PRIVATE PARTS:
PATENTS AND ACADEMIC RESEARCH IN THE TWENTIETH CENTURY

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1. Introduction

Over the past quarter-century we have seen a dramatic growth of patenting and licensing of publicly funded research by American research universities. This growth has contributed to some of the highest-profile debates in science and technology policy today. Witness, for example, the recent controversies over the high prices of drugs developed based on taxpayer-funded academic patents, concerns about the appropriateness of publicly funded researchers "racing" a private firm to sequence (and patent) the human genome, and fears that patents held by a public research university could hinder the future of embryonic stem cell research in the United States.

The issue of what aspects of academic research should be public--and what private--lies at the heart of each of these debates. In recent years we have seen a dramatic growth in the "private parts" of academic research, i.e. those that are disseminated via patents and licenses rather than simply placed in the public domain. These changes have been extolled by some as a new model of academic research: one which facilitates economic and social returns from universities. At the same time, they have been criticized by others as representing a socially inefficient "privatization" of academic research and as a threat to the ethos of science itself.

In this essay, I put these changes in historical context, providing a broad overview of changes in universities' patenting policies, procedures, and practices throughout the twentieth century, as well as an assessment of the effects of recent changes—in particular the Bayh-Dole Act of 1980—on economic returns from university research.

Since much of the policy discussion of these issues centers on economic returns from university research, I begin in Section 2 by discussing the various channels through which universities contribute to innovation and economic growth. This discussion reveals that patenting and licensing are one of many channels through which universities make economic contributions, and in most industries less important than the contributions made by placing scientific and technological information in the public domain. Indeed, as I show in Section 3, fears of compromising the "public" aspects of academic research—important not only to industry but for the advance of science itself--led most American universities to shy away from involvement in patenting and licensing throughout much of the 20th century. Though this reluctance began to fade in the 1970s, the major impetus towards increased university involvement in patenting and licensing was the Bayh-Dole Act, passed in 1980 to facilitate commercialization of university inventions. In Section 4, I discuss the political history of Bayh-Dole, showing that the intellectual foundations for this sea-change in federal patent policy were weak, based on a lack of understanding of the roles of universities in the innovation system. Nevertheless, assessment of the social welfare effects of Bayh-Dole (and growth of university patenting and licensing more generally) remains an open empirical question, which I tackle in Section 5. There I show that there is little evidence that increased university patenting and licensing has facilitated increased technology transfer or any meaningful growth in the economic contributions of universities. At the same time, there is no systematic evidence that the growth of the "private parts" of academic research is negatively affecting the conduct of or returns from public science. However, I do present some preliminary evidence consistent with the hypothesis that university patenting has moved upstream into the realm of "science," a

development that some may find unwelcome. I conclude in Section 6 with a discussion of policy issues relating to academic patenting and licensing that are currently on the table.

2. Universities, Innovation, and Economic Growth

Over the past century, American research universities have been extremely important economic institutions. In a range of industries, from agriculture to aircraft to computers to pharmaceuticals, university research and teaching activities have been extremely important for industrial progress.[1] Most economic historians agree that the rise of American technological and economic leadership in the postwar era was based in large part on the strength of the American university system.

The economically important "outputs" of university research have come in different forms, varying over time and across industries.[2] They include, among others: scientific and technological information[3] (which can increase the efficiency of applied R&D in industry by guiding research towards more fruitful departures), equipment and instrumentation[4] (used by firms in their production processes or their research), skills or human capital (embodied in students and faculty members), networks of scientific and technological capabilities (which facilitate the diffusion of new knowledge), and prototypes for new products and processes.[5]

The relative importance of the different channels through which these outputs diffuse to (or alternatively, "are transferred to") industry also has varied over industry and

[1] See Rosenberg and Nelson (1994) and Rosenberg (2001) for case studies of university-industry interaction in particular industries.
[2] This list draws from Rosenberg (1999), Cohen et al. (1998), and other sources.
[3] David, Mowery, and Steinmueller (1992) and Nelson (1982) discuss the economic importance of the "informational" outputs of university research.
[4] See Rosenberg's (1994) discussion of universities as a source of scientific instrumentation.
[5] See Rosenberg (1999).

time. The channels include, *inter alia*, labor markets (hiring students and faculty), consulting relationships between university faculty and firms, publications, presentations at conferences, informal communications with industrial researchers, formation of firms by faculty members, and licensure of patents by universities. Though the recent growth of patenting and licensing by universities has received considerable attention, it is important to keep in mind that patents are one of many channels through which university research contributes to technical change in industry and economic growth.

