

**The Pre-Entrepreneurial Development
of Technological Entrepreneurs**

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ABSTRACT

Empirical analyses carried out as part of a twenty years research program on technology-based enterprises add to our knowledge of the background characteristics of technological entrepreneurs, specifically as compared with control groups of employed scientists and engineers. Perhaps the most important finding is existence of "the entrepreneurial heritage", a strong tendency for entrepreneurs to come from families in which the father was self-employed. For those not from entrepreneurial homes, religious differences affect the incidence of technical entrepreneurs, but careful analyses dispel the myth of the first-born son. The typical technical entrepreneur is well-educated, in his mid-30s, with 13 years of pre-entrepreneurial work experience during which the prospective entrepreneurs significantly outproduced their technical colleagues, primarily in the developmental (not research) end of the R&D work spectrum.

The formation and growth of myriad new technology-based firms has uniquely characterized the United States post-war economy. Indeed, worldwide interests in replicating patterns in their own countries similar to U.S. technological entrepreneurship have rapidly increased during the 1980s, even as U.S. international competitive effectiveness has waned. However, during these several decades the opportunities presented by advancing technology have not been seized by all American scientists and engineers. Very few of the millions of individuals highly trained in existing technology have taken those steps needed to organize and launch a technological enterprise. This article seeks better understanding of the backgrounds of those few who become technological entrepreneurs.

Until recently the creators of new enterprises have been treated in the literature only in the folkloric tradition of Horatio Alger. Extensive accounts of the lives of men like J.P. Morgan, Andrew Carnegie, and the Rothchilds produce a feeling for the spirit and mystique of these capitalist giants. However, with a handful of exceptions, modern entrepreneurship has not been subjected to careful empirical examination. Three pioneering empirically-based works by David McClelland (1961), Everett Hagen(1963), and Collins & Moore (1964) provide a foundation of theory and perspectives for more recent explorations. McClelland, primarily a social psychologist, ties the entrepreneur to the elements of economic change and growth, his writings being strongly oriented to those psychological characteristics of entrepreneurs that make them likely to become business innovators. Hagen is an economist with a sociological bent, interested in explaining economic growth by the presence in societies of what he calls innovational personalities. With a strongly empirical psychological orientation Collins and Moore discuss the origins and experience of entrepreneurs.

None of these early works examined technological entrepreneurs. Fortunately, increasing numbers of relatively recent studies are examining the personal backgrounds of technological entrepreneurs, the nature of the organizations that incubate them, and the processes associated with their success. (Roberts, 1968; Cooper, 1971; Cooper & Bruno, 1977; Tyebjee & Bruno, 1982; Van de Ven, Hudson & Schroeder, 1984; Sexton & Smilor, 1986; Utterback et al., 1988) This article reviews the theories arising from the foundation literature on the background and development of entrepreneurs in general and goes beyond the more recent studies in providing new empirical evidence on the founders of advanced technology enterprises. Our variables of

emphasis are family background, education, age and work experience; empirical findings from the recent literature in regard to these dimensions are included where appropriate throughout the article.

EARLY EVIDENCE ON ENTREPRENEURIAL CHARACTERISTICS

McClelland (1961) sees the entrepreneur as the one who translates need for achievement (n-ach) into economic development. The entrepreneur in McClelland's scheme is "the man who organizes the firm (the business unit) and/or increases its productive capacity." (p. 205) McClelland's underlying assumption is that entrepreneurs have a high n-ach which will lead them to behave in certain ways in business situations. McClelland claims that entrepreneurs thrive on situations in which they can get a sense of personal achievement through taking responsibility for success and failure. Entrepreneurs according to McClelland tend to work hard and to do things in an innovative rather than traditional manner, especially when there is a challenge and when the completion of work to be done requires ingenuity rather than standard procedures. But they require concrete feedback in the form, for example, of production volume or profit as measures of how well or how poorly they are doing. McClelland argues that among the strongest factors directly associated with the development of n-ach are parental values.

Beyond his psychological studies using the Thematic Apperception Test primarily, McClelland's empirical data are restricted to family backgrounds and religious variables. He demonstrates differences in n-ach among the three primary religions in the United States, leading him to conclude (pp. 361, 365):

- (1) More traditional Catholics appear to have some of the values and attitudes that would be associated with lower need for achievement.
- (2) Other groups of Catholics exist, at least in the United States and Germany, which have moved away from some of these traditional values toward the "achievement ethic" [often associated with Protestantism].
- (3) There is little doubt that the average need for achievement among Jews is higher than for the general population in the United States

at the present time.

Everett Hagen, in his book On the Theory of Social Change, defines entrepreneurship as "... the organization of a group of human beings into a going concern that carries out a new concept." (p. 87) He, like McClelland, attempts to explain economic growth by the characteristics of entrepreneurial groups of people. However, he considers much more than n-ach as integral to economic development. In his study of economic growth in Colombia Hagen found that one group of people, the Antioquenos, were more frequently than any others the founders of substantial enterprises. To a high degree the Antioquenos manifested needs for autonomy, order and achievement. Hagen suggests that these personal characteristics increase the likelihood that the individual will be an innovator which in turn increases the likelihood that he will be successful as an entrepreneur.

One of the few modern empirical investigations of "the makings" of U.S. entrepreneurs is the Collins & Moore study, The Enterprising Man. (1964) In-depth interviews and Thematic Apperception Tests were used to determine the backgrounds and the psychological motivations behind entrepreneurs' behavior. Unfortunately from our interest, the 150 business initiators studied were seldom involved in technology-based companies, most being shopkeepers or operators of small service businesses. Collins & Moore found that entrepreneurs tend to subscribe to the Protestant Ethic, (Weber, 1956) a value system that stresses hard work and striving to produce an earthly, i.e., pre-heavenly, reward. According to Collins & Moore, they have an obsessive drive to push themselves even harder, what we often call "workaholics". Authority is a difficult area for the entrepreneur. He is unwilling to submit to it, unable to work with it and has a strong need to escape it. The entrepreneur cannot easily accept another's leadership and cannot exist in a situation where his behavior is controlled and dictated by others.

OVERALL SAMPLE SELECTION AND DATA COLLECTION

Beyond these three classic studies of entrepreneurs in general, the relatively few prior empirical studies of technical entrepreneurship also referenced above raise three methodological issues that are treated in the research reported here. All three issues limit the extent to which the conclusions drawn previously can be deemed reliable. (1) Sample size in several of those studies are small, leaving questions as to generalizability of

findings. (2) The samples are often developed from surviving or "successful" firms, providing no basis for knowing whether the non-survivors are similar or different in character. For example, use of Dun and Bradstreet listings of small companies in compiling entrepreneurial samples necessarily omits the large number (in my experience) of startup firms that never reach the stage of such listing. (3) Of most importance, none of the prior studies used any form of control group for comparison with the entrepreneurs. The prior research does not reveal whether determined characteristics of technical entrepreneurs are the same or different from those of matched groups of non-entrepreneurial engineers and scientists.

The data presented here are part of a twenty years research program on all aspects of the formation and growth of high-technology new enterprises in the Greater Boston area, including more than 40 separate but related research studies. Elements of the data collected in sixteen of those studies (shown in Table 1) are used in this article, covering information from several hundred firms founded by former employees of the MIT major laboratories and engineering departments as well as by the former employees of a government laboratory, a major non-profit systems engineering organization and two large technological corporations. The four non-MIT organizations were selected from the Greater Boston area for ease of data collection, seeking comparability with the size and nature of work of the MIT "sources". Contrasting information is used from a study of new non-technical consumer-oriented manufacturing firms. Occasional reference is also made to findings from other studies within the overall research program.

Wherever possible, these data on the entrepreneurs are compared with information collected from a control group of scientists and engineers still employed at two of the largest entrepreneurial "source organizations" that generated the research samples. In each of these "controls" twenty percent random samples of employees were created for mail questionnaire data collection. The high response rate of 76 percent provides some assurance of representativeness of the control group information, but no follow-up was pursued to test for bias among the non-respondents.

