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The role of social embeddedness in professorial entrepreneurship: a comparison of electrical engineering and computer science at UC Berkeley and Stanford

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Abstract

Professorial entrepreneurship has recently attracted much attention. This paper draws upon historical research, a survey of faculty, and an Internet-based methodology for identifying professorial affiliations with entrepreneurial firms at two of the premier electrical engineering and computer science departments in the US, The University of California, Berkeley and Stanford. We employ the concept of "nested embeddedness" to explain why the faculty members in these two institutions have different levels of entrepreneurship and corporate involvement. EE&CS faculty at both universities were found to be socially embedded in departments and disciplines that supported and placed value on entrepreneurial activities. However, while being embedded in a university environment with a history of success and high level of support for entrepreneurship, EE&CS faculty at Stanford had a significantly greater level of corporate involvement, including the founding of start-ups. Although significantly less than Stanford, the level of corporate involvement among EE&CS faculty at Berkeley was also substantial. This suggests that being embedded in an academic department and disciplines with cultures that are supportive of entrepreneurial activity can help counteract the disincentives created by a university environment that is not strongly supportive of these activities.

Keywords: Entrepreneurship; University; Professors; Electrical engineering; Computer science

1. Introduction

It is an observable fact that certain universities spawn more business start-ups than do others. Numerous explanations for this phenomenon have been advanced. For example, Zucker et al. (2002) trace the founding of biotechnology firms to the location of university star scientists.[1] Feldman and Desrochers (2003) found that the relative lack of entrepreneurial spin-offs at Johns Hopkins reflected the university's objectives and the context within which the university operated. Using data from university technology licensing programs, Di Gregorio and Shane (2000) found that intellectual eminence, the university's willingness to make equity investments in the start-ups,

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[1] This parallels an earlier finding in Kenney (1986). See, also, Zucker et al. (1998).

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and maintenance of a low inventor's share of royalties increased new firm formation. This paper compares entrepreneurship and formal corporate involvement by faculty in the Departments of Electrical Engineering and Computer Science (EE&CS) at University of California, Berkeley (UCB) and Stanford. What we seek is to better elucidate how the institutions in which these professors are embedded influence their entrepreneurial activity.

This is a timely study because there is substantial evidence that universities around the world are adopting a policies for encouraging entrepreneurship (Rappert et al., 1999; Goldfarb and Henrekson, 2003). Framed in a slightly different way, Etzkowitz et al. (2000) observed that the university as an institution is moving toward a more entrepreneurial paradigm. These and other discussions of university-related entrepreneurship have been conducted either through multi-university studies, or less frequently, with reference to a single university. Very few studies investigate how organizational histories and culture at universities impact faculty entrepreneurial activity.[2]

In our examination of entrepreneurship in these two premier electrical engineering and computer science departments, we draw upon the current sociological research on the importance of the social context within which economic action is embedded. The sociological literature on embeddedness provides a set of concepts with which to frame and understand professorial entrepreneurship (on embeddedness, see Granovetter, 1985; Uzzi, 1999; for an excellent overview, see Dacin et al., 1999). The argument that economic activity is embedded in social institutions has a long history that traces at least back to Max Weber, and more historically proximate, to Polanyi (1944). A more recent formulation is provided by Granovetter (1985). Simply put, a core tenet of this argument is that economic action is not solely the function of the self-interest of the individual or other social entity (e.g., organization), who acts independently in pursuit of utility preferences or other economic goals. Rather, economic action is also influenced by the web of social relationships and institutions in which the individual or organization is embedded.

In applying this argument to the problem at hand, we contend that the involvement of professors in entrepreneurial activity is influenced by the social relationships and institutions in which a professor is embedded. Moreover, this structure of social relationships and institutions is characterized by *nested embeddedness*; that is, an individual is embedded in a nested structure of institutional layers, each of which may influence his/her participation in entrepreneurial activity. The individual faculty member is a member of a department, an important organizational sub-unit of the university that has a certain measure of autonomy. The department is embedded in the larger university. In turn, the university is embedded in an exogenous environment at the regional, national, and international levels. Individual professors are linked to this exogenous environment, in part, through being embedded in a scientific discipline, which consists of networks of scientists both within and outside their university that has been referred to as an "invisible college" (Crane, 1972).

It is our contention that each of these nested institutional layers could influence professorial participation in entrepreneurial activities. For example, the ability of a professor to secure venture capital and skilled labor for a business start-up will be influenced by the regional environment. Proximity was found to be a significant factor in reaping the economic benefits from research sponsored at universities (Mansfield and Lee, 1996, p. 1058). This finding confirms patent citation analysis studies that have found that patents, whether filed by corporations or universities, had local knowledge spillover effects (Jaffe et al., 1993; Mowery and Ziedonis, 2001). This is also true for university spin-outs in biotechnology (Audretsch and Stephan, 1996; Zucker et al., 1998).

The decision of a professor to engage in entrepreneurial activity and the process of doing so would be influenced by the policies, formal institutional rules, and general ethos of support for faculty involvement in business activity promulgated by the university; and, by the reward incentives, normative expectations, and ethos of support by a professor's department, and network of colleagues in the discipline (Argyres and Liebeskind, 1998). This research examines how the nested structure of institutions in which a professor is embedded influence participation in entrepreneurial activity in the field of electrical engineering and computer science.

[2] For a notable exception, see Feldman and Desrochers (2003).

In studies of professorial entrepreneurship, engineering departments in general, and EE&CS departments in particular, have received scant attention. With the prominent exceptions of Agrawal and Henderson (2002), and Mansfield (1995), little research has been done.[3] The comparative lack of research is surprising considering that in the 20th century, electronics has been a transformative technology and electrical engineering has a long history of close collaboration with industry (Noble, 1977). It was only in the 1980s that the events during the pattern of commercialization in biology replaced the pattern in engineering as the dominant mental model for university–industry relations. When one considers direct university spin-outs, although Genentech, Amgen, and Biogen were significant, certainly as significant have been the various electronics and software firms including Cadence Design Systems, Cisco Systems, Digital Equipment Corporation, Google, Silicon Graphics, Sun Microsystems, and Yahoo, to name a few of the most prominent EE&CS-nurtured university spin-outs.

