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# Follow the Money: Engineering at Stanford and UC Berkeley During the Rise of Silicon Valley

**Stephen B. Adams**

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**Abstract** A comparison of the engineering schools at UC Berkeley and Stanford during the 1940s and 1950s shows that having an excellent academic program is necessary but not sufficient to make a university entrepreneurial (an engine of economic development). Key factors that made Stanford more entrepreneurial than Cal during this period were superior leadership and a focused strategy. The broader institutional context mattered as well. Stanford did not have the same access to state funding as public universities (such as Cal in the period under consideration) and some private universities (such as the Massachusetts Institute of Technology and the Johns Hopkins University in their early histories). Therefore, in order to gather resources, Stanford was forced to become entrepreneurial first, developing *business* skills (engaging with high-tech industry) at the same time Cal was developing *political* skills (protecting and increasing its state appropriation). Stanford's early development of entrepreneurial business skills played a crucial role in the development of Silicon Valley.

**Keywords** Entrepreneurial universities · High tech · Public universities · Silicon Valley · Regional economic development

In 1961, a delegation of officials from the city of Berkeley made a pilgrimage to the "site of the Miracle of Palo Alto." The industrial park adjacent to Stanford University, which included thirty firms and 8,600 employees, had become the subject of worldwide attention well before the surrounding region became known as Silicon Valley (Adams 2005). The Stanford Industrial Park had been featured in the Industrial Parks USA exhibit at the 1958 Brussels World's Fair, and had

S. B. Adams (✉)
Department of Management and Marketing, Franklin P. Perdue School of Business, Salisbury University, 1101 Camden Ave., Salisbury, MD 21801-6860, USA
e-mail: sbadams@salisbury.edu

been one of two California sites (Disneyland was the other) that French president Charles de Gaulle visited in 1960. Industrial parks were not new; the concept dated to the early twentieth century (Findlay 1992). The idea of anchoring an industrial park with a research university was new, however, and such parks would proliferate in America and around the world in coming decades (Luger and Goldstein 1991).

Nevertheless, the idea of the city of Berkeley importing ideas from Stanford University must have given pause to many on the Berkeley campus of the University of California (UC). For much of the twentieth century, UC Berkeley and Stanford had been in contrasting positions. UC Berkeley had long been a university of international distinction and one of America's "Big Six" research universities, and its faculty included nine Nobel laureates (Kerr 2001, 23, 56). By contrast, at midcentury Stanford had been a regional university on the make; it had pockets of excellence, but sought to improve the reputation of the entire institution (Leslie 1993, 45). By 1964, rankings of American universities by the American Council on Education would place UC Berkeley at the very top in terms of the number of departments in the top echelon, with 28. By then, Stanford had come a long way and, with ten departments in the top echelon, it rubbed shoulders with the elite. Engineering schools have played central roles contributing to academic/industry relations in high-tech regions, and the 1964 ratings put UC Berkeley's engineering program at the top, along with MIT's (Kerr 2001, 56–57), while Stanford's program was ranked slightly lower.

If one knew nothing else about the two institutions immediately following World War II, one would conclude that UC Berkeley was better poised to become a leading player in the coming knowledge economy, and specifically to anchor a high-tech region. In 1961, a casual observer might have wondered why a delegation of officials from Palo Alto was not making a pilgrimage across the Bay to "the site of the Miracle of Berkeley." Decades later, UC Berkeley could boast that its alumni had started several companies and made up a large share of Silicon Valley's workforce, including founders and/or high-level executives at Hewlett-Packard, Sun Microsystems, Intel, and the law firm Wilson Sonsini Goodrich & Rosati (ICF Consulting 2003, 3-3). During the formative years of Silicon Valley (1945–1960), however, no high-tech cluster grew up around UC Berkeley.[1] Why?

Of course, a university can influence but cannot control such an outcome. Maryann Feldman suggests that "although proximity to a major research university appears to be a necessary condition for local high-tech economic development, it alone is not a sufficient condition and provides no guarantee that economic development will follow" (Feldman 1994, 67). In answering why the Baltimore region had not "been able to capture the benefits of proximity to Johns Hopkins University" (Feldman 1994, 67), she cites insufficient concentration ("critical mass") in any one industry to launch a major high-tech complex as well as the lack of "many of the possible elements of a technological infrastructure of

[1] The last census prior to this period found that neither area had significant high-tech activity: fewer than one hundred engineers worked in manufacturing in the counties surrounding Berkeley and Stanford combined (U.S. Bureau of the Census 1939, 104).

innovation" (lawyers, consultants, marketing experts, and the like; Feldman 1994, 68, 71).

Applying a similar analysis to the University of California and the Berkeley area, Margaret O'Mara cites two factors external to the university that no doubt contributed to the outcome. First was the availability of land: she notes that although the city of Berkeley had twice the population of Palo Alto, it stood on a smaller plot of land. The relative scarcity of land made location in Berkeley more difficult and expensive for interested businesses. Second was the nature of the local workforce. The area that would become Silicon Valley (southern San Mateo County and northern Santa Clara County) had an abundance of white-collar college graduates, what we now call knowledge workers. By contrast, particularly in its industrial areas of Richmond and Oakland, Alameda County (in which Berkeley is located) had a greater percentage of blue-collar workers, a group that would not be in high demand in Silicon Valley (O'Mara 2005, 130).

My focus will be internal, however: the differences between the educational institutions themselves. How did the entrepreneurial behavior and related organizational capabilities of Stanford University compare to those of UC Berkeley across the Bay?

In 2006, Simcha Jong compared the biochemistry departments of UC Berkeley, Stanford, and UC San Francisco, and found greater entrepreneurial activity at UCSF during the late 1970s and early 1980s than at either of the other universities (Jong 2006). In 2004, Martin Kenney and Richard Goe compared the departments of electrical engineering and computer science at UC Berkeley and Stanford, and found more entrepreneurial attitudes at Stanford at the beginning of the twenty-first century (Kenney and Goe 2004). My approach differs from that of Kenney/Goe and Jong in that I push back the time period under review to the formative years of what would become Silicon Valley (1945–1960).

I will begin this article with a discussion of the concept of the entrepreneurial university. Then, using archival documents and oral histories from UC Berkeley, Stanford, and other universities, I will demonstrate that during the 1940s and 1950s Stanford's engineering school developed *business* skills: the ability to negotiate, to provide customer service, and to act quickly. Such capabilities mirrored those of industry, making Stanford an attractive organization for big business to deal with. Stanford became entrepreneurial because

1. it had the right leader to do so,
2. it had the luxury of adhering to a long-term strategy, and
3. it was in a financial predicament that made entrepreneurial activity attractive, if not necessary.

In contrast, the University of California relied on well-honed *political* skills. Cal's primary source of funds was a political entity (the state of California) and therefore Cal focused more on protecting that golden-egg-laying goose than on establishing lucrative relations with industry. Finally, I will suggest some general lessons regarding entrepreneurial behavior and expectations of public universities.

## The Entrepreneurial University

More than 25 years ago, in the pages of this journal, Henry Etzkowitz coined the expression *entrepreneurial universities* to describe academic institutions that promote economic development (Etzkowitz 1983). Since then, he has developed a model of university-industry-government relations (the "Triple Helix"), in which knowledge is transferred from research universities to industry, and then (via government) to society. "The entrepreneurial university," he writes, "is created as universities combine teaching and research with the capitalization of knowledge" and "increasingly provides the basis for economic development" (Etzkowitz 2002, 1). Scholars in fields ranging from education (Slaughter and Leslie 1997; Clark 1998; Geiger 2004) to economics (Audretsch, Keilbach and Lehmann 2006; Rosenberg 2003) to business (Shane 2004; Etzkowitz 1983, 1997, 2002, 2003) have weighed in on the ways in which universities could behave as economic entities. Such activity could include faculty consulting, commercialization of university-developed technology, performance of work (often on government contracts) for industry, or fostering start-ups.

