moving results of MIT research into societal use via technology licensing, through a process that is consistent with academic principles, demonstrates a concern for the welfare of students and faculty, and conforms to the highest ethical standards." It assists MIT inventors in protecting their technology and in

licensing that technology to existing companies and startups.

The TLO's licensees fall into three categories—well-established (large) companies, small (often local) companies, and startups. Although the TLO's licenses, in numbers, divide roughly evenly into the three categories, the majority of the exclusive licenses—the ones that fulfill TLO's mission to encourage the development of truly innovative technologies requiring significant investment—go to startup companies.

The primary reason for the TLO's strategic dependence on startup companies has been the reluctance of large companies to invest in "university-stage" technologies, because the risk and cost of development is high and the time to market is long. In many fields (e.g., pharmaceuticals) the large companies have become dependent on startups to bring university-stage technology into proven product concepts, after which the large companies license the product from the startup or acquire the young company. But the TLO's effectiveness in this strategy depends on venture investors' willingness to invest in early-stage technology, somewhat scarce in recent years following the burst of the "dot-com" bubble and very scarce in the current severe economic downturn. The TLO strives to maintain a "level playing field" among many venture capital firms to attract them toward MIT startup opportunities by communicating fairness and openness. Fortunately,

some venture capitalists and even more angel investor groups still are interested in early-stage technologies, even in difficult economic times.

Beyond the real incentives to faculty of having their ideas brought to fruition and use in the real world, some faculty, graduate students, and post-docs also participate on an ongoing basis in the companies that are started with their technologies, the faculty usually as advisors or board members, the students (once they are alumni) often as co-founders and full-time leaders of the firms.

A typical deal that TLO structures provides technology exclusivity in a clearly specified and limited field of use (to provide clear economic incentives to the licensee), a modest license fee ranging from \$25,000–\$100,000, and a royalty of 3 percent to 5 percent of the sales that arise from the licensed technology, often with a minimum annual royalty that escalates over time. If and when royalties are collected from the licensee, they are distributed (after reimbursement of TLO expenses) one-third to the inventors, one-third to the inventor's department, and one-third to MIT's general funds.

For startups, instead of cash up front and in lieu of some of the royalties, the TLO usually takes a small equity ownership that is less than 5 percent of the new firm. By its active engagement with faculty and

other entrepreneurs, as well as venture capitalists, the TLO is a vital participant in MIT's entrepreneurial ecosystem. Figure 19 shows the number of startup companies it has licensed with MIT technology in each of the past ten years, 1998–2007.

United States university licensing data are available for many years from the Association of University Technology Managers. In AUTM's latest survey, which covers 2006 (AUTM, 2007), MIT's twenty-three licenses rate it second only to the entire University of California statewide system. Table 16 shows all of the U.S. universities that licensed ten or more startups during 2006. For the 189 respondents to that AUTM survey, the average number of licenses per institution was four. In 2005, MIT was first in the nation with twenty startups being licensed, while the University of California system licensed nineteen, Cal Tech assisted sixteen, and the University of Florida provided licenses to thirteen. No other institution had licensed ten or more new firms during 2005.

Over many years, MIT almost always has been first among U.S. universities in technology transfer to new enterprises. We do not know how many of these licenses go to companies that are not MIT-alumni founded. Nor do we know how much "leakage" might occur with unlicensed MIT technology becoming the basis for new-firm

Figure 19
Number of Startups Licensed by MIT TLO, 1998–2007

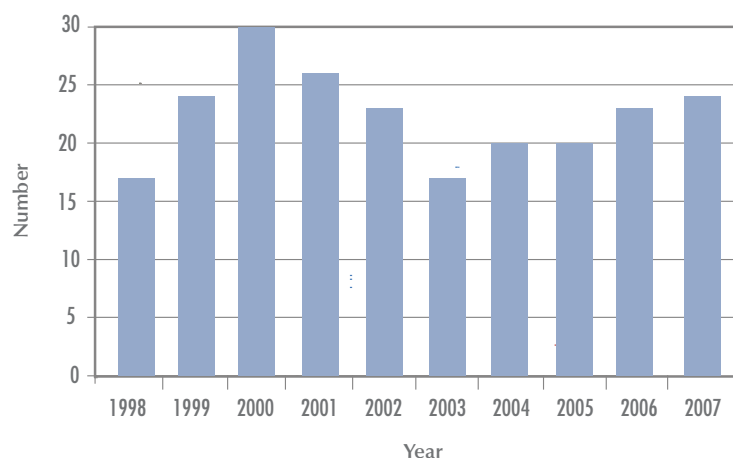


Table 16
Primary Universities Doing Startup
Licensing, 2006*

University	Startups Licensed
U. California system	39
MIT	23
U. Utah	17
Purdue	14
SUNY	12
U. Colorado	10
U. Florida	10
U. Washington	10

* Compiled by the authors from AUTM data

formation. Thus, the numbers cited here and in our alumni figures again inevitably understate overall entrepreneurial impact of MIT technology

Sometimes the time required for such early-stage licensed technology to have economic impact is quite long. For example, Cubist Pharmaceuticals was founded by two MIT faculty members with an MIT license in 1992. After long struggles, the company finally has advanced to the point that it is anticipating \$500 million in 2009 revenues, a long haul to successfully bring new science to the marketplace.

