THE EMERGENCE OF A COMPETITIVENESS RESEARCH AND DEVELOPMENT POLICY COALITION AND THE COMMERCIALIZATION OF ACADEMIC SCIENCE AND TECHNOLOGY

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During the past several years, the Washington-focused science and technology community has found itself on the edge of an unimagined future, what with the end of the Cold War and the impending reform of health care. The end of the Cold War undermines the time-honored rationale for mission agencies direction of substantial funds to corporations and research endeavors that sustain defense, threatening the well-being of what Dwight Eisenhower called the "military-industrial complex" (Eisenhower 1961, p.22). Similar change confronts the health sciences, particularly university-based medical education and research. Privatization and commercialization of health care seems likely to direct monies away from practitioners, clinical professors, and some established research fields, and toward corporate concerns, such as application of technologies, diagnostics and interventions to fully insured, large patient populations, giving pause to the medical-industrial complex.

Even before the standard justifications used to defend government spending on science and technology came into question, a new rationale to guide R&D policy began to emerge. The "competitiveness" agenda was proposed as science and technology policy in the 1980s, during the Reagan and Bush administrations, and found an articulate and ardent champion in President Clinton (Slaughter 1990, 1993, Greenburg 1993, Clinton/Gore 1992,). Competitiveness R&D science and technology policy uses government funds to commercialize science and technology through corporations and research and development agencies likely to increase U.S. shares of global markets and to increase the numbers of high technology, high salaried jobs in the domestic economy.1 With the

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1 Although the individuals and organizations promoting a competitiveness agenda usually see no disjuncture between increasing shares of global markets and increasing numbers of high technology jobs in the domestic economy, these may be alternative policies, one precluding the other, or at least inconsistent policies (Aronowitz
breakdown of the traditional epics—"winning the cold war," "the fight against disease"—that justify spending on science and technology, "global competitiveness" is an effort to create a new narrative of heroic proportion that serves the same purposes as the old.

Many participants in the science and technology policy communities write as if competitiveness policies can easily be substituted for military-medical-industrial policies and that, after a period in which military and health care industries make various adjustments, a new science and technology regime will be installed. (For examples of policy documents promoting the competitiveness R&D agenda see Business-Higher Forum 1983, 1986, Committee on Science, Engineering and Public Policy 1992, 1993, President's Council of Advisors on Science and Technology [PCAST] 1992, Kaufman and Waterman 1993, Marston and Jones 1992, Bernthal 1992, Government-University-Industry Research Roundtable 1992, Smith 1990.) Like many in the science and technology community, we think the shift from a Cold War to a competitiveness R&D policy is underway, but believe the transition will be lengthy, uneven, and incomplete. At least for a time, the Cold War and the competitiveness techno-science regimes will be sustained simultaneously. Given that the consequences of a Cold War R&D policy for the academy are well understood, in this article we explore the likely consequences of a competitiveness policy on academic science and technology.2

More specifically, we look at the assumptions undergirding the academic science and technology policy literature that takes a

2 In the interests of alliteration and convenience, we sometimes use the term "Cold War R&D" policy to include medical as well as military industrial policies, even though we realize this compresses and distorts the very different organizational and political support structures for these policies.
substitution approach, suggesting that universities will fare as well under a competitiveness regime as they did under the Cold War regime. The assumptions of this literature, written largely by university managers, university participants in policy making forums and spokespersons for professional and scientific associations, are several. First, the literature assumes that if science and technology are seen as contributing to economic competitiveness, funding for academic R&D, including basic research, will increase. Second, it assumes that science and technology funding with a commercial rationale will not greatly change scientists and the way in which they work. Certainly participants in the policy process recognize that problems are posed by commercial science and technology in a university setting—for example, secrecy with regard to intellectual property, conflict of interest, conflict of commitment—but they make the case that such problems are not insurmountable, and can be handled through a variety of procedural solutions (Etkowitz 1983, 1989, Louis 1989, Blumenthal 1986). Third, the literature often assumes that academic science and technology are somehow separate from the universities in which they occur: very rarely do these literatures speak to institutional problems and constraints that might stem from commercial competitiveness as a rationale for science and technology policy.

We argue that these assumptions are questionable. As indicated previously, we see a new pattern of support for academic science and technology policy emerging and think that this pattern will be substantively different than the constellation of support that undergirded academic science and technology from World War II until the 1980s. In this article, we: (1) describe the new bipartisan political coalition we see supporting commercial competitiveness as a rationale
for research and development (R&D); (2) point to selected changes in legal and funding structures in the 1980s that stem from the success of the new political coalition and suggest some of the connections between these changes and academic science and technology; and (3) examine the consequences these changes are having and might have on universities. In light of our analysis, we then re-assess the assumptions made by many researchers and policy activists with regard to competitiveness as a rationale for science and technology policy.

The theory that guides our analysis is post-marxian and post-structuralist. We chose post-marxian theory because it focuses directly on the power of capital, social class and knowledge as commodity, analytical foci important for examining commercialization of academic knowledge and its implications for universities. Post-marxian theory differs from marxian and neo-marxian theory in that it continues to offer a critique of oligopolistic capitalism, but sees class structures as fairly fluid, pays greater attention to a state distinct from capital, to human agency, to ideology, and to symbolism and social constructionism, and no longer looks to centralized socialism as the inevitable and only viable alternative to capitalism (Aronowitz 1988, Chomsky 1969, 1994, Krimsky 1982, Noble 1976, 1984, Rifkin 1983). Post-structural theory checks the marxian (whether neo- or post-) tendency to mechanistic structural explanations and grand narratives (Greenberg 1967, Dickson 1984, Latour 1987, Flinkstein 1990). Rather than looking only at the foreground where powerful social, political and economic actors and organizations shape policy, post structural theory also turns our attention to the background, where subversive, recalcitrant or unengaged actors and organizations pursue their own R&D and academic agendas.

Our design and data are relatively straightforward, as are the
problems they present. In considering the composition of R&D political coalitions, we examine longitudinal secondary data on changes in business strategies and corporate structures that made business elites in the defense and health industries more interested in promoting and supporting competitiveness R&D policies, but do not analyze primary data regarding the involvement of particular companies in shaping and lobbying for R&D policies and legislation. We identify and assess an array of national competitiveness R&D legislation passed in the 1980s and 1990s, concentrating on its implications for academic R&D, but do not perform a systematic content or discourse analysis of the legislative text. In appraising the effects of competitiveness R&D policies on universities and academic science and technology, we rely upon analysis of changes in time-series data (approximately 1983-1993) on science and technology indicators compiled by the NSF. We look for shifts in patents and publications activity, in the balance between support for basic and applied research, and in the targets of supports (e.g., individuals, teams, centers). We also draw upon other national data sets, such as faculty salaries in various fields. The strength of these national data lie in their uniformity over time and their breadth. The limitations are equally evident, including lack of clarity about exactly what goes into particular categories and an absence of linkage among the various data sets. In short, the data enables us to provide a "big picture" that suggests substantial change in coalitions, in legislation, and in impacts on academic science and technology.

R&D POLITICAL COALITIONS

Although the post World War II academic science and technology
community saw basic or fundamental research as very different than applied, academic researchers were nonetheless dependent on the mission agencies for the vast majority of their federal funds. The NSF, the only federal agency arguably dedicated to basic science, never accounted for more than 20% of federal monies for academic R&D in any given year between 1971 and the present. (Indeed, NSF monies declined from a high of 19.5% in 1973 to 14.1% of all federal monies for academic R&D in 1991 [NSF 1993]). The mission agencies supplied universities with 80-85% of their federal R&D monies, of which approximately 65-75% were designated as basic (NSF 1993). The academic science and technology community always interpreted "basic" or "fundamental" to mean that university-based researchers, following the imperatives of their fields, set direction for their research programs independently of the mission agencies (Smith and Karlesky 1977, Wolfle 1972). However, even when monies were tagged as basic, it was not clear how distinct these were from applied. Accounts of scientists' and engineers' negotiations with the mission agencies suggest that the academic interpretation of basic science was only partially shared by bureaucrats at the Department of Defense (DOD), Department of Energy (DOE), National Aeronautics and Space Agency (NASA) and the National Institutes of Health (NIH), organizations which had a much more instrumental definition of basic science. Some historians of science argued that basic science merely meant unclassified science and that even basic was powerfully and directly shaped by mission agency goals (Forman 1987, Leslie 1993). If basic or fundamental research were not as independent as the academic science and technology community might wish it were, then marked changes in the political coalitions forming mission agencies' constituencies means that academic science and technology will likely change when the composition and goals of R&D
coalitions change.