In recent years, such entrepreneurial activity has come to be known as the university's "third mission" beyond teaching and research (Etzkowitz 2002, 6). Through its third mission, the university engages in a transfer of knowledge to industry, where it can be commercialized and can fuel economic development. In this process, the university's knowledge creates wealth for the university itself, for its industrial affiliates, and for the surrounding region. Etzkowitz writes extensively about developments at MIT, and also singles out Stanford University as a prime example of a success story. Stanford is, he writes, an entrepreneurial university with a "strategy of academic-based industrial development and industrially based academic development" (Etzkowitz 2003, 114).

I suggest that it is no coincidence that both these preeminent entrepreneurial universities (MIT and Stanford) are private institutions. After all, to become entrepreneurial requires certain institutional habits that are more likely to be found at universities that must rely on funding from private sources, particularly in industry, than at universities that are beneficiaries of state funding. In examining the roles of particular institutions, Carlsson et al. (2007, 6) describe possible "organizational barriers, university policies, [and] attitudes among faculty and university administrators" that could prevent top research universities from becoming entrepreneurial. Some of these organizational barriers include the need to respond to political or economic interest groups in order to preserve the university's primary source of funding. Therefore, in many cases (such as Cal and Stanford in the years following World War II) there has been an inverse relationship between entrepreneurial behavior by universities and the efforts they expend to garner (or protect) state funds.

One university that seems to be a possible counterexample to that relationship is Johns Hopkins. As Maryann Feldman and Pierre Desrochers note, Johns Hopkins is a premier private university that did not easily make the shift to the "third mission" (Feldman and Desrochers 2003). Behind the traditional private/public dichotomy, however, is a more nuanced story because Johns Hopkins had key characteristics of a public university. The engineering program at Johns Hopkins was established in 1912 with a grant from the state of Maryland, and the university received an annual subsidy from the state to sustain the program throughout the period of Feldman's study. Indeed, in 1928, the dean of engineering at Johns Hopkins wrote, "if the School of Engineering is to *remain entirely dependent on state aid*…" (emphasis added).[2] Therefore, this is an example of a private university adopting a fundraising strategy usually associated with a public university. Each time its engineering program ran into a major budget difficulty, Johns Hopkins petitioned the state of Maryland for additional funds (Yoe 1989, 3–5). During a 20-year period beginning in 1928, for instance, Johns Hopkins engineering deans asked their presidents to petition the state for additional funds eight times.[3]

The university's success in soliciting funds from the statehouse and the engineering program's reliance on that funding may help to explain why Johns Hopkins did not develop the habits that lead to a university's behaving entrepreneurially. Indeed, the flow of state funds was sufficiently important that in order to protect that source of money, Johns Hopkins admitted an African American to the engineering program in 1945, the first student of color admitted to the university in the twentieth century. That admissions decision represented more an effort at continuity (reducing the risk that state funding would be withdrawn) than change (adopting less discriminatory racial policies), as indicated by the lack of a second admission of an African American student until the 1950s.[4]

The case of MIT is even more instructive regarding entrepreneurial behavior because it was one of two *private* land-grant universities (Cornell was the other). Founded in 1861, MIT garnered one-third of the grant from the state of Massachusetts (for "mechanical arts"), while the state university at Amherst garnered the other two-thirds for agriculture (Etzkowitz 2002, 20–23). MIT continued to receive an annual stipend from the state of Massachusetts until the state legislature banned grants to private universities in 1917, and alerted MIT that the stipends would stop coming in 1921.[5] Until the legislature acted to terminate the stipend, MIT's default response to periodic budget woes was similar to that of Johns Hopkins regarding engineering: to request more state money.[6] MIT was so reliant

[2] Whitehead to Goodnow, 10 September 1928, 474.2, 02, 135, Johns Hopkins University Archives (hereafter JHU). A 1935 balance sheet for engineering shows that more than 90 percent of the school's income, with the exception of tuition and fees, came from the state appropriation. Whitehead to Bowman, 22 November 1935, 474.2, 02, 136, JHU.

[3] Whitehead to Goodnow, 10 September 1928; Whitehead to Ames, 9 May 1930, 474.2, 02, 135; Whitehead to Ames, 19 April 1933, 474.2 02 136; Whitehead to Bowman, 14 October 1935, 474.2, 02, 136; Kouwenhoven to Bowman, 14 September 1940, 474.2, 02, 137; "Memorandum," 18 March 1942, 474.2, 02, 137; Bowman to O'Conor, 1 February 1945, 474.2, 02, 137; Bowman to Lane, 2 November 1948, 474.2, 02, 138, all JHU.

[4] Williams to Barton, 19 December 1944; Bowman to Williams, 3 January 1945, 474.2 02 136, both JHU. President Bowman wrote that Johns Hopkins "should not exclude such a person from our school of engineering, especially when we are receiving aid from the state."

[5] "Bulletin of the Massachusetts Institute of Technology: Departments of the President and Treasurer," January 1918, p. 20, Massachusetts Institute of Technology Archives, Cambridge, MA (hereafter MIT).

[6] Office of the President, AC 13, box 29, "Massachusetts Legislature—MIT Appeal for State Aid 1878, 1895, 1910–1911," MIT.

on state money that in 1910, when President Maclaurin secured an increase in the stipend to $100,000 per year, he wrote that MIT "has never been a private institution."[7]

That would change, however, and so would MIT's behavior. The need to raise money to replace the terminated stipend catalyzed some truly entrepreneurial behavior by the university, and much of it involved forging closer ties with industry. In 1919, the university adopted the Technology Plan, a contractual arrangement that brought annual grants from various companies in exchange for access to MIT's technology and graduates. The program had shrunk to irrelevance by the late 1920s because it shifted from a symbiotic relationship to one in which MIT offered similar access and services to smaller companies, many of which did not pay the annual stipend. Outraged by an apparent breach of contract, most original Plan participants dropped out (Lécuyer 1995, 81; Etzkowitz 2002, 42–45).

Years later, MIT adopted a more exclusive Industrial Liaison Program, in which companies from several industries made annual contributions to the university in exchange for access to technology developed at the university.[8] The motives behind the Liaison Program, as they had been for the Technology Plan, were primarily pecuniary. An information letter to the faculty from the director of the Industrial Liaison Office attributed the program's 1948 inception to "the immediate impetus of the financial problems raised by inflation [reduction of the real value of the MIT endowment] after World War II."[9] By the mid-1950s, the affiliates program represented a $10 million annual boost to the university's teaching and research.[10] In essence, the return to a symbiotic program enabled MIT to grow and to foster economic development. By 1960, the nearby region had more high-tech activity (start-ups and employees) than any other region in the United States (Saxenian 1994).