 Insert Table 1 about here

Beginning with strong cooperation of senior managers in each source organization, initial lists were developed of suggested names of spin-off

entrepreneurs from that organization. Follow-up interviews were used to screen these lists for inappropriate names as well as to generate further suggestions in a "snowball" sample creation process. Rigorous criteria were applied to include only those who had been former full-time employees of the source organizations, who later participated as founders of wholly-new for-profit companies.

Structured interviews with a detailed questionnaire, lasting typically one to two and one-half hours, were used to gather data from each entrepreneur personally, with telephone interviews used in less than ten percent of the cases and mailed interviews used only as a last resort in less than one percent of the cases. Some interviews stretched to seven or eight hours over two or three sessions! Despite extensive efforts to include all spin-offs from each source organization studied, no doubt some minor bias has crept into the sample of companies studied in that it is likely that any companies not located were less successful than those traced. The bias did not prevent many companies from being found and studied that were clearly failures or not very successful.

Answers to the detailed questionnaires led easily to the quantification of information. Most all of the answers were coded and arranged in computer data files. Incomplete information on some of the companies does not particularly affect the data analysis as relevant codes were given to isolate missing information.

Four clusters of influences upon a person becoming a technical entrepreneur are discussed here: family background; education; age; and work experience. While elements of each of these dimensions are shown to affect the "career choice" of starting a new company, whether or not each influences the entrepreneur's success or failure is left for later research.

BREEDING OF THE NEW ENTREPRENEURS

An understanding of the new technology-based entrepreneurs begins most logically with an examination of their home environments or family backgrounds. These provide the first influences that help mold the personal development, attitudes and orientation of the future entrepreneurs. In our studies of technical entrepreneurs, data were collected on unfortunately few family characteristics: father's occupational status, whether or not the

entrepreneur's father was self-employed and the entrepreneur's religious background. Sometimes we also found out the number of brothers and sisters in his family and the birth order among them. Wherever possible, we shall make comparisons with the control sample (research studies of the employees of some of the same MIT laboratories who did not spinoff to form new companies), to place the distributions for the entrepreneurs in more meaningful perspectives.

"The Entrepreneurial Heritage": Father's Occupational Status

The largest percentage (60%) of the technical entrepreneurs came from families where the father was either a professional or a manager. Comparison with the control group of MIT lab employees indicates little difference between the two groups on this dimension. However, a closer look at Table 2 shows four times as many entrepreneurs with professional fathers than one might expect based on the control sample of employed scientists and engineers. These results raise the strong possibility that sons of professionals are more likely to become entrepreneurs than sons of managers. (The reference to "sons" is an empirical rather a male chauvinist statement. Only three of the 113 technical entrepreneurs in this particular group were

 Insert Table 2 about here

women. Consequently, the male pronoun will be used in the remainder of this article in referring to the entrepreneurs.) To the extent that we believe that parents may influence their children through the example of their own behavior, the findings are not surprising in light of the nature of the work of the professional as opposed to that of the manager. A professional, such as a lawyer or a physician, is seldom a member of a large hierarchical organization. And even when in a large organization (corporation, law firm, or hospital), the professional typically possesses a degree of independence not held by a manager who is almost always part of a very structured organization. After witnessing his professional father's independence, the son is more likely to find it appealing to obtain some type of occupational independence himself. The entrepreneurs in our studies had parents of the previous generation, during which time period the primary occupational roles in the United States were being served by the father. As women of the present generation move more into both professional and managerial roles, they will also serve increasingly as career role models for their children.

Whether or not the entrepreneur's father was self-employed is a second and critical aspect related to the father's occupation. As shown in Table 3, the difference between technical entrepreneurs and the control group of employed scientists and engineers is quite striking. Entrepreneurs tend strongly to come from families in which the father was self-employed ($X^2=15.06$, $p=.0001$). These findings on entrepreneurs who spun-off from MIT labs and academic departments are strengthened by our studies of technical entrepreneurs who originated from other source organizations.

 Insert Table 3 about here

48% of the entrepreneurs who spun-off from a large electronic systems firm, 57% of those from a diversified technological corporation, 61% of the Massachusetts biomedical entrepreneurs we studied, and 65% of a sample of computer-related entrepreneurs had fathers who were in their own businesses. Although control studies are not available for direct comparison with these sample groups, an analysis of 1960 U.S. census data (to get data related to the entrepreneurs' fathers!) indicates that only about 25% sons of self-employed fathers should have been expected by chance alone. Presented statistically, the probability that a particular engineer or scientist will form his own company is significantly greater in cases where his father had his own business (0.01). This is still further supported by our control study of MIT faculty in which we found that even professorial sons of self-employed fathers more frequently claimed a serious interest in being in business for themselves (.05). All these evidences demonstrate that entrepreneurial fathers produce entrepreneurial sons disproportionately, supporting the effect of an "entrepreneurial heritage".

Yet seldom was the father's business at all related to his son's specific entrepreneurial activities, nor were many of the father's businesses (or occupations generally) even technical in nature. Most frequent parental businesses were small retail stores, farms, and small non-technical manufacturing firms. And many of the sons are in businesses that could not have existed in their father's time, e.g., computer software, electronic systems or biotechnology! It is the general image and example of father as self-employed professional or as independent business owner that provides the role model for the son, not any specific technical or managerial knowledge. Indeed it may be that simply familiarity with a business

environment, growing from "table talk" at home, is the key to increasing the probability that an offspring will become an entrepreneur.

Religious Background

Despite expectations arising from the general literature on entrepreneurship, no readily discernible religious differences were found between the overall group of technical entrepreneurs and the control group of employed scientists and engineers. A little more than half of both the entrepreneurs and the control group were Protestant, about 25% of both groups were Catholic, and slightly more than 20% in each group were Jewish. At first pass it appears that simply being of a certain religious background does not directly increase or decrease the likelihood that an individual engineer or scientist will become a technical entrepreneur. But I'll return to this question momentarily.

Family Size and Birth Order

The size of the family from which an individual comes also appears to have no direct bearing on the incidence of entrepreneurship. In addition, utilizing the family size breakdowns to establish an expected birth order, no important differences arise between either the entrepreneurs or the control group and the expected frequencies.

It is interesting that 55% of the entrepreneurs were first-born sons, seemingly supporting the folkloric prediction. But when we compare them to the control group of employed scientists and engineers, we find 54% of that non-entrepreneur group also to be first-born sons. It is likely that much of the general clamor about the important role of first-born sons arises from a lack of careful statistical comparison with the family groups from which these sons originate.

Incidentally, the entrepreneurs were born and brought up all over the world, but with a heavy bias toward New England origins, reflecting the sources of companies in our research samples. Of note is that ten to twenty-five percent of each sample of new firms in our research were founded by someone born outside of the United States. (Twelve percent of the Swedish entrepreneurs studied by Utterback et al. had immigrated.) Technical entrepreneurship seems to continue the "melting pot" nature of opportunities

for personal growth and development in the Boston area, attracting and retaining productive talent to the region.

A Second Cut at Family Background

Relative to an individual's family background and the incidence of technical entrepreneurship, the only significant findings concern the father's occupational status. This is true when the entire sample is considered, that is, the entrepreneurs and control group members with and without self-employed fathers. As indicated earlier, the hypothesis of an "entrepreneurial heritage" can explain why a disproportionate number of entrepreneurs are the sons of entrepreneurs. But what explains the entrepreneurial activity of those individuals, comprising almost half of our samples, whose fathers were not self-employed and who therefore could not be said to have an entrepreneurial heritage?

