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AUTHOR	Louis, Karen Seashore; And Others
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ABSTRACT

Interest in the relationship of entrepreneurship to organizational performance and validity is widely and increasingly discussed in educational contexts. An examination of academic entrepreneurship is presented in this paper. Five types of entrepreneurship are described, and many questions more directly related to organizational theory are examined, including the structure of entrepreneurship as a behavioral construct, the relation between individual entrepreneurship and possible predictors, the entrepreneurial elite, and whether there is any institutional patterning that suggests that universities have distinctive entrepreneurial strategies. Two surveys conducted in 1985 used a sample of life scientists and key administrators in major research universities. The life scientists were mailed a questionnaire dealing with their research activities. Data on university policies and characteristics were collected in a phone survey of 40 administrators having the most responsibility for life science departments. Data suggest that scientifically productive scholars are more entrepreneurial, and most academic groups do not develop norms that encourage multiple forms of entrepreneurship. A tentative conclusion is that entrepreneurship in academic settings is not an either/or condition, nor are the different forms minor variations on a similar social phenomenon. Contains 47 references. (SM)

ENTREPRENEURS IN ACADEME
EXPLORATION OF BEHAVIORS AMONG LIFE SCIENTISTS

Karen Seashore Louis

David Blumenthal

Michael Gluck

Michael A. Stoto

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Michael A. Stoto

Introduction

There is increasing consensus in the organizational and management literature on the significance of entrepreneurship for organizational effectiveness.[2] According to Beneviste (1987), risk-taking and accepting responsibility are interdependent, and equally important to an effective professional organization. Peters and Waterman (1982) link entrepreneurship with invention and innovation and argue that it is causally related to productivity, while Kanter (1983) suggests that there is a critical relationship between entrepreneurship and the overall competitiveness of our corporate sector in the world economy. The role of entrepreneurship in revitalizing ossified or traditional organizations is of particular social importance (Peterson, 1984), and is considered to be one form of strategic management (Mintzberg, 1973). Snow and Hrebiniek's (1980) analysis suggests that entrepreneurial organizational strategies (those based on rapid commercialization of new inventions) engender higher performance in industries operating in uncertain environments.

Interest in the relationship of entrepreneurship to organizational performance and vitality is not limited to the private sector, but is being widely discussed in educational contexts (see, for example, Mazzoni, 1987;

Etzkowitz, 1985). In this paper we will examine academic entrepreneurship, which we define as the attempt to increase individual or institutional profit, influence or prestige through the development and marketing of a new research-based product.

Universities are not usually viewed as leaders in entrepreneurship. In fact, there is often a tendency to distinguish between the search for truth in science (a legitimate function of the university) and the search for invention (an inappropriate focus on ideas because they have potential commercial or practical applicability) (Ravetz, 1971; Wade, 1984). Nevertheless, there has been a notable increase in the number of scientists and science watchers who champion increased entrepreneurship in universities. Entrepreneurship is believed to contribute to the rapid movement of scientific ideas into the commercial arena (Blumenthal, et al., 1985), to provide a critical contribution of scientists to the national economy and society (Ping, 1980), to revitalize the scientific endeavor through new sources of research funds, and to contribute to the university's financial base through royalties on patents (Blumenthal, et al, 1986b).

Sources and Distribution of Entrepreneurship

Whether entrepreneurship is good or bad, it is clearly not evenly distributed: some institutions and individuals demonstrate it more than others. Explanations for this variable distribution fall into patterns that are familiar to organizational theorists. Organizational psychologists tend to emphasize individual characteristics and attitudes (such as achievement motivation) as the source of entrepreneurship (McClelland, et al. 1976). Although achievement motivation does not have strong predictive power (Peterson, 1981), studies of academics indicate that other individual attributes may play a part. For example, Liebert (1977) indicates that past success (as measured by research publications) is associated with effective "grantsmanship". Age and gender may also be related to incentives. More established scientists may have more to "sell", may be less motivated by traditional academic incentives (tenure, Nobel prizes) whose outcome has already been decided, and may have greater financial incentives, such as children in college (see also Etzkowitz, 1984 and Zuckerman and Merton, 1972). Women, who have tended to be less scientifically productive, may also be less likely to be entrepreneurial (see Cole and Zuckerman, 1985). Attitudes can play a part as well. Etzkowitz (1984) and Peters and Fusfeld (1982) argue that some scientists seek out industry associations because they are predisposed to commercializing their ideas (as opposed to stumbling across a marketable finding, or waiting for industry to take the initiative to seek them out).

Another line of speculation concerns the importance of cultural support for entrepreneurship. Research indicates that <u>local culture</u> is more important than broad social values (see Peterson, 1981:70-71), a point strongly supported by Kanter (1983:129-138).[3] In the world of organized science, Pelz and Andrews (1976) note that colleagues in the work group have an impact on the behavior of individual scientists. This local contextual effect is not related to the size of the work group (Cohen, 1981), but to the tendency for members to conform to local norms of behavior regarding entrepreneurship (Peters and Fusfeld, 1982). Local behavioral norms can be reinforced over time through recruiting, socialization and retention (van Maanen, 1976). A recent analysis of relationships between life scientists and industry suggests dense institutional networks that are interpreted as an effect of local norms about entrepreneurship (Ennis, 1986).

A final reason that may account for entrepreneurship lies in the organizational structures and policies that may affect such activities. Previous research suggests that the size, complexity, and authority structure of the organization will be associated with innovativeness in educational settings (Baldridge and Burnham, 1975; Rosenblum and Louis, 1981; Daft and Becker, 1978). Along these lines, Kanter (1984) argues that the matrix structure supports entrepreneurship. Other writers emphasize the importance of policies and practices, such as reward systems, that may stimulate individual or group entrepreneurship (Kerr and Slocum, 1987).

Despite the high levels of interest in entrepreneurship, there is remarkably little systematic data on the nature of entrepreneurship in the university or other non-business settings. Discussions about what stimulates university faculty to be more entrepreneurial are similarly speculative. The research reported below begins to fill that gap using data obtained from life scientists located in research-intensive universities. This paper has two main purposes, and a variety of sub-goals:

(1) to describe (a) five different types of entrepreneurship, and (b) their incidence and their patterns of occurrence in the population of research intensive universities.

(2) to examine a variety of questions that are more directly related to organizational theory, including:

(a) the structure of entrepreneurship as a behavioral construct; (b) the relation between individual entrepreneurship and several classes of possible predictors drawn from the literature; (c) whether there is such a phenomenon as an entrepreneurial elite, either at the individual or institutional level; and (d) whether there is any institutional patterning that suggests that universities, like other organizations, have distinctive entrepreneurial strategies.

Study Design and Methods

The analysis presented below is based on two surveys, both conducted in

1985. One is of a sample of life scientists located in major research universities, and another of key administrators in the same universities.