Beyond their formal roles, the TLO staff members,

due to their organizational location and personal expertise, also actively contribute in their “spare” time to MIT classes and student activities. These include participation in sponsorship and judging of the \$100K Business Plan Competition, active involvement with the MIT Enterprise Forum, and guest lectures on patents and licensing in a number of courses, both undergraduate and graduate, and clubs.

Even prior to the Venture Mentoring Service (to be discussed later), which it now also helps, the TLO provided “open-door coaching” for any student thinking of starting a business, whether through an MIT license or not. Several dozen students per year participate. That coaching now includes having TLO staff take on roles as project advisors and I-Team Catalysts for the Deshpande Center. All of these endeavors tie the knowledge and connections of the TLO to the rest of MIT’s internal efforts at stimulating and aiding entrepreneurship. Note in Table 17 the increasing evidence over time of visibility and perceived impact of the TLO on venture formation, despite the fact that only a very small fraction of the alumni entrepreneurs surveyed in 2003 employed MIT-licensed technology in their new enterprises.

Case Example: A123 Systems

No doubt at least one interesting story can be told for each startup the TLO licenses. A most recent one⁶ illustrates primarily the formal role of the TLO in helping new companies to be created and MIT technology to go to market. It also again illustrates

Table 17
Technology Licensing Office Importance to Venture Founding (from limited sample only)

Proportion Rating University Factors as Important in Venture Founding* (percentage)					
Graduation Decade	1950s (N=73)	1960s (N=111)	1970s (N=147)	1980s (N=144)	1990s (N=145)
Technology Licensing Office	1%	0%	2%	4%	11%

*Respondents could check all relevant categories

6. *The A123 Story: How a Battery Company Jumpstarted its Business*, www.xconomy.com/2008/01/24/the-a123-story-how-a-battery-company-jumpstarted-its-business/.

the power and workings of the overall MIT entrepreneurial ecosystem. In spring 2001, Ric Fulop '06, a serial entrepreneur who had been involved in five startups by the time he was twenty-five years old, was looking for his next opportunity. Howard Anderson, also a serial entrepreneur who teaches the "New Enterprises" subject and several other MIT entrepreneurship classes and was founder of the YankeeTek venture capital firm, had participated in investments in two previous Fulop ventures that had lost \$10 million. But Anderson had deep admiration for Fulop and gave him space in his office to help Fulop think through his next undertaking. After a few months of research into the energy business, and then narrowing to battery technology, Fulop scanned the country in search of technological alternatives, including reviewing MIT TLO's database on MIT technologies. As a result, Fulop approached Professor Yet-Ming Chiang '80 with his idea of using carbon nanotubes as a basis for setting up a new battery company. Chiang quickly convinced Fulop that Chiang's lab had more interesting battery R&D underway and the two of them began serious discussions. As they looked for a third partner to run engineering, Chiang introduced Fulop to Bart Riley, who incidentally had been an early employee of American Superconductor, an earlier MIT spinoff that Chiang had co-founded in 1987. By September 2001, Fulop, Chiang, and Riley had decided to form a new battery company, A123 Systems, and began to negotiate with the TLO (leaving Chiang out of the discussions to avoid conflict of interest) for exclusive rights to Chiang's MIT battery developments. All went smoothly with MIT and, by December 2002, the company had completed its first round of venture capital funding from Sequoia Capital, Northbridge Ventures, YankeeTek, and Desh Deshpande (see later discussion of the Deshpande Center), who also became chairman of the A123 board. The A123 story since then has been magical, with more than \$250 million in venture funding by December 2008, six manufacturing plants in China and Korea, more than 1,800 employees, and more. A123 is moving rapidly forward with multiple products in its three target

markets, including cordless tool batteries (its first product application was the launch of a new line of professional tools by the DeWalt division of Black & Decker), multi-megawatt batteries for renewable integration into the electric grid, and batteries for transportation (with more than nineteen models of hybrid and plug-in vehicles with major American and European automakers under development). A123 already has become one of the world's leading suppliers of high-power lithium ion batteries.