An examination of the family background characteristics of only those individuals whose fathers were not self-employed reveals differences between the entrepreneurs and the technical employees, as indicated in Tables 4 and 5. Table 4 indicates approximately equal percentages of entrepreneurs and control group subjects in each religious category for the subset of the entire population whose fathers are self-employed. However, for those whose fathers are not self-employed, Table 5 shows that the

 Insert Table 4 about here

 Insert Table 5 about here

Catholic group has one third fewer and the Jewish group five times more entrepreneurs than expected based on the control group distribution ($X^2=6.33$, $p=.01$). In the absence of the entrepreneurial heritage syndrome, religious differences do seem to have an effect on the incidence of technical entrepreneurship. More specifically, confirming McClelland's predictions (1961, p. 365), more Jews and fewer Catholics can be expected to go into business for themselves from a mixed religious population of U.S. technologists that have no self-employed fathers.

A careful re-analysis of the data on birth order, searching for possible

differences related to parental self-employment, produced no new insights. To do this analysis correctly, expected frequencies of birth order distributions needed to be calculated, based on the family size data. Much of the literature is misleading in this regard, not accounting for family size in the populations being studied. Our results suggest no "first-born" effect, at least for high-technology entrepreneurs.

Thus it appears that the most influential aspect of a technical entrepreneur's family background in his decision to become an entrepreneur is his father's career. In the absence of a father whose career provided a role model with a high degree of independence or autonomy, i.e., from either self-employment or professional status, other demographic characteristics, primarily religious background, may then have an effect on breeding entrepreneurs.

THE ENTREPRENEUR'S EDUCATION

Many of the personal characteristics of the high-technology entrepreneurs with whom this article is concerned are probably true of all entrepreneurs. However, their educational characteristics provide one of the most prominent differences.

The Collins & Moore study of Michigan entrepreneurs reported that only about 40% of the entrepreneurs had any education beyond the high school level. (1964) In support our somewhat comparable study of consumer manufacturing entrepreneurs in Massachusetts had produced the same 40% post-high school educational attainment. In contrast, however, the technical entrepreneurs in the MIT spin-off group had a median educational level of a Master's degree, generally in engineering. Only 1% of the total high-tech entrepreneurs had no college education at all and only 9% did not have at least a bachelor's degree. The distributions of educational levels for the entrepreneurs and the control group of MIT technical employees follows in Table 6.

 Insert Table 6 about here

Probably the most important reason for these entrepreneurs' higher educational level is the nature of the source laboratories at which they worked prior to their enterprise formation and the training necessary for

employment there. Table 6 shows that the median educational level for the control group whose members were employed at the same source labs is also a Master's degree. The technical entrepreneurs in the two industrial spin-off samples and in the computer-related new enterprises averaged a Bachelor's degree plus some course work, reflecting the slightly lower educational base of the industrial labs relative to the MIT laboratories.

A comparison of the educational levels of the technical entrepreneurs with the general population as well as with fathers of technical entrepreneurs (taken from the study of an electronic systems firm's spin-off companies) follows in Table 7. The technical entrepreneurs are much better educated than the general population, and also better educated than their fathers, with the technical entrepreneurs heavily skewed toward the highest levels of education. A similar median education level of a Master's degree plus was found in our study of 29 Massachusetts biomedical entrepreneurs and by Van de Ven et al. (1984, p. 93) in their study of 14 educational software start-ups.

 Insert Table 7 about here

Family Background and Education

A detailed analysis of a smaller subset of the MIT spin-off entrepreneurs sought to explain further these educational levels. One finding was that the occupational status groupings of the fathers of the entrepreneurs (see Table 2) correlated significantly with the educational level of the entrepreneurs (Kendall tau=0.19, p=0.06, n=58). This means that the higher the paternal occupational status, the higher the level of education attained by the entrepreneur. This finding was confirmed by the spin-offs of the industrial electronics firm (0.02). No data were collected that would permit attributing levels of income to the various occupational status levels. However, one might expect these status levels generally to reflect differences in income. If this is valid, then the positive correlation with educational level can be explained in part on an economic basis. It is likely that those entrepreneurs who came from lower occupational status families did not have enough money to go to college as early or for as long as did those from higher status groups. Support for this position can be derived in the inverse statistical relationship found between paternal occupational status

and the age of the entrepreneur when he finished the B.S. (Tau=-0.23) and M.S. degrees (Tau=-0.30). This means that entrepreneurs who came from families of lower occupational status (and therefore probably lower income) received their B.S. and M.S. degrees at older ages than did entrepreneurs from higher occupational status families ($p=0.01$).

The same data sample indicated a nonlinear relationship between whether or not an entrepreneur's father was in his own business and the education level of the entrepreneur. Table 8 shows for entrepreneurs at each level of educational attainment the number and percent of all fathers who were in their own businesses. A statistical test confirmed the relationship between whether or not the entrepreneur's father was in his own business and whether or not the educational level of the entrepreneur was at least the B.S. degree but not more than the M.S. degree and course work (X^2 significance level=0.07).

 Insert Table 8 about here

One possible explanation for this finding is that those technical entrepreneurs whose fathers were in their own businesses were planning to go into business for themselves from an earlier age. Their education was therefore targeted (consciously or unconsciously) to a level appropriate to establishing a technically based enterprise. Going beyond the B.S. or M.S. degree was inappropriate because these sons of entrepreneurs long had in mind the specific goal of starting a company, not of doing research, teaching, or any other activity that might demand the still higher education of a Ph.D. Incidentally, no correlation was found in our research studies between the educational level of the fathers and the education of their entrepreneurial sons.

Degree Disciplines and Sources

Search for relevant educational data in regard to degree discipline reveals relatively little, the entrepreneurs looking more-or-less like their technically employed counterparts. About two-thirds of the technical entrepreneurs had degrees in engineering, thirty percent in science, and three percent in other fields. In our separate study of biomedical entrepreneurs more of the founders, who included several M.D.s, came from initial education in the natural sciences.

Of greater interest is that of the 217 degrees earned by the 106 technical entrepreneurs in one sample we checked carefully, only three were in management (at the Master's degree level), a similar percentage of management degrees as found in the group of employed scientists and engineers. In fact relatively few of the technical entrepreneurs had even taken business courses before company formation. Of course, some of them had co-founding partners with management education. Our more recent research samples of entrepreneurs include an increasing percentage of engineers with graduate management education, reflecting the growing popularity of the MBA degree.

Influenced no doubt by the high concentration on MIT departments and labs as sources in our research, the largest number by far of the technical entrepreneurs we studied earned their degrees at MIT. This dominance was also true, however, in the research data on spin-offs from non-MIT source organizations as well as in the special industry-related new enterprise groups, in which less bias toward MIT backgrounds might have been expected. The Greater Boston area concentration of my research program no doubt also explains a less-well-known phenomenon of high prevalence of entrepreneurs trained at Northeastern University, a large urban school with the largest "private" engineering enrollment in the country. In most of our research samples Northeastern-educated entrepreneurs accounted for far more companies than Harvard or other local or nationally-known educational institutions, although a wide diversity of college backgrounds is represented in the samples.

Education of Faculty Entrepreneurs

To this point no distinction has been made between entrepreneurs who were MIT faculty members and those who had worked as research and engineering staff members at MIT or elsewhere. In fact no significant differences exist between these groups in regard to family background, father's occupation and religion. The first major difference arises in regard to education. Nearly all the faculty entrepreneurs had Ph.D.s, reflecting MIT's faculty recruitment and selection criteria. For example, all nine faculty entrepreneurs from the Mechanical Engineering department have their doctorates (eight out of nine from MIT). Four of seven Aeronautical Engineering faculty founders have doctorates, the other three cases being

unique situations of age and/or circumstance. In contrast, for example, the non-faculty Aeronautical entrepreneurs (departmental staff members) included two doctorates and nine less-well-educated company creators.

AGE

Across all the research studies, with few exceptions, I have found rather remarkable similarity in the age patterns of technical entrepreneurs at the time of company founding. Table 9 shows data from eleven of my research studies, indicating the range and median of entrepreneurial ages. The range of ages in 243 companies is 23 to 69, with an overall median of 37 years. On an

 Insert Table 9 about here

"eyeball" judgment basis, the MIT laboratory spin-offs appear to be slightly younger, averaging 34 against a representative 38 years for their industrial and mixed source counterparts. This may be due to more positive encouragement at MIT for spin-off company formation as well as more access to advanced technological bases for new firms. The 60 Swedish entrepreneurs in the Utterback et al. (1988) sample also had a median age of 34 at the time of company formation.