A sample of 997 life scientists was selected in a two-step process. First, 40 universities were selected from among the 50 schools that receive the most federal research funds in the United States.[4] Then, for those 40 universities, the 3180 life science faculty members listed in published catalogs as members of the departments of biochemistry, molecular biology, genetics, microbiology, biology, cellular biology or botany were identified (Peterson's Guides, 1984). From this list 1594 individuals were randomly selected.

The faculty in the sample were mailed an eight-page questionnaire dealing primarily with his or her research activities. If the questionnaire was not returned within 3 weeks, a second mailing was sent and telephone follow-up was used. One hundred fifty-six respondents were ineligible (deceased, retired, no long associated with the university, or incorrectly reported as a faculty member in the catalog). Of the remaining eligible respondents, 69 % (997) completed questionnaires.

Data on university policies and characteristics were collected in a telephone survey of the 40 university administrators who were pre-identified as having the most responsibility for the life science departments included in the study. The telephone interviews were conducted by trained professional interviewers. Where necessary, other university administrators were also contacted to obtain complete information. As noted above, of the 50 universities identified as most research-intensive in the life sciences, 80 % responded to our requests for information.

Missing data at the item level in the two surveys reduced the number of usab .e faculty responses to 778 from 40 universities.

Defining and Describing Academic Entrepreneurship

In this paper we define five basic forms of academic entrepreneurship:

- large scale science (obtaining large externally funded research projects),
- consulting outside the university (knowledge transfer for personal gain),
- soliciting funds from industry (capitalizing on university-industry relationships to provide new sources of funding for research),
- patenting the results of research, and
- forming companies based on the results of research.

Although all forms of academic entrepreneurship stimulate occasional controversy in the academic community, the types are arrayed in rough order from the most to the least compatible with a traditional view of the university-based scientists' role (see Wade, 1984; Etkowitz, 1983; Krimsky, 1984).

Large Scale Science: Academic science increasingly requires big laboratories and many staff. This has affected the basis for evaluating individual performance: the size and number of research grants has come to be a "quick and dirty" indicator of the individual's disciplinary competence and prestige (Liebert, 1977). University budget processes have been shown to reinforce the importance of grantsmanship (Pfeffer and Salancik, 1974, Pfeffer and Moore, 1980). This type of entrepreneurship may be most challenging for younger scholars, who try to establish their reputations by developing laboratories of their own (Merton, 1968).

Individual involvement in large scale science was measured in this study by the total size of the annual externally funded research project budgets on which the respondent was listed as the principal investigator. The median size of the research funding in the sample is $195 thousand per year, exclusive of overhead. This amount is sufficient to fund a modest laboratory, with a small staff of semi-professional technicians and perhaps a few doctoral students. However, the standard deviation is rather high ($285 thousand), suggesting that there is considerable variation in this type of entrepreneurship even within a sample of faculty associated with research intensive universities. (Table 1 summarizes these and the remaining descriptive statistics).[5]

Supplemental Income: After World War II, the belief that scientists could maintain the ideal of basic research without sacrificing contact with the world of practice spread rapidly (Etzkowitz, 1984). Most universities explicitly condone limited consulting and some form of income augmentation is the norm for most academics. The typical amount of money earned from selling personal scientific expertise is not great, however, and the impacts of consulting on scholarly performance are limited (Boyer and Lewis, 1985).

Supplemental income was measured by asking what percentage over basic salary the faculty member earned in recent years.[6] A seven point categorical scale with the ranges 1-0, 2-1 to 10%, 3-11 to 20%, 4-21 to 30%, 5-31 to 40%, 6-41 to 50% and 7-over 50% was used. The median response was 2.26, with a mode of 2. About a fifth of the scientists have no supplemental income at all, while half earn no more than 10 % over their base salary. Fewer than 5 % supplement their income by 40 % or more, a figure that is somewhat lower than for a 1975 random sample of full time university faculty in all disciplines (Marsh and Dillon, 1977).

Not all forms of supplemental income are viewed as entrepreneurial, however, i.e., teaching additional courses in the summer. Most of the life scientists' extra income is derived from activities that might be considered modestly entrepreneurial, involving the sale of the individual's expertise through non-university employment (10%), consulting for profit (27%) and non-profit (18%) firms and the lecture circuit (19%).[7] The least common major sources of income are the most entrepreneurial (compensated directorships and royalties from licenses, with only 1 % each). The most traditional forms of earning supplemental income -- teaching extra courses and royalties from books -- provide significant sources of income for only 5 and 7 %, respectively.

An estimate of actual supplemental income was calculated using the response to this question and that from another question concerning the respondent's salary.[8] The median estimated supplemental income is a modest $4,843.[9] The standard deviation is quite high however ($7,198). For the nearly 17 % of the respondents who augment their income by more than 20 % the estimated average supplemental earnings were nearly $27 thousand.

Industrial Support for University Research: Recently the organization of industrial research and basic science research has become increasingly similar (Peters and Fusfeld,1982; Blumenthal, et al, 1986a, 1986b). This has lead to exchange of personnel, common research projects and, in some cases, large-scale joint ventures. There are a variety of motivations for scientists to seek funding from industry, but scientists who obtain money from this source are more likely to select research problems because of their potential commercial applicability (Blumenthal, et al., 1986b). This supports the contention that this form of entrepreneurship is more non-traditional than the two previously discussed.[10]

Industry funding was measured by calculating the proportion of the respondent's total externally funded grants and contracts budget that came from private industry. The median research support from industry was 7.7 %; again, however, the standard deviation is rather high (21 %), which demonstrates wide variability in this regard. Only 23 % of life science faculty receive some funding from industry, suggesting that this behavior is still the exception rather than the norm. Of those who do receive such funding, fewer than half get more than 25 % of their external research funding from industry; the mean is 34 % (see also Blumenthal, et al, 1986c.). However, there are a small proportion of faculty who might be assumed to be "industry dominated": about 7 % receive more than half of their external research funds from industry.

Patenting is a logical extension of the tendency toward increasing interest in commercially applicable results. The incidence of patents awarded to university scientists or universities has been growing; and many universities now contain patent offices or have stimulated independent foundations to deal with patents and royalties (Blumenthal, et al, 1986b). In addition, many private sector organizations report that they have made patent applications based on research that they have funded in universities (Blumenthal, et al, 1985).

Patent involvement was measured by whether the respondent had applied for or been granted patents, or had reported trade secrets. Patenting behavior still involves a minority of the life science faculty in major research universities: 19 % have applied for or been granted a patent or have generated a trade secret based on their research. Approximately 1/3 of the respondents indicated that research support from industry or consulting to industry contributed significantly to the work on which patents were based.

Direct Commercial Involvement: Etzkowitz (1984) points out that the emerging characteristics of Large Scale Science provide faculty with the management skills that permit easier entry into the private sector. The formation of private firms whose product is based on the university scientist's own research is be a logical extension of the trends listed above. This form of entrepreneurship is the most non-traditional and controversial in that it involves potential use of university facilities and graduate students to meet the firm's commercial goals (Blumenthal, 1986b).