Recent MIT Institutional Broadening and Growth

During the last few years, three major institutional additions at MIT have contributed immediately to the development and launching of new companies, and strongly to the overall MIT entrepreneurial ecosystem. They are the Venture Mentoring Service, the Deshpande Center for Technological Innovation, and the MIT Sloan Entrepreneurship & Innovation MBA Program, all of which we discuss below.

MIT Venture Mentoring Service

The MIT Venture Mentoring Service was proposed in 1997 as a joint venture of the MIT Sloan and Engineering schools, with the MIT E-Center expected to be its host. But, as with many new ideas, it took time, key people, and money to actually get underway. As a result of generous donations by two MIT alumni, Alexander Dingee '52 and Professor David Staelin '60, VMS finally got started in 2000, its premise being that a fledgling business is far more likely to thrive when an idea, a good business plan, and an entrepreneur are matched with proven skills and experience. VMS has an office in MIT's main building complex, under the MIT Dome, and a small, full-time staff directed by Sherwin Greenblatt '62, the first employee and later president of Bose Corporation, aided by a large number of part-time volunteers. It provides free and, hopefully, objective advice and assistance to anyone affiliated with MIT—student, staff, faculty, alumnus/a—who is considering the possibility of starting a new company.

As indicated in Table 18, between VMS's founding and mid-2007, more than 900 men and women participating in nearly 500 contemplated ventures have received guidance and coaching. Prospective entrepreneurs often come to VMS at very early stages in their idea process—usually before there is a business plan, a strategy and revenue model, a team, or any funding.

Table 18
Some VMS Data (mid-2007 report)

Ventures served since 2000	469
Entrepreneurs served	932
Companies formed	88
Funding raised by companies	\$350M +
Current mentor pool	121
Mentoring hours (just in the past 12 months)	more than 9,000

The VMS staff and volunteers don't screen to pick winners; rather, VMS's mission is to use any plausible idea as the focus for education on the venture creation process. The process of forming a viable company can take anywhere from a few months to as much as five years. Eighty-eight new companies, or more than 17 percent of the ventures that have signed up as VMS "clients," already had formed operating companies by mid-2007.

Ultimately, many of the prospective entrepreneurs find their ideas are not practical as ventures, but they have learned much about being entrepreneurs and forming ventures. Some of them return with another venture concept that does turn into a company. The ventures served during the first seven years of VMS have raised total funding that significantly exceeds \$350 million. This includes venture capital and angel investments, grants, and other seed capital.

VMS's mentor pool has grown from its founding group of seven in 2000 to more than 100 mentors actively engaged in the program and working with entrepreneurs. Another twenty mentors serve as ad hoc specialist resources.

The Venture Mentoring Service's major contributions seem to come from the "no-strings-

attached” advice and guidance of experienced mentors. This encourages entrepreneurs to make more educated, thoughtful, and informed decisions, thereby enhancing their chances for success. Typically, VMS builds a long-term relationship that significantly influences the startup. Among the ventures that have been mentored by VMS along the path from idea to operating enterprise, showing the variety of markets and technologies being tackled, are:

Brontes Technologies, Inc. Described previously in the section on the MIT Enterprise Forum, Brontes developed and commercialized a revolutionary single-lens 3D imaging technology, which it applied to the dental imaging market. The company was acquired by 3M in October 2006.

Corestreet, Ltd. Infrastructure and software for security and smart credentials.

Gaterocket, Inc. Advances the electronic design automation industry’s ability to develop advanced FPGA semiconductors.

Greenfuel Technologies Corporation. Uses algae forms to clean air by recycling carbon dioxide from industrial facilities and turning it into bio-fuels.

Interactive Supercomputing, Inc. Software platform delivering interactive parallel processing to the desktop, dramatically speeding up solutions to complex industrial and governmental research and operational problems.

Myomo, Inc. Described later in the section on the Deshpande Center, Myomo (previously called Active Joint Brace) is a pioneer in neuro-robotics, a new class of non-invasive medical device technology combining neuroscience and robotics

to restore mobility after neurological dysfunction. The company created the first portable, wearable robotic device to help stroke patients relearn how to move by enabling them to initiate and control movement of their partially paralyzed arms.

Smart Cells, Inc. Making use of a polymer-based dosing technology developed at MIT by its co-founder, SmartCells is developing a once-a-day, self-regulating, injectable formulation for treating diabetes.

Vela Systems, Inc. This mobile software for field activities in construction and capital projects management leverages capabilities of tablet PCs to deliver construction projects faster, with higher quality and lower risk. Vela now is used on more than 300 projects from Las Vegas to Dubai.