One possible explanation for the relative neglect of university–industry relations in electronics could be that the electronics industry, despite the numerous spin-outs, has been less directly dependent upon university research than was biotechnology (Moore, 1997; Swann and Prevezer, 1996). Also patents, the most easily traded research product that may be commercialized by universities, have been of less significance in EE&CS (Cohen et al., 1996; Hall and Ziedonis, 2000; Merges and Nelson, 1990; Agrawal and Henderson, 2002). In this paper, we shift the focus from biology to EE&CS and to faculty entrepreneurial activities emphasizing the closely related area of faculty assistance to small firms through participation and involvement in their operations (Argyres and Liebeskind, 1998).

These departments are ideal for this study.[4] For the last four decades departments at both universities have been among the top three or four in the US (MIT almost always has had the top EE&CS departments). In the postwar period, for the most part, Stanford and UCB have been ranked second and third in these disciplines.[5] For example, Mansfield (1995, p. 58) found that electronics and information processing firms rated the MIT and UCB EE&CS departments first and second, respectively. In electronics Stanford was tied with another university for fourth and in information processing Stanford was tied with two other universities for third. By any measure, these two departments are eminent and the faculty include "star" engineers. In 2003, the UCB EE&CS department had 18 active members (not emeriti or adjunct professors) in the National Academy of Engineering, while Stanford had 16 members. In prestige terms, the departments are comparable.

Both are located in the San Francisco Bay Area, which has the largest concentration of high-technology electronics firms and venture capitalists in the nation. There is no other location in the world with two such highly rated EE&CS departments in such close proximity. Their close proximity to Silicon Valley means that they are surrounded by an intensely entrepreneurial environment that should lead to higher levels of entrepreneurship than in other regional environments.[6] Stanford and UCB have played a critical and multi-faceted role in Silicon Valley's growth. The environment has also affected the universities. Not unexpectedly, venture capitalists are interested in funding the innovations developed in these departments.

Recognition that research universities and their professors have an economic impact is not new, but the proper role of the university continues to be contentious (Noble, 1977; Brooks, 1993; Rosenberg and Nelson, 1994; Bok, 2003). Moreover, the benefits the university can provide to industry are so multifaceted as to defy comprehensive measurement (Jaffe, 1989; Mansfield, 1991). What is clear is that a university's contribution to corporate innovation is directly related to the "quality of the university's faculty in the relevant department, to the size of its R&D expenditures in relevant fields, and to the proportion of the industry's members located nearby" (Mansfield, 1995, p. 64).

[3] David Noble (1977) showed the importance of industry in creating the discipline of electrical engineering.

[4] At UCB, EE&CS are in the same department while at Stanford they are in separate departments.

[5] In the 1996 Gourman Report, Stanford was ranked first in Electrical Engineering and second in Computer Science. UCB was ranked fourth in Electrical Engineering and fourth in Computer Science.

[6] For discussion of this environment, see Brown and Duguid (2000), Kenney and von Burg (1999), and Saxenian (1994).

Despite the widespread recognition of the importance of university spin-outs and the evidence for a significant local effect, there has been a paucity of comparative studies of the institutional environment and university regulations concerning the commercialization of university research through professorial entrepreneurship.[7] Put differently, we seek to explain why different universities with very nearly equal quality departments made up of professors having nearly identical educational backgrounds located in roughly the same region exhibit different professorial entrepreneurship patterns.

Section 2 of the paper discusses our methods. Section 3 discusses the history of the two universities with special attention to their policies regarding ownership of intellectual property and their attitudes toward and support of professorial entrepreneurship. Section 4 reports the results of our survey of EE&CS professors regarding entrepreneurship. Section 5 compares the entrepreneurial activity and corporate involvement of professors in both departments. In Section 6, we discuss the implications of the research results.

2. Research methodology

Three data collection methodologies were utilized in this research. The first stage of data collection was an examination of available historical and archival material on the universities and the departments. This was supplemented with informal discussions with Stanford and UCB administrators. Historical research on UCB was difficult because there was less material on professorial entrepreneurship. There was also a reticence to discuss entrepreneurship, and it clearly was not celebrated to the extent it was at Stanford. The historical data provides an understanding of the organizational context and culture of the universities within which both departments were embedded.

The second method was a mail survey of EE&CS faculty at both universities. This was meant to gauge their attitudes toward entrepreneurship and their perceptions of the overall institutional support for entrepreneurship. Each department permitted us to deliver the surveys directly to the faculty mailboxes. The survey administration was based on a modification of Dillman's (1978) Total Design Method. Those who did not respond to the first mailing were sent two follow-up letters and one e-mail query. A total of 179 survey booklets were distributed to the department mailboxes. The overall response rate to the survey was 13.4%. Broken down by university, the response rates were 13% for UCB faculty and 13.8% for Stanford faculty. This low response is likely attributable to the lack of free time among the faculty and the fact that this particular population is frequently subject to surveys, among other factors. The Stanford University department chairman stated that his faculty received an average of one survey per week.

The final method for data collection was the measurement of entrepreneurship and corporate involvement on the part of the faculty. To identify biotechnology start-ups, it is possible to draw upon various commercially available databases. However, there are no comparable databases for electronics. To overcome this difficulty, we used the Google search engine to search the Worldwide Web for each professor's name (assistant, associate, and full professor).[8] We inspected the first 100 hits manually for any indication of a firm affiliation. The most valuable sites were the professor's personal sites, followed by the sites of firms with which they were affiliated. The firm sites almost invariably had the professor's biography, which listed yet other firms. For each unique firm, whenever possible, we collected the type of affiliation, the firm's name, location, and the establishment date. This information was then entered into an Excel database.

Though we are not certain of the completeness of the data, we believe it is the most complete listing available. One complication is that the relationships may have been prior to the individual's joining the two universities as dating the relationships was difficult. Put differently, we were unable to establish the date of firm founding and this might bias the data. To check the validity of the data, we sent the information to each professor and requested the verification of its accuracy. The response rate for this e-mailing was 47% (43 faculty) at UCB and 51% (44 faculty) at Stanford.

[7] There are important exceptions. Matkin (1990) studied technology transfer at UCB, Stanford, MIT, and Pennsylvania State University.

[8] All other designations including emeriti, consulting, in residence, etc. were eliminated, because we wished to only measure the professors that responded to our survey.

The relationships recorded were only those that were formal and included all official positions except consulting. Consulting relationships were omitted for the following reasons: first, it is the most general activity and probably the least intimate. Second, a consultant has no fiduciary or legal responsibilities to the firm beyond the consulting contract specifications. Third, the content of most consultancy relationships is not well specified in the data to which we had access.