Equity involvement was measured by asking respondents whether they held equity in companies whose products and services were based on their own research. This form of entrepreneurship is the least common: only about 7 % indicated that they held equity in such companies, and only a handful held equity in more than one.

Theoretical Issues in Academic Entrepreneurship

The Structure of Entrepreneurship

The literature on entrepreneurship has not addressed the key question of whether there is clear cut phenomenon of an "entrepreneurial scholar", as distinct from the more traditional model. If the different types of entrepreneurship identified above cluster empirically, then such an academic type may be emerging. On the other hand, if the associations between the different types of entrepreneurship are not high, then we may conclude that the above characteristics may be a consequence of different motivations, impulses, or opportunities and represent very different styles of adaptation to the changing scientific and scholarly environment.

Table 2 presents a correlation matrix showing the relationship among the variables. Although the associations are statistically significant, they are not particularly large. The Pearson correlation between equity holding and supplementary income is r=.33, and this represents the strongest relationship in the table. Thus, we reach the preliminary conclusion that the "entrepreneurial scholar" who engages in multiple forms of entrepreneurship is not common among life scientists.

This pattern of relationships does not provide a strong justification for creating a summary scale of entrepreneurship, and a principal components analysis (not shown) produced only a weak first factor. Thus, we in the remainder of this analysis we treat entrepreneurship as a multi-dimensional concept.

Individual, Local and University Characteristics Measures for Predicting Entrepreneurship

Measures of individual demographic, career and attitudinal characteristics included in our survey are presented in Exhibit 1.

Another set of individual characteristics that may contribute to a prediction of any particular form of entrepreneurship is, of course, the individual's other entrepreneurial behaviors (OEBs), e.g., all other entrepreneurial behaviors other than that being predicted. These were shown to be modestly intercorrelated, and are therefore likely to predict each other. In this analysis OEBs will initially be treated as a separate group of predictors, in order to further investigate the structure of entrepreneurship behaviors.

Local norms, defined as the way in which most members of the organization behave, are also likely to influence behavior. For example, a faculty member located in a university where many other faculty members engage in heavy consulting with private industry may be more likely to do the same than one located in a university where such consulting is uncommon. Measures of local norms supporting entrepreneurship were developed by calculating the <u>mean</u> of the responses of the life scientists, <u>within</u> each university in the sample, for each of the five entrepreneurship variables; and attaching these means to the files of the individual. The formula for creating the local norms (contextual effects) variable for the five entrepreneurial behaviors was:[11]

(1) Let:

K = universities, index=k;

X_{ik} = the measure for the i^{th} individual in university k; and

n_k = the number of individuals in university k.

(2) Define:

$$X_{.k} = \left(\sum_{i=1}^{n_k} X_{ik} \right) \Big/ n_k$$

(3) Augment record (i,k) with $X_{.k}$

Analysis of variance was carried out to ensure that the variance between universities was statistically significant, i.e. that the variable did represent a local contextual phenomenon.

The local norm measures do not reflect work groups that have routine face-to-face interactions because most major research universities have several life science departments included in our sample. Rather, they are contextual peer groups, as defined by location and role. A substantial body of research supports the utility of using contextual effects of this type in studies of individual behavior (see Burstein, 1980, for a methodological review.) The measures and their indicators, along with the correlations between the individual and local norm variables are presented in Exhibit 2.

Organizational structures and policies supporting entrepreneurship vary widely. Some universities have large and complex support units (patent offices) and create institutional incentives (seed money grants to support faculty search for external funding) (Peters and Fusfeld, 1982). Auspices may also be important: in general, state universities are viewed as less supportive of entrepreneurship than private universities. However, some land grant colleges and schools with a technical focus have strong traditional ties with industry, while others have been encouraging patenting for some time (Peters and Fusfeld, 1982). Universities can also encourage or discourage faculty consulting and involvement in commercialization through the development and enforcement of policies (Wade, 1984; Gluck, 1987).

Administrative support data were obtained from the survey of university administrators. In each case the administrator's response was linked for analysis to the individual faculty file. Measures are presented in Exhibit 3.

Analysis

The Relative Importance of Predictor Groups: Our initial approach to answering the questions regarding the effects of different predictor groups involved looking at the relative contribution of each of the four groups of predictors: individual demographic characteristics and attitudes, other entrepreneurial behaviors, local norms, and institutional characteristics and policies. To this end, several ordinary least squares regression models were calculated:

1. The five forms of entrepreneurship were regressed on each of the four groups of predictors separately (Table 3). This analysis was intended to look at the relative importance of each group considered by

itself; the names of those variables whose t statistic was significant at the .10 level or greater are shown for informational purposes only.

2. Because the other entrepreneurial behaviors and the local norm variables were composed from the same survey items, it seemed prudent to explore their distinctive contributions to entrepreneurship. (Burstein, 1981).[12] Four stepwise regression models were computed. The first two entered individual/university variables as a first step, and OEBs (Table 4a) or local norms (Table 4b) as a second; the third entered individual/university/local norms as a first step, and OEBs as a second step (Table 4c); the last entered individual/university/OEBs as a first step, and local norms as a second step. The "dR^2" in the tables is the addition to R^2 associated with the variables entered in the second step.

Perhaps the clearest finding from these tables is that university administrative support has little effect on entrepreneurship. In Table 3, the largest amount of variance explained by university administrative support variables is 3.8%. University reputation (over which university administrators have little short term control) is the only institutional characteristic that enters more than one equation (not tabled), which reinforces the conclusion that university policies have little direct impact on faculty entrepreneurial behavior. When OEBs (Table 4a) or local norms (Table 4b) and organizational structure/policy variables are included in the same equation, no university variables achieve significance (not tabled).

Overall, individual characteristics, other entrepreneurial behaviors, and local norms appear to be about equally effective (in terms of R^2) in explaining entrepreneurship, except in the case of Size of Research Budget, where individual predictors dominate (Table 3). Tables 4a and 4c indicate, however, that OEBs--or the "entrepreneurship profile" presented by the individual respondent--makes a relatively weak independent contribution to the two variables reflecting the magnitude of research funding (Size of Research Budget and Funding From Industry). In the case of the remaining three entrepreneurial behaviors (Supplementary Income, Patenting and Equity

Holding), on the other hand, OEBs raise the multiple R2 by up to 10% where university and individual variables are included in the model (Table 4a). This effect is diminished for Patenting when the local norm variables are also added (Table 4d), but remain very strong for Consulting and Equity Holding.

In contrast, local norms of behavior increase the multiple R2 for all of the dependant variables between 4 and 5% when added as a second step after individual and university characteristics (Table 4b), an effect that is only slightly reduced when OEBs are also added to the regression models (Table 4d). For the least traditional forms of entrepreneurship--Industry Funding, Patenting and Equity Holding--the relative explanatory power of the local norms is similar to that of the individual characteristics.