We argue that broad bipartisan R&D political coalitions emerged after World War II, one around DOD/DOE/NASA/aerospace that came to the fore by the early 1950s, another around the NIH, that developed somewhat later (see Table I). The composition of these coalitions was complex, but fairly stable until the late 1970s and 1980s. At that point, a new coalition began to emerge, closely related to the older ones, but distinct enough to propose new directions and new mechanisms for doing R&D, whether inside or outside of universities.

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TABLE 1 ABOUT HERE
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The story of the bipartisan R&D coalition built around DOD/DOE/NASA/aerospace has often been told (Greenberg 1967, Chomsky 1969, Melman 1982, Forman 1987, Herken 1992, Leslie 1993). Defense industries, the armed forces, university administrators and many scientists, along with supporters of the Keynesian welfare-warfare state, pushed for the expansion of defense and defense related spending. These monies were generally justified as necessary for winning the Cold War, which meant defeating international Communism in its many and insidious forms (May 1988, Rogin 1987). DOD/DOE/NASA/aerospace as a share of all federal monies for academic science grew from the end of World War II to approximately 26.7% of all federal obligations in the early 1970s (Greenberg 1967, Forman 1987, NSF 1993). After the Vietnam war, these monies dipped dramatically, falling to 17.7% in the mid-1970s, a point in time at which corporations, including defense, moved away from
concentration on single products, such as military goods, and began to pursue more diversified growth strategies, a point to which we will return later in this narrative (NSF 1993).

A less frequently told tale is the degree to which funding derived from the Cold War permeated all of academe, extending far beyond the physical and biological sciences and engineering. As the Cold War assumed global dimensions, universities received support for foreign languages and area studies under the National Defense Education Act, support for social scientists and scientists and engineers in agriculture from the Agency for International Development, and support for a variety of faculty via the national intelligence establishment. As Steven Muller, President of Johns Hopkins, remarked, "In an overall sense the American university was mobilized for the war by the federal government in 1941, and demobilization did not occur until twenty-five years later (Muller 1979)."

The general goals of this broad, bipartisan political coalition were several. The coalition wanted increased R&D funding for industry, government and academic R&D to: (1) win the Cold War, (2) administer high profits to defense corporations, and, indirectly, to their contractors and suppliers, and (3) subsidize corporate and academic R&D.

The story of the bipartisan coalition built around the NIH is a more fragmented narrative than that about the Cold War, perhaps because it attracted less attention from university based dissidents protesting the war in Vietnam, perhaps because it was built initially around separate

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3 By agencies the shares of all federal monies for academic R&D from 1970 to 1989 were as follows: DOD, 12.8% in 1970, 8.4% in 1975, 11.3% in 1979, 11.6% in 1980, 16.7% in 1986, 13.7% in 1989; DOE, 5.7% in 1970, 4.2% in 1974, 7.1% in 1978, 6.7% in 1980, 5.2% in 1989; NASA, 8.2% in 1970, 3.6% in 1979, 3.7% in 1980, 5% in 1989 (NSF 1993). From the mid 1970s, the DOD/DOE/NASA/aerospace funds began rising again, reaching 22% in 1980, 25.9% in 1986, and falling to 23.9% in 1989.
diseases. Prior to the 1980s, physicians in private practice, non-profit hospitals and insurance companies, pharmaceuticals, university administrators and many professors formed the basis of the "medical-industrial complex" (Ehrenreich and Ehrenreich 1970, Meyers 1970). Like the military-industrial complex, the medical-industrial complex formed an R&D coalition that effectively lobbied Congress for more monies for fighting the war against an increasing number of specific diseases, foremost among which were heart disease and cancer. Unlike the military-industrial complex, which targeted the executive branch, particularly the President in his capacity as commander-in-chief, Congress was usually the arena in which a variety of private practitioners, non-profit hospitals and non-profit insurance companies, pharmaceutical companies, university managers and researchers, together with groups of relatives of disease-stricken constituents, lobbied to fight specific diseases or disease clusters. The National Institutes of Health became the mainstay of academic research and development, increasing its share of federal monies for academic R&D from 36.7% in 1971 to about 45% in the mid-1980s (NSF 1993).

The general goals of this political coalition were similar to those of the military-industrial coalition. The medical-industrial coalition sought to: (1) win the war against disease; (2) administer high profits to specialist physicians and pharmaceutical and (3) subsidize corporate and academic R&D.

Student protest against the Vietnam war and against university involvement in defense R&D severely disrupted the flow of funding from DOD/DOE/aerospace/NASA to college campuses (Dickson 1984). But the ties between the military and the academy were ultimately cut more cleanly by the falling rates of profits and productivity that plagued American
manufacturing corporations in the 1970s than by the anti-war movement. U.S. corporations' after-tax profits fell from a high of almost 10% in 1965 to a trough of 4.5% in the mid 1970s, and recovery was slow and uneven (Harrison and Bluestone, Figure 5.1, p.110, 1990). The long-run growth of productivity remained at just under 1% from the late 1960s through the 1970s, a far slower rate of productivity growth than in the 1950s and most of the 1960s (Harrison and Bluestone 1990).

The profits and productivity crises were accompanied by several major changes in the structure of U.S. corporations, which made the American business elite begin to re-think its commitment to Cold War R&D policies. These changes included diversification, increased commitment to high technology products, globalization, and a greater involvement with producer services. These changes occurred in corporations that had defense and defense related product lines as well as corporations in the medical and medical-related industries. The business class, the most powerful player in R&D politics, confronted these changes as it moved away from the Cold War R&D policy coalition and united in a competitiveness R&D coalition (see Useem 1984 for a definition of business class).

By the 1970s, many large U.S. manufacturing corporations had diversified. In 1939, 77.8% of the largest firms manufactured a single or dominant product, only 22.2% manufactured related products and none manufactured unrelated products. As late as 1959, 37.7% manufactured a single product, 57.4% manufactured related products, and only 5.0% manufactured unrelated products. In 1979, only 23.2% of the 100 largest

4 Productivity greatly increased in the 1990s, but median family income declined, pointing to low-wage productivity, a story that runs contrary to the high technology prosperity narrative told by the competitiveness coalition (Phillips 1993).
firms still manufactured a single product; 49.5% had diversified to related products and 27.3% had become conglomerates, manufacturing unrelated products, expanding the only way possible given the constraints of anti-trust law on horizontal and vertical integration (Fligstein 1990, Table 8.1, p. 261). This dramatic shift to unrelated products created an opportunity for defense industries, which also diversified in the 1970s, to rethink their corporate strategies.

Although conglomerate fostered diversification into unrelated products, increases in profits and productivity did not follow, calling considerable consternation in the corporate community. In the late 1980s, due to deregulation of antitrust law under Reagan and Bush, corporations moved away from this "‘firm as portfolio’" or conglomerate model to a related products strategy (Bhagat et al. 1990, Davis et. al. 1994). Antitrust laws were reinterpreted administratively and judicially to permit horizontal mergers, allowing firms to buy up competitors and firms producing related products, rather than pushing firms to acquire unrelated products in a conglomeration strategy. Despite the wave of "deconglomeration" in the late 1980s, the clear majority of the largest firms (Fortune 500) continued to operate in more than one industry, a decidedly higher level of diversification than in the 1950s and 1960s, even though large firm "diversification tended to be into closely related industries (Davis et. al. 1990)." In the 1990s, then, large corporations were still diversified, but focused on related products, often in high technology industries or industries pursuing intellectual property strategies.