The multiple method approach offers several advantages. First, the historical data and personal interviews provide insight into the organizational context and culture at each university. The survey data, although of limited value for statistical analysis due to the low response rate, provides insight into the faculty perceptions regarding the environment for the entrepreneurship-related activities. Finally, the Internet search data provided a measure of the formal involvement of faculty in private companies. The e-mailing of the Internet search results to the faculty provided further validation of the Internet search results.

3. The organizational contexts and cultures

3.1. UC Berkeley

The University of California was established in Berkeley in 1868 through a merger of the College of California, a liberal arts college incorporated in 1855, and the Agricultural, Mining, and Mechanical Arts College formed in 1866 under the aegis of 1862 Morrill Act (in this paper we are only interested in the original Berkeley campus). However, the UC is a public institution governed by a board of regents made up of political appointees, dependent upon the State Legislature for a portion of its funding, and thus can be affected by the politics of the moment. As a publicly funded institution, there is a belief that any commercially valuable inventions should not enrich the faculty inventors.

In organizational terms, UCB emulated Johns Hopkins University.[9] Given its difficulties competing with the established East Coast private universities in terms of salary, from the 1890s, UCB developed a strategy of attracting young scientists by providing financial support for their research (Matkin, 1990, p. 29). This attracted excellent young scholars that UCB was often able to retain, and was vital for propelling UCB into the first rank of research universities.

The first documented development of a commercial invention by a UCB professor came in 1907, when Frederick Cottrell invented an electrostatic precipitator. Because he believed that the university should not participate in business, and there was no UC policy regarding faculty inventions, he established the Research Corporation to handle the commercialization process.[10] In 1917, the UC received its first patent as a donation from a professor, though it did not prove profitable (Weiner, 1982, p. 123). In 1926, the UC system required that all employees report inventions to the University President (University of California Board of Regents, 1926). In 1931, this policy was rescinded, because the President stated that "the experience of the University with patents so far had not been satisfactory" (University of California Board of Regents, 1931). The topic reemerged in the early 1940s after two Davis scientists assigned their patent for a formulation of calcium pantothenate to the UC. In 1943, the UC Regents created a Board of Patents to oversee patenting (Weiner, 1982, p. 125), although the decision to file would be determined on a case-by-case basis (Mowery and Ziedonis, 2001; University of California Board of Regents, 1943). In 1952, a University Patent Fund was established to provide earnings to the endowment and to finance patent expenses and research activities. In 1956, the UC decided to protect all patents that were the result of sponsored research (Matkin, 1990, pp. 65–66). Still, for unsponsored research, submission of inventions to the UC patent program was voluntary until 1963 when it became mandatory for all employees and students (Matkin, 1990, p. 66).

The UC system has had strict conflict of interest rules mandated by the 1974 Political Reform Act. Initially intended for state employees and politicians, these rules were also applied to UC faculty. More recently, in 2002, the UC Office of the President began

[9] For discussions of the influence of Johns Hopkins on US research universities, see Geiger (1986) and Veysey (1965). Feldman and Desrochers (2003) examine Johns Hopkins' failure to spin many firms off despite doing world-class research and having a massive research budget.

[10] For a detailed discussion, see Mowery et al. (2004).

enforcing even stricter proposed conflict-of-interest rules with a more intrusive methodology for reporting faculty sources of income. Moreover, it shifted responsibility for deciding conflicts of interest from the department and the department chair to the Chancellor or his/her designate. This separates decision-making from the community of scholars who understand the practices in their particular discipline.

Establishing a firm is a difficult and time-consuming process. UC professors wishing to serve as a corporate officer, as a general rule must take a leave of absence. Moreover, under most circumstances assistant professors would not be granted leaves of more than 1 year. If a faculty member applies for an extension, the department chair must make the difficult determination about whether to extend the leave of absence. It also compels the professor to decide whether it is worth applying for an exception.

It is difficult to establish when in UCB's history an ambivalent or even negative attitude toward faculty entrepreneurship formed. One anonymous interviewee who teaches the College of Engineering's undergraduate entrepreneurship course said that the university exhibited the divide C.P. Snow (1959) wrote about in his classic work on the two cultures. Entrepreneurship is discouraged in two ways. The first way is a general attitude of superiority on the part of the "pure" or non-applied professors toward those in the more "applied" fields. This conceivably can be traced back to the inception of the UC, and the difficulties that the applied agriculture and engineering faculties faced from their arts and sciences colleagues. At the second level is the ideology surrounding UCB's status as a public institution in which the professors' salaries are paid by the taxpayer, and therefore the research benefits should accrue to the state or university rather than to the inventor. The result has been that the UC appears to be as interested in controlling the perception of professors benefiting from their research as it is in technology transfer. In an earlier study of technology transfer, Matkin (1990, p. 289) found that most UCB faculty members believed "that the university was doing nothing to encourage technology transfer." The history of entrepreneurship at the UCB indicates that the organizational environment provided little support for entrepreneurship.

3.1.1. The department of EE&CS

The UCB department of electrical engineering was established in 1892 (Sturgeon, 1988). In keeping with the times, professors consulted extensively for local public utility firms, and university research facilities were used for commercial testing (Sturgeon, 1988, p. 11). These linkages flourished with the formation of a small Bay Area electronics industry. At the time, there was a flow of personnel between UCB and local industry. The most salient of these was Leonard Fuller who joined the UCB faculty in 1931 after having been the head of research at Federal Telegraph, the pioneering Bay Area firm that invented the vacuum tube. After World War II, Fuller co-founded the Colin B. Kennedy Radio Company (Sturgeon, 1988). Fuller's career provides evidence of entrepreneurship in the department.

Entrepreneurial activity continued in the post World War II period. For example, in 1988 a UCB EE&CS professor co-founded Solomon Design Associates, which when it merged with Ecad, became Cadence that today is the largest semiconductor design software firm in the world. Another major chip design firm, Synopys, also has roots in UCB. Richard Newton, the current Dean of Engineering appointed in 2002, founded four firms and was a partner in the Mayfield Fund, a major Silicon Valley venture capital firm (Scalise, 2000). In the area of relational database software, Relational Technology Inc. was formed in 1980 by three UCB professors.[11] Yet, another avenue for commercialization was Teknekron, a firm established by a group of UCB engineering professors and industry professionals to incubate new technologies, many of which were developed by UCB engineering professors. As of 1990, Teknekron had been a host for 11 different firms, two of which had gone public and one of which was sold (Wagner, 1991). In 1969, the UC Board of Regents invested $1 million in a software program developed by two UCB computer scientists.[12] The company, the Berkeley Computer Corporation, eventually failed and the investment was lost. With this failure, the university resolved to invest

[11] Prior to going public RTI's name was changed to Ingres in 1988.