Tables 4c and d confirm that OEBs and local norm variables are measuring different effects. For all five entrepreneurship variables, local norm variables are significant predictors even when controlling for OEBs, and vice versa. In the case of Industry Funding, Patenting, and Equity Holding, individual variables other than OEBs are less likely to be significant when we add the local norm variables and OEBs. For these types of entrepreneurship, OEBs alone account for 27, 40, and 50 % respectively of the total R^2 that is attained by the full model, and local norm variables account for 41, 32, and 23 % respectively of the total R^2 that is attained by the full models.

<u>Which Variables Are the Best Predictors?</u>

A second approach to answering the questions posed at the beginning of this paper involved looking at the <u>specific predictors</u> that best account for each form of entrepreneurship:

3. Five regressions models were computed using the 16 individual, OEB and local norm variables. We excluded University variables because they were insignificant in previous regressions. Only variables whose regression coefficients are significant at the .10 level or better are

are reported in Table 5.

Individual Characteristics: Two individual level variables are related to several types of entrepreneurship. First, the individual's concern about the Risks to Science from working closely with industry is negatively associated in Table 5 with three forms (Supplemental Income, Industry Funding, and Patenting). This suggests that the deeper their concerns about protecting basic science from pressures to commercialize, the less likely scientists are to behave in an entrepreneurial manner. However, the causal relationship is unclear: scientists may change their attitudes in order to diminish dissonance between their own behavior and their interpretation of the scientific value system. Or, alternatively, exposure to entrepreneurship may convince the scientist of the robustness of basic science against corruption through such activities.

Second, the individual's Publication Rate in refereed journals is positively associated with all entrepreneurial behaviors except Industry Funding and Equity Holding. It seems clear that it is the scientists who meet the highest (quantitative) standards of productivity are most likely to be entrepreneurial.

Table 5 consistently indicates that the local norm variable corresponding to the behavior being analyzed matters the most. In other words, the individual's entrepreneurship of a given type is strongly predicted by the local behavior for the same form of entrepreneurship. Local University Publication Rate was also significant in two cases (Research Budget and Supplemental Income). This finding will be discussed in more detail below.

Each of the OEBs has a significant effect on at least two other forms of entrepreneurship. Two OEBs stand out: Both Patenting and Supplementary

Income are significant predictors of all other forms of entrepreneurship.

Predicting Different Forms of Entrepreneurship

Table 5 may be used to address another theoretical issue posed above. Rather than asking about the relative impact of different categories of predictors, we return to elaborate on the question posed earlier about the structure of academic entrepreneurship. If entrepreneurship is a multi-dimensional construct, the regressions should produce different patterns of significant predictors.

Research Budget: The most traditional form of entrepreneurship--Size of Research Budget--is by far the easiest variable to predict. Table 3 indicates that for every category of predictor variables except one (the OEBs), the R^2 statistics are highest for Size of Research Budget. The overall adjusted R^2 in the full regression (Table 5) is .288, which is substantially larger than the other equations.

Individual characteristics and attitudes are relatively more important as predictors of Size of Research Budget than for the other forms of entrepreneurship, accounting for .22 of the .29 R^2 (78 %) that is attained by the full model. Local norm variables are also significant (particularly the size of the research budget of colleagues), but OEBs barely reach significance and are much less important predictors of this entrepreneurial behavior than others. The pattern of significant variables suggests that this form of entrepreneurship may coexist easily with traditional academic values: it is associated with high levels of scientific productivity, is not associated with any significant contacts with industry (and presumably other sources of money for applied research), and flourishes in a context where other scientists are also productive and engaging in large scale scientific endeavors. In fact, we might relabel this variable as "elite entrepreneurship". These elite entrepreneurs are also younger.

Supplemental Income: The pattern for Supplemental Income is somewhat similar, but with clear differences as well. First, the "elite entrepreneur" pattern is complicated by the addition of new predictors. In particular, OEBs (particularly equity holding) are more important, accounting for 28% of the total variance explained Among the OEBs, only Industry Funding is not a significant predictors of Supplemental Income. Second, there is a corresponding reduction in the strong relationships between this form of entrepreneurship and individual characteristics (individual variables account for 60 % of the total explained variance). An additional difference between these two more traditional forms of entrepreneurship is that those who earn a large amount of extra income tend to be located in traditional graduate departments, and to be older, rather than younger.

It is worth speculating about the contrasting associations between age and these two more traditional forms of entrepreneurship. On the one hand, it seems probable that incentives to be involved in Large Scale Science are greatest among those who are on the fast track in major universities, but have not yet necessarily reached the peak of their scientific recognition. The motivation to compete for grants may decline as the scientist's position in the prestige hierarchy stabilizes. Because older scientists are more visible, they are more likely to be sought out as consultants. On the other hand, this may be a cohort effect: younger scientists are more likely to be in two career families (minimizing the need to supplement income), or they may be contributing to new norms about the appropriate scale of scientific endeavor (Etzkowitz, 1984).

Funding From Industry: Funding from Industry presents a somewhat more complicated picture, partly because the level of prediction is weaker than for the other models (only 11% of the variance is explained by the full regression model in Table 5). No individual demographic characteristics enter the equations. Attitudinal variables (the Risks to Science Index and the variable measuring approval of increasing University-Industry ties) are associated, but with the major causal inference problems noted above. The individual effects of OEBs are modest compared to the effects of belonging to a group of life scientists who get money from industry. It is clear that the model that has been specified here is not a good predictor of this form of entrepreneurship, and an alternative organizational-level explanation will be explored further below.

Patenting and Equity Holding: The models for the most extreme forms of entrepreneurship--patenting and equity holding--are more similar to each other than the other forms in terms of the predictive power of the variables, and the relative importance of different predictor groups. Yet, there are still some differences between them which emerge in Tables 5.

Equity Holding is better predicted (18% of the variance explained) with a simpler model. Only the percentage of life scientists in the university who hold equity, and the OEBs (other than Size of Research Budget) exhibit standardized regression coefficients that are significant at the .05 level or better. This supports the contention that Equity Holding is the most extreme form of entrepreneurship: the variables that significantly predict it are other non-scholarly entrepreneurial behaviors and being in a context in which entrepreneurship is the norm, with the former being by far the most important (accounting for 50% of the explained variance). Patenting, on the other hand, is both more complex and less stable across the different regression analyses. Like Equity Holding, the relative importance of local behavioral norms is very important, comprising nearly a third of the explained variance. All OEBs are significant predictors in Table 5.

Institutional Patterns of Entrepreneurship

The final theoretical question posed at the beginning of this paper concerns the degree to which these data reveal any evidence that there are entrepreneurial universities, rather than just isolated entrepreneurial academics. The above analyses reveal a consistent finding: for each form of entrepreneurship, the aggregated variable reflecting the local behavior on this dimension is among the most powerful predictors. To what degree does this statistical association actually reflect a concentration of faculty with certain types of behavior in particular institutions? To examine concentration we:

4. generated graphs which display the concentration of a given entrepreneurial behavior within universities (Exhibits 4-8) and looked at the association between different forms of entrepreneurship at the level of the university as a whole; and

5. identified universities scoring in the top quartile on the measures of entrepreneurship (Table 7).