These changes in manufacturing companies corporate structure--conglomeration in the 1960s and 1970s and deconglomeration accompanied by related products diversification in the 1980s--were paralleled in the
defense industry which was heavily concentrated in aerospace, communications and electronics (Markusen and Yudkin 1992). In the 1970s, defense high technology firms that manufactured single products or even related products were more likely to exit from the ranks of the 100 largest corporations than diversified defense or high technology firms. Undiversified firms such as Control Data, General Dynamics and Lockheed left the list in 1969-1979, while conglomerates with defense divisions such as Honeywell, Litton Industries, LTV, and Minnesota Mining and Manufacturing entered in the 1959-1969 period, and Rockwell International in the 1969-1979 period (Fliqstein 1990, Table 8.7, pp. 278-279). By the 1980s, defense firms that had been assimilated into corporations pursuing conglomeration strategies were no longer as deeply invested in the Cold War R&D coalition as when these firms pursued single product or closely related product strategies. Instead, they were more willing to support competitiveness R&D policies that allowed them to draw on federally funded R&D across a wide range of research-intensive, high technology fields (Business-Higher Education Forum January 1986).

Even when the Reagan administration greatly increased defense funding in the 1980s, only five corporations--Grumman, General Dynamics, Northrop, Martin-Marietta, and McDonnell-Douglas--of the top 15 defense contractors were dependent on DOD and NASA primes for more than 60% of their sales (Markusen and Yudkin 1992, Table 4.3, p.78, Nimroody 1993, Table 3.1, p.56). Some prime contractors moved to conversion "by increasing non-defense business with the federal government, especially the National Aeronautical and Space Administration," while more diversified companies, such as General Electric and Raytheon, pursued dual-use strategies or reduced their defense commitments (Nimroody 1992, pp. 57-58). Quite diversified companies, such as Ford and Honeywell,
abandoned the defense industry altogether. There were fewer defense
dependent corporations in the 1990s, although those that remained were
more highly concentrated, as suggested by the Lockheed-Martin-Marietta
merger. Diversification of the majority of large high-technology defense
firms made it possible for their leaders to consider growth strategies
other than DOD/DOE/NASA/aerospace contracting and to re-think their
commitment to the Cold War R&D policy coalition.

In the 1980s, the corporate structure of the medical-industrial
complex experienced shifts as great as those in the military-industrial
complex, although the concrete changes in corporations were quite
different. Unlike the military-industrial complex, in which corporations
were concentrated in manufacturing, the changes in corporate structure
in the medical-industrial complex occurred in service industries as well
as manufacturing: hospitals and insurance along with the pharmaceutical,
agriculture and chemical industries. Like the military-industrial
complex, the changes in corporate structure of the medical-industrial
complex made the corporations involved appreciate the benefits of a
broad, bi-partisan competitiveness R&D policy.

In the 1970s and 1980s, the structure of the hospital and insurance
industries changed from non-profit to for-profit. Prior to the 1970s,

the medical-industrial complex, referred to the linkages
between the doctors, hospitals, and medical schools and the
health insurance companies, drug manufacturers, medical
equipment suppliers, and other profit-making firms....[that
were connected to] a medical system that was still made up
almost entirely of independent practitioners and local, non-
profit institutions (Starr 1982, pp. 428-429).

After 1970, growing privatization of hospitals, health-care services,
such as health maintenance organizations and preferred providers, and the
insurance industry began to replace independent practitioners and local, non-profit institutions (Relman 1980, Starr 1982). In the 1970s and 1980s, non-profit community hospitals were consolidated and bought up by multi-institutional profit-making corporations. These profit-making hospitals grew rapidly. Independent health maintenance organizations too were increasingly purchased by large corporations. In the insurance industry, Blue Cross and Blue Shield, "voluntary" health insurers, controlled most health premiums until the 1970s. They were replaced by large corporate insurance companies (life, auto) pursing health insurance as a related product. Blue Cross and Blue Shield market shares for private insurance fell from a high of 45% in 1965 to a low of 33% in 1986, at which time they privatized, losing their non-exempt tax status (Navarro 1994). Currently, major insurance companies--

Metropolitan, Aetna, Prudential, Connecticut General, and the Blues, among others--are developing managed care plans and acquiring the already existing plans....Eighty-two percent of the delivery system is now under some form of managed care, contracted by, controlled by and/or influenced by insurance companies (Navarro 1994, p.207, 209).

As the health-care industry moved from non-profit status to profit-taker status, it began to pursue high-technology health-care solutions that focused on diagnostics, protocols, pharmaceuticals, and biotechnology to reduce labor costs and increase profits. In other words, the health care industry developed a strategy of horizontal and vertical integration under the relaxed anti-trust laws of the Reagan and Bush administrations and became very interested in non-Cold War research-intensive products.

As the health-care industry restructured, the pharmaceutical, agriculture and chemical industries began aggressively pursuing
biotechnology. Pharmaceuticals began working with dedicated biotechnology firms in the 1980s, using biotechnology "both as a production technology and a research tool.... [because] Biotechnology is likely to be the principal scientific driving force for the discovery of new drugs as we enter the 21st century... (Congress of the U.S. 1991, 94-95, see also Kevles and Hood 1992)." Sometimes pharmaceuticals acquired small dedicated biotechnology firms, but they often used "nexus-of-contracts" strategies to develop temporary research-intensive networks to develop specific products (Davis 1994, Powell 1990). Like pharmaceuticals, agricultural companies acquired dedicated biotechnology firms and invested in biotechnology (Kenney 1986, US Congress 1991), whether to increase yields, lower costs or create new products. The chemical industry, increasingly challenged by global competition in the 1980s, turned away from bulk chemical production, an area the markets of which had been captured by European companies, and began investing in aspects of pharmaceuticals and agriculture that had possibilities for biotechnology (U.S. Congress, 1981). In other words, the strategies of pharmaceuticals, agricultural companies and chemical companies became more similar, with all three types of firms investing in in-house research and purchasing or developed links with smaller research-intensive biotechnology firms. The industrial contribution to medical and related R&D increased from 39% in FY 1983 to 50% in FY 1993, indicating the commitment of these industries to research-intensive, intellectual property strategies for competition in a global economy (NIH 1994).

Structural changes in insurance and hospital companies and the pharmaceutical, agricultural and chemical industries prompted a greater interest on their part in a competitive R&D policy coalition in the
1980s. Privatization made insurance and hospital companies concerned with cost-containment turn to high technology strategies such as screening, diagnostics, and "magic bullets" (Brandt 1985). Simultaneous diversification and convergence focused the pharmaceutical, agricultural and chemical industries on biotechnology as the key area for future growth, with profit-intensive human therapies as a prime target. A competitiveness R&D policy that turned the NSF, NIH and DOD/DOE/NASA/aerospace toward commercial science and technology became increasingly important to these corporations.

The structural changes that occurred in U.S. manufacturing corporations in the 1970s and 1980s were in large part driven by changes in the global economy. At the same time U.S. corporations experienced profits and productivity crises, they lost some of the global advantages conferred by initial industrialization, empire and neo-colonial trade relationships. Markets, whether manufacturing or services, were increasingly internationalized, making it possible to speak of global markets in the 1970s and 1980s (Sassen 1991). Newly industrialized nations as well as established industrial nations competed, often successfully, with the U.S. for shares in these global markets. The problems faced by U.S. corporations were exacerbated by the Third World debt crisis, which undercut the position of transnational banks, leading to deregulation and the proliferation of global financial/producer services companies, often located in countries other than the U.S. (Thrift 1987, Sassen 1991).