To provide more detail on ages, Figure 1 shows the age distribution of 119 MIT spin-off entrepreneurs, including some from academic departments as well as the laboratories (range = 265, median = 34). Two thirds of the entrepreneurs started their companies when they were between the ages of 28 and 39. Only 7% of the entrepreneurs were younger than 28 and less than 10% were older than 48. Those who were older at founding had a higher educational level (.04).

 Insert Figure 1 about here

Indeed two of this MIT spin-off group were 65 years old, faculty placed into retirement at that age who felt they still had worthwhile ideas and the entrepreneurial energy to pursue them. The overall youth attributable to the entrepreneurs must fundamentally be more related to attitude than chronology alone, although this would be hard to prove.

But raising mention of the faculty does identify one of the exceptions to

the "rule" of mid-30s entrepreneurial ages. Examined separately, MIT faculty form companies at significantly older ages than their staff colleagues ($p=.05$). For example, in the Department of Aeronautics and Astronautics the ages of faculty founders ranged from 26 to 65 with a median of 44 at the time of company formation. Their non-faculty departmental colleagues who became entrepreneurs ranged from 26 to 40 with a median of 32. The difference no doubt reflects the longer educational periods (disproportionately more Ph.D.s, $p=.10$) required by the faculty members for entry into their primary career roles, combined with the long time then needed to secure their faculty position. Academic tenure tends to be awarded by age 36 and few faculty take much time away from teaching and research prior to the tenure decision. Presence of a few faculty entrepreneurs in each of the MIT lab spin-off groups listed in Table 8 slightly increases the median ages shown for those samples. Without faculty entrepreneurs included the MIT lab spin-offs would be even a bit younger in age pattern.

The second exceptional group we studied were the consumer-oriented manufacturers, our sample of greatest contrast with the high-technology entrepreneurs. That group ranged from 28 to 55 at the time of forming their companies, with a median age of 45. In that regard, but no other, they look like MIT faculty entrepreneurs. (The Collins et al. study of general entrepreneurs in Michigan found the average age to be 52.)

Most of the technical enterprises were founded by teams of several people, but the median ages of team members match the individual figures shown in Table 9. In one group of 20 technical companies studied, the median age of the youngest person on each team was 30, the median of the oldest was 41, with a median overall age of 37. A second sample of 20 companies produced a median youngest team member age of 34, a median oldest of 43, and a median overall founder age of 39.

Why So Young?

One probable cause of the young age of the technical entrepreneurs is the youthful age structure of the technical organizations at which they previously worked. A comparison of the entrepreneurial age distribution with the employed scientists and engineers at the MIT laboratories used as control studies shows roughly comparable age patterns, with the entrepreneurs about two to three years younger on average. Technical organizations such as the

MIT departments and labs, Air Force Cambridge Research Laboratory, or the large technology-based industrial organizations in the Greater Boston Route 128 area are the breeding grounds for new enterprises. Their age base sets the bounds within which entrepreneurship can take place. Yet on average it is the younger people relative to these organizations as a whole who leave and eventually start new enterprises.

A second but related influence on the young age of the technical entrepreneurs is the newness of the technology they are using. An older man or woman would first have to learn a new and emerging field that is the entrepreneur's training grounds in terms both of formal education and work experience. This can be a time-consuming and arduous task, even when possible. A lower bound on the technical entrepreneurs' ages is set by their almost universal college education, probably a prerequisite for acquiring the knowledge needed to form a technical company (despite exceptional college dropouts like Edwin Land who created Polaroid).

Depending on the particular research sample, anywhere from 75 to 100 percent of the entrepreneurs were married at the time of company establishment, most of them with children (two on average). This suggests a third possible influence on the youthful ages found. Financial requirements of the family with very young children are not usually so great, at least not in comparison with needs as the children grow and begin approaching their college years. The burden of loss of income from giving up a well-paying engineering job and taking less or no pay as a startup entrepreneur can be more readily absorbed by the young family. A prospective entrepreneur in his 40s, with mid-teen aged children, is likely to be more risk averse than his younger counterpart. Also those growing teenagers are going to be more time demanding, competing with the heavy time requirements involved in getting a new company off the ground.

Supporting these perspectives are the common findings of research on job turnover. The older a person, the less likely is he or she to change jobs; the more longevity of an individual's employment with one organization, the less likely is job turnover; and the higher a person's position, the less likely is job changing. Age, employer longevity and position are all highly correlated, but each acts independently in the same direction of discouraging voluntary departure from an organization. These general observations are bolstered by our control studies at two major MIT laboratories: staff

members who are older have been at the labs longer and have higher positions there (.001). Still older people feel more locked-in by pension considerations, too little work time left to find a job and build a new career should the enterprise fail, and reluctance to try something new. Risk-taking eventually ages out!

Note that some entrepreneurs form more than one company during their lifetime. For example, William Poduska was a co-founder of Prime Computer, then founded Apollo Computer, and later formed Stellar Computer. The age effects described above relate to the first-time entrepreneur. The multi-time entrepreneur's "career" has become "forming companies", to be continued until retirement from this career, or up to the semi-retirement practiced by a number of ex-entrepreneurs of investment management and/or college teaching!!

WORK EXPERIENCE

Phases of Experience

The median education level of the technical entrepreneurs (about Master's degree, usually obtained at age of 23 or 24), coupled with their age characteristics discussed above, leads to the logical deduction that the typical entrepreneur had about 13 years of work experience prior to starting his own company. Actually the mean number of years of work experience for one group of 111 carefully-studied entrepreneurs is 12.7 years. (The variance from this mean was almost 8 years, reflecting the inclusion in the sample of several MIT faculty members who started their companies when they were over 60 years of age, thus adding more than 40 years of work experience in several cases.) This seems to mirror the average 12 years experience of the 60 Swedish technological entrepreneurs studied by Utterback et al. (1988) and the mean of 13.2 years of experience in our biomedical sample.

Figure 2 presents the distribution of work experience, showing that the bulk of technical entrepreneurs, 79%, had from 3 to 16 years work experience prior to starting their new enterprises. Only 2% had less than three years and

 Insert Figure 2 about here

22% had more than 16 years experience. (In contrast, the consumer

manufacturing entrepreneurs averaged 24 years of pre-enterprise work experience.)

How did the entrepreneurs spend this 3 to 16 years of pre-entrepreneurial work experience prior to starting their new enterprises? As was the case with educational characteristics, the nature of the work experience of technical entrepreneurs differentiates them from other entrepreneurs. The Collins & Moore study of Michigan entrepreneurs characterized them as being lean on formal education but heavy on the education one gets in "the school for entrepreneurs". (p. 125) This perceived "school of hard knocks" was characterized by many job changes in which the prospective entrepreneur developed the skills destined to make him effective as an entrepreneur. Our impression is that the general entrepreneurs studied by Collins et al. did not have one key work experience that provided the reason and basis for a new enterprise. In contrast the technical entrepreneurs we studied did have one key work experience which not only gave them an opportunity to start a company that had a technological advantage at least initially, but also, mainly through this technological edge, enabled them to grow rapidly in sales and profits. Even in contrast with my impression of life in California's Silicon Valley, our data did not suggest a job-jumping phenomenon among our primarily Greater Boston entrepreneurs. In fact they had had relatively few employers with one, namely what I have been calling "the technology source organization", being the most important.

The entrepreneur's total work experience can be broken down into three segments: his work if any prior to "the technology source organization", his work at that organization, and his work if any between the "sources" we studied and the new enterprise. The mean number of years work experience prior to working for the source laboratory was 4.26 years (with variance about this mean of 5.59 years). More strikingly, for 41% of the entrepreneurs employment at the source organization was their first job. Fully 70% of the entrepreneurs had had 5 or less years experience elsewhere when they went to work for one of these source laboratories.