In Exhibits 4-8, the X-axis measures the cumulative proportion of all faculty from zero to one.[13] The Y axis measures the cumulative proportion of faculty with that behavior on a scale from zero to one. The diagonal line represents an equal distribution of the behavior across all universities. Discrepancies between the diagonal and the curve are a visual representation of the extent to which behavior is institutionally concentrated.

These figures reveal that the statistically significant associations correspond to what might be considered more socially significant facts. As might be expected from the discussion above, the highest levels of concentration are found for equity holding: 75 % of all faculty holding equity in a company whose products or services are based on their own research are located in universities containing only about 37 % of the faculty in the sample. Similar levels of concentration are found in the case of industrial funding: 70 % of the faculty who receive 25 % or more of their Size of Research Budget from industry sponsors are located in institutions that contain 40 % of the faculty. 50% of all of the faculty who have research budgets above $100,000 are located in institutions that contain only 32% of the life scientists in the sample; 50 % of those whose income is supplemented by more than 8,000 dollars a year over their base salary are located in institutions containing only 35 % of the faculty.

We know that the types of entrepreneurship are modestly associated at the individual level. However, if we look at the most entrepreneurial groups (identified by university affiliation), we find that there are apparent associations at this level (Table 7). For example, among the ten universities that have the highest proportion of faculty with Size of Research Budgets above the mean size for the sample, six are also among the top ten on two or three OEBs. Only one is characterized only by high levels of external funding. Similarly, of the ten universities that are in the top quartile on percentage of faculty holding equity, six are also in the top quartile on supplementary income, while only two are in the top quartile of percentage of research funding from industry.

There is a significant exception to this generalization: obtaining money from industry. Most of the universities that have close funding ties with industry are not entrepreneurial on any other dimension. Furthermore, several of those that score highest on this form of entrepreneurship but not on any other are located in public land grant colleges. These are likely to reflect long-term relationships with state-based industry to support research that are not necessarily a consequence of a broader local culture of entrepreneurship.

Discussion

Some Comments on Entrepreneurship and Science

> The search for truth is innocent and ennobling; and the eventual benefits to mankind...further secure the moral status of science. The very idea of a scientist being ...a man who offers his opinions for sale, is near to being a contradiction in terms" (Ravetz, 1971).

Ravetz' traditional view of scientific morality is increasingly controversial as policy makers turn to science as a vehicle for energizing our national economy and society, and administrators and faculty try to secure more money from both industry and state and national governments to support their research programs.

Irrespective of the position taken, our data suggest that life scientists in research-intensive universities _are_ modestly entrepreneurial. However, despite concerns about weakening the basic science mission of the university (Krimsky, 1984; Wade, 1984; Varrin and Kukich, 1985), there is little evidence in our survey to suggest that most life scientists are more interested in commercial activities than traditional scientific endeavors. Small minorities are involved in more extreme forms of commercial entrepreneurship, and these forms of entrepreneurship not strongly associated with running a large scale externally funded research endeavor. In other words, there is no evidence to suggest that a new kind of "entrepreneurial scholar" has taken over _most_ universities.

The data suggest that scientifically productive scholars are more entrepreneurial. Thus, this investigation supports Etkowitz' (1984) argument that entrepreneurial behavior has evolved naturally within the scientific community, and is not incompatible with maintaining the outward manifestations of scholarship. However, scholarly productivity is not an important predictor of the more commercial forms of entrepreneurship, which supports the argument that the newer types may be less compatible with traditional university values.

Our data also suggest that most academic groups do not develop norms that encourage multiple forms of entrepreneurship. If we exclude industry support for research in land grant universities, less than half of the research-intensive institutions exhibit evidence of strong entrepreneurship in any area, and only six appear distinctively entrepreneurial. One cause for the "science watchers'" concern is our finding that faculty in a number of the most prestigious universities are entrepreneurial on multiple dimensions. Clark (1983) notes that the evolution of less prestigious higher education institutions is mimetic: Where these lead in entrepreneurship, will the others be far behind?

Some Comments on Organizational Theory

The analysis supports a tentative conclusion that, at least in academic settings, entrepreneurship is not an either/or condition, nor are the different forms of entrepreneurship minor variations on a similar social phenomenon. The data suggest that the most distinctive patterns may occur in the case of getting funding from industry and obtaining large research grants. In the former case, except for very large industry-university agreements, securing industry funding may be less a consequence of individual entrepreneurship than much as the (presumably) more random event of being employed at a land grant institution. In the latter, the pattern of associations shown throughout the paper suggest that "elite entrepreneurs" are not likely to be drawn toward more extreme forms of entrepreneurship. These two cases are clear, but there are also unique patterns associated with each of other the different forms. Under the assumption that academics do not display a uniquely complex set of motivations and behaviors, this finding suggests that the literature on internal entrepreneurship in private firms might benefit from greater attention to the identification of different patterns and types.

Our cross sectional data do not permit drawing definitive conclusions about the causes of academic entrepreneurship. If, however, we look across all of the data a number of hypotheses may be made.

Until recently, research (and popular writing) on entrepreneurship has tended to focus on individual demographic, educational a. d employment characteristics rather than the characteristics of the organizations in which they are located, or the groups in which they work. This study suggests that individual characteristics provide relatively weak and unsystematic predictions of the less traditional forms of entrepreneurship that are at the center of the debates about academic entrepreneurs. This was rather surprising, since several of the individual variables that we examined--gender and age, for example--have been shown to be relatively strong predictors of other faculty behaviors, such as publication rates (Fox, 1984; Cole and Zuckerman, 1985), and our analyses suggest that they are very important in predicting the more traditional forms of entrepreneurship.[14]

We hypothesize, based on our data, that this is because the individuals' characteristics are moderated by their institutional location. There are several ways in which the relatively strong effect of local norms on individual behavior, and the data regarding the concentration of entrepreneurs in particular institutions may operate: (1) self-selection to produce value and behavior consensus (individuals are drawn to these settings because they are known to be supportive of or tolerate entrepreneurship); (2) behavioral socialization within a work group (individuals are affected by the behavior of their immediate colleagues and come to resemble them); (3) organizational culture (a broader set of institutional policies, procedures and values reinforces attitudes and behavior regarding entrepreneurship); or (4) strategic management (some universities use recruitment to position themselves in the forefront of changing patterns of academic behavior in order to reap the potential benefits in increased prestige and income). We cannot determine which of these is operating, and this issue is worth further exploration. We suspect, however, that it is likely that all of the alternatives explanations contribute, in part, to our findings.