[12] 1969 was the peak of the frenzied new issue market of the late 1960s. As has been quite typical of university forays into venture financing, it usually occurs during investment frenzies or unfortunately slightly after they peak.

in start-ups only through established venture capital funds (Matkin, 1990, p. 164).

Due to these early failures, until the mid-1990s, the UC system did not accept equity as compensation for use of its intellectual property. This changed in the mid-1990s when administrators were tantalized by the enormous capital gains that successful firms could generate and began to appreciate the difficulty early-stage, usually money-consuming, firms had in making royalty payments.[13] One example of this change occurred in August 1996 when Inktomi, an Internet infrastructure firm based in part on research done by the computer science professor Eric Brewer, issued 6667 shares of common stock to the UC in partial payment for a software license. These shares had an aggregate exercise price of $50,000 (Inktomi, 1998). In July 2000, the stock was worth $870,000. By April 2002, the stock would have been worth approximately $19,000.[14]

The historical record indicates that UCB EE&CS faculty have been entrepreneurial despite the anecdotal evidence that the UC system has not encouraged entrepreneurship. In organizational terms, there is evidence that despite being embedded in a relatively discouraging environment at UCB, the EE&CS departmental community of practice has included professorial entrepreneurship[15]. Moreover, there is anecdotal evidence that fellow faculty do not discourage this as long as the entrepreneurial professor discharges their departmental duties.

3.2. Stanford University

The railroad magnate Leland Stanford established Stanford in 1891. It has been avowedly politically conservative and cultivated a general ethos of wholehearted support for close relationships with industry (Veysey, 1965). The initial desire and even necessity of industrial patronage was spurred by the financial difficulties experienced from its birth through the 1940s (Lowen, 1997). In general terms, Stanford emphasized the natural sciences and engineering over the social sciences and humanities (Lowen, 1997). This emphasis is evident in the backgrounds of the nine Stanford presidents: four were scientists (38 years), two were historians (29 years), one was from medicine (27 years), one was a social scientist (8 years), one was an engineer (2 years), and one was a business person (5 years). In contrast, the presidents of the UC system and then the Chancellors of UCB served significantly shorter terms and were far more eclectic.

Stanford's entrepreneurship and intellectual property policies differed from those at UC Berkeley. There has been a long-standing tradition of strong support for entrepreneurial ventures. The earliest recorded instance of Stanford faculty or administrators assisting entrepreneurs was in 1909, when the founder of Federal Telegraph received early investments from David Starr Jordan, then the president of Stanford, and C.D. Marx, then the head of Stanford's Department of Civil Engineering (Sturgeon, 2000). This action preceded Frederick Terman's celebrated activities by nearly 30 years.

Frederick Terman, an electrical engineer who would become department chair and then Provost actively promoted industrial involvement and firm formation by Stanford-affiliated personnel. Having been educated at MIT, he was intimately familiar with MIT's close relationship with industry and believed it was vital for its rise to excellence (Matkin, 1990, p. 24). Terman constantly encouraged Stanford professors and students to be entrepreneurial (Lowen, 1997; Lenoir, 2002). This policy was evidenced in his encouragement of Stanford engineering students such as William Hewlett, David Packard, and the Varian brothers to establish firms. This extended to the faculty also. For example, in 1957 when Professor Dean Watkins was negotiating with the Kern County Land Company regarding their making a venture capital investment in a start-up he was launching, Frederick Terman, was actively involved in the bargaining process (Davis, 1957; Watkins, 1957; Terman, 1957). Though it is possible that high-level administrators at UCB may have been involved in such negotiations, we found no evidence for such involvement. The importance of these anecdotes is to illustrate an ethos of acceptance and even willingness to facilitate start-ups—sure evidence of support for entrepreneurship.

[13] The commercialization of biotechnology created a similar vision of wealth resulting from professorial research in the 1980s.

[14] Carnegie Mellon University was even more aggressive, retaining a 25% interest in the startup Lycos, whose value, if all of the shares had been retained until September 2000 and then sold at the peak, would have been in excess of $500 million.

[15] On communities of practice, see Brown and Duguid (1991, 2000) and Lave and Wenger (1991).

The reasons for encouraging entrepreneurship were not merely ideological. Prior to World War II, due to constant budget constraints Stanford professors were underpaid making recruitment and retention difficult. For example, in 1945–1946 the average minimum salary for a Stanford professor was $4500, while at UCB the average was $6000; and both averages were lower than the $10,000–12,000 paid at leading East Coast universities (Lowen, 1997, p. 103). Not only was faculty pay low, Stanford faculty also had little research support. For example, in 1927–1928 Stanford allocated only $3300 for research, while UCB provided $112,000, and MIT had over $200,000 (Matkin, 1990, p. 36). With low pay and little support for research, Stanford would have likely found it impossible to recruit high-quality faculty if they were not given an opportunity to earn an outside income. Frederick Terman recognized these limitations, and responded by encouraging faculty members to interact with the private sector, not only to secure research funding and discover new research problems, but also to increase their total compensation.

Prior to 1970, Stanford had no patent and licensing policy at all. Then in 1970 a new policy was promulgated, stating "except in cases where other arrangements are required by contracts and grants or sponsored research or where other arrangements have been specifically agreed upon in writing, it shall be the policy of the University to permit employees of the University, both faculty and staff, and students to retain all rights to inventions made by them" (13th Annual Report, Stanford University as quoted in Matkin, 1990, p. 70). Here Stanford formalized its unique policy of encouraging professorial entrepreneurship. Patent and licensing policy was an aspect of an entire gestalt. Neils Reimers (2003), the founder of the Stanford Office of Technology Licensing described the situation this way,

> The policy was, your technology belongs to you, unless the terms in the external research agreement required otherwise. But the latter really controls for the most part, [the research] was under some form of sponsorship. You had to deal with a sponsor. Anytime somebody wanted to get the rights back, if they wanted to handle [the invention] themselves, we would say OK. We would tell the agency Stanford chooses not to exercise its rights in this invention, and hereby authorizes professor so and so to directly petition for release.