What about the segment of the entrepreneur's work experience between the technology source organization and the founding of the new enterprise? Depending on the research sample chosen within our studies, between fifty and sixty percent went directly into their new businesses after they terminated employment at the source laboratory we assessed. About eighty

to eighty-five percent had 5 or less years work experience between the laboratory and the new enterprise. (Incidentally, I have also found that the time lag between the source laboratory and the new enterprise had a strong effect on the degree to which technology was transferred. Namely, the longer the time lag the less the degree of technology transfer.) The average number of years between the laboratory and the new enterprise was 2.4 years. Figure 3 indicates the evidence of new company formation after departure from the source organizations.

 Insert Figure 3 about here

Where then do our technical entrepreneurs get their principal training, experience and skills? For some it came from their experience prior to the source laboratory and for some, but many less, it came from their work between the so-called "source" and the new enterprises. But the vast majority of the technical entrepreneurs studied gained their relevant experience and training from one key period of work experience, that at the technology source organization. The typical entrepreneur spent 7.4 years at the so-called source organization (again biased upward by the inclusion of faculty entrepreneurs), longer by almost 3 and 5 years respectively than the average years worked before the laboratory and between the laboratory and the new enterprise. Fifty-three percent of the entrepreneurs spent 5 or more years at the source laboratory.

Almost 21% of the total sample of entrepreneurs worked only at what I have called a technology source laboratory. This is true not only for MIT spin-offs, but, for example, for those new enterprises formed out of the electronic systems company we studied. Another 37% worked only before and at the lab, which makes up the total here of 58% who went directly from the "source" organization to the new enterprise. Twenty percent worked at the source and between it and the new enterprise. Only approximately 22% of the entrepreneurs worked before, at, and after the source laboratory before starting their new enterprises. These data are summarized in Table 10.

 Insert Table 10 about here

Along with the notion that technical entrepreneurs usually have one key work experience, on the basis of which they start their new enterprises, must necessarily come some consideration of the elements of experience at that

organization. We measured four factors to characterize the entrepreneurs' experience at the source organizations studied: number of papers published and patents granted while at the "source"; percentage of time spent performing various types of work activities; kind of technical work engaged in on a scale from basic research to development; and lastly, several attitudes as to what the entrepreneur gained in terms of challenge and personal satisfaction from his work.

Productivity

Wherever possible I will consider the characteristics of the entrepreneurs' work experience in relation to those of the control group of employed scientists and engineers at those same source organizations. Note that the typical entrepreneur had spent 7.4 years at the technology source organization, while the typical non-entrepreneur staff member of these same technology source organizations had already been there 8.4 years when we collected our data, one full year longer than the entrepreneurs. (Obviously, the typical non-entrepreneur will be there even longer before eventually departing the source organization!) As a result when factors are considered such as papers published or patents granted during employment at the source, there is a bias of more years during which, for example, the non-entrepreneur staff member might have published more papers.

Despite this bias Table 11 indicates that the entrepreneurs while employed by the technology source organizations published almost three times as many papers per person as did the control group employees. In addition, almost twice as many entrepreneur employees as non-entrepreneurs published at least one paper while employed by these labs.

 Insert Table 11 about here

Examination of patents granted while at the source organizations reveals the same type of phenomenon. During employment by the technology source organizations, the typical entrepreneur was granted 32 times as many patents (a clearer index of commercial entrepreneurial tendencies than papers!) as his non-entrepreneur counterpart. In addition, 34% of the entrepreneurs were granted at least one patent while at these laboratories as opposed to only 5% of the control group. These data demonstrate a striking difference, even on measures of conventional technical productivity, between

the work experiences of the entrepreneurs and the control group. Even within the control group of employed scientists and engineers, those few who had been previously self-employed at one time or another had been granted far more patents prior to their employment by the source organization than their colleagues who had never been self-employed (.001). Apparently, not only do entrepreneurs start companies but they are among the most productive technical contributors while employed in research and development organizations.

Time Allocation

Another aspect of the entrepreneur's work experience at the technology source organization is the percentage of his time spent on various activities such as report writing, development, and so forth. Our data show that on the average both the entrepreneurs and the control group spent about 50% of their time doing direct research and development work. When we consider only the mean percentages of time spent at the various activities, the entrepreneurs appear to be much like the control group. However, the differences in the standard deviations about the means for the entrepreneurs and the control group indicate that on each activity the entrepreneurial group has much higher degree of variation. These data present a picture of individual entrepreneurs as working on particular activities for very different amounts of time, as opposed to the control group where percentages of time spent on the same activities do not differ much between individuals or from the average.

Entrepreneurs who had a longer employment at the industrial electronics laboratory studied not unexpectedly spent a significantly greater amount of time on personnel supervision (.01), confirming an earlier MIT research study of R&D management at that same source organization. (Rubin, Stedry & Willits, 1965) Though exact job position was not uniformly recorded in the studies, it appears that many of the entrepreneurs were technical supervisors in their source organizations. For example, 40% of the Instrumentation Lab entrepreneurs were technical supervisors at the Lab before founding their own ventures. By contrast, only about 15% of the Lab staff members are supervisors. Several factors contribute likely explanations for the higher entrepreneurial defection of supervisors: (1) their personal characteristics that led them into supervisory roles; (2) their exposure to a wide variety of problems; and (3) the high degree of responsibility they typically are given as supervisors. They come into

contact with suppliers and customers much more often than the average engineer, giving them a valuable source of market information and contacts.

Nature of Work

Beyond this simple inquiry into time allocation we made a more serious attempt to get each entrepreneur (as well as each employed scientist and engineer in our control studies) to characterize the technical nature of the work he performed. The approach for doing this was borrowed from a rather classic U.S. Department of Defense (DOD) comprehensive study of sources of technical advances that were embodied in the Bullpup missile project, this study in turn being part of Project Hindsight, a detailed analysis of military R&D productivity. (Office of the Director of Defense Research and Engineering, 1965) As such the nine classes of R&D work which follow, widely tested for reliability by the DOD, will be referred to as the individual's "Bullpup Classification":

1. Investigations in pure and applied mathematics and theoretical studies concerning natural phenomena.
2. Experimental validation of theory and accumulation of data concerning natural phenomena.
3. Combined theoretical and experimental studies of new or unexplored fields of natural phenomena.
4. Conception and/or demonstration of the capability of performing a specific and elementary function, using new or untried concepts, principles, techniques, materials, etc.
5. Theoretical analysis and/or experimental measurement of the characteristics of behavior of materials, equipment, etc., as required for design.
6. Development of a new material necessary for the performance of a function.
7. First demonstration of the capability of performing a specific and elementary function, using established concepts, principles, materials, etc.

8. Development of a new manufacturing, fabrication and materials processing technique.

9. First development of a complete system, component, equipment or major element of such equipment, using established concepts, principles, materials, etc. -- Prototype development.

Suffice it to say that 1 is basic research, 9 is prototype development, and in ascending from 1 to 9 the classifications become more developmental in orientation, as follows:

1	2	3	4	5	6	7	8	9	
Basic									Prototype
Research				---Increasingly Developmental---					Development

In some cases the assignment of classification by the coder was difficult due to the variety of work performed by the entrepreneur at the source technical organization. However, the more highly educated staff members are heavily skewed to the basic research end of the scale at Lincoln Laboratory (.001) and two other MIT labs (.08, .15) and among the electronic systems company spin-offs (.02). The assigned classification does correlate positively with the entrepreneurs' reporting of the percent of time spent on development work at MIT's Research Laboratory for Electronics (RLE) (.09) and at the MIT Electronic Systems Lab (ESL) (.05); and it correlates negatively with the entrepreneurs' reporting of the percent of time spent on research at RLE (.007), at ESL (.01) and among the electronic systems company spin-offs (.003). In addition these "Bullpup" classifications correlate with those assigned by the individuals' supervisors at two laboratories (.007, .13). These findings support adopting the "Bullpup" classification as a usable measure of the nature of work performed by the entrepreneur while at the source organization.