Table 19 below, showing essentially no perceived importance of VMS to venture founding, is actually quite reassuring from a research reliability perspective. Given that the Venture Mentoring Service was operational only in 2000 and the survey was conducted in 2003, it would have been disturbing if more than one or two respondents cited VMS as an influencing factor. But VMS, its founders, and key leaders were recognized by being awarded the Adolf Monosson Prize for Entrepreneurship Mentoring by the MIT E-Center in 2007.

MIT Deshpande Center

On January 3, 2002, MIT announced the creation of the Deshpande Center for Technological Innovation, funded by a magnanimous gift of

Table 19
Importance of Venture Mentoring Service to Venture Founding (from limited sample only)

Proportion Rating University Factors as Important in Venture Founding* (percentage)					
Graduation Decade	1950s (N=73)	1960s (N=111)	1970s (N=147)	1980s (N=144)	1990s (N=145)
Venture Mentoring Service	0%	1%	0%	0%	1%

*Respondents could check all relevant categories

\$20 million from Jaishree Deshpande and Desh Deshpande, whose most recent entrepreneurial achievement was as co-founder and chairman of Sycamore Networks. Housed in the School of Engineering, the Deshpande Center funds leading-edge research on novel technologies in collaboration with the New England high-technology entrepreneurial and venture capital communities. Via those linkages, the Center's unique thrust is to identify emerging MIT technologies that are especially likely to be able to be commercialized, and to accelerate and improve that process of movement to market. It thus seeks to bridge the innovation gap between idea and market.

Dr. Deshpande said: "MIT has always provided a fertile ground where its students and faculty can break through technology barriers, fuel new areas of research and development, and fundamentally transform whole industries...Our hope...is to give creative new entrepreneurs...the ability to translate their ideas into innovative companies and products." The Center supports a wide range of emerging fields, including biotechnology, biomedical devices, information technology, new materials, tiny tech, and energy innovations. It provides Ignition Grants of up to \$50,000 each to enable exploratory experiments and proof of concept, and then provides Innovation Program Grants of up to \$250,000 each to advance ideas past the "invention stage." Professor Charles Cooney '67 has served as the Center's director since its founding.

At the outset, the Deshpande Center was announced as linked to the MIT E-Center, most strongly evidenced by the establishment two years later of the jointly taught "Innovation Teams" subject, with mixed-student teams across MIT departments focusing on developing commercialization plans for Deshpande research projects.

The Deshpande Center engages in numerous activities to seek out new faculty participants and to aid those funded to gain visibility and networking assistance from the relevant community outside of MIT. The Center has recruited experienced

entrepreneurs and venture capitalists to serve as Catalysts who work closely with each research project to provide guidance about market and commercialization issues. Senior staff of the MIT TLO work closely with the Catalysts to assist the project principal investigators, as well as to help the I-Teams that get formed around many of those projects. One of the largest Deshpande activities with several hundred in attendance is the annual, one-day IdeaStream Symposium, featuring key MIT faculty presenters, venture capital panelists discussing the current "hot" fields, and display booths with chart sessions for all of the currently funded Deshpande grants.

From its founding in 2002 through the end of 2007, the Center had received about 400 research proposals from several hundred MIT faculty. It had provided \$8 million in grant funding to eighty projects. Follow-on research funding of the MIT projects, from both government and corporations, amounts to more than \$3.5 million. Thus far, fifteen companies have been formed, gaining more than \$100 million in outside capital investment and employing more than 200 people.

Case Example: Myomo

A few of the significant spinouts of the Deshpande Center are Brontes Technologies (previously described in the section on the MIT Enterprise Forum), Myomo, Pervasis Therapeutics, Q-D Vision, and Vertica Systems. One example of Deshpande Center commercialization is Myomo, started with Deshpande funding in 2002 as the "Active Joint Brace" research project of Professor Woodie Flowers '68. The case again reflects the strong interrelationships among various parts of the MIT entrepreneurial ecosystem. The project's evolution from academic research toward commercialization may be seen in the descriptions of the work used at various times. The research group's initial self-description was: "Our research group aims to create a wearable, affordable, unencumbering exoskeleton that augments human physical capability by working in parallel with existing musculature."

After its first pass with an I-Teams group effort, the work was described as: “Active Joint Brace is an orthopedic joint brace combined with a powered assist mechanism modulated by a neurological sensor.”

By the end of the semester with their I-Teams group, they were introducing their technology by pointing out: “Ten million of the twenty-one million Americans living with disabilities have difficulty lifting a light object such as a fork or a toothbrush.” At that point in 2004, the team, consisting of MIT faculty, students, and an alumnus, plus a Harvard student, entered the \$50K Business Plan Competition and won the Robert Goldberg Grand Prize of \$30,000. By January 2006, the research project was finished and Myomo Inc. (short for My Own Motion) was born. It received FDA clearance to market its first product in July 2007. In November 2007, it received the Popular Science “Best of What’s New” Award for its NeuroRobotic Technology Innovation.