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5 The NIH and NSF were not the only mission agencies to support biotechnology. While NIH provided the most support in 1991 at $2,275.95 (in millions), the DOD was second, at $118.80, NSF third at $93.80, USDA fourth at $84.00, and DOE fifth at $62.40, followed by AID at $43.76. Other agencies paricipated in biotechnology research, but at less than $10.00. National Science Foundation April 10, 1991, Table 2, p.9).
In concrete terms, global competition meant that U.S. corporations no longer dominated some markets. "Up to 1979, the U.S. had been the leading exporter of such [direct foreign] investments. By 1981, it had become the leading recipient, and had fallen to second place as an exporter of capital, behind the United Kingdom..." (Sassen 1991, p. 37). In terms of balance of trade, the U.S. was unable to uphold a "positive merchandise trade balance," falling from -2.3 in 1971 to -141.6 in 1985 (Cohen and Zysman 1987, Table 5.1, p. 62). U.S. share of world exports fell "in value terms from 26 percent of world markets in 1960 to 18 percent in 1980--before the dollar aggravated matters" (Cohen and Zysman 1987, Figure 5.1, p. 64). Even the U.S. high technology position was weak, with the majority of high technology exports concentrated in military goods (Business-Higher Education Forum 1986, Cohen and Zysman 1987).

The profits and productivity crises along with the Third World Debt crises and attendant deregulation of the international banking system led to the rapid rise of global competitiveness in manufacturing and services in a variety of countries (Sassen 1991). As the competitive edge held by the U.S. dulled, many corporate leaders began to develop new strategies. Given that newly industrialized countries were able to draw on cheap labor, the U.S., like other established industrial countries began to pursue a high technology, intellectual property strategy. High technology products focused on manufactured products that embodied sophisticated science and engineering, skills lacked by many newly industrialized nations. Intellectual property included infrastructure for the global market, such as telecommunications, producer services, biotechnology and software. All of these products relied heavily on R&D, but not necessarily the same sort of R&D promoted by the Cold War R&D
coalition.

Corporate leaders and national policy analysts began to articulate competitiveness strategies in the 1980s. They often looked to countries, such as Japan, in which corporations and the state worked in partnerships to foster national competitiveness in selected global markets (Ballard et al. 1989, Fligstein 1990, Thorow 1985, Reich 1983). They developed a critique of American business that included large and generally unproductive military expenditures (Business-Higher Education Forum 1986, Thurow 1985, Reich 1983, 1991). They sought to change anti-trust laws, promoting cooperation at home and competition abroad, and also called for increasing spending on commercial R&D.

The transition from Cold War to competitiveness R&D policies was made easier by the Reagan and Bush administrations’ liberal R&D spending. Military monies increased greatly as did legislation and monies that supported competitiveness (Nimroody 1988, Markusen and Yudkin 1992, NSF 1993). Under Bush, the President’s Council of Advisors on Science and Technology (PCAST) began to articulate a competitiveness R&D policy. Policy analysts and policy advisors regularly moved back and forth between the PCAST staff and the Council on Competitiveness (Greenberg 1993). By the late 1980s, even the NSF began to promote a competitiveness R&D program (NSF 1989). Cold War and competitiveness strategies were pursued simultaneously, receiving broad bipartisan support. Clinton borrowed much of the language and many of the concepts developed by Bush’s staff in his presidential campaign (Clinton and Gore 1992, Greenberg 1993, 1994).

In response to the crises in profits and productivity, the Armed Services as well as defense contractors began to develop dual-use policies in the 1980s (Slaughter 1990). Dual-use served as a bridge
between the Cold War and competitiveness policy communities. Some agencies within the Armed Services, such as the Advanced Research Projects Agency (ARPA) and the Office of Naval Research (ONR), began to promote research goals that included collaborative partnerships between the military, corporations and universities that were geared to products for civilian markets (ARPA 1994, Office of Naval Research 1994). (However, the Armed Services were more enthusiastic about competitiveness policies under the Reagan and Bush administrations, when Cold War R&D policy received the bulk of R&D non-health spending, and competitiveness looked like an add-on, than in the Clinton administration, when choices may have to be made between Cold War and competitiveness goals.) 6

University managers were enthusiastic supporters of the competitiveness agenda. Their early and eager support for competitiveness was most clearly demonstrated through their participation in the Business-Higher Education Forum, an organization comprised mainly of the CEO's of large firms and the presidents of prestigious universities. The organization built consensus among its leadership and their various constituencies for a variety of legislative changes that made the possible easy transfer of technology from universities to corporations and created the opportunity for universities to engage in a wider range of for-profit activity (Slaughter 1990).

The degree of support for a competitiveness R&D policy on the part of scientists and engineers was not clear. Scientists were not enamored

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6 The several states became deeply involved in competitiveness R&D policies in the late 1970s and 1980s, often anticipating programs later developed by the federal government. However, space constraints compel us to forego discussion of state R&D policies. For our research on the rise of state-university-industry initiatives, see Lambright and Rahm 1991; for research on changes in state legal structures to accommodate state-university-industry initiatives, see Slaughter and Rhoades 1993.
of industry-university-government collaborations when these projects diverted monies from grants for individual investigators. However, some scientists and engineers were very supportive of competitiveness policies, and professors generally, whether in science and engineering or other fields, thought that universities and colleges should pursue commercialization aggressively (Campbell 1995). Moreover, the majority of scientists and engineers have not organized for or against a competitiveness agenda in any noticeable way.

The pharmaceutical, agricultural and chemical companies together with the hospital and insurance corporations created a "new" profit-taking medical-industrial complex that drew heavily on discoveries and technologies based on NIH research. These firms joined together with diversified manufacturing companies that moved away from the Cold War R&D coalition in the 1970s and 1980s, to push for a broad-gauge competitiveness R&D policies that depended as much on intellectual property rights as on more traditional products. The goals of the competitiveness coalition were to: (1) win control of global markets through privatization and commodification of intellectual property; (2) establish government subsidies for high technology and producer services industries; (3) to move R&D, including university R&D, toward commercial science and technology (see Table 1).

Because our narrative of the rise of the competitiveness coalition is one of several we want to deploy in this article, we have glossed over a number of tensions, problems and contradictions unresolved by the supporters of this coalition. The relation of the competitiveness R&D coalition to the Cold War R&D coalition remains ambivalent. CEOs of large multinational conglomerates are active in both and unlikely to easily forego the cost plus/military specifications profit system
characteristic of defense contracting. Military spending encompassed much more than corporations: federal laboratories, universities, communities centered around military bases, contractors and suppliers as well as the beneficiaries of non-weapons defense procurement are apt to resist the cuts in defense spending that would make possible a fully-fledged competitiveness policy. As the industries and constituencies that surround the DOD/DOE/NASA/aerospace mission agencies balance between technoscience regimes that are sometimes competing and sometimes complementary, so too the industries and constituencies focused on the NIH sometimes share regimes and sometimes compete. Perhaps the strongest tension in the medical/biotechnology area is between insurance companies that strive to keep costs down and companies which develop and manufacture costly, high technology products, whether mechanical, electronic or biological.

ACCOMPLISHMENTS OF COMPETITIVENESS R&D

In the late 1970s and early 1980s, the emerging competitiveness R&D coalition began to iterate and reiterate a narrative of science and technology that differed on important points from the Cold War saga of winning the fight against Communism or the physician/non-profit hospital stories about defeating disease. Although neither of the heroic narratives--the struggle against the ultimate other, the Evil Empire, or the battle to vanquish dis-ease, perhaps finally triumphing over death itself--were ever abandoned, indeed continued to be invoked even as new narratives emerged, the narratives through which science and technology were addressed in public discourse began to focus more on economic competitiveness. The competitiveness narrative moved away from a tale
of basic science, ensconced in a university separate from society, in which scientists and engineers developed the "seed corn" from which national security, health and prosperity grew, and toward a story in which business and industry worked closely with science and technology to create commercial products and processes to become competitive in global markets (Slaughter 1993).

The important points of difference in the Cold War and the competitiveness narratives were several. In the competitiveness narrative, the needs of business and industry were paramount and the roles played by university-based scientists and engineers were secondary. Knowledge was valued not for its own sake, or for what it might someday contribute to economic development, but for its contribution to the creation of products and processes for the market of the moment. The ivory tower location of the university, separate, inviolable, beyond the sordid concerns of commerce and the petty squabbles of politics, shifted as the boundaries between commerce and the university dissolved into partnership agreements with the private sector. The university, like business and industry, began to participate in intellectual property profit-taking, and the boundaries between public and private organizations blurred. The government agencies that once had specific science and technology missions now combined across agencies to support science and technology geared to enhancing industry. Universities were valued as much for their training functions as for their capabilities for novel discovery.