Under Terman, Stanford developed a policy of actively encouraging interactions by departments and/or faculty with industry (Matkin, 1990, p. 47). For example, Stanford permitted professors to be officers in firms. It also was quite permissive in allowing current and, though less frequently, ex-students to use its facilities during the earliest stages of their ventures. These policies were part and parcel of a philosophy of minimal intervention in faculty interaction with industry. One Stanford faculty member summarized his opinions on the university contribution to technology transfer by saying, "the University encourages technology transfer by staying out of our way" (Matkin, 1990, p. 289). The operative policy seems to have been a trust in the faculty member's judgment. This provided ample opportunity for professors to exercise their ingenuity and entrepreneurial instincts.

In the early 1990s, this permissive attitude changed. The reasons for this are not entirely clear. The new president Gerhard Kaspar, formerly a law professor at the University of Chicago, was less imbued with the entrepreneurial Silicon Valley philosophy. Moreover, the Federal Government and others were becoming more concerned with faculty conflicts of interests (Koshland, 1990). A committee to reform Stanford's intellectual property ownership policy was appointed in 1992; and, in 1994, the policy was amended to require that all employees disclose all inventions including software (Ku, 2003). After 1994, these policies continued to be amended to clarify them and to take into account that ever more frequently, Stanford accepted equity from start-ups in lieu of an entirely cash payment.[16]

The motivation for the new policy was clear, i.e., to appropriate the benefits of inventions made at Stanford. Interestingly, with the previously voluntary

[16] As mentioned earlier, Stanford administrators had invested in Federal Telegraph much earlier. In the postwar period, Stanford had invested in start-ups directly, however, in 1978 the university formalized its policy to invest only in venture capital funds or to coinvest in deals led by professional venture capitalists (Adams, 1978). Feldman et al. (2002) show this is part of an increasing tendency to accept equity for their intellectual property at all universities. Feldman et al. (2002) show this is part of an increasing tendency to accept equity for their intellectual property at all universities.

disclosure of invention policy operating at Stanford and the mandatory policy at the UCs, the expected outcome that a comparable UC would have greater income than Stanford was not born out in practice. Income increased after the 1994 policy change (Stanford Office of Technology Licensing, 2002), though Katharine Ku (2003), the Director of the Stanford Office of Technology Licensing, says it is too early to tell if this was driven by the change in 1994.

Stanford administrators supported entrepreneurship almost from its inception. The rules were deliberately loose so that professors could supplement their income, and, in fact, departments encouraged entrepreneurial activity on the part of the faculty and students. More significant though is a pride in this entrepreneurship. For example, a university website lists all of the start-ups by Stanford faculty and students. The history, culture, and the rules have been aligned to support entrepreneurship, and the changes made in the 1990s did not change this ethos.

3.2.1. The departments of electrical engineering and computer science

In 1893, 2 years after the university was established, Stanford hired its first professor of electrical engineering (Stanford University, 2003). From its inception, the Stanford professors of electrical engineering interacted with large established firms and also the small start-ups that formed in the area (Sturgeon, 2000). Faculty entrepreneurship in EE (and later CS) has a long history, also. As mentioned earlier, Frederick Terman was actively involved in discussions regarding a fledging venture capital-financed firm one of his EE professors was planning to start. This pattern has continued. In 1984, for example, MIPS Computer Systems was founded by a Stanford professor to commercialize a new type of microprocessor. Another Stanford professor, Jim Clark, established the workstation firm, Silicon Graphics, to use the new MIPS microprocessor. These firms commercialized technology developed in faculty founder's laboratories.[17]

[17] The most famous Stanford spin-out successes were not the result of professorial initiative. For example, Sun Microsystems (Sun is an acronym for the original Stanford University Network project) was established in 1982 by a Stanford Ph.D. student in EE, two Stanford MBAs, and a UCB CS student. Yahoo! was founded by two EE&CS Ph.D. students. Cisco Systems was the result of entrepreneurship on the part of Stanford technical staff members.

The tradition of entrepreneurship in EE&CS began with the formation of firms by graduates that were encouraged by the faculty and administrators. Professorial entrepreneurship was less easy to identify in the pre World War II period. However, the ethos of support for entrepreneurship is now nearly 100 years old. The historical record suggests that it is now accepted that professors and students can be involved with entrepreneurial ventures. In the case of students, this might occur even while they are still students. Stanford and the EE&CS departments actively publicize the fact that they encourage entrepreneurship.

3.3. Comparing the two universities

Our historical examination indicates similarities and differences between the universities. In terms of regulations, Stanford allowed faculty and students to exploit their inventions until 1994, whereas UCB asserted ownership over all inventions from 1963 onwards. Equally as significant, Stanford leadership was actively involved in assisting and personally funding start-ups nearly from the inception of the university. At UCB there is no record of such involvement and support by university leaders. On the contrary, the culture appears to discourage such involvement. These results suggest the hypothesis that Stanford should exhibit greater levels of entrepreneurship than UCB. Such a hypothesis, however, is predicated on the assumption that university culture and regulations exert a strong influence on professorial entrepreneurship in academic departments; put another way, the culture of the larger university in which an academic department and constituent faculty members are embedded is an important factor in affecting entrepreneurial activity and corporate involvement by individual faculty.

Despite the discouragement at the university-level, UCB's EE&CS department does have a history of entrepreneurship. This suggests that EE&CS as a discipline has a practice that supports and values entrepreneurship; and, that entrepreneurship has occurred at UCB despite the faculty being embedded in a larger institution whose organizational rules and cultures are not strongly supportive.

In the only prior study of this issue, Matkin (1990, pp. 282–283) found that UCB faculty had a larger number of patents than did the Stanford faculty. Despite the larger number of patents, the attitudes

toward commercialization differed between the two faculty. When queried as to how far faculty members took their research on a scale of 1 (published or gave to sponsor) to 6 (received royalty income), Matkin found that Stanford professors had an average value of 4.77, while UCB had a value of 3.56, suggesting more extensive involvement in commercial research activities among Stanford professors. Unfortunately, he did not ask whether they had started a firm or assisted start-ups. These findings provide some indication that faculty at the two institutions had different levels of experience with research commercialization.