Figure 4 pictures the distribution of entrepreneurs' technical work at the electronic systems company from which we traced spin-off enterprises.

 Insert Figure 4 about here

While at least one founder was classified in each "Bullpup" category the distribution is skewed heavily toward the developmental end of the spectrum, as might be expected in an industrial systems-oriented organization.

In Table 12 a subset of ninety-four MIT-based entrepreneurs are categorized by the source organization from which they spun-off and by the type of work they performed at the source. The totals indicate that only two

 Insert Table 12 about here

of the entrepreneurs performed work that was primarily basic research while twenty-six did primarily prototype development work. This is understandable. Basic research does not present much technology that has immediate practical utility. It is not supposed to. Prototype development work on the other hand involves much technology of practical utility. That is its nature. Entrepreneurs should be expected to come to a greater degree from the more developmental types of work.

The table also provides further support for the credibility of the coding scheme we used to categorize the entrepreneurs' prior work. The entrepreneurs from MIT academic departments, who included many faculty, did much more research-oriented work than those who originated from the major MIT laboratories (0.01).

Table 13 shows the work ratings of randomly sampled MIT Lincoln Laboratory personnel and Instrumentation Laboratory personnel (from our control studies) along with their related spin-off entrepreneurs. In each comparison the entrepreneurs were more developmentally oriented than their laboratory counterparts (.06, .13). A subjective evaluation of the entrepreneurs' work done at two other MIT laboratories, the Electronic Systems Lab and the Research Laboratory for Electronics, drew the same conclusion. We can now conclude that the more developmentally oriented people do have a greater tendency to become entrepreneurs.

 Insert Table 13 about here

Attitudes Toward Source Organization

An individual's attitude toward his work plays an important role in his learning process. A person who finds his work challenging and enjoyable can be expected to learn more easily and develop his skills more fully. With few exceptions the interviewed entrepreneurs spoke very highly of their "source" technical organizations. For example, the MIT spin-offs typically said that their MIT lab work had been the most interesting work they had done, often at the leading edge or frontiers of science and technology. Eighty-nine percent indicated that their lab was a place in which they had learned substantial new technology, in contrast to primarily applying knowledge they had already possessed.

84% of the MIT-based entrepreneurs indicated that their work at their "source" laboratory or department organization was above average in challenge. Sixty-five percent indicated furthermore that their "source" work was at least as or more challenging than any other work experience they had before starting their new enterprises. Ninety-two percent of the entrepreneurs indicated that they had derived above average enjoyment and personal satisfaction from their work at the source organization. Seventy-six percent felt that their laboratory experience was at least as or more enjoyable than any other employment prior to starting their new enterprises. Not surprisingly the challenge of the work and the satisfaction and enjoyment derived from doing the work are strongly related (Kendall Tau=.60, $p=.001$). This relation between prior work challenge and satisfaction was true even for the consumer manufacturing entrepreneurs (.04).

The entrepreneurs who had come from the electronics systems company had similar attitudes. Only two of those individuals disliked the industrial laboratory and only one felt that it offered no challenge. The entrepreneurs on the whole felt the challenge about equal to that of other companies they had worked for and said that they enjoyed the work at the source laboratory more than that at other laboratories. It was obvious that the technical entrepreneur has a strong dislike for meetings. Those entrepreneurs who found the work most challenging tended to spend the least time in meetings while at the laboratory (.04). Similarly, the entrepreneurs who most enjoyed their work at the company spent very little time in meetings (.008), those entrepreneurs also generally preferring development work to all other work, as indicated earlier.

Occasionally an entrepreneur reported leaving the source organization

with unpleasant feelings. For example, out of 23 Instrumentation Lab spin-offs providing this information two felt their managerial talents were being underutilized (perhaps intentionally so, given Lab policies to encourage turnover), and a third entrepreneur had been asked to leave. But negative attitudes were uncommon.

Indeed, many of the entrepreneurs indicated that they had become so involved with their work on a given project at the source organization that when these projects were completed they felt that their work too was completed. Several of the entrepreneurs attested that their sense of identification with the source 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. The information required to do a rigorous analysis of the effect of completion of projects on new company startups was not available, however. Psychological aspects of the entrepreneurs' motivations are presented elsewhere. (Roberts, 1988)

SUMMARY

This article sought to explain empirically the origins of the technology-based entrepreneur, comparing several samples of spinoff entrepreneurs with appropriate control groups of employed scientists and engineers. The major conclusions are presented here and synopsised in Table 14. The first and perhaps most important finding is what I have labelled "the entrepreneurial heritage": a strong tendency for entrepreneurs to come from families in which the father was self-employed. This phenomenon characterizes 50 to 65 percent of the technical entrepreneurs, depending on specific sub-sample, and is at least twice what should be expected from a purely random sample of the U.S. population.

Secondly, for those who do not come from entrepreneurial homes, religious differences do affect the incidence of technical entrepreneurship. In line with McClelland's writings about achievement motivation being linked to certain religious and ethnic family backgrounds, relatively more Jews and fewer Catholics establish technology-oriented firms.

But careful analyses dispel the myth of the first-born son as being significantly related to technical entrepreneurship. Proportionately as many

first-borns are likely to remain as employed scientists and engineers as are likely to spin-off to their own firms.

In contrast with prior studies of "general" entrepreneurs, our research demonstrates the technical entrepreneur to be well-educated, the median educational level being from slightly below to slightly above a Master's degree, more typically in engineering than in science, and only infrequently educated in all other disciplines including management.

The mid-30s is the dominant age range of technical founders, with MIT laboratory spin-offs being on the younger side and faculty entrepreneurs being older exceptions to the age "rule" in our several sub-samples of entrepreneurs.

The typical technical entrepreneur had 13 years of work experience, more than half of it at the incubator technical organizations I have labelled the "source" organizations. Close to two-thirds of the entrepreneurs went directly from these dominant technical work experience sites into their own companies. At the source organizations the entrepreneurs significantly outproduced their technical colleagues along the conventional output measures of papers and patents. Many had already risen into technical supervisory roles. Indeed, starting a company might be just another avenue for the productive energies and knowledge of these outstanding people!

Their work backgrounds evidence that not only are entrepreneurs more likely to come from engineering rather than science, but especially from the developmental (not research) end of the R&D work spectrum. Translating technology into use is more likely to spawn entrepreneurs than is the more basic creation of new technical knowledge.

Insert Table 14 about here

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TABLE 1
Data Sources for Entrepreneurial Backgrounds Study *

A. Basic Information on Entrepreneurial Spin-offs from Technological Source Organizations

<u>Sources of New Enterprises</u>	<u>New Companies Identified</u>	<u>Participants in Research Study</u>
MIT major laboratories (4 studies)	107	96
MIT academic departments (5 studies)	74	60
Air Force Cambridge Research Laboratory	16	15
MITRE Corporation	5	5
Electronic systems company	45	39
Diversified technological company	<u>58</u>	<u>23</u>
Totals	305	238

B. Comparative Study of Non-Technical New Enterprises

Consumer-oriented manufacturers	51	12
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C. Control Studies of Employed Scientists and Engineers

MIT major laboratories (2 studies)	391 persons	299 persons
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* Among my research assistants and thesis students who contributed importantly to this research were Erich K. Bender, Frederick L. Buddenhagen, Howard A. Cohen, Dean A. Forseth, Jerome Goldstein, Michael W. Klahr, Donald H. Peters, John C. Ruth, Christopher L. Taylor, and Paul V. Teplitz, as well as my former research associate Herbert A. Wainer.

TABLE 2
Father's Occupational Status

<u>Father's Occupational Status</u>	Technical Entrepreneurs (n=113)* <u>%</u>	Employed Scientists and Engineers (S&E)(Control Group) (n=296) <u>%</u>
Professional	32	8
Managerial	27	44
Clerical & Sales	9	7
Skilled Labor	18	21
Unskilled Labor	10	11
Farmer	<u>4</u>	<u>8</u>
Totals	100%	99%+

* Data on 113 entrepreneurs were used for the comparison shown here. Total sample sizes vary from possible maximum throughout this article due to missing data and the use of various samples.