MIT Sloan Entrepreneurship & Innovation MBA Program

Entrepreneurship & Innovation (E&I) is a new option within the two-year MIT Sloan MBA Program, made available for the first time to selected applicants in the entering MBA Class of 2008. The program focuses on teaching committed grad students how to launch and develop emerging technology companies. It builds a select lifetime cohort of collaborative entrepreneurial MBA classmates and leads to an MIT Sloan Certificate in Entrepreneurship & Innovation, in addition to the MBA degree. The E&I curriculum heavily emphasizes team practice linked to real-world entrepreneurial projects, balances theoretical and practitioner education, and provides a thorough exposure to the many building blocks of an entrepreneurial career. Perhaps not surprising to some, more than one-third of the entering MBA students applied for admission to this new opportunity when it was announced in June 2006, but the 125 had to be screened down to fifty first-year students to manage program

introduction. About one-quarter of the MIT Sloan MBAs now enter this entrepreneurship concentration.

The E&I program begins with the standard first-semester MIT Sloan MBA core, permitting the entrepreneurship cohort to become fully integrated with their classmates in all activities. But during that first term, the E&Is also take an overview course that introduces them to all aspects of entrepreneurship education and practice at MIT. Both academic and practitioner faculty meet with the group, as do the heads of the MIT VMS, TLO, Deshpande Center, and several local entrepreneurs and venture capitalists, creating special access to the MIT entrepreneurial ecosystem. The semester is followed almost immediately by an intensive one-week group trip to Silicon Valley, arranged by the MIT E-Center. The class visits leaders of multiple venture capital firms and meets in small groups with a large number of carefully selected, early-stage high-tech firms in the life sciences, medical technology, software, information technology, advanced materials, and new energy fields. During the following three semesters, the E&I program requires students to participate in at least one MIT \$100K team (described above) and to choose several additional subjects from a restricted menu of entrepreneurial electives (including E-Lab, G-Lab, and I-Teams, all described previously) that prepare them to start and build companies, while letting them enroll in other broadening MIT and MIT Sloan courses such as finance or marketing.

One of the students in the inaugural class, Nikhil Garg, MBA '08, described his experience: “I could have spent my entire two years on campus meeting like-minded entrepreneurs here and there. But everyone in this class wants to start a company. It’s so much easier to facilitate ideas and business relationships with other MBAs and techies in this type of environment.” Will O’Brien, MBA '08, spearheaded weekly, thirty-minute “Open Mic” sessions to encourage his classmates to practice their pitches, preparing them for future encounters with venture capitalists. “The caliber of ideas has been phenomenal,” says O’Brien. “They’ve ranged from new ventures in wind energy, developmental

entrepreneurship, media, and even beer manufacturing.” In December 2008, O’Brien launched a Web 2.0 company that he began with an E&I classmate during their second year in the program.

Half of the inaugural group previously had founded their own or been part of startup companies. Many more company formation initiatives began even within the first term of the students’ arrival on the MIT campus. A group of the first-year E&I class demonstrated its entrepreneurial savvy by winning the UC-Berkeley School of Business “Media Case Competition,” sponsored by Yahoo!, and took home a check for \$10,000. Another first-year E&I participant became part of an African-American team that won the \$10,000 first prize at the 2006 Whitney M. Young New Venture Competition at the Wharton School, the three finalists being MIT, Stanford, and UCLA. One more classmate was a \$1K winner and another a finalist in the MIT \$100K competition. In November 2008, with three E&I classes underway, the evidences continue to grow of MBA students’ strong desires to create their own new firms, despite the E&I program leadership’s guidance that they first gather more real-world experience working in startups before initiating such actions on their own. Twenty-five ‘08 MBA graduates, the first year of E&I program completion, started their own companies before or upon graduation from MIT Sloan, three times the number of immediate startups from the Class of 2007. This may be an early sign of the E&I track’s impact on its own group as well as on other entrepreneurial classmates.

Conclusions: Enhancing the Role of Research/Technology Universities in an Entrepreneurial Economy

Universities that are strong in research and technology are at the forefront of knowledge creation and potential application. When the university is able to couple this capability with the inclination and resources needed to connect ideas and markets, impressive possibilities exist for generating entrepreneurship-based economic impact at the local, as well as national and global levels. Most important in making this transformation is having the institution's leadership adopt the will to accomplish this. Numerous changes are needed in most universities over an extended period of time in rules, regulations and, more important, attitudes and institutional culture. None of these will be accomplished without strong and committed university leaders.