Thus, the fact that the policies and structures that universities claim are part of their response to changing patterns of entrepreneurship have little impact on faculty entrepreneurship should not be taken to rule out an institutional effect (although it suggests that institutions cannot easily engineer entrepreneurship). Local norms of behavior (as measured here) are an institutional characteristic, and may also be a consequence of a variety of other policies and practices that we have not examined. For example, the definition and enforcement of policies relating to consulting or conflict of interest varies quite widely among research institutions (Louis, Swazey and Anderson, 1988), and may send significant messages about how faculty are expected to behave. In addition, departments rarely have complete autonomy in defining personnel needs, and this provides another leverage point for administrators. We hypothesize that these and other policies and procedures reflect underlying values and cultural assumptions about what constitutes appropriate entrepreneurial behavior.

But, given the range of controls available to administrators, and the notorious difficulty of managing organizational cultures in large institutions, fostering or controlling entrepreneurship from the top may be less effective than working at the departmental/division level. The recruitment of key individuals who may help to alter or set new behavioral norms, or the use of task forces to investigate or recommend changes may help to frame new expectations about behavior. Developing specific policies may send a signal, but the organization is basically very dependent on behavioral expectations that are reinforced below. This may, of course, be a finding that is relevant only to organizations, such as universities, that are "loosely coupled" (Weick, 1976). However, the ability of a large organization to maintain a very strong entrepreneurial culture without middle-level support and reinforcement may be questionable even in more tightly structured settings. Overall, since having a productive faculty appears to be so critical, the traditional strategy of continually supporting the recruitment of the best people in the field is a precondition to the effectiveness of other policies that may stimulate (or control) entrepreneurship.

FOOTNOTES

1. This research was supported by the Andrew Mellon Foundation and the Department of Health and Human Services, grant DHHS-100A-83. We thank our colleagues, Tom Louis, Jack Fowler, Stan Seashore, Ron Corwin, Jim Hearn and David Wise for their helpful comments on earlier drafts, as well as three anonymous reviewers. The remaining flaws are, of course, our own.

2. This attention is relatively recent. For example, two well known books on organizational effectiveness published in the late 70's and early 80's contain no references to entrepreneurship, or innovation/invention (Goodman, et al., 1977; Cameron and Whetton, 1983).

3. This point is, of course, consistent with classic organizational investigations such as Seashore (1954).

4. The university administrator survey was conducted before the faculty survey. For the faculty survey, only institutions where the key administrator had responded were included, which eliminated 10 of the top 50 institutions.

5. Ten % of the faculty get $3 thousand or less of external funding per year, while the top 20 % of faculty get $251 thousand or more of external funding, with a few receiving several million dollars per year. To adjust for the skewed distributions, logs were used for large scale science, consulting income, and research funding from industry.

6. Respondents were asked to exclude unearned income.

7. Respondents were asked to check the top two sources of supplemental income.

8. Salary categories were: less than 20,000, 20,000 to 29,999, 30,000 to 39,999, 40,000 to 49,999, 50,000 to 59,999, 60,000 to 69,999 and 70,000 or more. Consulting income was estimated by multiplying the midpoint value of the respondent's income category by the midpoint value of his or her consulting category. The mean salary for the population was $50,775, with a standard deviation of $14,997.

9. In 1975, the average for all faculty was approximately 2,700 dollars, which in 1984 dollars would be $5,415.

10. More than 50% of our respondents indicated that research support from industry "provides resources for research that could not be obtained elsewhere" and "involves less red tape than federal funding." Also, the market for obtaining industry support is less tied to the applicant's past productivity than federally funded research, which may make industry more attractive to younger scholars or others with weak track records (Liebert, 1977).

11. The individual i was included in the calculations of $X_{.k}$ for record i.k. Each institution had between 20 and 45 responses, so the use of this simple model may increase the correlation between the X measured at the individual level and at the contextual level by a maximum of 5%. This was considered tolerable for the exploratory analysis presented in this paper.

12. Burstein argues that distinct estimates can be made in regressions where individual and contextual effect measures are included, but not where "frog pond effects" (the difference between the individual i's score on X and the contextual score on X) are also part of the equation. However, given the existing controversies about the use of contextual effects data based on attitudes in organizational research, we decided to examine them separately.

13. To form this variable faculty members were grouped by their university affiliation. University groups were then ranked in descending order according to the proportion of faculty in the university who exhibit the behavior.

14. To test the robustness of this conclusion, we also conducted additional analyses using alternative individual characteristics (such as rank, and actual age) and looked at additional attitudinal batteries in the survey. None of these analyses suggested a powerful effect of individual level variables.

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TABLE 1

DESCRIPTIVE STATISTICS FOR SELECTED INDICATORS OF ACADEMIC ENTREPRENEURSHIP

Variable	Median	Standard Deviation
External Research Budget	$195,000	$285,000
Proportion of Research Budget From Industry	.077	.216
Estimated Supplemental Income	$4846	$7198
Percentage with a Patent	.191	--
Percentage holding Equity	.073	--

TABLE 2

PEARSON CORRELATIONS BETWEEN FIVE MEASURES OF ENTREPRENEURSHIP

	Research Budget	Suppl. Income	Industry Funding	Patenting	Equity Holding
1. Size of Research Budget (RES$)	---				
2. Consulting Income (CONS)	-.19**	---			
3. Proportion of Funding From Industry (PRIND)	.05*	.13*	---		
4. Patents (PAT)	.16**	.22**	.15**	---	
5. Equity (EQU)	.13*	.33**	.12**	.25**	---

* Pearson r sig at the .05 level

** Pearson r sig. at the .01 level or better

EXHIBIT 1

MEASURES OF INDIVIDUAL LEVEL PREDICTOR VARIABLES

Variable	Measure
Type of Appointment	whether the individual is located in a medical school.
Professional Age	years since completing the doctoral degree.
Gender	
Concerns about Industry	score on a battery of questions indicating the degree to which involvement with industry represents a potential risk to traditional scientific values[1]
Attitudes about UIRs	a single item indicating whether respondents would like to see the involvement between their university and industry increase alot, somewhat, stay about the same, decrease or decrease alot.
Professional Productivity	The number of articles published during an average three year period over the respondent's professional lifetime.

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1. Faculty were asked to indicate the whether each of the following posed a great risk, some risk, only a little or no risk: Creating pressure for faculty to spend too muich time on commercial activities, shifting too much emphasis toward applied research, undermining intellectual exchange and cooperative activities within departments, creating conflict between faculty who support and oppose such activities, alterning the standards for promotion and tensure, reducing the supply of talented university teachers, and creating unreasonable delays in the publication of new findings. Responses were added to form the summary RISK scale.

EXHIBIT 2

MEASURES OF GROUP LEVEL PREDICTOR VARIABLES[1]

Variable	Measure
Industry Funding	the mean percentage of research funding from industry within the life science departments in the University. (r=.25)
Consulting Patterns	the mean proportion of income over and above base salary earned from consulting. (r=.29)
Funded Research	the mean amount of external research funding for life scientists at the university. (r=.35)
Patenting	the percentage of faculty that have a history of patenting. (r=.26)
Equity Holding	the percentage of life scientists that hold equity in a firm that uses their research. (r=.28)
Productivity	the mean number of articles published over the past three years by life scientists at the university

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1 The correlation between the variable measured at the individual level, and the aggregated group variable is shown in parentheses.