The most striking outcome of this qualitative section is that the institutional contexts are significantly different at the university level, but exhibit greater similarity at the department level. This is suggestive of two conclusions: (1) there is a significant difference in the cultures and regulations concerning entrepreneurship at the two universities; and (2) the communities of practice for EE&CC professors at the department level is far more similar in that entrepreneurship occurs at both institutions. In effort to further corroborate these findings, the survey of EE&CS faculty contained questions designed to measure their perceptions of the institutional culture and level of support for entrepreneurship at each of the respective universities.

4. Faculty perceptions of the environment for entrepreneurship at the two universities

In order to measure the role of entrepreneurship in the expenditure of faculty time, the survey asked EE&CS faculty to estimate the percentage of time they devoted to: teaching, research, administration, entrepreneurship, service to industry, and service to government. By far, the vast majority of faculty time at both universities was spent on research and teaching. Stanford faculty spent a greater percentage of their time on teaching while UCB faculty spent a greater percentage of their time on research. At both institutions, the third and fourth largest time expenditures were for administration and entrepreneurial activity.

An estimated 50% of the Stanford faculty responding to the survey stated that they devoted some of their time to entrepreneurship. This is compared to 45% of the UCB faculty that responded to the survey. Contrary to what might be expected, however, UCB faculty perceived themselves as spending a higher percentage of time devoted to entrepreneurship (an average of 8.2% compared to 5.8%).

Table 1
Faculty ranking of the personal importance of professorial activities

	UC Berkeley ($n = 7$–11)		Stanford University ($n = 11$–12)	
	Rank	Mean	Rank	Mean
Research	1	1.00	1	1.36
Teaching	2	2.38	2	1.67
Administration	3	4.00	3	4.08
Service to industry	4	4.14	6	5.09
Entrepreneurship	5	4.43	5	4.58
Service to government	6	4.71	4	4.36

Rank (1 through 6, 1 being most important to 6 being least important).

Table 2
Faculty ranking of the perceived importance attached by their departments to professorial activities

	UC Berkeley ($n = 12$)		Stanford University ($n = 11$–12)	
	Rank	Mean	Rank	Mean
Research	1	1.00	1	1.00
Teaching	2	2.00	2	2.08
Administration	3	3.83	3	4.08
Entrepreneurship	4	4.42	4	4.09
Service to industry	4	4.42	5	4.64
Service to government	6	4.67	6	4.73

The faculty were also asked to rank the personal importance they placed on the six activities and their perception of the importance placed on these activities by their department and university. These results are listed in Tables 1–3. We provide the mean for ranking purposes. First, no major differences were found in the

Table 3
Faculty ranking of the perceived importance attached by their universities to professorial activities

	UC Berkeley ($n = 12$)		Stanford University ($n = 11$–12)	
	Rank	Mean	Rank	Mean
Research	1	1.17	1	1.40
Teaching	2	1.92	2	1.80
Administration	3	3.33	3	3.50
Service to government	4	4.17	5	4.67
Service to industry	5	4.83	6	5.00
Entrepreneurship	6	5.33	4	4.22

Source: Faculty survey.

personal importance attached by faculty to research, teaching, and administration (RTA) (see Table 1). The most salient difference in the personal views of the professors was the lack of importance Stanford professors attached to service to industry, while UCB professors believed this was their most important non-RTA activity (see Table 1). In contrast, service to government was considered the most important non-RTA activity by Stanford professors. Entrepreneurship was ranked the fifth activity in terms of personal importance to the EE&CS faculty in both universities with the mean ranking being slightly higher for Stanford faculty.

Several differences were found between the two institutions in regard to the importance attached by the departments to the six activities (see Table 2). At UCB, the faculty perceived the importance attached to entrepreneurship and service to industry by their department to be approximately equal (fourth most important activity with a mean rank = 4.42). At Stanford, the faculty believed the department valued administration and entrepreneurship almost equally. Administration was perceived to be the third most important activity to the department (mean rank = 4.09) while entrepreneurship was perceived to be fourth most important (mean rank = 4.08). Thus, faculty at both universities perceived entrepreneurship to be the fourth most important activity to their departments, although at Stanford it was almost as important as administration. In the departments at both universities, entrepreneurship appears to be part of the community of practice.

When the faculty were asked how their university's ranked these activities, a noticeable difference was observed (see Table 3). Stanford faculty believed that the university rated entrepreneurship as the fourth most important activity (mean rank = 4.22). In contrast, at UCB, entrepreneurship was perceived as being the least important activity to the university; and, it was rated substantially lower than the fifth-ranked activity, service to industry (mean rank = 5.33) (see Table 3). Thus, the faculty at Stanford perceive their university as attaching greater importance to entrepreneurship compared to faculty at UCB. These findings support the conclusion from the historical analysis that Stanford possesses a university culture that is more supportive of entrepreneurship compared to UCB.

To further understand the university's objectives, we asked the faculty what they believed were the university's motivations for supporting entrepreneurship (see Table 4). For Stanford faculty, the most important motivation was to "increase the status of the university." At UCB, faculty believed the university's most important motivation was "to benefit economically." The Stanford faculty believed that the pecuniary motive was the second most important motivation while the UCB faculty believed that the second most important motivation was to increase the status of their department (see Table 4). The most salient result here is that increasing the status of the university was perceived to be the most important motivation at Stanford while only the sixth most important motivation among UCB faculty. This finding supports the historical analysis in that it suggests that entrepreneurship is more widely embraced at Stanford and is considered more important to the status of the university.

At the same time, the fact that increasing the status of the department was perceived to be the second most important motivational factor for university support

Table 4
University motivation for encouraging start-ups

	UC Berkeley faculty (n = 9–10)		Stanford University faculty (n = 11–12)	
	Rank	Mean	Rank	Mean
To benefit economically	1	3.40	2	3.75
To increase the status of the department	2	3.10	4	3.55
To facilitate the commercialization of university innovations.	3	3.00	3	3.58
To increase the status of the faculty	3	3.00	7	3.00
To expand research opportunities	3	3.00	6	3.33
To increase the status of the university	6	2.90	1	3.82
To enhance career opportunities for students	7	2.70	5	3.42

Source: Faculty survey. In your opinion, "what motivates your university to support entrepreneurship?" (1 = not a factor, 5 = essential).

among UCB faculty suggests that entrepreneurship is important to the status of the EE&CS department at UCB. This finding is consistent with the view that support of entrepreneurship is important to the status of EE&CS departments as part of the larger community of practice within these disciplines, regardless of the culture of the larger institutions in which the departments are embedded. This is not surprising given that the professors are drawn from the same graduate schools, interact with the same types of firms, and teach a similar curriculum.[18] It should be noted, however, that even though increasing the status of the department was perceived to be only the fourth most important motivation among the Stanford faculty, the mean rank for this item was still slightly higher in magnitude compared with the UCB faculty.