The MIT history described in this report provides numerous and detailed examples of how one major institution achieved significant entrepreneurial impact over its first 150 years. Early examples of engaging the academic with the real world, even including entrepreneurial actions by senior and respected faculty and university officials, did much to capture the attention of more junior faculty members, as well as students and alumni, to the legitimacy of technology transfer and commercialization. Big differences between institutional histories of entrepreneurial output no doubt are explainable to a great extent by this distinction alone in leadership roles and behavior. MIT's history suggests that the appropriateness of rules and regulations needs to be assessed carefully to be sure that they do not create barriers to faculty participation in industrial consulting and, more vitally, that they do not hinder faculty initiatives in new companies' formation. A shift from

barriers toward incentives will take much time to occur in most organizations, and will be accelerated if advocates for entrepreneurship pay strict attention to establishing and enforcing guidelines against conflicts of interest.

Until quite recently, MIT had followed a "hands-off" approach toward entrepreneurial engagement, in contrast with many other universities in the United States and abroad. MIT has neither created an internal incubator for ventures nor a venture capital fund to make life easier for prospective startups. Those facts have permitted MIT to avoid degrees of internal conflict and occasional embarrassments that have plagued other academic institutions that have tried to hurry the entrepreneurship process. But MIT has had the advantage of a surrounding community that essentially has provided those functions, as well as other aspects of a supportive infrastructure for new enterprises. In less well-endowed neighboring circumstances, a university may have to supply with great care the active help and at least some funding to get entrepreneurial ventures off the ground.

Instead, MIT has relied internally on growing faculty, student, and alumni initiatives, especially during the most recent thirty years, to build a vibrant ecosystem that helps foster formation and growth of new and young companies. All these have, over time, significantly enlarged the number of interested and involved participants, with corresponding increases in their activities and outcomes. If an institution is deliberately trying quickly to become more entrepreneurial, the MIT approach would take an amazing degree of patience and self-restraint.

Outreach to alumni is achieved easily in the form of self-organized seminars, and faculty visits and

lectures, facilitated by direct “distance viewing” of classes and conferences. Organizations such as the MIT Enterprise Forum often can be accessed in local communities, perhaps just by joining or partnering instead of needing to replicate the organization.

Educational programs require investment in and acquisition of faculty to develop and teach such programs. Effective and well-trained academics are, unfortunately, still scarce in most entrepreneurship-related disciplines. Fortunately, successful practitioners are available everywhere and the MIT history indicates that they are quite willing and enthusiastic about sharing their time and experiences with novice and would-be entrepreneurs. The list of MIT student clubs suggests the numerous ways by which students across the university might find their own paths toward entrepreneurial efforts. The \$100K Business Plan Competition is the most vibrant and perhaps most effective of these clubs on the MIT campus, leading directly to high levels of new companies being formed. Students at other universities can learn easily how to undertake their own comparable competitions through attending the annual MIT \$100K Global Business Plan Workshop. Furthermore, the MIT one-week intensive Entrepreneurial Development Program, conducted annually in January by the MIT E-Center, may well be a helpful supplement for those institutions attempting to create an overall program of education and student activities that will encourage entrepreneurship.

The alumni activities and educational and student endeavors provide a strong basis for building an entrepreneurial ecosystem. But formal institutional activities also are critical. At MIT, changing the Technology Licensing Office into a proactive and supportive-of-entrepreneurship program office has contributed much to technology transfer from the research labs. This was done twenty years ago and has had the time to mature in its effectiveness. More recently, MIT’s creation of the Venture Mentoring Service, its own form of volunteer lightweight but quite effective “incubation,” has generated a model of helping that is clearly possible in many other university communities. And direct, targeted funding

of faculty research that has commercial potential, as done in the new MIT Deshpande Center, is certainly a possibility elsewhere.

This report has documented how much dramatic economic impact has been generated by MIT alumni, students, staff, and faculty who have formed new enterprises over the past fifty years. Throughout we have attempted to communicate the many elements of what we call this university’s entrepreneurial ecosystem and how each part has contributed to the venture formation process. In many examples we have cited, multiple aspects of that ecosystem have been at work in making entrepreneurship happen and be successful. We have tried also to show how other universities may be able to strengthen their own entrepreneurial achievements and, in turn, their contributions of economic impact to their communities, regions, and countries.