In the 1980s, competitiveness narratives were told over and over gain in countless policy documents, position papers and congressional hearings. (For examples of policy documents promoting the competitiveness R&D agenda see Business-Higher Forum 1983, 1986, Committee on Science,
Engineering and Public Policy 1992, 1993, President's Council of Advisors on Science and Technology [PCAST] 1992, Kaufman and Waterman 1993, Marston and Jones 1992, Bernthal 1992, Government-University-Industry Research Roundtable 1992, Smith 1990. For examples of Congressional hearing see Committee on Science, Space and Technology 1987, 1992, 1993). That policy makers found the new narrative compelling was evident in the way the competitiveness narrative was embodied in law and various government rule-making modalities in the 1980s and 1990s. In this section, we look at the competitiveness R & D coalition's legislative accomplishments (see Table 2), briefly note the ways the law incorporates and embellishes the competitiveness narrative, and examine some of the implications of these laws and rules for academic science and technology. We also document the degree of bi-partisan support for the new competitiveness R&D coalition, assessing its strength.

The Bayh-Dole Act (1980) signaled the inclusion of universities in profit-taking. It permitted universities and small businesses to retain title to inventions made with federal research and development monies. In the words of the Congress, "It is the policy and objective of the Congress ... to promote collaboration between commercial concerns and nonprofit organizations, including universities" ([emphasis ours] Bayh-Dole Act 1980, 94 STAT. 3019). Prior to the Bayh-Dole Act, universities were able to secure patents on federally funded research only when the federal government, through a long and cumbersome application process, granted special approval.

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TABLE 2 ABOUT HERE

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The Bayh-Dole Act changed the relationship between university managers and faculty in several important ways. As potential patent holders, university trustees and administrators could suddenly see all research generated by faculty as possible intellectual property. Faculty too could conceptualize their discoveries as products or processes, private, valuable, licensable, no longer as knowledge to share publicly with a community of scholars (Rhoades and Slaughter 1991, 1991a). Relationships between administrators and faculty changed as they negotiated ownership of intellectual property through university committees and in state courts and as states developed legislation that addressed ownership issues, further contractualizing faculty-management relations (Slaughter and Rhoades 1990, 1993, Chew 1992, Olivas 1992). The Bayh-Dole Act gave new and concrete meaning to the phrase "commodification of knowledge." The act enabled universities to enter the marketplace, made them profit-takers, directly, when universities held equity positions in companies built around the intellectual property of their faculty, and indirectly, when universities licensed intellectual property to private sector firms. In a very real sense, the Bayh-Dole Act encouraged academic capitalism (Slaughter and Leslie, forthcoming 1995).7

Competitiveness legislation blurred the boundaries between public and private sectors. The several technology transfer acts, beginning with the Stevenson-Wydler (1980), pioneered the legal and administrative mechanisms for transfers between public and private entities. These acts were aimed primarily at the Federal laboratories, but also touched on universities. For example, in the Federal Technology Transfer Act of

7 In 1983, by executive order, Reagan included all corporations in the Bayh-Dole Act, changing a law meant to benefit small business and universities to one that included large corporations as well.
1986, the Federal laboratories were able to enter into cooperative research and development agreements with "other federal agencies, state or local governments, industrial organizations, public and private foundations, and non-profit organizations, including universities" ([emphasis ours] Federal Technology Transfer Act of 1986, 100 STAT. 1785). Although universities were not one of the main targets of Stevenson-Wydler, the technology transfer acts were important in incorporating universities into the competitiveness agenda because they pioneered the legal structures that shaped collaborative research agreements between public, non-profit and private sectors, not least of which was the Collaborative Research and Development Agreement (CRADA). CRADAs permitted private corporations to select marketable products and processes from inventories of federal laboratories' intellectual property and work in collaboration with federal scientists to bring the product or process to market, in return for which the federal laboratories received a share of the profits through license or royalty agreements. Whether or not they participated in CRADAs, universities emulated them, developing directories of the problems of which scientists and engineers were working, and sharing the directories with the business community in hopes of promoting collaboration. Like the Bayh-Dole Act, the several technology transfer acts changed common understandings of what public and non-profit meant. Again like the Bayh-Dole Act, the Stevenson-Wydler authorized segments of public and non-profit organizations to participate in the market, dissolving the boundaries between university and society, and allowing interpenetration in areas of market potential.

The place of universities in the competitiveness agenda was underscored by the Small Business Innovation Development Act (1982). This act mandated that federal agencies with annual expenditures over $100
million devote 1.25% of their budgets to research performed by small businesses, deemed the engines of economic recovery. It passed despite the opposition of major research universities (Slaughter 1990). In FY 1989, $18.6 million of the NSF budget went to small business programs (NSF 1989, p.3). Although the amounts of money captured for commerce by the Small Business Innovation Development Act were insignificant items in the mission agencies budgets, they symbolized the inability of the research university lobby to hold their share of federal dollars when they acted outside the purview of the competitiveness R&D coalition.

Several pieces of legislation—the Orphan Drug Act and the National Cooperative Research Act—revealed the increasing importance of research in business strategies. Research served multiple functions for corporations, enabling product development, in the case of orphan drugs, but also promoting government subsidies and serving legal and ideological functions, as in the case of the National Cooperative Research Act, which weakened national anti-trust legislation. While universities were able to participate in the opportunities created by this legislation, they were not its target, and benefitted from it only in so far as they were willing to embrace the competitiveness R&D agenda.

The Orphan Drug Act (1983) provided incentives for developing drugs for rare diseases affecting human populations of under 200,000. This act encouraged biotechnology firms, which drew heavily from academically-based, federally funded R&D, whether through university spin-off companies or through licensing, to pursue niche-markets for vaccines and diagnostics for diseases that struck relatively small groups, such as Huntington's chorea, through tax incentives and market monopolies. Such companies received a 50 percent tax credit for the cost of conducting clinical trials, often performed by universities, as well as a seven year
right to exclusivity in marketing the product (US Congress 1991).

The 1984 National Cooperative Research Act afforded special anti-trust status to R&D joint ventures and consortia. This act was crucial to university-industry collaborations. Previously the courts had ruled that collaborations at the enterprise level were inappropriate, barring joint R&D efforts by firms in the same industries on the grounds that these constituted restraint of trade. The National Cooperative Research Act made an exception for R&D, enabling broad government-industry-university funding of R&D, such as occurred with Sematech. Currently, there are over 100 such ventures (NSF 1989). The National Cooperative Research Act was also a counter in business leaders' strategy to overhaul national anti-trust policy, promoting cooperation at home and competition abroad (Dickson 1984, Fligstein 1990).

A series of acts--the Drug Export Amendments Act of 1986, the Omnibus Trade and Competitiveness Act of 1988, the North American Free Trade Agreement of 1993, the General Agreement on Tariffs and
1994--embodied the competitiveness coalition's global intellectual property strategy. The Drug Export Amendments Act of 1986 allowed drugs not yet approved by the Food and Drug Administration (FDA) for use in the U.S. to be exported to twenty-one foreign countries that had regulatory mechanisms. Prior to 1986, U.S. companies with new drugs that wanted to reach those foreign markets with more rapid regulatory processes than the U.S. had to forfeit proprietary rights to technology to their multinational partners in those countries in order to gain access (U.S. Congress 1991). Like the Orphan Drug Act of 1983, the Drug Export Amendments Act created a supportive climate for the development of biotechnology, perhaps the most dynamic sector among burgeoning university-industry relationships. The 1988 Omnibus Trade and
Competitiveness Act (PL 100-418) stressed the growing importance of intellectual property in world markets. This act stipulated that anyone who sold or used in the U.S. or who imports without authority a product made by a process under patent protection by the U.S. was liable as an infringer. Like much of the competitiveness R&D coalition legislation, the 1988 act increased the protection of intellectual property and heightened penalties for violation, again stressing knowledge as commodity. The North American Free Trade Agreement (NAFTA, 1993) extended the protection of intellectual property regionally and globally, treating intellectual property like any other commodity, barring discrimination against cultural exports, even when that meant fragile, partially industrialized cultures could be inundated with U.S. cultural products. The General Agreement on Tariffs and Trade (GATT, 1994) compelled signatories to honor intellectual property laws (patent, trademark and copyright), which means that Third World countries that previously used Western products ranging from pharmaceuticals to learned books and journals without paying licensing fees or royalties now have to pay for them. (In a post-colonial twist, established industrial countries are able to patent biological resources indigenous to newly industrialized countries, ultimately requiring that these relatively poor countries pay to use products based on their own raw materials.)