+ Round-off error

TABLE 3
Whether or Not Father was Self-Employed

<u>Father Self-Employed</u>	Technical Entrepreneurs (n=119) <u>%</u>	Employed Scientists and Engineers (n=296) <u>%</u>
Yes	51	30
No	<u>49</u>	<u>70</u>
Totals	100	100

$\chi^2=15.06, p=0.0001$

TABLE 4
Religion of Those with Self-Employed Fathers

<u>Religious Background</u>	Technical Entrepreneurs (n=51) <u>%</u>	Employed Scientists & Engineers (n=83) <u>%</u>
Protestant	41	40
Catholic	27	25
Jewish	<u>31</u>	<u>35</u>
Totals	99%*	100%

*Round-off error

TABLE 5
Religion of Those with Fathers who were Not Self-Employed

<u>Religious Background</u>	Technical Entrepreneurs (n=50) <u>%</u>	Employed Scientists & Engineers (n=168) <u>%</u>
Protestant	70	68
Catholic	20	30
Jewish	<u>10</u>	<u>2</u>
Totals	100%	100%

$X^2=6.33, p=0.01$

TABLE 6
Educational Level

Educational Level	Technical Entrepreneurs (n=124)		Employed Scientists & Engineers (n=299)	
	%	Cumulative %	%	Cumulative %
High school	1	1	1	1
College without degree	8	9	5	6
B.S.	7	16	8	14
B.S. plus courses	20	36	31	45
M.S.	18	54	12	57
M.S. plus courses	11	65	21	78
Professional Engrg. degree	3	68	2	80
Ph.D.	31	<u>99*</u>	20	<u>100</u>
Totals		99%*		100%

*Round-off error

TABLE 7
 Educational Distribution of Technical Entrepreneurs
 Compared to Other Groups (%)

<u>Educational Level</u>	<u>General Population</u>	<u>Fathers of Technical Entrepreneurs</u>	<u>Technical Entrepreneurs</u>
Less than High School	58	23	0
Some High School	15	--	0
High School Graduate	15	53	1
Some College	5	--	9
College Graduate	5	25	90

TABLE 8
 Entrepreneurs within Each Educational Level
 Whose Fathers were Self-Employed (n=96)

<u>Educational Level</u>	Entrepreneurs in each Educational Group (<u>Number</u>)	Fathers Were in Own Business (<u>Number</u>)	Total (<u>Percent</u>)	Percentile Combination of Paired Groups (<u>Percent</u>)
No school beyond high school	1	0	0	33
College without any degree	8	3	38	
B.S. degree	2	2	100	56
B.S. degree and course work	16	8	50	
M.S. degree	13	8	62	61
M.S. degree and course work	10	6	60	
Professional engineering degree	3	1	33	36
Ph.D. or greater	<u>11</u>	<u>4</u>	<u>36</u>	
Totals	64	32	50	

TABLE 9
Age Distribution of Technical Entrepreneurs

	<u>Sample Size</u>	<u>Age Range</u>	<u>Median</u>
<u>MIT Laboratory Spin-off Studies</u>			
Electronic Systems Laboratory	11	27-43	35
Instrumentation Laboratory	27	24-55	33
Lincoln Laboratory	47	25-65	34
Research Laboratory for Electronics	13	29-64	36
<u>Other New Enterprises Research Studies</u>			
Spinoffs from diversified technological company	23	25-54	39
Computer-related firms (2 studies)	42	24-51	37
Recently formed high-technology firms	18	26-52	39
Analyses of business plans	20	24-8	37
Search processes for raising venture capital	21	24-3	35
In-depth analyses of venture capital investment decisions	20	26-9	39

TABLE 10
Work Experience before Starting the New Enterprise

<u>Work Experience</u>	<u>Technical Entrepreneurs (%)</u>
Technology source organization only	20.6
Technology source organization plus employment between it and the new enterprise	19.6
Experience before the source organization and at it	37.4
Experience before, at and after the technology source organization	22.4

TABLE 11
Papers and Patents--Entrepreneurs vs. Control Group

	<u>Technical Entrepreneurs</u>	<u>Employed Scientists and Engineers Control Group</u>
Papers published per person while at the source laboratories	6.35	2.2
Percent who published at least one paper while at the labs	63%	38%
Patents granted per person while at the source labs	1.6	.05
Percent who were granted at least one patent while at the labs	34%	5%

TABLE 12
Nature of Work of MIT Spin-off Entrepreneurs (n=94)

<u>Source</u>	Work Classification ("Bullpup" scale)									<u>Totals</u>
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	
<u>Major Laboratories</u>										
Electronic Systems Lab	-	-	-	-	3	-	1	2	4	10
Instrumentation Lab	-	-	-	-	1	-	-	1	7	9
Lincoln Lab	2	-	6	4	3	1	3	1	12	32
Research Laboratory for Electronics	-	-	2	1	3	-	4	-	2	12
Labs Totals	2	-	8	5	10	1	8	4	25	63
Median=7, Mean=6.6										
<u>Academic Departments</u>										
Aeronautics and Astronautics	-	1	3	8	5	-	-	-	-	17
Electrical Engineering	-	-	2	-	2	-	1	-	1	6
Materials Science	-	-	4	-	1	1	1	1	-	8
Depts. Totals	-	1	9	8	8	1	2	1	1	31
Median = 4, Mean = 4.5										
MIT Totals	2	1	17	13	18	2	10	5	26	94

TABLE 13
Nature of Work of Source Personnel and Spin-off Entrepreneurs

<u>Sample</u>	Work Classification ("Bullpup" scale)									<u>Median</u>	<u>Mean</u>	<u>Total</u>
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>			
Lincoln Laboratory Personnel*	9	15	22	16	16	4	11	1	56	5	5.75	150
Lincoln Spin-Off Entrepreneurs	2	-	6	4	3	1	3	1	12	6	6.06	32
Instrumentation Personnel**	3	3	2	18	14	1	6	6	81	9	7.33	134
Instrumentation Spin-Offs	-	-	-	-	1	-	-	1	7	9	8.44	9

* The difference in the work ratings of the Lincoln personnel and the Lincoln spin-offs is statistically significant at the probability level of .06 (Mann-Whitney U Test).