Appendix: Sources of Information⁷

Company Database

In 2003, MIT initiated a rigorous and comprehensive survey effort, in which the authors participated, to identify, carefully study, and assess the impact of new enterprises created by all living MIT alumni.⁸ The survey produced detailed information on 4,611 companies founded by 2,111 graduates. To provide still more information about these companies, including current sales, employment, industry category, and location, this new MIT database on alumni companies was further updated and upgraded from the 2006 records of Compustat (for public companies) and Dun & Bradstreet (private companies). Our report's findings with respect to total employment and sales, MIT-enrolled department of company founders, industry, and age of the companies, are based on this updated database. We use data only on MIT alumni companies that still were active in 2003, that information coming from a carefully conducted survey process. In this way and many others, the numbers in our report are conservative in their estimation of the total economic impact of MIT-related entrepreneurs, ignoring the entrepreneurial outcomes of the many non-alumni faculty, staff, and other employees, as well as other spillovers from MIT.

Alumni Survey

MIT conducts periodic surveys of all alumni to get up-to-date demographic information. As we indicated previously in this report, in 2001 MIT sent a survey to all 105,928 living alumni with addresses on record. MIT received 43,668 responses from alumni; of these, 34,846 answered the question about whether or not they had been entrepreneurs. A total of 8,179 individuals (23.5 percent of the respondents) indicated that they had founded at least one company. In 2003, we developed and sent a survey instrument focusing on the formation and operation of their firms to the 8,044 entrepreneur respondents for whom we had complete addresses. Of the 2,111 founders who completed surveys, approximately 2.2 percent of the cases had been reported by more than one MIT co-founder. Removing those duplicates (the average number of MIT co-founders per team is 1.29) left 2,059 unique alumni entrepreneur respondents who founded 4,611 companies. Most teams also had non-MIT co-founders, but this fact does not require any correction in the sample.

Because many of the founders of the largest MIT alumni companies no longer are affiliated with their companies or have passed away, the companies

7. Information on MIT Entrepreneurial Organizations

We deeply appreciate the help of several others at MIT in the preparation of this report. In particular, Trish Fleming and Antoinette Muller, directors of the MIT Enterprise Forum of Cambridge and globally, respectively, along with Joseph Hadzima, chair of the global Enterprise Forum organization, provided huge amounts of information from which we developed much of the detailed history of that remarkable organization. Karina Drees, lead organizer during 2006–2007 of the MIT \$100K Business Plan Competition, assembled and presented all of the information in regard to the \$100K. Lita Nelsen, director for many years of the MIT Technology Licensing Office, gave us much insight into the MIT entrepreneurship process and supplied all of the data on the TLO's history and operations. Sherwin Greenblatt, director, prepared the data on the MIT Venture Mentoring Service. Professor Charles Cooney, its faculty chair; Leon Sandler, executive director; and Ken Zolot, senior lecturer in entrepreneurship, provided key information about the MIT Deshpande Center and the related Innovation Teams class. We appreciate the significant help in the survey creation and initial data analyses by our collaborator David Hsu, PhD recipient from MIT Sloan and now faculty member at the University of Pennsylvania.

Additional Thanks: Celia Chen, Jennifer Peterson, Minnie Moy, and Yuqiao Huang made important contributions to the data analyses and presentations in this report. We are grateful for their assistance and hard work.

Finally, we are especially appreciative of all of the editorial assistance and suggested rewrites provided by E.J. Reedy of the Ewing Marion Kauffman Foundation. His help made the entire report far more understandable. In addition, Barbara Pruitt and Lesa Mitchell, both of the Kauffman Foundation, as well as William Bonvilian and Jose Pacheco of MIT, were invaluable in their efforts in bringing this report to the public. Of course, any errors in the final work are the responsibilities of the authors.

8. Ten years before, the Economics Department of BankBoston (now part of Bank of America) collaborated with MIT on an analysis of MIT-related companies. The 1997 publication by BankBoston used information on some number of then-active, MIT-related companies that it had identified as created by MIT faculty, staff, and employees of MIT-affiliated research labs.

represented in the survey responses are somewhat more recent and average fewer employees than the universe of MIT alumni-founded companies. All told, these 4,611 specific surveyed firms included in the direct responses employ more than 585,000 people. We estimate, however, that the entire population of MIT alumni firms employs more than 3.3 million people.

The report's findings on where and why companies locate where they do, what gives them their competitive edge, how they received initial funding, where they sell their products, and how many patents they have, are taken directly from the responses to this 2003 survey, updated to reflect the 2006 corporate information obtained from Compustat and Dun & Bradstreet. To estimate accurately the entrepreneurial activity and economic impact of those in the entire MIT alumni population who did not respond to the surveys, we multiply the direct response numbers by a scale factor. For further details, see the Appendix section, "Estimation Methods," below.