This legislation, which enabled corporations in the competitiveness coalition to enact global competitiveness strategies on a playing field designed by the U.S., did not focus particularly on universities, although the legislation had grave consequences for them. Research universities trained the intellectual workers who transformed knowledge, once the communal possession of an international community of scholars, into products and processes in which both faculty and universities in
traditional industrialized countries had a share, committing professors and institutional managers to further commercialization of science and technology. That universities were not central to, or the target of this well-articulated, legislatively embodied intellectual property strategy underlines the secondary role the academy has in the competitiveness narrative.

The secondary role of universities was well-demonstrated by the Defense Appropriations Act of 1993's Technology Reinvestment Project, a project that exemplifies trends toward centralization of decisions about research across government agencies and collaboration across industrial sectors. The Technology Reinvestment Project is headed by the Advanced Research Projects Agency (ARPA), but spreads across the military services, the Departments of Commerce, Energy and Transportation, NASA, and the NSF. Its mission is to merge defence and commercial industrial bases so that DOD can have access to low cost critical technologies. The program combines eight statutory programs that fall into three areas: technology development for cutting edge dual-use products and processes; technology deployment that uses third-party providers to deploy manufacturing and management technologies to small and medium size firms seeking to develop dual-use capacity; and "Manufacturing Education and Training projects [that] combine university and industry expertise to formulate new programs of education in the science of manufacturing (DOD 1994, p. 71)." ARPA legislation typifies the position of competitiveness legislation in the Clinton administration with regard to academic science: initial mention usually speaks only to a training function for universities. Proposals for these monies must be submitted by teams, partnerships, and consortia of industry, local governments, and institutions of higher learning, with proposers sharing at least 50% of
the costs. The ARPA initiative builds on competitiveness R&D coalition legislation that allows free movement of technologies, costs and profits between previously discrete sectors of the economy, shares budgetary and mission responsibility across federal agencies that previously had distinct goals and objectives, and relies heavily on consortia and collaborative efforts, strategies that reduce costs but also commit sectors previously outside the market to commercialization through dual use.8

Table 3 shows the degree to which support for competitiveness legislation was partisan.9 Of the eleven laws, four were passed by voice vote in both houses of Congress, seven by roll-call vote. Voice votes are taken for various reasons, including members' wish to have no record of their vote or because consensus is so strong that a roll-call vote is inefficient (see notes to Table 3 for clarification of the circumstances.

8 While dual-use bridges the competitiveness and military-industrial techno-science regimes, dual-use at the same time remains a separate option for the military-industrial regime and is pursued as such, depending on the strength of the competitiveness R&D coalition. In other words, policies such as dual-use only relieve the tensions between the military-industrial and the competitiveness R&D coalitions on some occasions (see MacCorquodale et al. 1993).

9 Legislation is only one aspect of the rule-making structures that shape competitiveness R&D policies. Other legal structures important to creating a climate that promotes competitiveness are administrative interpretations of new laws, rulings by administrative law judges, and litigation in civil courts. For example, the Internal Revenue Service does not tax universities' royalty income, creating a strong incentive for universities to encourage patenting and copyrighting (Martino 1992). In 1980, in Charkabarty v Diamond, the Supreme Court ruled that living organisms were patentable. In the same year, the Patent and Trademarks Office issued the Cohen-Boyer patent on rDNA to Stanford. In 1988, the Patent and Trademarks Office issued Harvard a patent on the transgenic mouse, (later globally marketed by DuPont as oncomouse, a laboratory animal for researchers). In 1990, the California Supreme Court ruled that a patient did not have a property right to his body tissues after they were used by researchers to develop a commercially important cell line (U.S. Congress 1991). Rule making modalities other than legislation interact with new statutes to create a dense administrative-legal infrastructure for the new competitiveness policy.
surrounding the several votes).

When roll-call votes were taken, only NAFTA showed a lack of bipartisan support. Bipartisan support was strongest for legislation that permitted U.S.-based corporations to use public resources for economic competition or permitted non-profit institutions to enter the marketplace by holding title to intellectual property or forming alliances with corporations. The more likely regional or local agreements were to take jobs or decision making power away from home, as was the case with NAFTA, the less likely Democrats were to support competitiveness measures. Nonetheless, all legislation on which a formal vote was taken, other than NAFTA, had broad bipartisan support, if such support is construed as 70% or more of each house voting for passage.

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TABLE 3 ABOUT HERE
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The competitiveness R&D coalition created a new narrative for science and technology policy, one that, as we have noted, differed from the Cold War narrative on important points. In the 1980s, the new narrative was told and re-told in countless policy documents, for proceedings and congressional hearings. As the narrative was iterated and reiterated by the competitiveness R&D coalition, parts of it were embodied in legislation and other rule-making modalities, until legislation and rules formed further iterations of the policy narrative. Although such narratives have fictional elements and devices that persuade and convince, obscure and distort, as does all discourse, policy
narratives have concrete consequences. The competitiveness coalition
instituted changes in legislation that reshaped the rules governing R&D.
The rule changes allowed public and non-profit entities, whether
universities, government agencies or non-profit research institutes,
entry into the market, changing our common-sense understanding of what
is public and what is private. Institutions still labeled public and
non-profit were able to patent and profit from discoveries made by their
professional employees. Simultaneously, private, profit-making
organizations were able to make alienable areas of public life previously
held by the community as a whole: scientific knowledge, data bases,
technology, strains and properties of plants, even living animals and
fragments of human beings. Historically, this shift in ownership rights
is on a scale with the enclosures of communal property by large
landholders in Great Britain and Latin America with the onset of market
economies.

Competitiveness legislation made possible the fluid movement of
commodities and capital among private, non-profit and public
institutions. This fluidity gave rise to new organizational forms: arms
length agencies run by universities to handle profit-making activities,
for-profit corporations created with non-profit and state funds,
collaborative research agreements that were funded by university-
government-corporate contributions, on which a variety of arrangements
could be made about ownership of intellectual property and disposition
of profits. These changes in academic organization complemented changes
in corporate structure, facilitating academic interaction with
corporations pursuing nexus-of-contract strategies. These changes
integrated the state into the production process more directly than
before, to some degree rendering problematic distinctions between the state
and the economy. Altogether, competitiveness R&D policies created the possibility of a novel technoscience regime, distinct from the Cold War technoscience regime, although simultaneous and overlapping.

**EFFECTS OF THE COMPETITIVENESS R&D POLICY**

Although we cannot show direct causal linkages between the emergence of the competitiveness R&D coalition and changes in academic science and technology, we can point to changes and suggest that they may stem from the competitiveness coalition’s successful introduction of new rule-making structures. We will review briefly changes in federal obligations for business and university research and development, in federal funding for the NIH and NSF for individuals, teams, centers and major facilities, and in all obligations for academic science and technology. We will also look at the changes in faculty patent behavior, in numbers of academic-industry coauthored scientific and technical articles, in composition of NSF review boards, and at faculty salaries. We will use 1980 or 1983 as a base point, because these were the years in which the competitiveness agenda first began to take legislative form, and compare 1980 and 1983 data to 1990s data, when possible to 1993. Overall, we see changes in the balance of research that the federal government supports, in the sites where research is performed and in the mechanisms through which academic science and technology monies are awarded, in faculty research behavior and in faculty rewards.

