Boundaries and Quandaries:
Professors Negotiate Market Relations

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University of Houston Law Center/Institute for Higher Education Law and Governance (IHELG).

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So the hallmark of the current form of global capitalism, the feature that sets it apart from earlier versions, is its pervasive success: the intensification of the profit motive and its penetration into areas ... previously governed by other considerations. Non-monetary values used to play a larger role in people's lives; in particular, culture and the professions were supposed to be governed by cultural and professional values and not construed as business enterprises. To understand how the current global capitalist regime differs from previous regimes, we must recognize the growing role of money as intrinsic value. It is no exaggeration to say that money rules peoples' lives to a greater extent than ever before (George Soros, *The Crisis of Global Capitalism*, pp. 115-16).

Since the early 1990s, many science and technology policy analysts have made the case that structural changes in the global economy have increasingly privileged knowledge as intellectual property. Scholars and policy analysts now see academic science and technology as critical to firms' and enterprises' intellectual property strategies and as central to U.S. competitiveness in global markets (Gibbons 1994, Slaughter and Rhoades 1996, Council on Competitiveness 1996, Brooks 1996, Branscomb 1997, Slaughter and Leslie 1997, Stokes 1997, Etzkowitz, Weber and Healy 1998). Income from faculty's intellectual property is increasingly important to university revenues (National Science Foundation 2000). Most U.S. research universities have developed a broad array of relations with corporate partners (Cohen, Florida and Goe 1994, Florida and Cohen forthcoming).

A number of surveys have examined the impact that increased interactions with industry may be having on scientists' and engineers' norms and values (Blumenthal et al 1986, 1997). While early surveys showed little change with regard to norms and values (Blumenthal 1986), later surveys revealed patterns of contradictory responses, suggesting that changes which have not been captured by survey instruments may be occurring (Louis, Anderson and Rosenberg 1995, Blumenthal et al 1997, Campbell 1997, Lee 1997). While there are several historical studies (Etzkowitz 1988, Kleinman 1995), as well as studies employing interviews with small numbers of scientists and engineers, often at a single institution (Rhoades & Slaughter 1991, Slaughter & Rhoades 1990), there are still few qualitative studies of academic scientists' and engineers' interactions with industry (for an exception that deals with the United Kingdom, see Cohen, McAuley and
Duberley 2001).

Although relatively few academic scientists and engineers—approximately 5 percent—interact regularly with industry, they tend to be clustered in standard-setting programs at elite research universities in high growth fields close to the market (Louis 1995). At these institutions, the numbers of faculties who interact with industry are often much higher; in some fields, such as biotechnology, 30-50% of faculty are involved with corporations (Krimsky in Soley). Because academic scientists and engineers located at elite institutions in "hot" areas often exert strong normative influences on the cultures of their fields and professions, the contradictory patterns of response revealed in previous survey research beg for broad and deep qualitative examination. We explored this gap by analyzing thirty-seven interviews conducted with academic scientists and engineers involved in industrial collaborations, attempting to discern how academic norms and values might be changing in ways that previous research has overlooked.

The theories we drew on were process theories of professionalization, particularly the work of Andrew Abbott (1988) and Steven Brint (1994), set against a backdrop of hypercapitalism, or, as George Soros (1998) puts it, "the intensification of the profit motive and its penetration into areas that were previously governed by other considerations," and our own work on "academic capitalism" (Slaughter and Leslie 1997). ¹

¹We also drew on our previous studies about intellectual property and professionals (Rhoades and Slaughter 1991, 1997; Slaughter and Rhoades 1990, 1993; Slaughter 1993). We did several of field studies that detailed how academics were moving to the market through creating knowledge that had intellectual property potential and was patented or partnered with industry in a variety of ways, documenting the ways in which this work re-normed traditional values in academic science and engineering. However, most of our work centered on a single university in a specific state, raising questions about generalizability. Moreover, this work was based on data from the mid 1980s, the period when structural changes in the economy were in the early phases of shaping the new climate for university-industry relations. We have another stream of work that deals with the ways in which structural changes in the global economy interact with academic science and technology (Slaughter and Rhoades 1996, Rhoades and Slaughter 1997, Slaughter and Leslie 1997, Slaughter and Rhoades forthcoming). These studies provide macro-level context for the micro level changes described in this paper.
Abbott argued that jurisdiction was the major struggle in which professionals engaged, and that they had to maintain boundaries around their expertise so that they were recognized as legitimate and called upon to resolve knowledge issues in their domain. We too saw boundary work as critical for professionals, but the boundaries that preoccupied the scientists and engineers we interviewed were not so much between one profession and another as they were boundaries between academe and industry. Although the scientists and engineers we talked to interacted regularly with industry, they were not "boundary elites," who moved back and forth among high level positions in industry, academe and government (CEO of firm, President of university, head of agency). Rather, the professors in our sample were firmly rooted in academe, but their work with industry drew them across professional boundaries into new territories ungoverned by academic values.

In his 1994 work, Steven Brint saw professionals as moving from the "social trustee" professionalism that characterized the rise of professions in the last quarter of the nineteenth century to "expert" professionalism, which became the hallmark of professions in the last quarter of the twentieth century. Social trustee professionalism had norms and values that stressed using knowledge altruistically, for the common good and for the good of the client. In contrast, the norms and values of expert professionalism stressed the utility of knowledge in the marketplace, particularly the utility of knowledge to the techno-science core of the economy. While we see Brint's distinction as telling, we do not think he goes far enough. We see the space that professionals, working with and through the state (e.g., testing, licensing, certifying), created for themselves, a space between capital and labor (Perkin 1989), as now being closed down in response to "the intensification of the profit motive and its penetration into areas that were previously governed by other considerations" (Soros 1998).

Studies of professionalism generally overlook the university, including research centers and departments, as institutions, and concentrate instead on professional associations. Yet universities train, socialize and award degrees that are a necessary step in the professional certification process. We
(Slaughter and Leslie 1997) examined at the way colleges and universities, along with professors, were promoting, subverting, redefining and resisting market values in higher education. We argued that the university, often funded by the state or operating within civil society, nominally outside the market, has absorbed the values of capitalism and that some segments of universities and some professors have become market actors or state subsidized entrepreneurs. In this study, we make the case that professors are often pushed and pulled, occasionally in very different directions, by corporations seeking profits and by state institutions seeking to enhance profits through intellectual property.

**DATA AND METHOD**

Our data, gathered in 1997, was a subset of a larger study National Science Foundation study that explored faculty and administrators relations with private sector firms (Campbell and De Toro, in press). We analyzed data from 38 semi-structured interviews with faculty who had interacted with industry in the past five years. Fourteen institutions in California, Arizona, Texas, North Carolina and Massachusetts were selected because of their significant research interactions with industry. For the most part, the institutions were large, research intensive universities. Faculty members were selected for participation in the study by contacting Vice Presidents for Research at each institution, who were asked to provide the names of at least 20 professors in the sciences, engineering, and medicine who had worked with for-profit firms in the past five years. If the professors identified by the VPs for Research were unwilling or unavailable to participate in the study, we asked whether they would recommend colleagues who would consider participating. Our final sample comprised 10 department heads or center directors and 28 faculty members. We included department heads as part of our faculty sample because previous research suggested the views of department chairs were not significantly different from the views of faculty (Campbell 1995, 1997; Lee 1997). Nineteen were engineers, of whom 5 were department heads or center
directors; 12 were from the sciences, 4 of whom were department heads or center directors; and 7 were in medical schools, one of whom was a department head. While every effort was made to include professors of all ranks as well as women and members of minority groups, several members of these groups declined to participate, citing a lack of time. Only four female faculty and three assistant professors were willing to participate. The sample reflected the majority of faculty who were engaged in collaborative activity with firms: male, tenured full professors.

All of the professors in our sample had ongoing relationships with industrial partners which ran the gamut from simple consulting to holding equity positions in start-up companies. In fact, all faculty consulted and many had consulting contracts with industrial partners in order to support their research and graduate students. Almost all consulting contracts were related to firm-oriented research, and many faculty were participants in government-university-industry relationships (GUIRSs) that often took the form of government-funded consortia for entrepreneurial research (Cohen, Florida and Goe 1994). Approximately 60 percent held patents and 40 percent were involved in spin-off or start-up companies. Almost all also had federal research funds, often from several agencies.
Data analysis consisted of three phases.

First, a team of four engaged in open coding in order to identify themes and patterns in the transcripts. Three significant patterns emerged. First, there was a tendency for speakers to discuss distinct binaries and trinaries whose boundaries were clear in some cases, and fuzzy, blurred or contested in others (See table 1). Furthermore, they spoke in ways indicating that the subordinate, less valued term of each of the binary oppositions had “ascended,” become more salient, and that the relative value of components in two triplets had “descended,” become less important, creating a new reality for doing science. When talk about these shifting boundaries occurred, it very often led to a second pattern, that of a dilemma or a “quandary” in the professor’s life, created by the shifting boundary. A third pattern was the presence of “mythical” stories of the fantastically good and bad which had occurred in either their own or their colleagues’ collaborations with industrial partners.