Prior to the 1970s and the beginnings of the biotech revolution, the heart of university entrepreneurial activity was in engineering schools, such as those at MIT and Stanford. Therefore, a key role in such developments was often played by the dean of the engineering school. Frederick Terman, dubbed the "Father of Silicon Valley," spent most (1944–1958) of this key period as dean of Stanford's engineering school, where he fostered key relationships with industry and government and presided over Stanford's rise in academic ranking. Terman's opposite number at UC Berkeley during this period (1943–1959) was Morrough P. "Mike" O'Brien. Their different approaches to the job of dean combine with the institutional constraints under which they operated to make for a striking contrast. I will show that as a result, Stanford's engineering school was more entrepreneurial than Cal's, which allowed it to establish financially rewarding industry relations sooner, to hire faculty members who attracted outside funding, and to promote

7 Maclaurin to legislature, 8 December 1910, AC 13, 29, MIT.

8 Bartz to Committee on Industrial Liaison, 18 February 1949, AC 4, 118, 5, MIT.

9 Weems, "Information on the Industrial Liaison Program," 15 December 1954, AC 4, 119, 2, MIT.

10 "Industrial Liaison Program Pledges," 1 April 1956, AC 4, 119, 5; "Detailed Allocation of Industrial Grants from 1949–1950," AC 4 188 4; Little to Kispert, 10 February 1953, AC 4, 119, 1, all MIT.

start-up activities sooner—in short, making it a better candidate to anchor a high-tech region.

## Leadership

In 1937, both Mike O'Brien and Fred Terman moved into academic administrative positions for the first time, O'Brien as chair of mechanical engineering at UC Berkeley, and Terman as chair of electrical engineering at Stanford. Both men had pursued degrees at MIT, the prototype of the entrepreneurial university, at the same time (the early 1920s). The similarities end there, however. Terman earned a PhD in electrical engineering (the department at MIT with the most highly developed industry relations), whereas O'Brien's terminal degree was a B.S. in civil engineering. O'Brien accepted a position at UC Berkeley sight unseen in 1928; he was later surprised to discover that the position was in mechanical rather than civil engineering (O'Brien 1988). When Terman joined the faculty at Stanford in 1926, he knew what he was getting into; he had earned his undergraduate degree there, and his father (Lewis Terman, an eminent psychologist) had been on the Stanford faculty since 1910 (Gillmor 2004).

Differences in the backgrounds of these two men would have a profound impact on the divergent institutional paths of the engineering programs at UC Berkeley and Stanford in several ways. Terman, armed with a PhD (and the son of a professor with a doctorate) always paid more attention to graduate study and graduate students than to undergraduates—and used the production of PhDs as the ultimate arbiter of school productivity. O'Brien lacked graduate work in both his pedigree and on his CV, and during most of his years as a faculty member (the 1930s), his dean, Charles Derleth, emphasized the undergraduate curriculum for engineering (Karl S. Pister, interview with author, 1 May 2009). The respective fields of study that the two men had pursued also mattered a great deal. Trained as a civil engineer, O'Brien did most of his research on location, near a large body of water (his subfield was coastal engineering). His work relied more on terrain than on building what Terman would call a "community of scholars." By contrast, Terman the electrical engineer did his work in a laboratory, and that laboratory could—in theory—be almost anywhere. Anywhere could quickly become somewhere: in the second half of the twentieth century, clusters of high-tech companies grew up around many prominent electrical engineering programs—with the areas surrounding MIT and Stanford as the best-developed high-tech regions.

When he became dean of engineering at Stanford in 1944, Terman was the first electrical engineer to do so. He succeeded Samuel Morris, who, like O'Brien, was a civil engineer. Morris had left Stanford in 1944 to become chief engineer and general manager of the Los Angeles Department of Water and Power (Terman 1975, 116). The greatest opposition to Terman's appointment came from the civil engineering department, where faculty members harbored concerns that Terman might favor electrical engineering at the expense of other departments (Gillmor 2004, 264). If that turned out to be the case, then Terman would be just the first of their worries. Only one of Terman's five successors to 2009 has not come from electrical engineering (William Kays, mechanical). Indeed, in 2000 the university would appoint John Hennessy, an electrical engineer, as its president. Meanwhile, Cal replaced O'Brien in 1959 with the electrical engineering professor John Whinnery, signaling a similar trend beginning fifteen years later than at Stanford. As of 2009, only two of O'Brien's eight successors as dean have not come from electrical engineering (George Maslach, mechanical; Karl Pister, civil; Kuh 2007, 101).

Stanford's appointment of an electrical engineer as dean in 1944 helped give it a "first mover" advantage during the coming electronics revolution. As dean, Terman gave more attention to electrical engineering at Stanford than O'Brien did at Berkeley. Whinnery, who had joined Cal's electrical engineering faculty in 1947, recalled that "although [O'Brien] didn't ignore electrical engineering, he spent less time with electrical engineering than with any of the other major [divisions]. I suppose that's partly because of his background" (Whinnery 1996, 73). The results were striking. Terman recalled that "Stanford got a running start after the war as compared with our competitors around the country…because we had, in effect, a carefully thought-out plan that was a successful one. And [Dean O'Brien] lost two or three years in the start because he started in the wrong way" (Terman 1975, 117).

A 1956 report on electrical engineering at UC Berkeley by MIT professor Gordon Brown and Hewlett-Packard cofounder (and Stanford engineering grad) William Hewlett confirmed Whinnery's point about priorities and Terman's point about planning. Overall, they found a "lack of long-term planning," something that was never scarce in Terman's school. UC Berkeley lagged in key areas on the cutting edge of the electronics revolution such as solid-state electronics and information processing (areas in which UC Berkeley would later excel). Brown and Hewlett found that the electrical engineering division lacked depth and too many of its faculty had "improper backgrounds." UC Berkeley's approach to hiring new faculty involved a process that was too centralized and slow, and the report's authors suggested giving more latitude to the electrical engineering division chair.[11]

The ponderous process at Cal was more a leadership issue than a structural one. Across the Bay, Fred Terman had also accumulated considerable power in the dean's office—even serving simultaneously as engineering dean and provost for three years. That power concentration did not, however, coalesce into a bottleneck. Instead, Terman used it to act swiftly regarding hiring, contracts, and relationship-building. This reflected Terman's single-minded devotion to the advancement of his institution and to his academic career.

O'Brien described himself as a reluctant administrator. He spent so much time as a consultant (100 days during the 1956–1957 academic year, for instance) that his faculty viewed him as a half-time dean (Karl S. Pister, interview with author, 1 May 2009). Indeed, in 1947 O'Brien accepted a position in industry, but then changed his mind and stayed at Cal. By contrast, Terman reveled in administration and operated as if he would be at Stanford for the long haul. When he became dean, Terman's strategic plans involved a twenty-year time horizon because during that period much of the faculty and administrative leadership would turn over (Terman himself would

[11] Brown and Hewlett to O'Brien, 31 May 1956, CU 149, 40, 5, Bancroft Library, University of California, Berkeley (hereafter BL).

reach mandatory retirement age in about 20 years).[12] He received administrative offers from universities such as Cornell and Northwestern along the way, but in the end he may have seen them more as a way to advance himself at Stanford than as serious alternatives (Gillmor 2004, 138–139).[13]

At Cal, the leadership problem led to a structural solution. As Clark Kerr recalled later, UC Berkeley's "great dispersion of authority came somewhat later to engineering, as it had earlier to the rest of the campus" (O'Brien 1988, x). Budgetary authority at UC Berkeley was dispersed to department heads, so O'Brien kept engineering as a single department to maintain budgetary authority in his own hands. Alone among UC Berkeley's deans, he served as both department chair and dean, with division heads (civil, mechanical, etc.) reporting to him. This hampered the recruiting process. George Maslach referred to O'Brien as a "one-man recruiting team." It was not until President Kerr ordered O'Brien to reorganize in 1958 that the head of a department (such as electrical engineering) could initiate a faculty search (Maslach 2000, 245–247).