In terms of total federal obligations for research and development for business and universities, business’ share remained about the same during the ten year period, while higher education’s share grew slightly, from 13% to 17% (see Table 4). With regard to basic research, industry
year period, the shares for doing science at NSF and NIH shifted. At the NSF, the percentage of monies going to individuals dropped from 71% in 1980 to 62% in 1989, while the percentage going to teams rose by 2%, and percentage going to centers by 5%. The NIH funding revealed a change away from individuals to centers. The percent going to individuals dropped 4% in the nine year period, while percentage going to teams increased by 6%. However, the percentage going to centers dropped by two percent. In terms of major facilities, neither the NIH nor the NSF showed great change. Over the nine year period, the clearest change in both agencies was a shift away from individual researchers. This trend may reflect the competitiveness coalition's emphasis on collaborative efforts across sectors, discussed earlier, efforts that are geared toward facilitating the transfer of knowledge from public and non-profit entities to corporations and commercial endeavor.

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TABLE 5 ABOUT HERE

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The individual researcher is not alone in his/her loss of federal share. Overall, federal support for academic R&D has declined markedly in the past twenty years, from 69% of academic R&D to 56% in 1993, or 13% (see Table 6). If we consider only the ten years from 1983 to 1993, federal support has declined by 7%. State and local governments remained relatively stable at about 10%, while industry contributions to academic R&D increased 4%. As if to compensate for loss in federal share, universities increased their contribution most dramatically, from 11% to 20%. While universities may be trying to keep their research profiles
high by making up for their loss of federal shares, they may also be using their monies in new commercial research investment strategies (see also Feller and Geiger 1993). Universities may be committing more monies to R&D so they are able to match funds from mission agencies and industry in pursuit of collaborative ventures, such as those funded by ARPA's Advanced Technology Program.

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TABLE 6 ABOUT HERE
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Examination of trends in R&D spending on the part of all parties engaged in such endeavors suggests that competitiveness R&D legislation may be changing the flow of research dollars to academic science, but says little, with the exception of the shift from individual scientists and engineers to teams and centers, about how changes in funding shape laboratory life. Over the last decade, some measures were developed that directly capture changes in scientists and engineers behavior. These measures focus on patenting activity and patent income, on academic-industry co-authorship, and on changes in peer review processes.

After the 1980 Bayh-Dole Act changed the patent law, there was an explosion of growth in patenting by universities, indicating universities efforts to take advantage of commercial opportunities. In 1980, the number of all academic patents was 390; in 1991, the total number of academic patents was 1,324, an increase of 240%. If we look not at the total number of patents for all institutions, but at which institutions gained and lost patent shares, two interesting patterns emerge. First, commercialization apparently enabled the strongest R&D performers to
acquire more patents. The number of academic patents awarded to the top 100 R&D performers among universities was 290 in 1980; in 1991, it was 1,112, an increase of 283%. The top 100 R&D performers increased their share of total academic patents from 74% in 1980 to 84% in 1991. Second, performance with regard to patents was not necessarily the same as R&D performance. Within the top 100 R&D performers, the top 30 lost share of total academic patents, by 3.5%, and the bottom 70 gained share. This pattern is consistent with Feller and Geiger's (1993) finding that there was a pattern of dispersion and shifting of R&D expenditures among the top 200 R&D universities in the 1980s. For example, the share of research expenditures of the top ten performers fell from 20.2% in 1979-1980 to 17.9% in 1989-1990. "[A]mong the largest 60 performers in 1979-80, 20 gained share and 40 experienced declines. Among the next 110 institutions, gainers of share outnumbered losers 64 yo 46" (Feller and Geiger 1992, p.10). In other words, the shift to a competitiveness R&D policy may have implications for universities' positions in rankings, whether standard R&D performance rankings, or new rankings, such as numbers of patents.

In 1993, the Association of University Technology Managers began to rank institutions by patent income, allowing us to look not only at number of patents acquired by institutions, but also at revenue generated (Blumenstyk 1994). Institutions that ranked high on federal R&D funds tended to rank high on patent income: for example, the University of California system, Stanford, Columbia, University of Wisconsin and the University of Washington were one through five, respectively. But Iowa State, Clemson and Tulane were in the top twenty, suggesting that the ability to generate patent income may reshape the academic research and development playing field, perhaps foreshadowing new and multiple
modalities of competition between universities not closely governed by rules and regulations established by the mission agencies or peer review process.11

Time-series data suggest that as academics became more involved with the market they were more likely to collaborate with their industrial counterparts in intellectual endeavor. Across all fields, the numbers of academic-industry co-authored scientific and technical articles rose from 22% of all industry articles in 1981, to 35% in 1991 (NSF 1993). This rise in the rate of industry articles co-authored with academics may reflect the success of legislation aimed at increasing collaboration between universities and industry to better achieve global competitiveness.

As competitiveness R&D was embodied in legislation, changes occurred in the peer review process, especially in fields close to business and industry. In the 1980s, seventy-eight companies became members of the NSF’s Engineering Research Centers’ Policy Advisory Boards. The NSF advisory committee for its Science and Technology Centers program had seven industrial members of twenty-four total members. In the Small Business Innovation Research program, industry participates in the proposal review process as well as the advisory committee system. All in all:

Approximately 10% of the slightly more than 1,000 advisory committee members in 1988 were from industry, including about 25 from small businesses. NSF uses industry members most heavily in the Directorates for Engineering; Computer and Information Science and Engineering; and Scientific,

11 The Association of University Technology Managers also tracked legal fees expended by institutions and legal fees reimbursed, noting that institutions were reimbursed for $224 million, or only about 45% of legal costs, illustrating that universities engaged in academic capitalism took risks sometimes associated with being market actors.
Technological, and International Affairs. The Foundation also frequently uses industrial scientists and engineers as reviewers of grant proposals. (NSF 1989, p.6)

Whether or not 10% is a significant amount, the areas in which industry members are used most heavily are the areas of greatest growth in NSF funding.

Changes in faculty compensation patterns were yet another effect of the R&D competitiveness policies and legislation. Faculty in fields able to engage in commercialization and able to move close to the market gained greatly in terms of remuneration, while those unable or unwilling to do so did not prosper. Analysis of changes of faculty salaries by field in the decade between 1983 and 1993 show that faculty and fields with the highest salaries and the greatest percent increase (70% and above) were in fields concerned with technology (engineering and computers), producer services (business and management, law) and health sciences, all fields focused on knowledge as commodity and on intellectual property strategies (see Table 7). The greatest gains were made by engineering, an applied science closely geared to R&D competitiveness policies, business, health sciences, computer and information science and law, all also closely connected to R&D competitiveness policies, while the physical sciences and mathematics, the doyens of "pure science," did not make nearly such dramatic gains. Even if salary level rather than percentage of increase is considered, the physical sciences and mathematics are substantially below the top tier, with a difference that ranges between $10,000 and $23,000. The lowest salaries and the lowest percentages of increase are in the third tier in fields farthest from the market, closer to the social welfare
functions of the state. The difference in the percentage of salary increases between the lowest five fields in the third tier (philosophy and religion, foreign language, home economics, letters, and education) and the five fields in the top tier ranges between 22-30%.

TABLE 7 ABOUT HERE

Examination of R&D funding trends strongly suggests that changes occurred that turned academic R&D toward the competitiveness agenda (Teich 1994). As federal monies diminished, universities used institutional funds (often state dollars) to subsidize research, increasingly committing to collaborative partnerships, jointly funded by federal, state, institutional and industrial monies, geared toward competitiveness. As part of the collaborative, cross-agency approach, fewer individual researchers were funded, while more monies went to teams, and, in the case of the NSF, to centers. The shift toward the competitiveness agenda on the part of scientists and engineers at the laboratory level went beyond a shift from individual to team or center. As they worked on commercial endeavors, academic scientists and engineers associated more closely with their industrial counterparts, substantially increasing the numbers of articles co-authored with them, perhaps subtly shifting the content of journals, if not fields of knowledge, toward areas of study with more commercial potential. At the same time,

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12 With the exception of philosophy and religion, these fields have majority female student bodies. For an analysis of the gender implications of the restructuring precipitated in part by competitiveness R&D see Slaughter 1993.
scientists and engineers became more involved in commercialization, which meant attending concretely to the possibilities of knowledge as product, filing patents rather than writing articles, and becoming market actors themselves as they as well as their departments and institutions profited from commodified knowledge. Although the competitiveness R&D agenda did not replace the Cold War agenda, the competitiveness agenda became a part of academic science and technology in the 1980s and early 1990s.