From these patterns we were able to generate the research questions for the rest of our analysis: (1) What do scientists and engineers say about boundaries between academe and industry? (2) What quandaries do scientists and engineers face as a result of these new boundaries? (3) How do scientists and engineers

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2 The team of four was comprised of students in a graduate seminar studying qualitative data analysis.
negotiate the new boundaries? (4) How does the talk of scientists and engineers both reflect and constitute shifting professional norms and values in the institutional social space known as "the university"? These questions allow us to address our theoretical concerns about jurisdiction (who shapes research agendas and according to what criteria?), about the utility of science and expert knowledge (are science and engineering moving closer to the techno-science core of the economy?), about the normative quandaries scientists and engineer grapple with as they confront these changes (how do professors deal with ethics and values as the context in which they do science changes?) and about the institutional context and values in which professors work (is nonprofit, professional space becoming a site for profit-taking?) With the research questions formulated, a team of two (Slaughter and Archerd) engaged in focused coding of the transcripts.

As we coded, we attended to metaphors (Lakoff and Johnson 1987; Lakoff 1987) and narrative (Harraway 1989, 1997). We also considered the ways in which speech acts themselves constitute power relations, especially in institutional sites such as universities, paying attention to the ways in which one discourse comes to prevail over another (Fairclough 1995). We sought to understand the ways scientists' and engineers' talk itself were re-shaping professional norms and values.

**SHIFTING BOUNDARIES**

*(Shifting) boundaries and a former "space/time."* The scientists and engineers in our sample spoke clearly and consistently about a boundary between the past and the present, between a former and a current time and "space." The former "space/time" was characterized as being populated by scientists and engineers located securely and comfortably within academia, working together closely with federal funding agencies while industry stood as a "silent partner" in the background waiting patiently for scientists to hand off fundamental scientific work for development and application. Government grants were valued more than industrial contracts, research activities more than consulting, and basic, long-term research more than applied, short-term research. In the former space/time, boundaries were spoken of as clear, well-established, and representative of precise locations where the values defining the academic/scientific profession ended, and the
values of industry began. Indeed, these scientists and engineers spoke of what they saw as the (mythic) "Golden Age" of science in America.

My friends who are nearing retirement age... all say, "We were here at the Golden Age." The last ten years getting money has been tough but through the 60's and the 70's, the money was for the asking. Actually the federal government employees would call faculty in the 60's and say, "I have money to do research in this area. Would you be interested in doing some?" and negotiate it on the phone, you ['d] write a one-page letter of intent, a five-line budget and you got your money. That's as far apart as from what we go through now... as possible but there are plenty of people who remember that as the modus operandi. (Professor, head of electrical & computer engineering)

You know, this sort of simple, idyllic world that we lived in maybe 20 years ago in which we thought our best tech transfer and our best involvement with industry is this collection of wonderful young minds and wonderful young people that we were training to ship out... that was really a wonderful world. I think a lot of us would like to go back to that world, but it ain't going to happen..... [I am] chairman of the intellectual property committee, and so I have spent a lot of time wrestling with just these kinds of issues and, you know, there's five guys over here yelling...to give everything [intellectual property] away and then there's five guys over here yelling you have to do everything in your power to protect it, and market it just like anything else we market. (Professor, head of chemical engineering)

While most professors in our sample spoke of a marked difference between the past and the present, many times romanticizing the past, a few acknowledged the long history of university-industry relations, pointing out some of the problems created by lack of oversight in the "Golden Age."

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3 All italics in quotations represent our emphasis.
...you could no longer get away with what used to be commonplace 40 years ago, 30 years ago. Just like 30 years ago, we poured the acetone down the drain. Everyone knows this. We don't do that now. (Professor, Head of electrical & computer engineering)

Regardless of the tendency to mythologize the past, the majority of scientists and engineers described the pressure for profit-taking intensifying over the years, and that was a key point of difference between the past and present space/times. In this new context, government, academe, and industry were still seen as the major players; however, in the new scenario, it was industry and universities that occupied the foreground, while government stood in the background as the silent partner. Speakers described boundaries as permeable in the current space/time and frequently merged previously separate categories in their discourse, thereby creating new categories and meanings. Talk about quandaries in the previously unproblematic “sacred domains” of funding, research direction, and graduate student training exemplifies the shifting boundaries involved in redefining science over the past quarter of a century.

*Quandaries in sacred domains.* In descriptions of the Golden Age, the scientists and engineers clearly articulated that federal grants used to be unequivocally more highly prized than private contracts with industry, and research more than consulting. Large, long-term, unrestricted grants from the federal government were privileged and “easy.” In their own words:

When I was younger, I was very upset by the attitude of the chair of my department. He and the other thoroughbred academicians [said] that drug company money was dirty money and that's always been a notion in academia. That [attitude] has [since] changed. (Professor, biochemistry)

Ah, 20 years ago...[participating in a start-up company] would have been thought, for an academic person, this would have been terrible... Some people still feel that way. It's obviously much more common, ... over the past 10-15 years, it's becoming much, much more common, but there are still people... older generation people who still think this is not a proper thing for an academic person to be doing, and that's inevitable there will be conflicts of interest somewhere along the line. It's very hard to keep separate what is happening in one place and what's happening in the other. (Professor, endocrinology)

When I first came here 28 years ago, the major concern was...don't do anything that industry could do because there would be all kinds of hell to pay.... the wall [between academe and industry] was really high....We didn't want anybody in the world to say that... Joe Blow was using the state resources for gain..... Then what happened was about ten years ago, it shifted markedly to the sort of idea that something else could pay the toll booth.... there was then a
push and a great liberalization of what universities could do. (Professor, head of chemical engineering)

However, when describing the current space/time, the boundary between grants and contracts had become markedly less distinct, and the value of each, contested. Federal grants were still the most highly valued source of external support. As a professor and head of earth sciences said, "...there's this idea somehow that a grant is higher in the scheme of point scales than a contract" because they were long term and relatively unrestricted. As the head of an electrical engineering department put it, "God bless NSF [National Science Foundation] for all they've done and everything like that, but their funds are easy funds. You get the funds, a year later you write a report. Hey, man, that's the kind of funds I want."

But federal funds had become problematic, their value determined relative to the ease and availability of industrial funding. As an associate professor of biomaterials and engineering put it, "It's [federal funding] drying up and also there are more [researchers]... asking for it so per head, it's coming down." A professor of chemical engineering explained:

[B]ut if you look at what has happened over the last 10 to 15 years... grants were sufficient size that you only needed to have one or two of these, maybe three of these things and you could run a research program because they would be of sufficient size that you could have several students on each one. Today, these grants are all so small that you have to go out and almost have a grant per student so if you run a big group, you've got to have eight, nine, ten grants which means you have to do all this paperwork... One of the things that people argued against industrial funding was the fact that it usually was on a year-to-year basis. Everyone said, oh look, I can go get my three-year grant from the government and I don't have to worry about renewal. That used to be true. But... these grants are going shorter times, there are smaller amounts of money, and renewals for the government are big documents. Once you get in with a company, like the companies I've been in with, it's only like two or three pages. For me to renew every time is just a trivial exercise. In fact, the reason right now that I won't write a government grant is because I don't have the time to write a 50-page document that I have to worry about every detail to get $75,000 a year. This isn't worth my time. If I can go out and cultivate one industry, I can get more than that per year and then my renewals cost me zero time.

An assistant professor of mechanical engineering and material sciences (FEV 1002) put it succinctly: "...it's extremely difficult to get agency funds." In short, the highly prized, abundant, and unrestricted federal funds of the past had become less highly prized due not only to their relative scarcity, but also to their decreases in
intrinsic monetary value as measured by the ability to fund graduate student workers, and in proportion to the amount of time necessary to administer them.

The relativity of grants to contracts also came through in the speakers' habit of collapsing "grants" with contracts." Specifically, "grantsmanship" has come to mean that professors are successful at obtaining funding regardless of whether that source is technically a government "grant" or an industrial "contract." In the words of a professor, head of electrical engineering:

...you have to accept the fact that it [research] is going to be driven by the people who give you money. [If] the state gives us money, they tell us what to do. [If] NSF gives us money, they tell us what research they want done. [If] DOD [Department of Defense] gives us money, the government... why is it any different than industry? I see no difference whatsoever.

Although this professor was an outlier in his conceptualization of the power relations between professors and their sponsors, his words attested to the importance professors placed on funding, regardless of source, and an awareness that other agendas must be taken into consideration, even when working with federal funds. In other words, funds no longer arrive at universities' unrestricted.

The speakers quoted above demonstrate the ways in which professors experience research funding as a push-pull phenomenon. While the scarcity of federal funding pushed them toward industry, in many fields the abundance of industrial funds simultaneously pulled them toward commercial research. An associate professor of bioengineering explained as follows:

Well, because this side [biology] of science was not really to open to patents and things like that in the past. People really didn't make money in this area of science before. The biologists, the biochemists, all those people just worked in the labs. Basically you were pure academics. The money issue was not there. On the engineering side, it was always there. Then all of a sudden, this is the past 10 to 15 years, this field has opened up...[with] ridiculous amounts of money being involved in start up companies.