Terman's and O'Brien's subfields also highlighted a major contrast between the two engineering programs. UC Berkeley, as a public university, was imbued with a sense of public service to the state (which was reflected in its concern with state infrastructure). Stanford, as a private institution, had priorities less defined by the boundaries of the state and was free to focus on programs and relationships that would attract resources to improve the university. This would have an impact on the extent to which their respective engineering programs could (or could not) focus on strategic objectives. It was fitting that during this key period, Stanford's dean was an electrical engineer and Cal's was a civil engineer. As Albert Bowker, who was a statistics professor at Stanford from 1947 to 1963 and later served as chancellor at UC Berkeley, noted, "Stanford wouldn't have very much development in anything that the federal government wouldn't support, like, say, road construction or civil engineering…You usually find that more typically in land-grant universities…Berkeley traditionally has had to have engineers for roads, sewer systems, and whatever the state needs" (Bowker 1995, 140).

At UC Berkeley, there were few fields that were as logical vessels for public service as civil engineering. One of those few was agriculture. According to O'Brien, "the University of California [rode] the reputation of its College of Agriculture. The majority of [members of] the Senate and the Assembly in Sacramento were from farm counties, and they were so impressed with the work done by Agriculture that anything the university asked for, it got" (O'Brien 1988, 47). Mike O'Brien admired the public service model of Cal's College of Agriculture, which, he wrote, "serves agriculture, and the people of the state generally, in a manner which Engineering should emulate."[14] Research activities in agriculture alone consumed more than half of all university-sponsored dollars but

[12] Terman to Davis, 29 December 1943, SC 160, I, 1, 2, Stanford University Archives, Stanford, CA (hereafter SU).

[13] Terman to Sterling, 7 April 1953, SC 216, 39, 24, SU.

[14] O'Brien, "Post-war plans of the department and college of engineering," 22 June 1944, C 39, 5, 24, BL.

netted less than 5% of contract research. So O'Brien pushed for a model of resource gathering that relied heavily on state funds, which in turn required responding to the needs of the state's constituents.[15]

Stanford was more proactive. Strategy guru Michael Porter has argued that "setting limits is another function of leadership," and that leaders must make necessary tradeoffs to pursue a fruitful strategy, "to provide the discipline to decide which industry changes and customer needs the company will respond to, while avoiding organizational distractions" (Porter 1996, 77). Terman opposed, for instance, accepting government contracts that did not advance Stanford's academic program or enhance the reputation of its faculty (Lowen 1997, 115). He also opposed accepting subcontracts from industry that would involve the university's ceding control over the research.[16] Fred Terman's primary goal was to build the institution of engineering at Stanford (and later the overall university), and he would allow little from inside or outside the university to distract him from that goal. A telling example came in 1955, after Stanford's unilateral severance of an agreement to build a 500-bed hospital in Palo Alto. Terman wrote, "The primary function of the Medical School is to educate and not to render medical service; excessive service…deviates from research…activities of the faculty" (Vettel 2006, 57).

## Strategy and Resources

One of the hallmarks of the entrepreneurial university, writes Burton Clark (1998), is pursuing a clearly defined strategy. Terman did just that; in essence, he set out to establish an entrepreneurial engineering school. He presciently recognized that universities would become central players in the coming knowledge economy. "Industry is finding that for those activities that involve a high level of scientific and technological creativity," he wrote, "a location in a center of brains is more important than a location near markets, raw materials, transportation or factory labor."[17] Ideally, that center of brains would be Stanford, creating a virtuous cycle. "The idea is to get lots of good Stanford people well placed in industry," he wrote. "And then as time goes on and they begin to work up to responsibility, see that they hire good Stanford men to work for them, and so on ad infinitum."[18]

Part of Terman's effectiveness as an administrator derived from his focus on fields of study that he believed would have a "big" future, such as electronics. It also derived from his ability to choose not to pursue "distractions" that would have "small" futures.[19] Toward that end, he was willing to push the limits, such as suggesting the firing of two engineering professors whose field of study was illumination. The reason: Stanford could get "more for its money" from professors in other fields. Stanford's president, in support of the tenure system (if not the

[15] Kerr to Sproul, 20 February 1953, table 2, CU 5, 4, 28, 7, BL.

[16] Terman to Larson, 21 May 1951, SC 160, 2, 18, 8, SU.

[17] Terman speech, 5 November 1963, SC 160 8, 3, 3, SU.

[18] Terman to Davis, 29 December 1943, SC 160, 1, 1, 2, SU.

[19] Terman to Morris, 18 June 1945, SC 160, 1, 1, 8, SU.

individual professors), denied Terman's request.[20] Although Terman did not always get what he wanted, perhaps his biggest luxury at Stanford was the ability to avoid "distractions" and to focus on the "customers" he wished to.

Cal did not provide that level of autonomy but had many resources that Stanford lacked. Divergent approaches to resource gathering embodied yet another contrast between the engineering programs at UC Berkeley and Stanford. For UC Berkeley, the default mode for seeking funding (at least until the 1970s) was focused on state government, whereas Stanford received no money from the state of California. The search for resources was perennial at Stanford's engineering school because in the 1930s and 1940s Stanford University was in a nearly constant budget crisis. Salaries of Stanford faculty were low compared to salaries at other research universities, and resources for research were scarce. In 1927–1928, UC Berkeley's funding for research was $112,000, compared to Stanford's $3,300 (Matkin 1990, 36).

Budgets were sufficiently tight in engineering at Stanford in the 1930s that when the roof of the electronics laboratory leaked, the solution, instead of repairing it, was putting out wooden trays lined with tar paper to catch the water. This became a running joke to such an extent that Bill Hewlett brought some goldfish to live in the trays (Gillmor 2004, 137; Malone 2007, 37). Terman later noted that Samuel Morris, Stanford's dean of engineering in the 1930s, "didn't have any resource to distribute" (Terman 1975, 9).

Meanwhile, UC's president, Robert Gordon Sproul, who had become familiar with the workings of the state legislature as the university's chief financial officer in the 1920s, had gone over the heads of the legislators to speak directly to the voters, as in a radio address in April 1933 (less than one month after President Roosevelt's first fireside chat). Sproul also had encouraged UC Berkeley students to have their parents appeal to their state legislators. Such efforts helped to shield the University of California from the sort of budget crisis that Stanford faced in the 1930s and 1940s (Stadtman 1970, 259). Even by the standards of public universities of the time, the University of California was an extreme case in terms of its reliance on the state for funding. During the period just prior to World War II, UC received almost 70% of its funding from the state, whereas a contemporary study found that 57 public universities received an average of just over 50% of their funding from their respective states.[21] Awash in public funds, by 1940 UC Berkeley's research spending was among the top five universities in the country, while Stanford was still, as Stuart Leslie puts it, a "benchwarmer" (Matkin 1990, 31; Leslie 1993, 12).

During the 1940s and 1950s, UC pursued a strategy aimed at protecting its resource base. There was a lot to protect. Some states (including California) emerged from World War II in strong fiscal condition, and many public universities reaped the benefits. In the period 1945–1955, capital spending at public universities exceeded that at private universities by 50–80%, and UC Berkeley's spending per student more than doubled. Cal's deeper pockets proved a boon to its core capabilities of teaching and research, whereas Stanford suffered from what

[20] Terman to Wilbur, 16 March 1941, SC 38, 18, SU.

[21] Hill to Sproul, 29 October 1952, CU 5, 4, 28, 6, BL.