The effects of competitiveness policies were felt not only in scientists’ and engineers’ laboratories, but in research universities as a whole. Changes in faculty compensation patterns seemed to hinge on the degree to which faculty and fields were willing and able to share the goals and projects of the competitiveness R&D coalition. The institutional consequences of the division of faculties into clear salary tiers are several. Marked imbalance in rewards creates permanent discontent and factionalization, precipitating intense daily struggles over almost all institutional resources, including workload. Internal practices that set the academy off from other work places—control over everyday work load, collegial decision making at the department level, shared governance at the institutional level—depend on equity among professionals and become difficult to sustain as divisions between faculties increase. Moreover, faculties heavily engaged with the market are likely to spend less time with undergraduate students, further disturbing equity relations among professionals.

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13 Faculty who filed patents in which the university was named usually received a share of institutional income. The faculty share of royalties varies from state to state, and, in the private sector, from institution to institution. The shares range from the very generous to less generous, but all can involve significant additions to faculty’s personal income if the product or process finds a market (see Rhoades and Slaughter 1991, and Chew 1992).
CONCLUSION

The academic science and technology policy literature that takes a substitution approach that suggests universities will fare as well under a competitiveness regime as they did under the Cold War regime has at least three assumptions. First, this literatures assumes that if university-based science and technology are seen as contributing to economic competitiveness, then funding for research, including basic research, will increase. The second assumption of the substitution approach literature is that competitiveness monies will not greatly change the ways in which scientists work at the laboratory level. The third assumption is that what happens to academic science and technology has no consequences for the rest of the university. Our analysis of the effects of national competitiveness, presented in the previous section, suggests that these assumptions are unfounded. More than the rhetoric about the ends of science has changed. As policy narratives shift away from winning battles against Communism and specific diseases and toward competitiveness narratives, funding patterns, laboratory life and faculty compensation practices began to change, altering the daily lives of many members of research university communities.

Although our research strongly suggests change is occurring, it leaves many questions unanswered. We need to know more about the boundaries of the R&D competitiveness coalition and the nature of its linkages to political economic processes, generally, and to the Cold War coalition, specifically. As we suggested earlier, we see the Cold War techno-science regime as deeply rooted, difficult to destabilize and fairly flexible, able to accommodate many competitiveness initiatives through dual-use policies. Boundaries demarcating the Cold War and
competitiveness coalitions could be determined several ways: by studies of corporate leaders' business and political strategies as manifested through investment in R&D and pursuit of a national industrial policy (Graham 1992); by studies of the policies promulgated by organizations in which leaders of the largest corporations participate—for example, the Council on Competitiveness, various think tanks, ranging from the Brookings Institution to the Heritage Foundation, and special purpose organizations, such as the Business-Higher Education Forum (Slaughter 1990); by studies of Political Actions Committees and lobbyists supported by leaders of the largest corporations; by studies of the political activities of beneficiaries of R&D competitiveness policies. Another way to approach the R&D competitiveness coalition's membership and level of commitment is to study how political coalitions position themselves on issues likely to force choice on Cold War versus competitiveness policies. Examining the position of corporate leaders, university leaders and politicians on such issues through Congressional testimony, and various popular, political media might define coalition boundaries more clearly. For example, we think that the competitiveness R&D coalition will begin to push more openly for an industrial policy aimed at supporting large corporations in the global marketplace and to take positions against non-dual-use military spending.

Studies of coalition boundaries may reveal a more complex picture than that which we have sketched out. Instead of a split between the post-World War II military-medical industrial complex and a single competitiveness R&D coalition, a number of competing competitiveness coalitions could emerge: for example, in the medical arena, a coalition aligned with insurance companies and health maintenance organizations, committed to prevention and low-cost treatment might compete with a
coalition aligned with biotechnology companies, academic researchers and specific disease lobbies. In the manufacturing arena, a coalition concerned with traditional manufacturing might compete with one that pushed for high technology.

Similarly, we need to know more about the goals and strength of the bipartisan coalition supporting competitiveness legislation in Congress. The goals can be determined by studies of party platforms, campaign and candidate position papers, the strength by continued tracking of voting records on competitiveness R&D legislation. If the bipartisan coalition is strong, we would expect support for competitiveness R&D to persist, regardless of which party is in power. The recent GATT legislation is a case in point. Although some Republicans spoke out forcefully against GATT, garnering a great deal of media attention, in fact most Republicans, like most Democrats, voted for this legislation, which is central to R&D competitiveness policies. So too, we would expect Republicans bent on trimming the federal government to speak out initially about cutting departments such as Commerce, but think that Commerce, site of many recent competitiveness initiatives such as the Advanced Technology Program in the National Institute of Standards and Technology, will probably be preserved and enhanced, with R&D functions moved away from NSF and the traditional mission agencies and into organizational structures housed in Commerce so that R&D can be more clearly focused on economic development. The strength of the competitiveness R&D coalition in the executive branch can be fairly easily tracked through an analysis of changes in organizational structures, personnel and budgets.

Finally, we need to broaden studies of the effects of changes in national R&D policies on academic science and technology. Changes over
time in national data sets need to be examined and interpreted in light of competitiveness R&D policies: for example, amounts of funding for particular fields and sub-fields; numbers of patents by fields and sub-fields; numbers of students and gender of students receiving degrees by field and sub-field; changes in rankings of institutions, using a variety of scales, such as changes in funding, patenting, and student populations occur. At the institutional level, we need to examine control and management of commercial science and the problems and possibilities it creates for universities. Changes in organizational structures can be fairly easily tracked. As the commercialization of knowledge increases, we would expect to see the creation of interdisciplinary academic organizations that more nearly match the research directions of the manufacturing and service corporations that rely on commodified knowledge. Although these new interdisciplinary units might be small and fluid, and faculty in them might gain some autonomy by developing intellectual property, we think their very success may bring about tighter regulation and greater oversight in the name of responsible management and accountability to the public. At the same time, faculty not involved in commercialization of knowledge are likely to be more closely managed and regulated to ensure their delivery of the traditional instructional functions of the university. As federal and state funds for research and education are increasingly targeted for specific purposes, such as commercial science, institutions will become more and more concerned with devising means to generate discretionary revenues. For example, public service may be redefined as service for a fee, not service for free. Consulting and scholarship may become subject to various institutional taxes. For example, all professors may have to contribute a share of their income-generating or consulting services to
the institution, as university-based physicians currently do; similarly, the institution may take a percentage of royalties on scholarly books and articles. All in all, we think that commodification of knowledge will probably result in greater contractualization, regulation and bureaucratization in research-intensive universities.

Although we have focused on changes in policy coalitions in which business elites are the central actors, we think that it is possible for popular social movements to destabilize, re-shape or modify technoscience regimes as was the case with the student movement’s attack on the Vietnam war and the military-industrial complex in the late 1960s and early 1970s. Currently, there are no social movements as strong or as focused on R&D policy as was the student movement, but a number of popular groups have a strong interest in R&D policy. Among these are various military conversion groups that would have us turn swords into plough shares, environmental groups that are not enamored of biotechnology, women’s health groups and AIDS activists who pressure the government for greater R&D spending for particular diseases or disease clusters. Any of these social movements could alter the direction of the competitiveness technoscience regime in unforeseeable ways. However, none of these groups are particularly concerned with preserving or re-instating values dear to the hearts of professors, such as the autonomy of the research community or veneration of basic science. Like leaders of the competitiveness R&D coalition, persons in popular social movements concerned with R&D want more applied science and technology, or at least fairly goal-directed research, accountability and pragmatism, signaling the reduced centrality of universities, and the likelihood of closer linkages between universities and society.
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