Participants were very clear that the best research was still long-term research, just as in the Golden Age, and that industry was usually unable or unwilling to invest in it. They were also nearly unanimous that a few big research projects were better than many small projects. However, that ideal was fast becoming harder and harder to achieve.
In talk of the Golden Age, faculty were clear that "basic" was more sacred than "applied." Basic science was pristine, driven by scientists' and engineers' professional agendas, which were attentive to professional inquiry, not industrial demands. After making basic discoveries, as was the case with atomic energy, for example, the science was then handed off to industry for application and development into products and process. In current space/time, the purity of basic research was not dwelt upon, and the boundaries between basic and applied were less well marked. The ways in which scientists and engineers talked about basic and applied research suggested strategic shifts in meaning, including eliding and collapsing the categories.

For example, professors no longer went to industry seeking funding for their own specific research program. Instead, as the professor below notes:

I think the better approach is the approach I try to take where you say, well, I have things in mind that I want to do. And then go and listen to what these companies want to do. Then what we try to do is to see if there is some middle ground where we can both accomplish those goals without swerving too far away from where we want to be. (Professor, chemical engineering)

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4 As the example suggests, the concepts of basic and applied science have always been problematic. In the case of atomic energy, "atoms for peace," in which industry developed atomic energy for civilian uses, were preceded by atoms for nuclear annihilation and involved university scientists and engineers in the military-industrial complex. Perhaps scientists and engineers have supported the notion of basic science because their fields were always highly involved with industry and the state as represented by DOD/NASA/DOE. (Foreman 1987, Leslie 1993, Grieder 1998) The idea of basic was a way to draw a boundary to maintain distance, even if the boundary on scientists and engineers cognitive maps did not match political economic terrain.
A number of professors were pragmatic. If they were able to work on "interesting" problems, they paid little heed to categories such as basic and applied, nor did they care who provided the funding. "Probably the overriding driving force is ... identify[ing] an area I'm excited about, that is interesting to me, that I think will lead to a new understanding of an engineering or a scientific phenomenon... worth... pursuing." (Assistant professor, engineering and materials science) FEV1002.

Still others made the point that the boundaries between basic and applied research can shift, depending upon how industry sees the strategic value of the research change as more and more understanding is gained about the subject material. For example,

I consult for a company called Metasyn [which is] involved in magnetic resonance imaging and we've, for many years, been involved in ... coordination test. Years ago that was the purest of pure research in the sense, [that] from an industrial [perspective] it was useless. And then it was discovered that gallium compounds are useful as magnetic resonance image enhancement agents because these are paramagnetic agents. And so this about a $300 million a year industry at the moment. And a small venture capital start-up firm called Metasyn was interested in some of our compounds... We have a research program which involves an agreement between [home institution] and Metasyn. (Professor, chemistry)

According to this professor, any basic research was potentially able to be re-valued as applied or entrepreneurial, depending on its strategic importance for industry. When that happened, professors were pulled into industrial partnerships by the easily available funding.\(^5\)

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\(^5\) There was some variation by discipline. On the one hand, faculty from professional schools such as medicine and engineering took the position that basic research was important, but the purposes of their fields were finding cures for disease or making products and processes work. On the other hand, physicists had the "attitude of, well, something so practical, that's dirtying my hands...that's not our job. That belongs to the engineers" (Associate professor, physics). However, most of the physicists in our sample "did not have that attitude," suggesting that discipline may influence professors positions with regard to industrial work, but does not determine it.
Although there was substantial variation, these professors no longer talked about basic research as research performed in the academy that focused on agendas set by professors and funded by government agencies that did not intrude in the research process. Instead, they talked about basic research as research that was "interesting," as research that was of Ph.D. dissertation quality, or publishable in well-regarded peer-reviewed journals. They did not even distinguish basic from applied by whom the research agenda was set.

However, some boundaries were maintained. When speaking of "long-term" versus "short-term" funding and research, participants were very clear that the best research was long-term research and that industry was usually unable or unwilling to invest in it. Participants were also nearly unanimous that several big research projects were better than many small projects. Because these professors thought that industry was likely to become a permanent partner in government research, they often suggested that consortia or government-university-industry research relations were the form that funding should take.

My preference would be to work with industry through this Center kind of structure or where you do what people in the academics usually did, pure research, but then funded by industry. (Professor, chemistry)

That's probably the best example and certainly our administration seems to agree that this sort of three-way collaboration—agency, university, and industry—is the way forward [in reference to an entrepreneurial research partnership between USGS, US Air Force, the state Division of Mines, a local company and his university] (Professor, head of earth sciences)

I think industry needs solutions... to develop that I think that industry probably expected... a consortium set-up. So many industries putting moneys together as a part of a bigger picture, like auto industry putting money together to... look at their common problems like battery problems for example. But also at the same time, [industries] focusing by themselves into specific groups as to whether... how they can interact with the universities. But first of all, there has to be an understanding of how the university functions... I think the consortium would help a great deal...(Associate professor of aeronautics)

Professors preferred consortia because they provided some of the features similar to federal funding in the (mythic) "golden age": predictable, long term funding for big projects. However, professors realized that consortia were not an easy solution. As a professor of biochemistry noted, industry and academe were "two different cultures" and these differences, especially the industrial push for profit taking, created quandaries for professionals, discussed below. More generally, as the associate professor of aeronautics noted, "... there is a
big mistrust between the people who work in industry and the university."

A final quandary faced by professors engaged with industry was how their graduate students fit in the current space/time. These professors defined themselves as researchers and teachers of graduate students. According to them, professors could not be professors without funded research because external funds were necessary to support the graduate students and post doctoral students who comprised their laboratory work groups. The professors understood that graduate students were cheap labor for their labs, but valued graduate students primarily as apprentices and future colleagues. Most of the professors said they were in academe rather than industry because of the importance they placed on teaching. While the hours they spent in the classroom were not many, usually no more than one 3-credit hour course per year, the hours they spent in the lab were long and combined work and instruction around research. Professors did not move mechanically toward industrial funding and the market; rather, they felt driven to raise money to maintain their laboratories and their identities as researchers and teachers. (For a detailed account of professor-graduate student relations under industrial funding see Slaughter et al 2002). Ironically, as they began to work closely with industry, they very often faced quandaries about their identities as teachers and researchers because they confronted conditions that challenged professional norms and values.

In sum, the story professors in our sample told about the past was simple and highly mythologized, an account that had served to promote professorial interests, especially professional autonomy and funded inquiry, during the period when research funding and universities were expanding (see Table 2). The "golden age" (1940-1972) they saw was characterized by "pure," "basic," or "fundamental" research and by abundant resources, the use of which was not closely supervised. Although this pattern in large part reflected the grant and contract processes developed by military-industrial-university complex during the Cold War (Foreman 1987, Greenberg 2001), most professors in our sample did not mention the Department of Defense (DOD), nor did they seem to recognize the funding they favored was rooted in DOD funding practices. The Department

6 The Department of Defense accounted for more federal R&D funding than all other R&D funding budget functions
of Defense was a generous sponsor that provided large grants, long time lines and little oversight. Even though their daily work and the long term success of their careers depended on external support, most of the professors in our sample did not attend to the political and economic forces that shaped federal, state and corporate funding for research. They were generally articulate about needing resources, but not about the political alliances that shape funding.

[INSERT TABLE 2]
A small minority did speak to the political and economic alliances external to the university that shaped academic R&D funding. Their talk revealed some elements of the "competitiveness" discourse that puts science and engineering at the center of the "new" economy as the element that will enable America to win ever greater shares of global markets. This story was haphazardly integrated into their accounts of the past and present, with little attention to what changed discourse and funding patterns. Another missing element was how professors related to their sponsors. In the "Golden Age" mythology, professors, located in the university, were funded because their non-intrusive government sponsors and the public had faith they would make important discoveries that would ultimately protect or better humankind. While that story did not attend to the power of sponsors and masked professors' involvement in structures of power, such as the military and health industries, it nonetheless drew clear boundaries between state, corporation and academe. The idea of professors located at the "frontiers of science," metaphorically far beyond partisan politics or economic pressures, was a way of preserving professional autonomy by maintaining values that saw research as more than a cash transaction, an exchange between sponsor and research performer. In the "competitiveness" story professors told, they were no longer separated from the economy, but they did not locate themselves with any specificity within the economy nor directly connect their economic location to the many quandaries they saw themselves facing.

MAINTAINING AND POLICING BOUNDARIES

Border conflict: negotiating market relations through intellectual property. Given their involvement with industry, it is not surprising that these professors saw boundaries between academe, industry and government in flux. The three points of greatest dispute over the borders between academe and industry were: (1) access versus secrecy; (2) publishing versus patents; (3) and contested ownership of a wide variety of intellectual property. That these are points of dispute was not surprising, given that they all provide opportunities for profit-taking. What was somewhat perhaps surprising was that these three points often generated conflict and tension between faculty and their institutions.
attempted to increase revenue through generating profits from their professors' research, they often made claims that interfered with negotiations between professors and industry, further eroding familiar boundaries and creating new quandaries.

**Publishing versus patenting.** According to U.S. patent law, if information about a product or process is published, then it becomes part of the public domain and can no longer be patented. If a product or process is patented, first it must be "reduced to practice" or demonstrated, and an application for a patent filed with the U.S. Patent Office. The patent office then reviews the patent to see if it is original, and issues a patent, which ideally protects the product or process from being copied by another party for 17 years. The average time from submission to the U.S. Patent Office to issuance of a patent is 12 to 18 months.⁷ Among the difficulties that patents pose for academics is that patenting may hold up publication.