President Wallace Sterling referred to as “a kind of chronic malnutrition” (Geiger 1993, 42, 74, 118).

The financial disparity between the two universities was particularly acute in their respective engineering schools. In January 1947, Terman reported to Sterling’s predecessor, Donald Tresidder, that “there is not a single member of the School of Engineering faculty…who will draw as much salary during the year 1946–47 as would his opposite number at the University of California with the same rank and years of service.” As of 1947, minimum salaries for UC Berkeley full professors in engineering exceeded those at Stanford by 33%, associate professors by 20%, assistant professors by more than 10%, and instructors by 20%. As if that were not difficult enough to swallow, Terman added that about half of Stanford’s engineering professors made less money than their counterparts at San Jose State College, which was not accredited by the Engineering Council for Professional Development.[22] The cash-strapped Stanford’s consolation prize, however, was a tradition of entrepreneurial activity, especially in the School of Engineering, that would serve it well as the future academic anchor of Silicon Valley.

In the wake of and in response to the budget crisis, Stanford developed symbiotic relationships with industry, becoming a “permeable” university (Christophe Lécuyer’s term, which he applied to MIT). Terman employed the sort of bootstrapping that would make entrepreneurs proud (Lécuyer 1995; Carlson 1988). He convinced several established national firms to donate equipment to the school. In seeking money for fellowships, he tried seemingly everything—including using photos of the products of a prospective contributing firm in his textbook *Radio Engineering* (Leslie 2000, 49–50). After World War II, Terman became identified with a series of industry outreach programs that were designed not just to be financially self-supporting, but to be money makers. Stanford Industrial Park, which Terman did not initiate but in which he became a key player after its start in 1951, brought leasing income from dozens of firms by 1960. The Honors Cooperative Program, established in 1953, required member companies to pay tuition plus a per student fee of about $10,000. Terman limited the number of employees each firm could enroll, which was partly a function of how much the firm contributed to Stanford’s electrical engineering program.[23] Another example was the Industrial Affiliates Program, which John Linvill (whom Terman had recruited to establish solid-state electronics at Stanford) created in the late 1950s. Companies paid Stanford annual fees to gain access to Stanford-developed technology in advance of publication as well as the opportunity to meet (and recruit) Stanford students (Adams 2005, 41–42).[24]

Terman also engaged in “salary splitting,” placing the burden on faculty members to raise much of their own money (Lowen 1997, 150–157; Ronald Bracewell, interview with the author, 21 November 2006). Maslach noted that for

[22] Terman to Tresidder, 8 January 1947, SC 165, 3, 3, 6, SU.

[23] “Honors Cooperative Program in Electrical Engineering: 1957 Situation,” 28 January 1957, SC 160 3, 31, 6, SU.

[24] Terman to R. Shank, 9 September 1958, SC 160 3, 18, 1; Press release, 3 December 1959, SC 160, 3, 18, 1, both SU.

many professors at "private universities such as MIT and Stanford…50% of their time comes from grants and contracts, and 50% of their salary comes from tuition and so on." In that respect, Maslach observed, "private universities are quite different from public universities" (Maslach 2000, 203). Such leveraging of faculty members engaged in sponsored research would be quite common nationwide by the 1960s; in California, the major private engineering schools (Cal Tech, Stanford, and the University of Southern California) all did it. Albert Bowker recalled that at Stanford in statistics, "most of us were heavily in a percentage on what would be called soft money, even though some of us had tenure-bearing ranks…Berkeley was much more conservative in those years. On the other hand, it had lots more money than Stanford" (Bowker 1995, 133).

The University of California had a policy against faculty earning extra compensation for contract research during the academic year.[25] Rather than fighting such a policy, the engineering school embraced it. As Dean O'Brien recalled, "My most important contribution to the engineering college was to put the whole engineering faculty on the university budget, on hard money, state money…We didn't want to get in the position where we were scrambling to get money and then taking any kind of contract we could get to pay faculty. We are unique today in that respect. The faculty here are quite happy about this" (O'Brien 1988, 34). Maslach, who was a professor under O'Brien, agreed: "We at the University of California are extraordinarily lucky to have the system that we have had, in which we are able to do research, public service, and teaching" (Maslach 2000, 203).

The result of these contrasting systems was a self-selecting contrast in the faculties of the respective schools. Cal's tended to be more internally focused and risk averse, whereas Stanford's were more externally focused and entrepreneurial. They knew that it was their responsibility to bring in resources, and in so doing they enhanced the university's relations with industry. Much of UC Berkeley's approach to gathering resources continued to involve petitioning the state for more or battling for a larger share of California's public education pie. Indeed, for a long time UC feared "substitution:" the idea that amounts of money raised from private sources would be subtracted from the university's portion of the state budget (Richard C. Atkinson, interview with the author, 18 May 2009; Karl S. Pister, interview with the author, 1 May 2009).

For years, the UC leadership had been concerned that the state college system might trespass on the University's domain (for example, by offering graduate programs). For instance, Dean Norman Gunderson of San Jose State's engineering school recalled confronting Cal's objections "to, what they called, the dilution of state resources."[26] One of the difficulties was that the University and the state colleges reported to different governing bodies. In 1945, the State Board of Education (which had jurisdiction over the state colleges) and the Board of Regents of the University of California established a Liaison Committee to balance the

[25] Kerr to Sproul, 20 February 1953, CU 5, 4, 28, 7, BL.

[26] Gunderson oral history, 1987, San Jose Folio LD 729.6.S4 G86 1987, San Jose State University Archives, San Jose, CA (hereafter SJS).

interests of California's various levels of higher education. That did not, however, stop the striving of the state colleges, on the one hand, or the exclusionist efforts of the University of California, on the other.

By the late 1940s, California's state colleges were offering graduate programs in several subjects—but not in engineering, and that is where the University of California would ultimately make its stand. Therefore much of the attention of Dean O'Brien and Associate Dean Howe was external (as was Fred Terman's), but instead of forging relationships with high-tech industry, O'Brien and Howe were battling a rear-guard action against other institutions of higher education. One of their key arguments was that UC Berkeley and UCLA could meet all of the state's higher-level needs in engineering education without state colleges entering the arena.[27]

Whether the University of California or the state colleges were correct regarding the nature of demand for additional engineering educational offerings (including at the graduate level) would be debated in earnest from 1945 until the state legislature approved the California Master Plan for Higher Education in 1959. The key point is that leaders at UC's College of Engineering had limited time to devote to any issue. Jurisdictional battles made a huge claim on O'Brien's time, requiring that he serve on several committees and attend countless meetings. Therefore, even if O'Brien entertained aspirations to do what Stanford was doing with industry, the institutional context in which he operated would have distracted him from such entrepreneurial activity.

As it was, the goals of Cal and Stanford in engineering were quite different. During the mid-1940s, Terman and O'Brien each wrote strategic statements for their respective schools of engineering that reflected their contrasting priorities. In June 1944, O'Brien wrote a report titled "Post-War Plans of the Department and College of Engineering." The eleven-page document mentions electrical engineering only in passing. Instead, the document's plans for expansion (in curriculum, facilities, and staff) focus on chemical engineering, engineering physics, industrial engineering, ceramic engineering, and metallurgy. UC Berkeley's role with respect to industry research and development, O'Brien wrote, should be greatest "with companies and associations of companies too small to support a research organization…Many small companies cannot afford research programs which may require more than their accumulated reserves before a profitable conclusion is reached."[28] Implicitly, the flow of resources was from UC Berkeley's College of Engineering to industry.