** Significant at a level of .13 (Mann-Whitney U Test).

TABLE 14
Characteristic Influences on Becoming a Technical Entrepreneur

Family Background

"Entrepreneurial heritage" -- son of self-employed father

Some influenced by achievement-oriented religious background

Age and Education

Master's degree, usually in engineering

Mid-30s age at founding

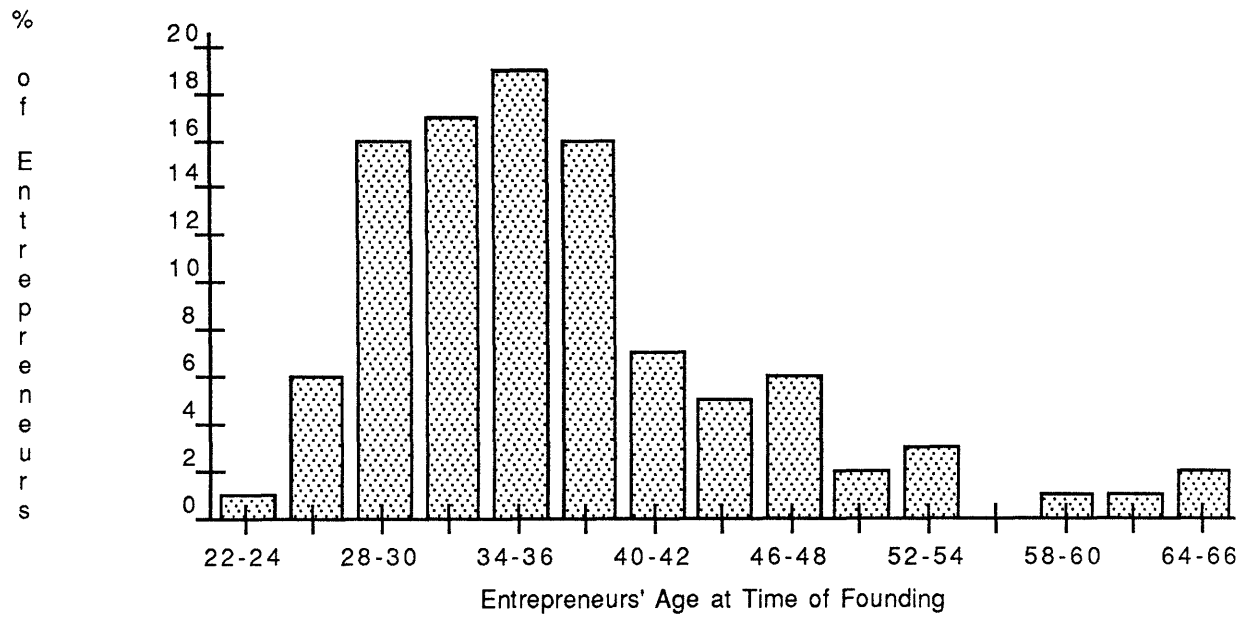
Work Experience

Decade plus of work, dominated by experience in "source organization"

Developmental (rather than research) work orientation

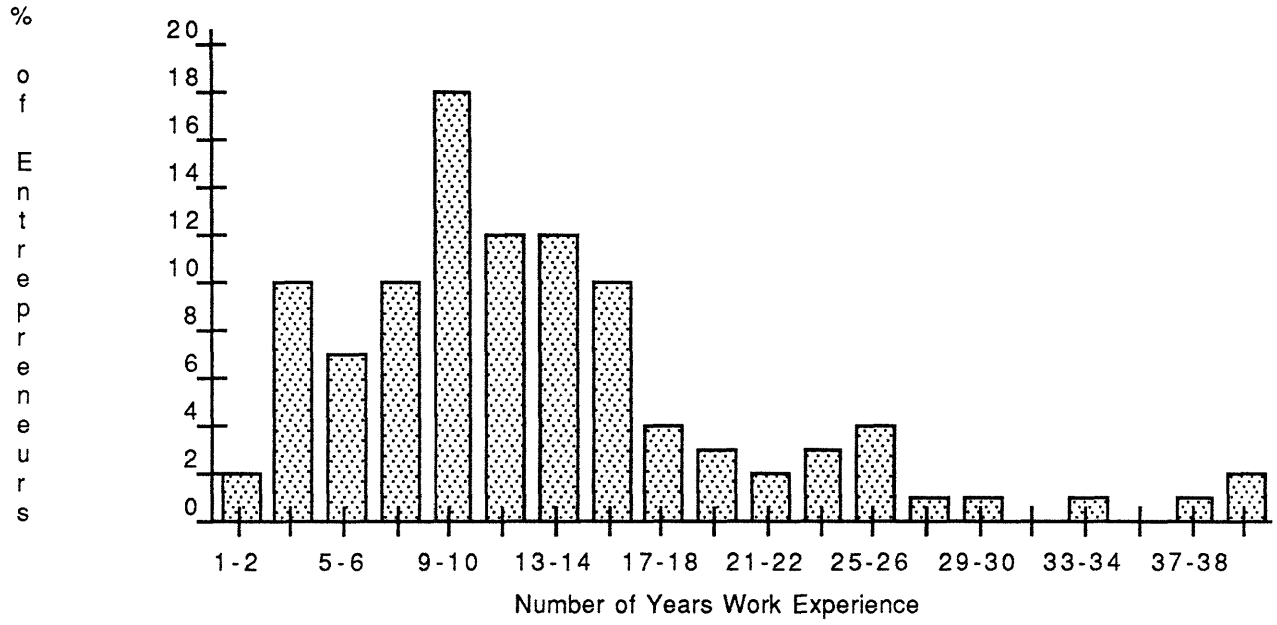
Highly productive technologist

FIGURE 1
Age Distribution of MIT Spin-off Entrepreneurs
at the Time they Started their New Enterprises (n=119)*



* Round-off error; adds to 102 %

FIGURE 2
Work Experience of Technical Entrepreneurs
Prior to Starting their New Enterprises (n=111)*



* Round-off error; adds to 103 %

FIGURE 3
New Enterprise Formation
Related to the Years after Termination of Employment at the Source (n=121)

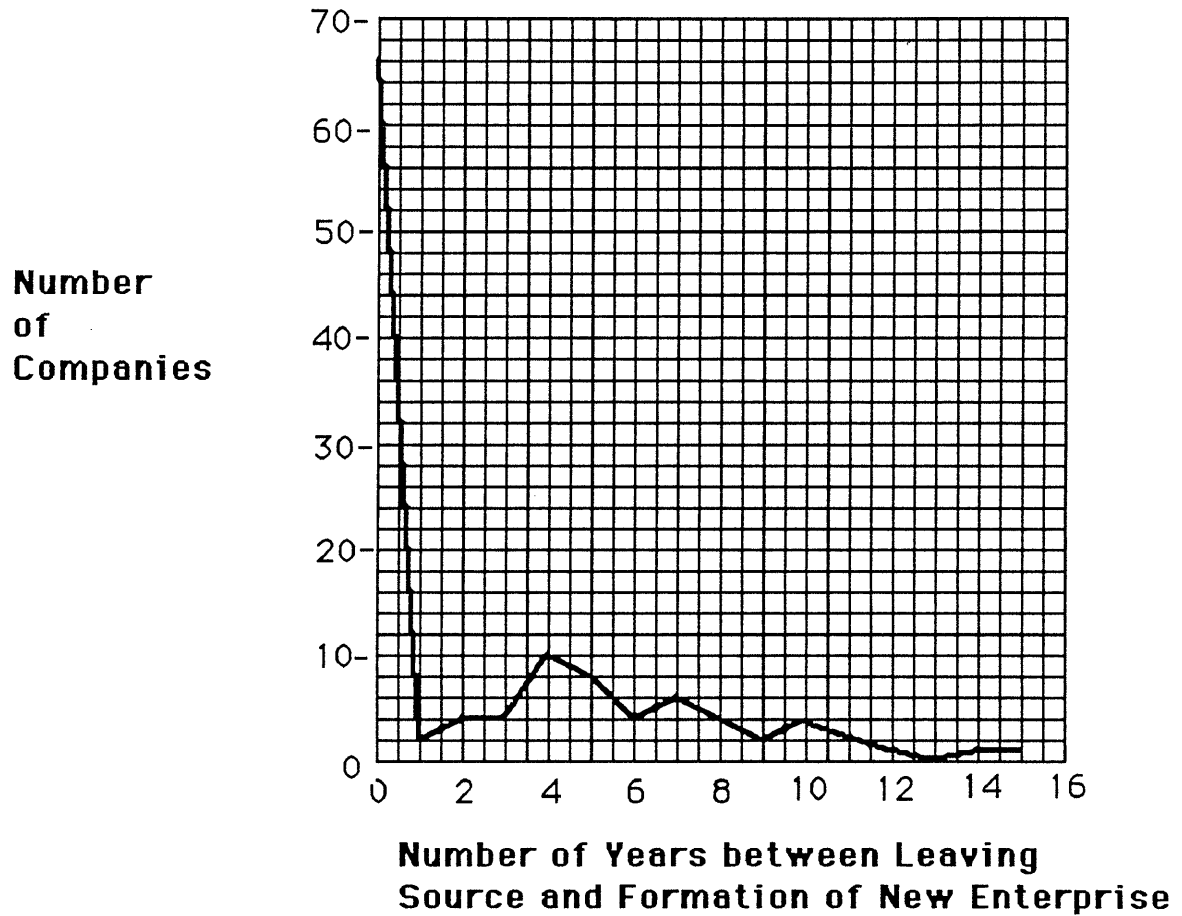


FIGURE 4
Nature of Entrepreneurs' Laboratory Work
in Electronic Systems Company (n=35)