About 60 percent of the faculty we interviewed held patents. Almost all valued publishing research papers more highly than patenting. A few thought patents had some merit, but they were the exception. As a professor of chemical engineering explained:

A patent is hard to get, okay, but a patent doesn't need to be a scientific document. This is the problem. You can patent things that are just scientifically terrible. And it happens all the time. Most patents are scientific nightmares. However, some people like to say, well, if you've got a patent, it shows you did something novel because you were able to get a patent. Okay. That may be true. But I think most people in academia would say that you've got to put together...I think the thing that is valued the most is a high-quality scientific publication. So, you know, there's certain level, this journal is better than this one. But in the top journals, it really takes something quite significant to get in. I think that is perceived as the highest value.

Patents were "like icing on a cake. You have to have a cake first" (Associate professor of Physics). And research was the cake. Most professors did not attend closely to how their institutions set intellectual property policy and to the share they would receive if they "got a big hit." They understood

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⁷The average cost of a patent is $335.00; the issuance fee, if it is granted, is an additional $640.00. Maintenance fees for the life of the patent are about $3,100.00. These are fees must be paid to the U.S. Office of Patents and Trademarks (phone conversation with patent office official 9/20/01, 1-800-786-9199). They do not include legal fees often associated with the application, nor do they include the costs of defending patents from infringement. These legal costs are often quite high.
that the chances of making a great deal of money from a patent was like winning the lottery. As a
Center/Lab director of electrical and computer engineering put it:

I remember when it [intellectual property policy] was first instituted there was some
people who objected because they had a looser policy. The patent thing is one kind of
dissatisfying thing to a lot of people, to the companies, to the faculty. I don't think people
are too concerned about the percentages because typically it's like a lottery ticket. You
either get nothing or there's going to be a substantial amount. And if it's percentaged
smaller, you know, I think that people don't win the big prize but win the second prize,
they're still pretty happy because their chances were very much that they were going to get
nothing. I think that's the way most people feel about the patent thing.

Most tenured professors with established industrial connections had figured out how to publish
and patent. They employed a technique we call "sequencing." Professors who had ongoing shared
research agendas with corporations timed their publications so they did not interfere with patenting.

As senior faculty, they did not feel pressed to publish and could afford to wait. A professor of chemistry
said:

Like any other collaboration, you have to be able to get along with the people and work
with them and trust them. And of course that has to work two ways, so the company, of
course, is interested in making sure that if it makes a big investment of money, that it's not
going to lose that investment for whatever reason, whether the investigator's disclosed too
much too early or whatever. And so there is a legitimate interest of the company in not
disclosing things until patent applications are finished and so forth. Generally I have found
that that doesn't have to be very restrictive. I'm slow enough in writing out my papers
anyway so that another month or something isn't going to make a big difference. So, while
I think it is important to keep in view the academic issues of freedom to publish and so
forth, but certainly one doesn't want to compromise those things. In practice, I've not run
into any big conflicts there.

A professor of endocrinology elaborated this pattern:

As long as publishing is fairly quick ...as long as things are not so hidden for years, I don't
think it's that big a deal now... if somebody was going to say "patent it or not, we're not
going to tell anybody about this for five years," then, you know, I think it would. But...
we're talking about a year or so, and I don't think [it] matters all that much....Even if
you're writing a paper without any patent involved or anything, it's going to be a year to
year and a half after you do the work before probably the work comes out, so you write
the patent and you write the paper and it's going to be year - year and a half before it
comes out anyway, so I'm not sure it's that much of a difference.

Because these senior professors had developed close relations with industry, they saw industry as having "a
legitimate interest" in not disclosing information until patents were proved. They argue that there is little difference between publishing with a patent or without a patent, given the slow pace of publishing, a somewhat disingenuous position given the prevalence of prepublications and on-line publications in the sciences. Nonetheless, many professors had so naturalized sequencing that they saw no conflict between patenting and the free flow of information.

However, assistant professors were not so sanguine about their ability to publish and patent. A young assistant professor of biology noted that she had difficulty patenting quickly enough to get her publications out in a timely fashion. Her difficulties were with her university, not a corporation.

If you think you have something that is commercially relevant, you are required to file a disclosure to the university before you publish it. *So they are essentially sort of censoring what's being published... the university, if you step back and think about it, the university is in business, too, really, and so it's annoying in one respect because being in academics, you need to have all this freedom, but if you actually read the university faculty handbook, like I said, anything that you think is commercially relevant has to be filed first and then they have up to six months to decide the fate of what you are working on, and depending on what you are working on, you may publish it as quickly as possible and that includes presentations at meetings. So, I don't know. The lines between industry and universities are sort of merging.*

She understood that universities, like corporations, had become invested in profit-taking, and both types of organizations now pushed for patents. As a result, the university, historically understood to be more committed to "academic freedom" than corporations, sought to constrain the free flow of knowledge when patents, licenses and royalties were in the offing. Despite her insight, this professor was willing to excuse universities. "... in a way, I can see the side of academics because times are getting tough and they can't just wash potential profits down the drain either."

Many of the professors we interviewed had partially redraw the traditional boundary between industry and academia, in which industry scientists patented and professors published. Professors still believed that publications were much more important than patenting, but many were convinced they could publish and patent. This belief was most powerful among senior professors with long term research programs who published regularly.
Secrecy versus access. Although the question of whether patenting interfered with publishing was a quandary with which professors were grappling, there were other ramifications surrounding patents. Perhaps the most important was the question of how industry used patents. Some professors thought industry wielded patents in order to block access to data for whole fields, seriously impeding the free flow of knowledge, perhaps even arresting new discovery. Moreover, patents were not professors' major interface with industry. Professors routinely interacted with industry as consultants. As consultants, they encountered a variety of restrictions on their free use of information. They often had to sign non-disclosure agreements with industry, had to deal with industry's data management conditions and had to submit research papers to industry for pre-publication review.

Some professors, especially those who had worked with industry, took the position that universities seeking to maximize revenue flow by patenting and obtaining licensing and royalty agreements were naive. As an associate professor of electrical and computer engineering said:

...the issue with patents is very tricky... you write the patent and you think that money will start flowing in the next day and then you want to move on to license it... writing the patent is the easy part. The hard part is what do you do once you have the patent. You need to go after certain industries to make sure that they carry it. It's a real estate kind of issue. With your patent, you cover some real estate. The question is, can you challenge other people so they pay you enough and in most cases, you cannot do it. The patent issue in big companies is more like a Cold War situation. Suppose you are AT&T and I am IBM. So we both write 200 patents a year. We meet once a year, we have a coffee and we say, "Okay we just exchange and use those things. We can both use it." But once you suddenly write 200 and I have only 10 then we meet for a coffee and you say, "I'm a nice guy but I have 200 and you have only 10." So it's more like a cold war situation. Everyone has his own arsenal and they basically exchange.

Or, as a professor of organic chemistry put it:

There's no one patent you can get which will make a lot of difference to one company because if it's in an area of their major concern, they'll create a network of patents, process patents, little changes in structure and so on. So your patent can't even be independent of their patents so I think university administrators have a very unrealistic idea about this.

These professors were making the point that industries saw patents as valuable not because they promoting discovery and free competition but because they precluded it. Indeed, these professors thought industries
saw patents as a strategic means for staking out future directions for product development, preventing investment in these areas on the part of other firms.8 If universities held only one or two patents in a product area and were unable to deploy them strategically, they were unlikely to reap a rich revenue stream. If universities began to treat patents as strategic for a line of product development, as has the University of California system with regard to its biotechnology patents, then universities become more like corporations, engaging in prolonged, complex, multi-state litigation to protect themselves and align research endeavor with business plans, further eroding boundaries between business and industry (Baez and Slaughter 2001).

If the strategic potential of patents becomes paramount for corporations, problems other than withholding publication arise. As an associate professor biomaterials (FMP0702) pointed out, when a product essential to the research process is patented, a whole field can be constrained.

Patenting a product really does create some problems. Let me give you an example. There is a growth factor that we use, bone growth factor .... you can derive it from animal bones but it takes... tons and tons of bones to extract it and not every place can do that. It's very expensive. They [the corporation] have a way of chemically doing it, recombinant, but that technology is licensed. It's owned by one company and they don't give out their stuff to anybody unless... you sign ... an obscene agreement. You sign your life away... Every thing that will come out of it belongs to the company... Now, to me, that's a deterrent to progress because there are so many people who'd like to use that and if it was freely available, the whole field can move forward. But since one company's controlling it and wants to control everything that comes from it, I think it's negative. It... might make money in the long run but... it's impeding science.

Other professors were less concerned with patents blocking whole fields of science, and more concerned with industry blocking profits for universities, colleges and faculty members. As a head of electrical engineering (HEP0604) said:

8 Whether patents function as an incentive for invention and investment in research or a monopoly that curtails invention and research has been a hotly debated topic for many years. See for example Heller and Eisenberg 1998, David 200.
You got to be careful because if you give the rights to industry, they can shelve it which is [what their] competition does... They have to have performance guarantees. So if they want to shelve it, I don't care as long as they are paying. They are paying the university. They pay the researchers. Everybody is part of this. The university gets a percentage, the researchers get a percentage...[The university needs an agreement with industry that says] 'Here's what we think this thing will do. You agree to this. If you don't do that, either give all the intellectual property rights back, or you pay the retainer whether you sell it or not.'