By contrast, the strategic manifesto Terman wrote as part of his annual report to the president of Stanford wrapping up the 1946–1947 academic year indicated that Terman was always aware that Stanford needed to go where the money was. It would be easier to build a strong program by attracting money from established firms than by serving firms that were strapped for cash. Terman's report was very explicit about this: "If western industry and western industrialists are to serve their

[27] O'Brien and Boelter to Sproul, 14 September 1949, CU 5, 4, 16, 3; Howe to Sproul, 8 December 1950, CU 5, 4, 16, 3; O'Brien to Sproul, 2 March 1951, CU 5, 4, 16, 3; Howe and O'Brien to Sproul, 14 May 1951, CU 5, 4, 16, 3; O'Brien to Sproul, 17 December 1952, CU 5, 4, 16, 3; "Minutes of Technical Advisory Committee," 10 December 1952, CU-5, 4, 16, 3, all BL.

[28] O'Brien report dated 22 June 1944, CU 39, 5, 24, BL.

own enlightened and long-range interests effectively, they must cooperate with western universities and, wherever possible, *strengthen them by financial and other assistance*" (emphasis added).[29] O'Brien saw industry outreach as primarily a service to *industry*, whereas Terman saw it as an opportunity to build and strengthen the *university* (Adams 2005). In short, O'Brien's model of industry outreach was a political one, looking to curry favor in Sacramento, whereas Terman's was more businesslike and symbiotic—or, as Etzkowitz would describe it, an "interactive model of innovation" (Etzkowitz 2003, 116).

As dean of engineering at a one-campus private university, Terman could focus on the strategic issues he chose. He set out to establish two things: "steeples of excellence" and "communities of technical scholars." "Steeples of excellence" referred to a conscious choice to establish a limited number of visible fields of top-notch expertise, as opposed to an attempt at comprehensive coverage. Decades before Lynn Zucker published studies showing a correlation between technical academic stars and a proliferation of start-ups in the vicinity of research universities, Terman pursued top-notch talent, with the belief that they would bring along—and attract—superb academicians as well as funding from government and industry (Zucker and Darby 1996). Terman used the analogy of high jumping: would you rather have one star who could jump six feet or two lesser lights who could each jump three? (Gillmor 2004, 255)

Terman liked to talk about Stephen Timoshenko, an expert on theoretical and applied mechanics, who had been a professor at the University of Pittsburgh. When this star expressed interest in coming to the West Coast, a bidding war broke out between Stanford and Cal. Stanford won, and Terman considered Timoshenko a bargain at twice the salary of an associate professor.[30] Stanford would continue recruiting selected stars to establish other steeples of excellence (such as John Linvill in electrical engineering). Cal took another tack. "This convinced me," O'Brien said, "I should never again try to get a senior professor who had his position established; the heck with that. From then on, I didn't recruit anybody as a [full] professor" (O'Brien 1988, 66). The result was a strategy focused on growing his own talent, which meant less likelihood of hiring professors who already had key industry relations or who brought external funding with them.

Terman's other principle was "communities of technical scholars," the idea of establishing a high-tech cluster near the university—an idea that Cal's O'Brien never publicly espoused. Terman's version of Stanford's third mission was: "great universities which have strong programs in engineering and science, surrounded by companies emphasizing research and development, under conditions where there is continual interaction among all of the components—some formal, some informal, some organized, others unorganized" (Terman 1965, 291).

A good example was General Electric. In 1953, GE approached Terman with a project involving microwave tubes. Terman responded, "Some…contractual activities of a research character are difficult to handle when the cooperating parties are widely separated geographically. This would of course not be the case if

[29] Terman 1947 annual report to President Tresidder, LD3002.A1 44 TH 1946/47, SU.

[30] Terman to Davis, 29 December 1943, SC 160, 1, 1, 2, SU.

the Electronics Division of G.E. found it feasible to establish a research laboratory of its own close to Stanford."[31] GE subsequently moved into Stanford Industrial Park, hired Stanford electrical engineering graduates, and sent employees to the Honors Cooperative Program. Only one year after moving its division to Stanford, GE would credit Stanford graduates in its employ with attracting to the company contracts worth nearly $300,000. A GE official wrote to Terman, "We owe Stanford University more than we can ever repay."[32] With rent at the Industrial Park, Honors Cooperative Program tuition, and Industry Affiliates Program fees, however, Stanford had already been paid handsomely.

This had more to do with networking than public service, and was also closely related to Terman's efforts to build engineering at Stanford. Need local jobs for Stanford grads? Cultivate a relationship with Hewlett-Packard. Need the latest in semiconductor technology? Cultivate a relationship with Shockley Semiconductor (James F. Gibbons, interview with the author, 7 January 2005; Lécuyer 2005). Need funds to establish teaching positions? Cultivate a relationship with Lockheed. In return, Stanford was able to offer each of these firms access to the technology Stanford developed or first shot at hiring its graduates—and in addition, each paid Stanford rent as a tenant of the Industrial Park.

The underlying similarity of all of these relationships was that they brought valuable resources to Stanford. This was no charity operation; rather, it represented what Etzkowitz (2003, 116) calls a "confluence of interests." Terman's Stanford sought to tap deep pockets more than to improve the public welfare. The irony is that the institution less conspicuously dedicated to public welfare ended up as anchor of the world's foremost high-tech region, a bonanza of job creation and regional/national economic growth, and the source of technologies that would be instrumental in improving productivity.

## Organizational Structure and Process

One of the characteristics of an entrepreneurial institution is the ability to respond quickly to opportunity. A centralized, hierarchical structure can be anathema to entrepreneurial activity—both in industry and in academia. At the same time, an institution with an insufficiently coordinated multilocational structure, where the responsibilities of each part are not sufficiently clarified, can get in its own way. Such was the experience in engineering at the University of California in the 1950s. The establishment of additional UC campuses combined with the growth of the California state college system to create both geographic and hierarchical jurisdictional issues. These issues shaped some of the key differences between industrial relations at Cal's and Stanford's engineering programs.

A centralized approach to administration had worked well when UC Berkeley *was* UC. Robert Gordon Sproul had been the right man at the right place in the early years of his long tenure as president of the University of California system

[31] Terman to I. J. Kaar, 2 July 1953, SC 160 2, 18, 8, SU.

[32] H. R. Oldfield to Terman, 3 January 1955, SC 160 2, 18, 8, SU.

(1930–1958). His style of management was not as effective as the system grew. Sproul essentially clung to a micromanagement style suited to a smaller enterprise—sometimes a much smaller one. In 1940, for instance, UC Berkeley's dean of engineering Charles Derleth needed to obtain permission from Sproul to spend $200 (from Derleth's own budget!) on a mimeograph machine.[33]

Cal chemistry professor Joel H. Hildebrand, addressing the faculty senate in 1943, said: "The fact is that the president divides his attention between seven campuses and numerous public affairs. Even a department chairman may have to wait days for an interview and weeks for a decision. The administration seems to be trailing its business rather than steering it. There is little leisure for long-range planning. There is little delegation of authority, even when the President is absent. The government is then carried on by mail" (Kerr 2001, 462). Not the ideal setup for moving in new directions to seize opportunity presented by the coming knowledge economy.