While the low response rate to the survey does not allow for rigorous tests for statistical differences between the two universities, the findings presented are consistent with the findings of the historical analysis. These findings suggest that entrepreneurship is more strongly supported at Stanford University where the administration perceives it to be an activity that increases the status of the university. At the same time, EE&CS faculty at both institutions tend to devote part of their time to entrepreneurship. Additionally, a similar level of importance is attached to entrepreneurship by the EE&CS faculty and departments at both universities.

In summary, the historical analysis coupled with the survey findings suggest that EE&CS faculty at both universities are socially embedded in departments and a larger community of practice in their respective disciplines that are supportive of entrepreneurship. However, at the same time, they are embedded in universities that exhibit differences in their cultural ethos concerning entrepreneurial activity. EE&CS faculty at Stanford are embedded in a university that has long encouraged entrepreneurship and views it as important. In contrast, EE&CS faculty at UCB are embedded in a university that historically opposed professorial entrepreneurship, and in the contemporary era, does not appear to strongly encourage it (at least in the eyes of EE&CS faculty). The open question is whether these differences at the university level have an impact on participation in entrepreneurial activity and other forms of corporate involvement among EE&CS faculty. We now present the findings from the Google search methodology in effort to address this question.

[18] In examining the educational background of faculty at both universities, it was found that 64.8% of the faculty at UCB and 68.2% of the faculty at Stanford earned their Ph.D. from Electrical Engineering or Computer Science programs ranked in the top five according to the Gourman Report.

5. The involvement of EE&CS faculty in entrepreneurial and related corporate activities

The data derived from the Google search engine and the follow-up survey of faculty revealed that EE&CS faculty at each university had a wide range of different types of corporate affiliations. Corporate affiliations that were identified were coded into the following categories: (1) Firm Founder; (2) Board of Directors, Chair; (3) Board of Directors, Member; (4) Advisory Board, Member; (5) Advisory Board, Chair; (6) Advisor; (7) Chief Scientist or Chief Technical Officer; (8) President, CEO, or Vice President; and (9) miscellaneous affiliation. The affiliations held by each faculty member were also summed to get a total number. The average number of affiliations per EE&CS faculty member was calculated for all of these categories for each university. The differences in means for each university was then tested using a Pooled *T* test. In addition, the proportion of EE&CS faculty with each type of affiliation was calculated for each university. The differences in proportions for each university was then tested using a *Z* test.

In total, 168 corporate affiliations were identified for UCB professors while 253 were identified for Stanford professors (see Table 5). Although we have not included them in our analysis, our research identified six relationships that UCB professors had with large traditional firms (Siemens, Daimler Chrysler, Kawasaki Steel, NTT, Fuji Xerox Palo Alto Research Center, and an ST-Cadence Joint Venture) and three with mature start-ups (Sun Microsystems, Synopsys, and Cadence). We also identified six relationships with traditional firms by Stanford faculty (Sperry, NTT Docomo, Lockheed-Martin, El Paso Natural Gas, Hitachi, NCR, and France Telecom) and four with start-ups that have long since matured (LSI Logic, Cisco, Oracle, and Intel). All of the other relationships were with start-ups or small firms. In terms

Table 5
Total and average number of corporate affiliations held by UC Berkeley and Stanford EE/CS professors[a]

Title of affiliation	Number of affiliations held by UCB faculty ($n = 92$)	Mean number per faculty member	Number of affiliations held by Stanford faculty ($n = 87$)	Mean number per faculty member	Pooled T test for differences in means
Total number of affiliations	168	1.8261	253	2.9080	−2.17*
Advisory Board, Member[b]	69	0.7500	106	1.2184	−1.58
Advisory Board, Chair	0	0.0000	2	0.0230	−1.46
Founder	36	0.3913	58	0.6667	−1.99*
Board of Directors, Member	22	0.2391	40	0.4598	−1.55
Advisor[c]	16	0.1739	12	0.1379	0.49
Chief Scientist, Chief Technical Officer	11	0.1196	20	0.2299	−1.66
Board of Directors, Chair	4	0.0435	8	0.0920	−1.19
President, CEO, Vice President	6	0.0652	4	0.0460	0.41
Miscellaneous affiliations	4	0.0435	3	0.0345	0.24

Source: Authors' database.

[a] It was possible for one professor to have more than one relationship with a firm, e.g., founder, member of technical advisory board. Each of these was counted as one relationship. It was possible for more than one professor to have a relationship with the same company, e.g., Professor A and Professor B could serve on Company A's technical advisory board.

[b] This includes members of scientific, technical or any other advisory board.

[c] Advisor was unexplained, so it may refer to membership on an Advisory Board.

* $P < 0.05$.

of total number of corporate affiliations, UCB faculty averaged 1.83 affiliations per faculty member while Stanford faculty had an average of 2.91 affiliations. This difference was found to be statistically significant (see Table 5).

In examining specific types of corporate affiliations, significant differences were found between UCB and Stanford faculty in regard to one type of affiliation; that is, being a founder of a new firm. In total, UCB professors either solely founded or co-founded 36 firms, while Stanford faculty founded or co-founded 58 firms. On average, UCB faculty founded 0.39 firms per faculty member compared to 0.67 firms per faculty member for the Stanford faculty. This difference was statistically significant (see Table 5). Thus, EE&CS faculty at Stanford were more extensively involved in founding new start-ups compared to the faculty at UCB.

In regard to the other types of corporate affiliations, Stanford faculty were more extensively involved as Chairs and Members of Boards of Directors, Chairs and Members of Advisory Boards, and Chief Scientists and Chief Technical Officers. In contrast, UCB faculty were more extensively involved as advisors and corporate CEOs, Presidents, or Vice Presidents (see Table 5). None of these differences, however, were statistically significant.

In terms of proportionate involvement in corporate activity, 66.7% (58/87) of the Stanford faculty had at least one corporate affiliation of any type compared to 48.9% (45/92) of the UCB faculty. This was statistically significant (see Table 6). In relation to the establishment of new start-ups, an estimated 41.4% of the Stanford faculty was a founder or cofounder of at least one firm compared to 28.3% of the UCB faculty.