EXHIBIT 3

MEASURES OF UNIVERSITY PREDICTOR VARIABLES

Variable	Measure
State/Private	
Seed Money Support	whether or not the money is provided to support faculty in writing grants and contracts proposals for external funding.
Patent Office Size	the number of professional employees in the university patent office,
Traditional Industry Ties	administrator response to a single three-point item indicating how strong the universities relationships with industry have been in the past
Univ. Entrepreneurship	a summary scale indicating the number of mechanisms that the university has for commercializing the research of its faculty[1]
Life Science Patents	number of life science patents held by the university
Reputation	the National Academy of Science's average quality rating on a 1-5 scale of all of the sampled departments (Jones, 1982).

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[1] The items included: holding equity in faculty owned firms, holding equity in firms employing faculty members, holding equity in firms providing support to faculty me. bers, having a research foundation to invest in faculty firms, have an offi r center for stimulating faculty companies, invest venture capital in life-science firms, and donate land or space to science parks and other commercial enterprises.

TABLE 3.

EXPLANATORY POWER OF GROUPS OF INDEPENDENT VARIABLES

	Dependent variable				
	Research Budget	Suppl. Income	Industry Funding	Patenting	Equity Holding
Individual variables					
R^2	.224***	.130***	.040***	.056***	.034***
	Med +	Med +			
	Age -	Age +			
	Risk -	Risk -	Risk -	Risk -	Risk -
	Pubs +	Pubs +		Pubs +	Pubs +
			Appr UIR +		
University variables					
R^2	.038***	.035***	.000	.012**	.010**
	Seed -		Ties +		
	Repu +	Repu +		Repu +	
Other entrepreneurial behaviors					
R^2	.051***	.148***	.031***	.103***	.141***
		Bud +		Bud +	
	Sup +		Sup +	Sup +	Sup +
		Ind +		Ind +	
	Pat +	Pat +	Pat +		Pat +
		Equ +		Equ +	
Local norm variables (including publications)					
R^2	.118***	.080***	.055***	.063***	.071***
	Bud U +	Sup U +	Ind U +	Pat U +	Equ U +

Med - Medical School
Risk - Risks to Science Index
Appr. UIR - Approval of university-industry relationships
Seed - University provided seed money for proposals
Repu - University reputation in the life sciences
Ties - Traditional University ties to Industry
Bud/Bud U - Log Res. $ for indiv./Mean log of res. $ for all fac.
Sup/Sup U - Supplemental income for indiv./Mean sup. inc. for all fac.
Ind/Ind U - Industry $ for indiv/Mean indus. $ for all fac.
Pat/Pat U - Individual holds a patent/% of all fac. holding a patent
Equ/Equ U - Individual holds equity/% of all fac. holding equity
Pub/Pub U - Individual # publications/Mean # publications for all fac.

TABLE 4

RELATIVE IMPORTANCE OF OEBs AND LOCAL NORMS: STEPWISE REGRESSION RESULTS[1]

	Dependent variable				
	Research Budget	Suppl. Income	Industry Funding	Patenting	Equity Holding
a. Effect of OEBs given individual and university variables					
dR2	.011**	.078***	.027***	.060***	.103***
b. Effect of local norms given individual and university variables					
dR2	.039***	.040***	.042***	.044***	.055***
c. Effect of OEBs, given individual, university, and local norms					
dR2	.010**	.069***	.030***	.035***	.090***
d. Effect of local norms, given individual, university, and other entrepreneurial behaviors variables					
dR2	.038***	.031***	.045***	.051***	.042***

1 * = sig. at .05
** = sig. at .01
*** = sig. at .001

TABLE 5.

FULL REGRESSION MODEL[1]

	Dependent variable				
	Research Budget	Suppl. Income	Industry Funding	Patenting	Equity Holding
Med		-.05			
Age	-.21***	.11***			
Risk		-.08**	-.11**	-.07	
Pubs	.33***	.21***		.11*	
Appr UIR			.09*		
Bud		.08*		.08*	
Sup	.08*		.10**	.07	.25***
Ind		.08*		.10**	.07*
Pat	.07*	.06	.11**		.16***
Equ		.22***	.06	.16***	
Bud U	.30***				
Sup U		.24***			
Ind U			.24***		
Pat U				.24***	
Equ U					.24***
Pub U	-.10	-.11*			
Multiple R	.549	.513	.361	.416	.443
R2 (adj.)	.288	.249	.113	.157	.180
F statistic	21.93***	18.13***	7.63***	10.64***	12.38***

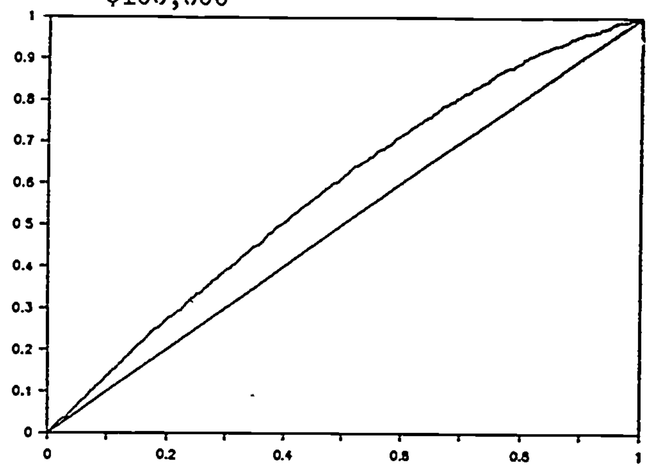
1 Only variables whose t statistic was significant at the .10 level or better are shown. * = sig. at .05; ** = sig. at .01 and *** = sig. at .001.

Med = Academic appointment in the medical school
Risk = Risks to Science Index (attitude)
Appr. UlR = approval of university-industry relationships (attitude)
Bud/Bud U = Log Res. $ for indiv./Mean log of res. $ for all fac.
Sup/Sup U = Supplemental income for indiv./Mean sup. inc. for all fac.
Ind/Ind U = Industry $ for indiv/Mean indus. $ for all fac.
Pat/Pat U = Individual holds a patent/% of all fac. holding a patent
Equ/Equ U = Individual holds equity/% of all fac. holding equity
Pub/Pub U = Individual # publications/Mean # publications for all fac.