These two professors were at opposite ends of the spectrum, the first raising questions about what happens to free inquiry when knowledge becomes alienable and patents are used as a protection strategy that keeps scientists away from data, the second insisting that industry not take university discoveries and "shelve" them so competitors were unable to use them unless industry was prepared to pay a fee for doing so. Both thought that patents were part of a larger game, perhaps even a "Cold War," in which universities were peripheral players but the consequences for universities were significant.

However, patents were not professors' major interface with industry. Professors routinely interacted with industry as consultants. As consultants, they encountered a variety of restrictions on their free use of information. They often had to sign non-disclosure agreements with industry, had to deal with industry's data management conditions and had to submit research papers to industry for pre-publication review.

Many professors were not troubled by pre-publication agreements. As a professor of chemistry said, "I have no problem at all with them [the sponsoring companies] wanting first glance at anything...the bottom line...is that if they can't have some way of knowing what's coming out ahead of time to do damage control if they have to, they're not going to give you a contract. It's just black and white." He was convinced the corporations he worked with would "correct errors," but not tamper with his interpretation of the data, nor hold up his publications, even if they contained material detrimental to the corporation. He interpreted the corporations he worked with as supporting his academic freedom, even though he understood they would "do damage control" prior to release of his results, perhaps undercutting and
challenging his science.

Other professors were willing to accommodate to corporate requests for secrecy with regard to data analyzed as part of consulting agreements so long as were able to publish.

With the oil companies, that's the most important thing to clarify up-front... how much freedom do I have to publish my contributions? The scenario where the work I do remains secret is not an attractive one at all. Usually, if I'm shown the data at all, then it's available to me. Sometimes it's muted in the sense that the locality is very generalized so that I know sufficient for my purposes where the oil well was drilled. I don't know whether it was a well that produced oil or not and I don't know accurately enough which well within a large field it might be... *So they don't necessarily give me all the data.* (Professor of earth sciences)

According to an assistant professor of mechanical engineering and materials science, he would not consult with industry if he could not publish, although he had to manipulate his data presentation to get his material past corporate reviewers and into journals.

... this is a big problem with high tech industry. Proprietary rights and all this kind of stuff... if a company comes to you and says, "Well, we'd like you to work on this. We have the money for it but you can't publish anything," well then I wouldn't do then because there's nothing in it for me because I really do need to be able to publish it. Now, *frequently you can get around that by writing publications where you don't divulge all the secret recipes that they don't want to give away. Or you can wait a little bit* and often for high tech industries if you wait six months it's already old hat and they don't care about it anymore.

Although this professor experienced corporate censorship, he saw it as irritating rather than as a substantive challenge to his academic freedom. When he talked about submitting a paper for pre-publication review, he related the following:

...you have to go through a couple of passes, often. You write a draft proposal, a draft paper and it goes through the company bureaucracy and you know, it goes through various peoples' desks. And they always get paranoid about the most innocuous little words that you might have in the paper. *It'll come back all red-lined and "Can you take this work out?" and yeah, of course, it doesn't make any difference.* So those little things can easily be done without compromising the basic...

In some cases, he gambled that the corporation would be so "desperate" for his work, that they would continue funding him and allow him to publish despite the company's unhappiness with the situation.

Other professors found company pre-presentation and pre-publication review more problematic. A
professor of earth sciences recounted how a paper he and a student had planned to present at a scientific meeting was barred by the oil company whose data they were using.

The oil companies can be a little bit paranoid about who gets to see the research when it's done. Initially, they were convinced that the work that my student wanted to do on the side was of no particular merit to the oil exploration process and that was fine. We made the mistake of talking about it as the project developed. We got permission for him to give abstracts at meetings and others from the company decided that this is really rather interesting; we could use it. So suddenly, the project was no longer available for reading outside of the company and so, well within the first year, that project essentially folded as an option for a Ph.D. So we found another one and then we took the tack of not talking about it outside of the department, essentially.

Industries often required professors who consulted with them to sign non-disclosure agreements. These agreements protected any industrial data the professor might use and captured the potential profit that might accrue from intellectual property derived from faculty work. Because professors often had complex relations with a variety of companies and government agencies in order to keep their labs and graduate students funded, they sometimes agreed to keep confidential information from several companies. A professor of chemical engineering recounted that faculty had great difficulty in keeping verbal agreements straight, so his institution devised a policy whereby professors could only accept confidential (non-disclosable) information in writing.

... We were sitting in a room like you and I are and we talked about something and then half a year later [the corporate representative says] well you can't work on that because I mentioned this to you in the room... Which happened before... it's hard, you know, especially when you're dealing with so many different companies and stuff. I can't remember who said what in that kind of detail two years down the road. So now, it's up front in the language from <home institution> that if anybody... give[s] us any confidential information it has to be in writing that it is confidential and we both sign it so we don't get into trouble.

Although his telling of the tale left some doubt, another faculty member was confident of his ability to manage multiple non-disclosure agreements

Q.: Many faculty have told me when they work with private data, sensitive data, they sign a nondisclosure agreement. Is that something that you've done?
R: Yeah, I've signed a lot of those.
Q: And do you find it hard to keep track of which one's you've signed and, you know, do they usually have a length of time on them or is it forever and ever?
R: Actually I never looked that closely. I should go look for the one's that I have. Do I...I honestly don't know that. And do I find it hard to keep track of? No. I keep them strictly separate. (Professor, aeronautical engineering)

Yet another professor took pride in having signed only a single non-disclosure agreement with industry.

...my students and I have only signed one non-disclosure agreement and probably won't sign anymore. Like we haven't signed one with Intel even though we have, by far, the most extensive collaboration. It's much simpler for them. They simply don't tell us things that are very secret to them or ... important for confidentiality. And we are working in an area where that's okay. So an example might be that we will know what materials are present in some structure they build for us, integrated circuit structure but we may not know how exactly those materials were deposited because the means of deposition ... is a big competitive advantage. I don't want to be responsible for knowing what those very expensive, very important secrets are and we don't have to know that. So often when you read scientific papers, there comes a point where in the classic paradigm anyone with the right equipment and competence can read a scientific paper and reproduce the results. That's the ideal. That's rarely the case. First of all, there's usually not enough length allocated in papers to give all the details. Here we simply don't know all the details and they're not relevant to the results that we publish. That's the way we work around in matters that part of this is confidential, we don't know about it, and part is. And most faculty I know don't like to sign nondisclosure agreements because you're constantly second-guessing. "Can I talk about that?" But my work with Intel, everything I know I can say in public. It makes it very clean-cut, right, it makes it very clean cut. (Professor, department head electrical and computer engineering)

This professor disliked non-disclosure agreements because he found it difficult to keep track of what was public and what was secret. He preferred to let companies draw the line for him and keep their secrets. He realized he had violated "the classic paradigm" in which "anyone with the right equipment and competence can read a scientific paper and reproduce the results," but he did not care.

Other professors did not wait for the company to draw the line for them, but instead developed ways of "sanitizing" data. "Sanitizing," a term used by a full professor of aeronautical engineering (FEV1405), involved removing data from a thesis that industry wants to protect in order to publish.  

R: I mean, you know, you can, you can go in for various of sanitization of a thesis, right?  
Q: Sanitization meaning ... What do you mean by that?  
R: Well, you know, you've gotta ask... what's really objectionable in this thesis to the company? I mean, usually it's the specific numbers might be in there... Usually it's not the

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9 For a fuller discussion of this case see Slaughter et al 2002.
entire thesis, right? The objection to the entire thesis is...a real big problem. But if it's...numbers then take the numbers out.
Q: And just don't... report those?
R: Yeah.

The professors were convinced such omissions do not compromise the integrity of their research, and seemed not to understand, or disregarded, that it may undermine the scientific method, which calls for the possibility of replication. Instead, they affirmed propriety rights that constrain the free flow of knowledge.

Most professors naturalized the constraints—pre-presentation, pre-publication, non-disclosure agreements—corporations imposed on their consulting agreements and managed to publish regardless. Even when there seemed to be egregious violations of traditional academic norms, as in the case when a student was prevented from using data he had analyzed in a presentation and in a thesis, professors were willing to make excuses for the company. As they sequenced their research write-ups when they worked on patents, so they sanitized their data when they consulted. Although having multiple non-disclosure agreements with industry raised the possibility of legal difficulties should a company make the case that a professor had used their data in ways that benefitted another sponsor, most professors did not seem to take this seriously.

Although institutions had policies that tried to regulate professors behavior with regard to disclosing, patenting, and publishing, and corporations too wrote consulting contracts with professors that aimed at controlling their behavior, professors were able to some degree to manipulate their employers and sponsors. In large part that was because professors were the experts, the pioneers at the frontiers of knowledge, and their employers and sponsors often did not know enough to regulate them. The faculty member in his or her lab was difficult to monitor, because very often only he or she was in a position to decide whether something should be disclosed to the institution, shared with a corporation through a contract that might include a bonus for a patent, or, as we will explore below, become the basis of a start up company. Faculty took advantage of their knowledge on the grounds, as a professor of biochemistry put it, that "extraordinary people do extraordinary things."
Most professors sought quadruple benefits from consulting: they were able to conduct research; they got paid over and above their university salaries; they were able to fund graduate students on the contracts; and they were able to publish, advancing their scholarly careers. Professors were very clear that publication was important. However, pre-presentation and pre-publication agreements in consulting contracts meant that professors were not always certain they could speak publicly about their data or publish.