Insufficient delegation continued to be a problem in the 1950s. In January 1955, for instance, Sproul responded to a memorandum from UC Berkeley chancellor Clark Kerr about student research funds in the Electrical Engineering Division. Sproul's three-paragraph memo contradicted itself and left the issue unresolved. A member of Kerr's staff sarcastically called Sproul's response "a classic," and complained, "We've been trying for two years to get Sproul to reshuffle the budget to better allocate teaching and research costs. Not even a good answer to our proposals. We're only talking about $5,000 in a $23 million budget!" Kerr simply responded, "Just forget it."[34]

The centralized decision-making apparatus within the University of California could act as a brake when compared to the simpler structure and reporting relationships at Stanford. Karl Pister, an engineering professor at Cal in the 1950s and later dean of the school, describes the dean's position at Cal as a "middle manager" in terms of authority, in comparison to the "executive" role played by the dean at Stanford (Karl S. Pister, interview with the author, 1 May 2009). When it attempted to obtain external funding, process problems plagued Cal's engineering school. Contract research at UC Berkeley in amounts greater than $1,000 required approval from the president's office. H. A. Schade, the director of Berkeley's Institute of Engineering Research, expressed frustration that "the approval seems to be purely nominal, but obtaining it is time consuming."[35] Dean O'Brien took the same view, complaining to Sproul that "the imposition of additional layers of surveillance and authority over individual research projects constitutes an abridgement of the freedom of research on the part of the individual engineering faculty members."[36]

In February 1951, this unwieldy process had a tangible impact. Schade described to O'Brien how the "ponderous complexity of the current system" sabotaged UC Berkeley's efforts to garner contracts in a particular field: "Stanford Research

[33] Derleth to Sproul, 2 December 1940, CU 5, 2, 1940, 408, BL.

[34] Sproul letter to Kerr, 17 January 1955, CU 149, 40, 5, BL.

[35] Schade to O'Brien, 8 February 1951, CU 5, 4, 28, 3, BL.

[36] O'Brien to Sproul, 17 July 1950, CU 5, 4, 28, 3, BL.

Institute was well started on their underwater explosion research project," he noted, before Cal's institute "was able even to get approval of the graduate Dean's office for the Berkeley proposal." Therefore, Cal was "several months late in getting started," and forfeited an opportunity to engage in a field of technology "important to national defense."[37]

By contrast, a keen sense of urgency in the engineering school helped move Stanford into the top three university recipients of sponsored research funding from the military (Leslie 1993, 60). In the months following the outbreak of the Korean War in 1950, Terman proposed creation of an applied engineering laboratory "between fundamental research and industrial development." The lab would perform defense work, which other institutions would desire: "If there is a delay of even one month," he wrote, "we are likely to be passed over for the present and may then never regain our present position."[38] Stanford's board approved the contract ($750,000 for two years) with little debate (Leslie 1993, 60).

Stanford demonstrated the same sense of urgency in dealing with industry. On 31 July 1956, Terman wrote to Willis Hawkins, the "keystone" of engineering at Lockheed, about a possible joint appointment of Nicholas Hoff to Stanford's faculty and Lockheed's staff. A professor at Brooklyn Polytechnic Institute, Hoff had declined a full-time position at Lockheed that had not included an academic affiliation. Terman found a way to add Hoff to the Stanford faculty, while having his salary paid by external sources. Hawkins had written a proposal on 12 July, and Terman apologized profusely for responding so late (key individuals Terman needed to contact had been on vacation). The upshot was that Terman had gotten the necessary approvals of the president and the board of trustees—all in less than three weeks.[39] This reinforced a point that Terman had made in one of his first annual reports as dean of the engineering school: "Stanford, as an independent university, has the flexibility essential to carrying out its special mission."[40]

Engineering at Cal was a different story. Instead of focusing attention and resources on strategic objectives, as the leadership at Stanford's engineering school did, Cal's engineering leadership was pulled in many directions. In addition to dealing with bottlenecks within the university, the school answered to the vast constituencies of the University of California. Nominally, the Board of Regents operated relatively free of legislative interference because the legislature was uninvolved in the appointment of regents. Nevertheless, the University of California was not protected from political winds—especially when its primary source of funding seemed at risk.

Cal's predicament is best exemplified by an ill-fated venture in what would become Silicon Valley. Fittingly, the actions of Stanford University acted as a catalyst. The creation of Stanford Industrial Park in 1951 resulted in the ability of some tenants to attract employees based on proximity to Stanford. In 1954, Stanford

[37] Schade to O'Brien, 8 February 1951, CU 5, 4, 28, 3, BL.

[38] Terman to Sterling, 12 September 1950, SC 216, 38, 38, SU.

[39] Terman to Hawkins, 31 July 1956, SC 160, 3, 38, 1, SU.

[40] Terman 1947 annual report to President Tresidder, LD3002.A1 44 TH 1946/47, SU.

formalized its Honors Cooperative Program, aimed at providing employees of local companies with graduate engineering training and degrees (Gillmor 2004, 305).

In establishing the co-op program, Terman demonstrated a keen understanding of supply and demand for academic services. Therefore, Terman made sure that the Honors Cooperative Program retained the properties of a scarce resource by consciously scaling the program short of completely meeting demand. This meant that some companies were limited to fewer spots in the program than the number of their employees who expressed interest, and other companies with willing employees were left out entirely. At UC Berkeley, Dean O'Brien observed that the selectivity of Stanford's Honors Cooperative Program "left the companies in a difficult position because [Stanford] enhanced the desirability of graduate study but excluded many of the employed engineers who desired to enroll."[41]

The local market responded quickly to the restrictions of Stanford's program. In October 1954, a month after the program's formal inception, IBM (which had opened a San Jose research facility in 1952) and the San Jose–based Food Machinery Corporation (FMC) requested that Cal create a graduate engineering program in the valley.[42] Representatives of the University of California were dubious about the demand for such a program.[43] Without a powerful champion, the initiative rattled around offices of the dean of engineering, the Graduate Division (north and south), the UC Berkeley chancellor, and the president of the University.

In 1957, after waiting for almost three years, local employers stirred the pot again. This time, instead of asking just the University of California to provide graduate education in the valley, representatives of IBM, Westinghouse, and FMC approached San Jose State with the same request.[44] After dragging its feet regarding the new program, UC pursued a quite visible full-court press to prevent San Jose State from meeting the need. That's when local assemblyman Bruce Allen brought the issue to the attention of the Board of Regents and Governor Goodwin Knight, and proposed legislation to allow state colleges to seek accreditation and to grant master's degrees (Hasegawa 1992, 67–68).[45] Creating the new graduate engineering program then became a means of fending off San Jose State's offensive. In a reflection of how central jurisdictional issues had become, UC's Vice President Stanley McCaffrey argued to the Regents' Committee on Educational Policy that if the university moved quickly to meet the need for graduate engineering courses in Santa Clara Valley, it could "sidetrack efforts by the state colleges to do so."[46]

The Regents approved the program in May 1958, and the Cal administration pressed ahead even though the legislature did not provide funding to house the

[41] O'Brien to Kerr, 11 March 1958, CU 149, 40, 5, BL.

[42] Haitt letter to Merriam, 13 April 1958, CU 149, 40, 5, BL.

[43] "Off campus graduate instruction in engineering," 14 July 1958, CU 149, 40, 5, BL.

[44] McDowell to Allen, 23 July 1957, MC 193, unlabeled binder, SJS.

[45] Allen to Knight, 5 August 1957, CU-5, 4, 16, 5; and 10 March 1958, CU 5, 2: 1957, 4, both BL.