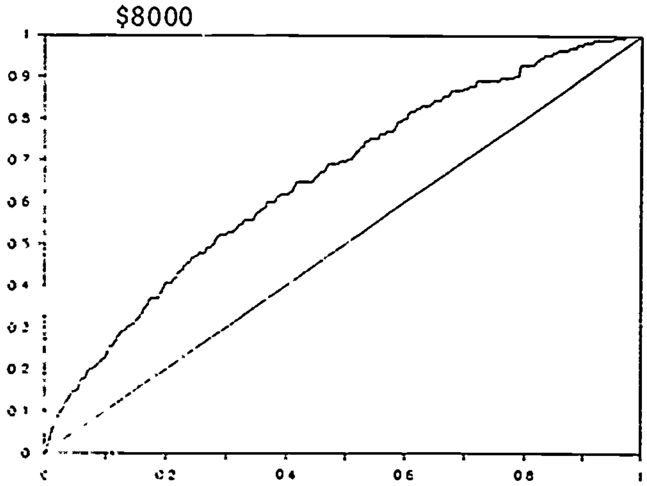
Institutional Concentrations of Entrepreneurial Behaviors

These graphs display the concentration of each entrepreneurial behavior within universities. The X-axis measures the cumulative proportion of all faculty from zero to one. The . -axis measures the cumulative proportion of faculty with that behavior on a scale from zero to one. The diagonalline represents an equal distribution of the behavior across all universities. Discrepancies between diagonal and the curve are a visual representation of the extent to which the behavior is institutionally concentrated.

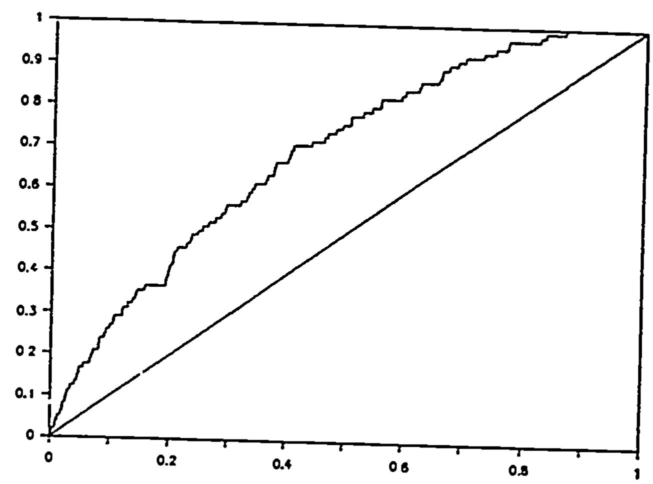
4. Research Budget in Excess of $100,000



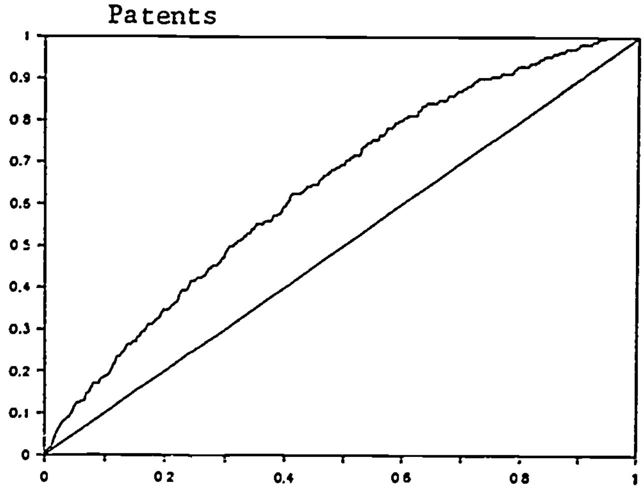
5. Supplemental Income in Excess of $8000



6. More Than 25% of Research Budget Supplied By Industry



7. Research Has Resulted In Patents



8. Holds Equity in a Firm Related to Own Research

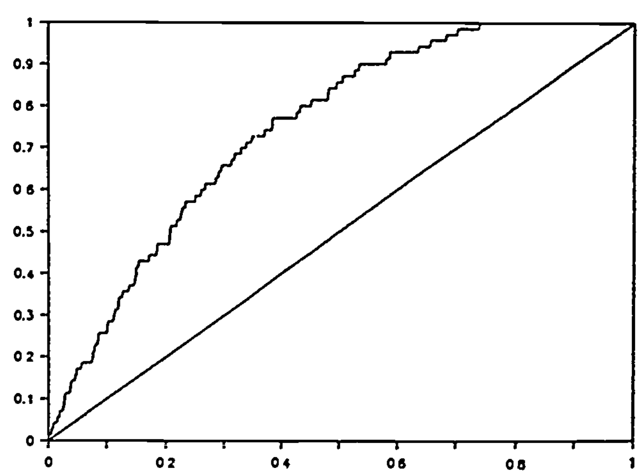


TABLE 6

UNIVERSITIES WITH HIGH ENTREPRENEURSHIP

% of Faculty is Among the Top Ten*

University	Res.$ <195K	Suppl. $ <10%	Indus. $ >25%	Patenting	Equity Holding
Harvard	+	+		+	+
M.I.T.	+	+	+		+
Baylor	+		+	+	+
U. Washington	+			+	+
Yale	+	+			+
U. Cal. Berkeley	+	+			+
U. Maryland	+				+
Columbia	+	+			
U. Rochester	+		+		
U. Utah		+		+	
Stanford		+			+
U.S.C.		+		+	
U. Minn		+			+
Purdue			+	+	
Mich. St.				+	+
Northwestern	+				
Penn St.		+			
Oregon St.			+		
Ohio St.			+		
Cornell			+		
U.N.C./Chapel Hill			+		
U. Florida			+		
Case Western			+		
Johns Hopkins			+		
U. Pittsburgh				+	
Duke				+	

* The ranges of faculty behavior among the top ten are as follows:
Research Budget over $195: 80% (U. Washington) to 42% (Northwestern)
Supplementary Income over 10%: 59% (M.I.T.) to 17% (Penn State)
Industry Research $ over 25%: 38% (Oregon St.) to 12% (Case Western)
Patenting Holding: 40% (U. Washington) to 12% (Baylor)
Equity Holding: 44% (M.I.T.) to 26% (Harvard)

Biographical Information: Entrepreneurs in Academe

Karen Seashore Louis ["Entrepreneurs in Academe"] is Associate Professor of Educational Policy and Administration, University of Minnesota, MN 55455. Her current research centers on the effects of alternative school structures on the quality of teacher work life, and the changing role of the university in regulating research, faculty and student behavior. She received her Ph.D. in Sociology from Columbia University.

David Blumenthal ["Entrepreneurs in Academe"] is Senior Vice President of the Brigham and Women's Hospital Center, Boston, MA 02119. His research has focused on health policy, including Medicare, health care technologies, and biotechnology. He holds an M.D. and an M.P.P. from Harvard University.

Michael E. Gluck ["Entrepreneurs in Academe"] is Assistant Professor of Health Policy and Management and Senior Associate, Center for Hospital Finance and Management, Johns Hopkins University, Baltimore, MD 21205. His research focuses on health care financing, practice and policy. He received a Ph.D. in Public Policy from Harvard University.

Michael Stoto ["Entrepreneurs in Academe" is Senior Staff Officer, National Academy of Sciences, Washington, D.C. 20418. His recent research is on AIDS and smoking, and he is the coordinator for the National Institute of Medicine's project on Health Objectives for the Year 2000. He received a Ph.D. in Statistics from Harvard University.