**Contested ownership of a wide variety of intellectual property.** We present one narrative of an assistant professor to illustrate the complexity of intellectual property issues. This story did not fit neatly into our binary categories of secrecy/access, or publishing/patenting, but raised issues about power relations within universities as well as "good faith" on the part of corporations. The university in which the professor worked seemed to be as interested in the intellectual property in question as the corporation.

An assistant professor of biology thought she had “really good technology” for sequencing DNA that would have speeded up the process of identifying persons in criminal cases. According to state law and institutional policy, she disclosed the technology to the technology transfer office. Her institution directed her toward an interested company. However, the company never offered her a research contract or worked out a formal relationship with her. She began to suspect that her work was competitive with the company's, and that the company wanted to either co-opt or stall her work, to increase the value of their own intellectual property.

And, in hindsight, I don't think it made a lot of sense for the company to get involved, that particular company, because what... my laboratory is developing is essentially ... a cost effective technology, but the company that [home institution] hooked me up with initially makes [a similar technology]... so it would be sort of stupid for them, I think in hindsight, to go forward with a technology that would reduce their bread and butter.

She did not attempt to resolve the dispute herself, but turned to her Technology Transfer office.

When no contract was forthcoming, the assistant professor began to worry that the delay would hold up her publication schedule, ultimately threatening tenure. Again, she talked to the head of the
technology transfer office about her concerns, but he turned the tables on her, suggesting that she would not get tenure if she published before a decision was made about the intellectual property in question. She discussed the incident with her chairman and "sort of got an apology back." Despite her "negative experience" she began negotiating with another company, although she expressed doubts about her ability to work out a deal that would satisfy her.

And when it comes time to hopefully negotiate something with... this other company that we are sort of working with now... I have no clue as far as what's reasonable and what's not.... it's sort of incredibly diffuse and there should be some business person to monitor this. I don't know what's reasonable and I don't know anything about law ....scientists are not business people....

One of the reasons she pursued relations with industry was that she needed funding to do her science.

When asked if industrial funding was valued as highly as government funding, she replied that she understood that NSF and NIH funding were more highly valued. However, she believed that she needed resources to do her work, regardless of their source.

*In my mind, money is money...so long as it lets me do the science, that's all I care about.* I mean, I don't think that it is seen as a negative. So long as I have money to do the science, I mean, it's not like we're getting it from drug traffickers or something like that...

The assistant professor was engaged simultaneously in disputes with her institution and the industry with which she was trying to establish a relationship. The contested boundaries were around ownership, profit and publication. Both institution and industry tried to protect their interests, and evidenced little concern for the faculty member. The institution was located in a state that had an aggressive intellectual policy property and was part of a statewide network promoting high technology economic development. The institution generally took the position that it would not patent unless industry was interested and bore the costs, thus pushing the professor over the boundary that divided industry and academe. The professor was unable to negotiate boundaries for herself, given that industry displayed interest in her property for strategic reasons, perhaps to prevent development of competitive intellectual property. When the professor talked of publishing before patenting, she was threatened by her technology
transfer officer, who broke boundaries surrounding professors' academic freedom. Despite the professors' ambivalence about working with industry, she continued to pursue relations with industry both because of her belief in the technology she was working with and because she saw "the lines between industry and universities are sort of merging." In this case, the boundaries between academe, industry and the state, as represented by the public institution and state policy toward technology transfer, were shifting in such a way that the markers that had conferred autonomy on academe—open access to information, publication, and inattention to profit—were compromised, but not yet clearly redrawn.

Professors faced many quandaries in working with industry. According to a department head of an electrical and computer engineering department, "... the natural tendency of companies is to not want to give up any more than they have to and the natural tendency of the universities is to want to lay it all out and tell the whole world what you are doing. And there will always be that tendency." (However, even this professor thought it was still possible to have productive collaborations with industry.) Professors devised new strategies to deal with the quandaries they faces with regard to secrecy v access, patenting v publishing and contested claims to intellectual property. They sequenced, sanitized and agreed to corporate censorship of their work. Although these strategies transgressed norms of science established in the "Golden Age," the faculty in our sample saw their strategies as enabling them to work with industry and remain part of the scientific community.

START UP STORIES

Approximately 40 percent of the professors in our sample were involved with start-up companies. We used the term start up loosely, including companies in which professors received stock equity in return for knowledge as well as companies that professors started themselves. The defining characteristic of start ups was that professors owned stock based on their discoveries, so they were simultaneously holders of human capital and share holders with investment capital in their own knowledge.

Start ups captured the imagination of many of the participants in our sample because they were emblematic of the transformations "academic capitalism" brought to the academy (Slaughter and Leslie
1997). Start-up stories generally emphasized the wealth available to professors able to transform
discovery into public stock offerings and marketable products. Even if they had not participated in start-
ups, roughly a quarter of the professors in our sample told start-up stories, suggesting the power these
stories held over the professorial imagination. These stories sounded somewhat like fairy tales in which
the hero finds an object with magical properties that convert dross into gold. In the professors' case, the
object was a discovery, and the alchemical process was “taking it public” or “going public.” The
discovery led to a product or process, a company was formed and its stock sold to the public on national
and international exchanges, making millions of dollars for everyone involved, often before a product was
fully developed, let alone successfully marketed. Most the elements that professors emphasized in their
start-up stories were contained in the engineering department head's story.

You know, we had a guy...a faculty member in computer science where this is the easiest
to do this today, he started a company... 18 months ago, probably built it up to something
like 15 employees, never had a dime of profit of course, probably never sold anything, just
getting going. Eighteen months old, the company was bought for $220 million. And this
was in the paper. Bought by a big company, Sysco Systems. So his corporate days are
over, he had 10% of the company. He comes back as a <home institution> faculty member
after his 18-month leave of absence and he's worth $22 million. So his <home institution>
salary becomes his pocket change...They always take leaves of absence, leave... our new
dean, our brand new dean of engineering did this, started a company in '84. Two year
leave of absence, got the company going, continued to be involved after he came back
from his leave of absence. The company actually was probably going to fail but the parts
that it made was so important to Silicon Graphics, which is the world's foremost high-end
work station, that they bought the company because they need the company to survive. So
they captured it for themselves for $480 million. So I don't know how much our dean
owned at the time as a founder, not 10%, but judging by his estate in Atherton, just north
of here, where the very, very wealthy people live, he got plenty. And he's 44.

The professors in the story are hard-working innocents ("never had a dime of profit...just getting by," "the
company...was probably going to fail...but the parts it made were so important to Silicon Graphics"), not
motivated by greed. They avoided polluting their universities by taking leaves of absence, clearly
separating academy and corporation. Their work was transformed by the corporate interest and investment
into multimillion dollar companies. The professors were not captivated by the corporate world. After the
corporations' took over their companies, the professors returned to their origins, the university. They
reaped rewards in their private lives, moving into lavish estates, perhaps living happily ever after as princes of the new economy.

The dazzling feature of the start-up story was the transformative power of corporations, conferred by their almost unimaginable wealth ("$220 million,” "$480 million"). What was not commented on by the tale teller was how the professors fit back into the university, given that their salaries were "pocket change," and that the professors were now stars, but not necessarily in an academic firmament. This story, as did many of the other uncritical stories told by participants, represented a naïve imaginary in which professors could profit enormously from their discoveries without changing themselves or the universities in which they worked. However, it threw into sharp relief the professional quandary of whether professors valued discovery for wealth or knowledge.

When professors moved away from mythic start-up stories to their own experiences, their accounts became more complex. The boundaries that had confined questions about ownership to private sector, profit-making entities now encompassed some segments and actors in nonprofit and public entities and the lines that had separated disinterested research from corporate profit making were being redrawn, creating quandaries for professors. The quandaries they struggled with were similar to those discussed previously, but intensified because equity and ownership interests made the stakes even higher. Among the quandaries they struggled with were: 1) who owned what, or how to sort out the claims of faculty, institution, government and taxpayer to intellectual property that was developed at least in part using (public) university facilities and federal research funds; 2) how to maintain boundaries between professors' traditional use of expertise in external settings and institutional intrusion into these practices when both professors and institution shared equity in the same company; 3) how to insure that graduate students involved in start-ups were not exploited. A quandary the professors with start ups sometimes faced that did not appear in professors' other relations with industry was; 4) how to guarantee that the products and processes they worked on were safe and sound, given that they were not able to exercise much oversight or
influence over the companies that developed their products and processes into consumable goods;

The legal line that determined whether the professor or his or her institution owned a discovery depended on time and use of facilities. If professors can claim that they made a patentable discovery when they were not working on university time (which included summer salaries), nor using university facilities, they could then claim ownership of a discovery. As universities began to see intellectual property as a potential source of income, they developed technology transfer offices and patent offices, and more aggressively claimed their faculty's intellectual property (Slaughter and Rhoades 1993). Universities sought a share of professors' profits, arguing that if faculty used university facilities in developing their ideas, then the idea belonged to the university, while the professor who made the discovery could claim only a (negotiable) percentage of the profits from university licensing and royalties. However, given the individual nature of faculty expertise, this could be quite difficult to enforce.