The detailed questionnaire used for this survey is available at www.kauffman.org/MITstudy. We encourage other universities to undertake and share comparative analyses. We also should note here that, although we correctly identify all of the alumni in the MIT database as "MIT alumni," a substantial fraction of them are also alumni of other universities in the United States and other countries. So the economic impacts cited in this report reflect the direct and indirect educational impact of many institutions of higher learning in science, technology, and management.

Estimation Methods

As in all surveys, a large segment of the alumni population did not respond to the MIT alumni surveys. Therefore, estimation of the total impact of MIT alumni entrepreneurs requires extrapolation to account for non-respondents. To estimate the numbers for the entire MIT alumni population, we multiply by a scale factor to give an accurate estimate of the entrepreneurial activity of those who did not respond

to the surveys. Since we have aggregated data from both the 2001 and 2003 MIT surveys, with adjustments from the 2006 Compustat and Dun & Bradstreet databases, the appropriate scale factor depends on the particular statistic or question being answered.

1. For survey items where we have data on all companies created over the life of the entrepreneur, the base scale factor is approximately 9.476 (i.e., $2.425 \times 3.906 = \sim 9.476$). These numbers are approximate because we actually use more than three digits after the decimal. We multiply by 2.425 because, as indicated above, the total population of MIT alumni is 105,928 and 43,668 responded to the first survey. To get from 43,668 to 105,928 we have to multiply by 2.425 (i.e., $105,928/43,668 = \sim 2.425$). Then we multiply by 3.906 because 8,044 indicated that they were entrepreneurs and only 2,059 responded to the Founder's Survey (i.e., $8,044/2,059 = \sim 3.906$). We multiply that by 0.773 to avoid duplicate counting by correcting for multiple MIT alumni on the same founding teams. Because 23.4 percent of the reported companies were out of business by 2003, we finally multiply by 0.766 to count just those companies likely to still be active.
2. For items where we only have data on one of the companies the entrepreneur founded, we then multiply by 1.61 because 1.61 is the number of companies on average each entrepreneur has founded (27 percent of the entrepreneurial alumni are repeat/serial entrepreneurs). For example, if we take 100 alumni entrepreneurs, on average they would have created 161 companies during their careers. If we only have data on total employees for one company each (100 companies), then we must multiply by 1.61 to get an estimate of the real total number of employees for all the companies founded by that entrepreneur.
3. We further adjust the scaling factor for items where data are missing due to entrepreneurs skipping a survey item. This process may seem

complicated, but it gives a much more accurate estimate than any previous efforts.⁹

It is important to point out that, although we correctly identify many MIT alumni-founded companies in various discussions throughout this report (e.g., Tables 10 and 11), in the underlying database that gets scaled we only use those firms formed by alumni who completed survey reports in 2003. Thus, some very significant MIT alumni firms were NOT included in the database, such as Arthur D. Little, AMP, Campbell Soup, Genentech, Hewlett-Packard, Intel, McDonnell Douglas, Raytheon, Rockwell, and Texas Instruments, because the MIT founder had died in all these cases. These omissions illustrate the importance of the scale factor we employed to produce a more accurate estimate that partially compensates for the many firms explicitly omitted.

This scaling method rests on three assumptions. One is that the proportion of entrepreneurs among the respondents is the same as the proportion of entrepreneurs among the non-respondents. The second is that the respondent entrepreneurs are equally as successful as the non-respondent entrepreneurs. The proportion of entrepreneurs among the non-respondents (or their success level) could just as easily be higher as it could be lower than the proportion among the respondents. The third is that, for entrepreneurs who started more than one company, then on average the performance of their former or subsequent firms is similar to the firm we observe.

Let's consider how wrong we might be in these estimates. The effect of cutting our scale factor by two (which would represent the extreme case where twice as many respondents as non-respondents were entrepreneurs, or where respondent entrepreneurs were twice as successful as non-respondents), generates the results that are in the conservative

wording we chose to use in the introduction of this report:

...if the active companies founded by MIT graduates formed an independent nation, conservative estimates indicate that their revenues would make that nation at least the seventeenth-largest economy in the world.

Under these circumstances, we would be estimating that 12,900 companies created by MIT alumni employ 1.6 million people and have annual world sales of \$1 trillion. That is roughly equal to a gross domestic product of \$500 billion, a little less than the GDP of the Netherlands and more than the GDP of Turkey (2006 International Monetary Fund, nominal GDP—not purchasing power parity or PPP).

9. Similar extrapolation methods were used in a recent study of immigrant entrepreneurs' role, using a scale factor to extrapolate from 2,054 responses in their survey database to the estimated economic impact drawn from 28,776 companies, a scale-up factor of ~14.010 (Wadhwa et al., 2007).

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