[46] McCaffrey had made sure to remind Allen that there was more at stake for his region than a possible upgrade for engineering at San Jose State. McCaffrey letter to Sproul, 14 October 1957, CU 5, 4, 16, 5, BL. Until 1960, San Jose was the preferred location for a new south central coast UC campus, which ultimately went to Santa Cruz. Conference on university expansion, 23 June 1960, CU 5, 8, 10, 10, BL.

program. This meant that the program would lose money for UC Berkeley at the same time that Fred Terman's industry outreach programs were attracting vast resources to Stanford. This put Dean O'Brien, who had supported the program until 1956, and then reversed course based on doubts regarding demand, in the position of pitting the university's jurisdictional political interest against his own judgment.[47] In July, O'Brien announced that he would discontinue efforts to establish the program. Kerr, who had just become president of the UC system, called O'Brien's announcement "insubordination." It is a reflection of the importance to the University of protecting its primary source of funding that this one act, more than any other, would cost O'Brien his deanship. Under pressure from President Kerr and other university officials, in the fall O'Brien announced his planned resignation as dean and retirement from the faculty.[48]

O'Brien turned out to be prescient about demand for the program: although a spring 1958 survey of local employees indicated that more than one hundred would enroll in the program, only seven students completed the Sunnyvale course in the fall of 1958, and only nine enrolled in the spring of 1959.[49] In early 1959, before the first academic year of the new program was complete, Kerr announced the program's termination. He cited three factors: demand, supply, and jurisdiction. Representatives of local companies had not shown sufficient interest in the program. The College of Engineering reported that few faculty wished to participate. Most important, the Engineering Council for Professional Development had accredited San Jose State's civil and electrical engineering programs, and San Jose State had established a master's program in electrical engineering (Kerr 2001, 81). The university had lost its battle to prevent the state colleges from offering graduate programs in engineering.

It is clear that Terman was the right man at the right time to establish an entrepreneurial engineering program at Stanford, and that O'Brien would not have been. Yet O'Brien's experience at Cal also shows that Terman had a distinct advantage as dean at a one-campus private institution—especially during the years when the state of California was sorting out responsibilities for its various levels of higher education. If Terman had been at Cal during the 1940s and 1950s, it is hard to imagine that he could have had anything close to the impact as an academic entrepreneur that he had at Stanford. At Stanford Terman had the luxury, which O'Brien lacked at Cal, of judging each commitment to industry based solely on what he perceived as the merits: the extent to which the relationship would improve Stanford University's financial situation and enhance its academic horsepower.

## Conclusion: The Entrepreneurial Public University?

What are the lessons to be gleaned from the contrast between Cal and Stanford during Silicon Valley's formative years? Having an excellent engineering program

[47] McConnell to Kerr, 13 November 1957, CU 149, 40, 31; O'Brien to Kerr, 11 March 1958, CU 149, 40, 5, both BL.

[48] Kerr to O'Brien, 21 November 1958, CU 5, 8, 76, 14, BL.

[49] "Proposal for off-campus graduate program," June 1958, CU 149, 40, 5, BL.

is necessary but not sufficient to make a university entrepreneurial. Leadership is also essential in developing and implementing the right strategy. Being entrepreneurial not only is based on deploying resources toward promising opportunities but also involves the autonomy to choose those opportunities. Organizational barriers, incentives, attitudes, and policies can make a tremendous difference.

Can we conclude from this study that public universities are ill-equipped to become entrepreneurial institutions? Richard C. Atkinson, president emeritus of the University of California, had the sort of experience that could help answer that question. Atkinson served as a faculty member at Stanford beginning in 1956, when Terman was engineering dean and provost. Atkinson later recalled that he was "able to apply the knowledge I gained from Fred's work at Stanford years later [in 1980] when I became chancellor of the University of California, San Diego (UCSD). I sought to use the 'Terman Model' as a roadmap for UCSD's partnerships with the telecommunications and biotechnology industries that were beginning to spring up in the region…We were successful in San Diego, and I owe a debt of gratitude to Fred Terman for providing me with a perspective on the evolving role of the research university" (Gillmor 2004, ix).

Granted, much had changed between the 1950s and the 1980s, when a cluster of companies with connections to UCSD began to appear. At universities in the Bay Area (particularly Cal, UCSF, and Stanford) as well as elsewhere, biotechnology had emerged as a major growth area of university "entrepreneurial" activity, and therefore the arena for such activity had expanded beyond the realm of engineering schools. Offices of technology licensing had proliferated at many universities, and the Bayh-Dole Act had provided universities with the opportunity to reap economic benefits from technology developed as part of federal government contracts. In California and elsewhere, public research universities experienced cutbacks in the flow of money from the state. Universities that had once relied on state government for the lion's share of their funding now were receiving one-third, one-fifth, or—in the case of the University of Virginia—less than 10% of their total budgets from state government (Dillon 2005). As Clark Kerr noted, "Multiversity I (federal riches at the national level [during the 1950s and 1960s]) has given way to Multiversity II (poverty at the state level [by the 1990s])" (Kerr 2001, 177, 164–176).

Nowhere was this shift more dramatic than in the state of California. After the period examined in this article, when the state of California provided generous support to the University of California, things changed markedly. During the 1970s, reductions of state funding to the UC system included a denial of funds for expansion of research capabilities in UC Berkeley's electrical engineering department. In 1975, Dean Ernest Kuh responded by beginning an informal industry liaison program that was aimed at raising money for laboratories and other research-related facilities (Kuh 2007, 99). Kuh began by establishing an industry advisory committee, with representatives from Bell Labs, GE, and IBM, among others. The primary goal was, as it had been at Stanford in the 1950s, to garner additional resources from industry. "They are big companies," recalled Kuh, "and [once they see the need] it is easy for us to ask them to support us so that we get additional funding." The program also allowed students to mingle with engineers from industry and learn about the sorts of problems they worked on. And it also helped the faculty attract industry research grants. The program, noted Kuh, represented a sea change for Cal's engineering program: "Research money came from industry, starting at that time. Before they figured UC is a state public university that didn't need money" (Kuh 2007, 59–61). As dean of engineering, Kuh followed up with a formal industry affiliates program for the College of Engineering beginning in 1979, with 160 members. Although Cal came to the industry outreach party late, it did so in style (Kuh 2007, 87, 98–100).

The experience of engineering at Cal suggests the extent to which public universities may have more movable parts (additional levels of hierarchy, political constituencies, and jurisdictional concerns) than private universities do. Kuh's response, as well as developments in biotechnology in the Bay Area and in San Diego, would suggest that simply being a public university does not preclude entrepreneurial activity. Instead, it is the institutional habits of organizations that matter. The cases of Stanford and Cal in the 1940s and 1950s, as well as the experiences of MIT and Johns Hopkins, all suggest that a necessary requirement for the entrepreneurial university (public or private) involves where its principals look when they need money to build up technical programs. Devoting primary attention to the state capital may provide political rewards, but it also may delay the development of entrepreneurial capabilities oriented toward industry and regional economic growth.

Public universities are increasingly expected to promote economic development in general, and specifically to anchor high-tech regions. Meanwhile, states increasingly complain about brain drain: the idea that their public universities invest in educating individuals who then move away to enter the knowledge workforce and contribute to economic growth elsewhere. Rising expectations of public universities fostering regional economic growth accompany a trend toward the "privatization" of public universities in the United States. Hence, the comparison of Stanford and Cal in the 1950s becomes increasingly relevant to today's policymakers. The ability of some public universities to apply a Terman-like model suggests a rich line of further inquiry that would include anchors of high-tech clusters such as Atkinson's UC San Diego, the University of Texas, and the University of North Carolina (Link 1995).

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