Some professors in our sample still claimed that their intellectual work was independent of the university and they were therefore entitled to all the profits of the start-up. In making this claim, an associate professor of chemical engineering distinguished between spin-offs and start-ups. For him, a spin-off was derived from university work on federal grants (spun off) while a start-up was independent. When he talked about his company, he said the following:

I make a real effort to keep them very distant.... The start-up has nothing to do with my research and I have vigorously resisted having anything in my home lab... Now there are a variety of reasons. One of them is I'm protecting my own financial interests because if the university can claim that I used university resources to facilitate the start-up, then the university has a legitimate claim on the company ... This would not be good. I would get crucified by my co-start-up people. But the other thing is I just don't want to create even the hint of guilt... I just want it to all be perfectly clear....

This professor mediated multiple, conflicting claims to his knowledge: his own financial interests (personal), the interests of his co-start-up founders (private sector), and the interests of the university (public sector). He balanced punishment (getting "crucified" by the private corporation) against "even the hint of guilt." As if to atone for the start-up from which he was profiting, he said he was engaged in
another one, from which the university too would profit.

Although this professor tried to avoid guilt, he found it difficult because crossing the boundaries between academe and industry created so many quandaries. The most obvious source of guilt was the issue of who benefits, who pays. As he noted,

we're sitting here in a building paid for by taxpayers and the stuff in my lab ... a lot of it's federal money... the electricity, the lights, the ventilation and stuff are all taxpayer supplied. I draw my salary from tax bonds. And to go and say that I'm now going to start a company and it's going to be my company and it's not going to be yours... seems just not fair. I mean the university's intellectual property policies are reasonable....I can license it from them for some reasonable amount of money... and they can get a cut.

Even though the professor may seem to be profiteering at the public expense, the question of who benefitted, and who paid was not a black and white decision, but a quandary because "the legislature probably likes it [start-ups] a lot because you're creating jobs for the people of your state." Other quandaries he detailed were as follows: the start-up could become a "consuming interest" so that faculty "neglected [ed] their other tasks." Yet at the same time, "you can get a real sort of intellectual synergy [between the department and the corporation] because the company's poised to take what comes out of the academic fountain. " Similarly, start-ups created intense competition "there's a certain testosterone aspect"-yet "it makes...uniformly stronger faculty." So too, student projects could "be made too biased to the interests of the company," yet students who participated in start-ups were often "much more savvy about the job market and in the end they have jobs."

The question of ownership sometimes became far more complex than making decisions about whether the professor, the institution or the corporation owned intellectual property. In some cases, the state in effect acted as a venture capitalist, backing a professor's company. Rather than licensing the discovery to a private corporation, the state engaged in financing production and profit-taking, acting, along with the professor, in an entrepreneurial capacity. In these cases there was no boundary between academe and industry.

A professor of endocrinology who acted as a state subsidized entrepreneur outlined some of the
complexities of his situation. He was the head of a large bone group that worked on drugs for osteoporosis. In his words,

It [osteoporosis] became popular with the pharmaceutical companies because all of a sudden they realized there was an enormous market... they had a big-time disease out there affecting millions of people with no decent drugs..., and the chances of enormous profits if they had a good drug... and so when I first starting working in research about 20-25 years ago, it was like really tiny, hardly anybody in it...

In other words, his situation was transformed by corporations seeking profits in new areas. Rather than allow corporations to capture all the profits, the professor worked with his university to develop a plan from which both the institution, the state and the professor benefitted.

So, what the university has done is, we have decided on this specific area of research of direct discovery for osteoporosis... and they have allowed me to go out and hustle, form a separate company, and hustle companies from outside for money to support this. They get part of the equity and it's just like a sense of gift for them, and ... I'm still a full-time faculty member. So...at this stage is that I have a company which has gotten the right to actually license its products to any big major pharmaceutical company out there, but in addition, I'm responsible for this big operation at the school which is also dealing with other companies, but through the school. So, we have some patents which are handled through the school which involve usually pharmaceutical companies through the school, so that the school owns the patent and the school is actually doing the licensing. And, then we have this other operation where the school is like a minority shareholder. So, it's a little complicated.

This professor never touched on the many conflict of interest issues inherent in his situation, all of which raised professional quandaries. What would the professor and his institution do if the clinical trials suggested that their were health problems related to the drug? Neither university nor professor could claim to be disinterested parties to the trials, given their direct economic interest in the outcome. How did the professor decide which discoveries to channel through the basic discovery group, in which the university was a "minority shareholder" and which through the school, where the university owned the entire product and controlled the licensing? How did the professor avoid "disclosing" knowledge he gained in one project to participants in another, given that all the knowledge was contained in his mind, and very likely one discovery cross-fertilizing others?

Start-up stories did not always avoid exploring the professional dilemmas professors encountered
when they crossed boundaries between academe and industry. A professor of chemistry described how he began working with a corporation as a consultant, became enmeshed in corporate decision making and the company’s future, and found himself sliding down a slippery slope into professional quandaries. He was recruited as a consultant by a former undergraduate student because he worked on related (and federally funded) research. Because the company ran short of money, the professor took an equity position and funding for a postdoc, who worked for the company, in lieu of consulting fees. He acknowledged the problems possible in his course of action:

... That’s why you have to file all sorts of financial disclosures and so forth because, of course, the university wants to make sure that you’re not working your graduate students or postdoctorates to death to put dollars in your pocket. And so in that case, and this was the first time I’d ever done this, it was a small company and they didn’t have huge amounts of money and so the agreement was that they would pay me half my usual consulting fee with the other half being in stock options. And so, I mean, I didn’t get a huge equity position in the company but it ended up, you know, being a smart financial move because when the company was sold, I was obliged to sell that stock but at a substantially higher price.

Although the professor understood the ethical issue of student and post doc exploitation (“working your graduate students or postdoctorates to death to put dollars in your pocket”), he nonetheless let the company fund the postdoc, perhaps because otherwise the company would have failed and he would have lost his consulting fees and stock options. He did not speak to whether the postdoc received an equity share in the company. The chemistry professor justified his corporate success by saying that there was “a new paradigm,” noting that “times have changed...companies are....looking to invest money” in “university laboratories” as was the case with biotechnology.

Not all faculty were happy with their start-up experiences. An associate professor of biomaterials who held an equity position in a start-up, discussed what he experienced as loss of control of his research. The loss of control came in two ways: first, he was shut out of the company with which he was working; second, he implied that he could not control the way the company presented his findings to the world, which confronted him with ethical quandaries.
He took an equity position with the company in trade for his technology. However, his equity position did not entitle him to a voice in corporate decision making, let alone a seat on the board. Within a year, he was pushed out of the company, although his technology stayed, and he retained his equity position.

I've had a very bad experience [with a spinoff].... after we got the company up and going, we were asked to leave within a year.... the technology from us, it was basically my lab .... [but] these products, or so-called products, don't really see the light of the day, especially in this area. By the time they see the light of the day they are so different and there are patents upon patents that any gain that you might get from royalties is almost nonexistent.... And once the company starts, it's got a life of its own.... the faculty members are not officers.

He was concerned with having a voice in how his discovery was used, and feared that it might be buried in the company's overall strategic deployment of patents (which would also, as he notes) diminish any royalties he might hope to receive). He also implied that corporations—perhaps even the corporation that held his technology—sometimes misrepresented what the technology could do, creating ethical dilemmas for academics.

... we see so many problems. I mean, the silicon problem, now we have polyethylene wear on the total joint. I just feel wrong in supporting something that will, maybe, which I feel that the indications might be a problem. Even though it's my technology but just because you have a technology, doesn't mean it's working right now. It might need another five years working on it to fine tune it.... I do believe, often times, young start-up companies—not the big established ones, the big established ones don't have to worry about it too much—the young ones, in order to survive, do tread very close to that ethical line, if not cross it at times. Where as sometimes not all the data is shown and it should be shown. You know, if you are testing 100 animals and you put in a gray implant and three of them do well and the others don't do well. Then in the pictures you show, you show those three perfect ones as representative. Now that's kind of... You're not saying that all of them were like this but when you show those pictures, you imply that all your cases were like that...Now is that ethical? To me, it's not.

Start-ups dramatized the quandaries faced by professors involved with industry. Once the boundaries between university and industry had been fairly clear. According to (mythical) professorial custom and tradition, professors had been responsible for basic science, and industry for applied, neatly separating science and commerce. Now industry, driven by "the intensification of the profit motive" mined
the university for commodifiable knowledge “penetrat...[ing] into areas ... previously governed by other considerations" and professors began respond to “the growing role of money as intrinsic value” (Soros 1995). The professors were pressured and tempted not only by industry; the institution in which they worked, the university, had also moved toward market values. As the full professor and head of chemical engineering we quoted earlier said, "... the wall was really high.... We didn't want anybody in the world to say that... Joe Blow was using the state resources for gain.... Then what happened was about ten years ago, it shifted markedly to the sort of idea that something else could pay the toll booth.... there was then a push and a great liberalization of what universities could do." Like industry, universities encouraged professors to capitalize their knowledge. Although universities and states had rules to guide professors' work with industry, the regulations were to some degree undercut by institutions insistence on their rights in intellectual property and their share of profits. For the most part, professors dealt with the quandaries that emerged when they crossed boundaries between academe and industry on their own, as individuals.