Table 6
Results of Z tests for differences in the proportion of UC Berkeley and Stanford EE/CS professors with specific types of affiliations

Type of affiliation proportion with	UCB ($n = 92$)	Stanford ($n = 87$)	Z
Any corporate affiliation	0.4891	0.6667	−2.40*
Advisory Board, Member	0.2935	0.4138	−1.68
Advisory Board, Chair	0.0000	0.0230	−1.46
Founder	0.2826	0.4138	−1.84
Board of Directors, Member	0.1304	0.2414	−1.91
Advisor	0.1196	0.1034	0.34
Chief Scientist, Chief Technical Officer	0.0978	0.1954	−1.85
Board of Directors, Chair	0.0435	0.0805	−1.03
President, CEO, Vice President	0.0326	0.0460	−0.46
Miscellaneous affiliations	0.0326	0.0230	0.39
Number with an affiliation	45	58	–
Number with no affiliation	47	29	–

Source: Authors' database.

* $P < 0.05$.

This, however, was not found to be statistically significant (see Table 6). Stanford also had a proportionately greater number of faculty involved as Chairs and Members of Boards of Directors, Chairs and Members of Advisory Boards, Chief Scientists and Chief Technical Officers, and corporate CEOs, Presidents, or Vice Presidents. UCB had a proportionately greater number of faculty involved as advisors, or in miscellaneous affiliations. However, none of these differences were statistically significant (see Table 6).

In summary, Stanford EE&CS faculty had a significantly greater proportion of faculty with corporate affiliations and a significantly greater number of affiliations per faculty member in absolute terms. Moreover, they founded or co-founded a significantly greater number of start-ups.

6. Discussion and conclusions

The research findings suggest that the institutional history, culture, and regulations of the broader university in which a faculty member is embedded influence professorial entrepreneurship and corporate involvement. The research design employed in this study has attempted to hold constant a number of the factors that influence professorial entrepreneurship and corporate involvement. The EE&CS departments at both universities are among the top programs in the country in their respective disciplines, and both contain "star" engineers. Moreover, the majority of EE&CS faculty in both universities were trained at the top EE&CS programs in the country and are linked to the broader community of practice in their respective disciplines which places some value on, and support of, entrepreneurial activity. Both departments are located in same region which provides ample access to venture capital, skilled labor, law firms, consultants, and other resources necessary to form a start-up. A key variable in the design is that the two universities differ in terms of their institutional histories, culture, regulations, and administrative support concerning entrepreneurship. These differences are supported by the findings of the historical analysis, and the perceptual data collected in the faculty survey.

Within the context of this research design, EE&CS faculty at Stanford were significantly more involved in entrepreneurship and corporate activity compared to the faculty at UCB. It is important to emphasize that the findings do not necessarily establish strict evidence of a causal link between university embeddedness and professorial entrepreneurship and corporate involvement. They do suggest, however, that this factor is likely to be important, although several caveats should be noted in accepting the validity of this conclusion.

First, this conclusion is based on data that likely contains some measurement error. The response rate to the faculty survey was low, although nonresponse was evenly balanced between the two universities. The Google search data on the corporate affiliations of faculty also likely contains some measurement error. The follow-up with faculty via e-mail to verify the accuracy of the affiliation data revealed that in some cases, the Google search methodology undercounted the number of affiliations actually held by certain faculty. However, the number of affiliations missed by the Google search methodology was larger for the Stanford faculty compared to the UCB faculty.[19] This suggests that the differences in entrepreneurship and corporate involvement between the two universities may actually be greater than observed in our data, although the ratios are unlikely to change significantly.

Second, while both universities are broadly located in the same region, there may be important differences in their immediate locational environments. Stanford is located in the center of Silicon Valley while UCB is in the East Bay. However, while this geographical distance would not prevent UCB professors from having access to resources required to form a start-up, or participating in corporate assistance activities, it is possible that the closer proximity to Silicon Valley at Stanford has an effect in promoting entrepreneurship and corporate involvement. This could indirectly influence the behavior of faculty through affecting the university environment, or directly through more frequent faculty contact with, and exposure to, entrepreneurs, venture capitalists and Silicon Valley firms.

A third caveat is that the study findings may reflect a self-selection process in operation; that is, newly minted students and professors with an attraction to, and propensity for, entrepreneurial activity might

[19] The results of the follow-up survey indicated that the Google Search methodology missed 25 corporate affiliations among 43 faculty at UCB and 40 affiliations among 44 faculty at Stanford.

purposely choose to pursue employment at Stanford over UCB because of the greater institutional support for these activities. This may likely be the case as the academic networks among EE&CS faculty could transmit this information to candidates for faculty positions. If this were true, however, it would serve to reinforce our key finding that the institutional history, culture, and regulations of the broader university in which faculty members are embedded have an effect on professorial entrepreneurship and corporate involvement.

It is also important to note that despite having a significantly smaller number of corporate affiliations than Stanford, the EE&CS faculty at UCB still exhibited a substantial amount of corporate involvement (an average of 1.83 affiliations per faculty member). This implies that there has been some resistance among the UCB faculty to the less-supportive university environment for entrepreneurial activity. In turn, this suggests that having an ethos of support for entrepreneurial activities at the department level and within the broader community of practice of a discipline may help counteract any disincentives for such activities provided by the larger university. It also suggests that were the State of California to be interested in increasing the levels of entrepreneurial activity, relatively simple policy changes removing restrictions on professorial entrepreneurship might result in significant economic benefits.

This exploratory study is one of the first to explicitly examine the institutional histories and cultures of universities in which professorial entrepreneurship is embedded. Our findings suggest that future research should focus on identifying the specific aspects of university culture, and university regulations which influence professorial entrepreneurship and corporate involvement. Moreover, it is important to gain a better understanding of the elements of departmental culture and the communities of practice in disciplines that act to modulate entrepreneurial activity, and can overcome larger institutional disincentives.

This study has described the complicated and often contradictory institutional environment within which professorial entrepreneurs or potential entrepreneurs are embedded. The histories, cultures, and rules of the two universities had an impact on the entrepreneurial activity of their faculty, and the amount of support they provided to entrepreneurial firms. We have also demonstrated what the evolutionary economists have argued, namely history and institutional norms, rules, and routines matter. Finally, for those interested in making policy, an understanding of these should make for better policy making and implementation.

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