Generally, the professors resolved quandaries by accommodating industrial and institutional demands because they saw no other way of maintaining their core identity as teachers of graduate students and researchers. The new narratives about competitiveness told outside universities stressed, the intrinsic value of money, and the willingness of the neo-liberal state to fund university-industry-government ventures. These narratives made it easier for professors to elide academic and commercial values. (That professors often benefitted economically from work with industry probably was perhaps not incidental to their accommodation.) Even when professors were critical of industry and academic institutions—and they were usually more critical of academic institutions than of industry—they often recognized the utility of the new partnerships, whether these were making students more ready for the market, bringing new revenue streams to the institution or state, or building regional economies.

CONCLUSION

According to the scientists and engineers in our sample, the geography of science had changed
over time, and a new map, on which boundaries were still uncertain and speculative, was emerging. In the Golden Age, the boundaries between faculty, the state, and the private sector were fairly clear. Scientists and engineers were located in civil society, a space outside of either state or private sector, even though they were generally funded by the state, most usually the federal government, and supported by their institutions, either arms of the state, if public universities, or heavily state subsidized, if private universities. The state in its several forms was not an arena for profit taking.\(^{10}\) State-supported scientists handed off their discoveries to industry, which was in a separate realm, where discoveries were applied and developed. In this space/time, scientific norms and values—such as science as a non-monetary good, free access to knowledge, a research community that transcended national boundaries and commercial interests, and disinterested skepticism on the part of the researcher (Merton 1942/1973)—were far from universal but at least possible because scientists and engineers had some degree of separation from the corporate sector and the state.

\(^{10}\)There were, of course, exceptions. Much work funded by the Department of Agriculture—for example hybrid seed corn—brought professors, universities, and commerce together, and precipitated some of the earliest (1950s) intellectual property cases in which professors were involved (Berlan and Lewontin, 1986; Kloppenberg 1988). In the 1920s, professors at the University of Toronto developed insulin, which was produced by Eli Lilly, and the University of Wisconsin developed the WARF foundation to manage patents from rat poison and vitamin D irradiation). But the these exceptions did not disrupt the “Golden Age” narrative of science and its boundaries, nor involve the numbers of faculty members and universities that is currently the case.
In the current space/time professional or scientific space was no longer clearly demarcated from the corporate sector and the state. The corporate sector no longer waited for discovery; instead, business/scientists, often Ph.D. holders of physicians, located in corporations worked with professors to delineate research projects, exercised some oversight over their scientific content, and evaluated their success, a judgement based on the market, not on peer review.\textsuperscript{11} This geography was different from the Golden Age, in that in the past business/scientists were located in large industrial laboratories, and for the most part did not manage projects in universities. In the current space/time, the state, most noticeably at the level of the institution, became an interested party in the matter of knowledge production, not simply a supporter or funder. The state, sometimes in cooperation with the private sector, sometimes in competition,\textsuperscript{12} also sought to turn professors’ science into intellectual property and/or commodities that make profits, a share of which bring resources to the university. Perhaps the “triple helix” (Etzkowitz, Weber and Healey 1998) another and unproblematised geography of science, began braiding industry, university, and the state so closely together that the space is which scientists operated (relatively) autonomously began to close.

\textsuperscript{11}The exchanges between corporate scientists and university scientists are two-way. While university scientists work with corporate leaders to make products, corporate scientists publish increasingly in peer reviewed journals, of which many university scientists are reviewers (National Science Foundation 2000). A question this raises is how scientists separate their judgements when in operating in the different spheres.

\textsuperscript{12}A number of universities engage in litigation with corporations over faculty/institutional intellectual property. Some, like the University of California system, aggressively police their patents and trademarks (Baez and Slaughter 2001).
Abbott (1988) argued that jurisdiction, the ability to exercise authority over domains of knowledge through a variety of devices, including legal monopoly, was the central struggle of professionals. We believe the stories that the scientists and engineers in our sample tell suggest that jurisdiction is central to maintenance of professional status, authority and organization, but that the boundaries between academe and industry are as crucial as boundaries among professions. As a professor and head of chemical engineering quoted earlier, noted, in the past "...the wall was really high" between academe and industry and now it has come down. Like the dismantling of the Berlin Wall, the crumbling of the wall between academe and industry has created shifts in the political economy of academe, moving industry to the foreground and making the state less responsive to professors' construction of science as something that could be funded for its own sake. Jurisdictional struggles between industry, academe and the state about, centering on issues of ownership, access and control of knowledge, pre-empting jurisdictional quarrels among disciplines.

Professors manifested their concerns over sharing scientific jurisdiction with industry in a discourse that mixed metaphors about boundaries, professional values, ethics and control. Their language suggested that the jurisdictional issues they experienced were frequently unexpected, surprising, threatening, dangerous. They said "the sands keep shifting," that they ran into "snags," saw relations between academe and industry as a "two-edged sword." They saw themselves as "treading the borderline between ethical problems" and asked "where does your lab end and where does the company start?" "Where do you draw the line?" Or, as one professor succinctly put it: "We all have to compromise. But the question is, how large is the compromise?"

Boundaries were complicated demarcations, separating jurisdictions, but also distinguishing among cultures, values, and idea systems. To some degree, the ways that scientists and engineers talked about these boundaries depended on the nature of their relationship with their industrial partners. The majority of the scientists and engineers in our sample, who had unproblematic (or less problematic)
relationships with industry, spoke matter-of-factly, employed a vocabulary which minimized and muted the salience of the older values of "social trustee" professionalism (Brint 1994), blurring boundaries between academe and industry even as they paid rhetorical heed to norms and values formerly hegemonic in defining the standards of behavior for academic scientists and engineers. While these scientists and engineers spoke to the old categories and boundaries as guiding their work, they did so in ways working to collapse, expand, parallel, and redefine the "traditional" cognitive-semantic categories of the academic faculty-researcher's professional world, thereby working to produce and reproduce a professional reality which they found beneficial and rewarding (Fairclough 1995). In many ways, their talk suggests they had moved beyond "expert" professionalism (Brint 1994) which is characterized by serving the techno science core of the economy by training graduate students and producing research, to taking a place as actors and stake (and sometimes stock) holders in the techno science core.

The minority of scientists and engineers who had problematic (to greater and lesser degrees) industrial relationships spoke in more contentious tones, employing a vocabulary that highlighted the salience of the values associated with "social trusteeship" at the same time that they described the very real boundary transgressions they confronted in their daily work lives. However, the less satisfied professors generally did not use their talk to contest and resist the re-valuation of social trustee professionalism. Instead, their critique seemed to crumble because they acceded to the prevailing neo-liberal ideology that valorizes competition and profit as the logic of capitalism.

Professors had to deal not only with boundaries between academe and industry, but shifts in the way their institutions constructed the terrain that belonged to professors and that which was claimed by the university. Like corporations, segments of their universities—often technology transfer offices, offices of vice-presidents for research and offices for economic development, aided by state and federal legislation that enabled them to capture resource streams from faculty intellectual property for their institutions—sometimes tried to direct and shape professors research agendas so as to maximize profits that
would be realized through licensing and royalties. Although universities were technically nonprofit, either public (state) entities or private (civil society), they developed profit-sharing arms and became part of the new economy. Universities often encouraged professors to become state subsidized entrepreneurs and then intervened in the research process to maximize profits. Universities' positions with regard to intellectual property and profit taking often presented professors with dilemmas because even as they encouraged professors to become market actors, they sought to regulate their activity through conflict of interest policies, disclosure policies, ethics courses and open access policies. Unlike the corporations, the universities, sought not only profit, but forms of legitimacy associated with social trustee professionalism. This created continual quandaries for professors who were expected to respond to these very mixed signals.
REFERENCES


TABLE 2. SHIFTING ALLIANCES AMONG ORGANIZATIONS THAT PERFORM RESEARCH

**University-government-industry (1940-1980)**

University foregrounded, setting the direction for basic research; large, long term grants with little accountability. Government as funding source with industrial relations serendipitous.

**Untold and contradictory story.** University-military-industrial complex, in which government (military) funds the majority of “basic” research for a relatively small number of researchers at elite universities.

**Government-industry-university (1980-1990)**

Government sets direction for research by moving in an entrepreneurial direction, linking research to industrial and economic development. Even formerly “pure” agencies (NSF, NIH) which have universities as major clients moving toward entrepreneurial research.

**Unheard story.** Faculty do not hear or listen to accounts of the complex political power relations between corporations, the state, universities and administrators, and various faculty and professional groups that move R&D resources toward an entrepreneurial agenda.

**Industry-government-university (1990-future)**

Industry moves to the fore, setting agendas directions in basic and applied research, which are elided so as to become entrepreneurial research. Universities and faculty often participate in this research, which government funds.

**Faculty support for a greater role for industry in research.** Most faculty in our sample— but not all—are supportive of a greater role for industry, especially in the absence of increased federal funding. However, many see the new alliance as creating quandaries for their scientific and professional identities and understand that there are not easy solutions to the dilemmas they now face.