Indeed, in most industries patents are a relatively unimportant channel. In a survey of R&D managers of firms in the U.S. manufacturing sector, Cohen, Nelson, and Walsh (2002) asked respondents to rank different channels through which they learn from university research. They found that in most industries, the channels reported to be most important were publications, conferences, and informal information exchange. Patents and licenses ranked near the bottom of the list.[6] A study by Agrawal and Henderson (2002), focused on two major academic units at the Massachusetts Institute of Technology (MIT), provides corroborating evidence from the "supply" side of academic research. Faculty members reported that a very small fraction of the knowledge transfer from their laboratories to industry (7%) occurs via patenting. Other channels—Agrawal and Henderson focus on publications--are more important.

It is interesting that the most important channels of university-industry knowledge transfer--publications, conferences, and informal information exchange--are those associated with what the sociologist of science Robert Merton called the norms of "open science" (Merton, 1973), which create powerful incentives for academics to publish, to

[6] There is, however, considerable inter-industry variance. Patents and licenses are considerably more important channels in pharmaceuticals than in other industries. However even in pharmaceuticals, the other channels historically have been extremely important (Gambardella 1998).

present at conferences, and to share information, i.e. to place information in the public domain (Dasgupta and David 1994).

Outputs of academic research disseminated via open science are useful not only to industry, but also feed into future academic research. Academic research is a cumulative process that builds upon itself: recall Sir Issac Newton's famous aphorism, "if I have seen further, it is by standing on the shoulders of giants." Thus prominent sociologists of science (e.g. Crane 1972, Merton 1973, Price 1963), philosophers (e.g. Polyani 1962, Kitcher 1994, Campbell 1994, Ziman 1984), and economists (e.g Dasgupta and David 1994, Weitzman 1995) have pointed to the importance of information sharing and communication (via formal and informal channels) for the advance of academic research.

3. University Patenting Before Bayh-Dole

Indeed, throughout much of the twentieth century, universities were reluctant to become directly involved in patenting and licensing activities precisely because of fears that such involvement might compromise, or might be seen as compromising, their commitments to open science and their institutional missions to advance and disseminate knowledge. Consequently, many universities avoided patenting and licensing activities altogether, and those that did get involved typically out-sourced their patent management operations to third party operations like the Research Corporation, or set up affiliated but legally separate research foundations to administer their patents.

As discussed in more detail in Mowery and Sampat (2001a), the Research Corporation originated from the research of Berkeley chemist Frederick Gardner Cottrell, to administer his patents on the electrostatic precipitator, a pollution control device. He considered dedicating the patents to the public domain. However, anticipating the

argument that would later be central to the passage of the Bayh-Dole act, he concluded that patents and exclusive licenses were necessary to induce commercialization, arguing:

> A certain minimum amount of protection is usually felt necessary by any manufacturing concern before it will invest in machinery or other equipment, to say nothing of the advertising necessary to put a new invention on the market. Thus a number of meritorious patents given to the public absolutely freely by their inventors have never come upon the market chiefly because "what is everybody's business is nobody's business" (Cottrell, 1912, p. 865).

Thus, Cottrell intended to license his patents, and (since he was not interested in the royalty income) to use the proceeds to support scientific research. Implementation of this plan, however, required the development of an organization to manage the licenses. Cottrell first considered using the University of California as a licensing manager, but rejected this possibility because of concern about the effects of licensing on the culture of scientific research at the University. He later recalled:

> A danger was involved, especially should the experiment prove highly profitable to the university and lead to a general emulation of the plan. University trustees are continually seeking for funds and in direct proportion to the success of our experiment its repetition might be expected elsewhere . . . the danger this suggested was the possibility of growing commercialism and competition between institutions and an accompanying tendency for secrecy in scientific work. (Cottrell, 1932, p. 222).

Instead, in 1912 he founded a non-profit third party technology transfer agent, the Research Corporation, to administer the precipitation patents. When he founded the Research Corporation, Cottrell also thought that it might also serve a broader purpose, namely to license patents developed by:

> the ever growing number of men in academic positions who evolve useful and patentable inventions from time to

> time in connection with their regular work and without looking personally for any financial reward would gladly see these further developed for the public good, but are disinclined either to undertake such developments themselves or to place the control in the hands of any private interests (Cottrell, 1912, p. 865).[7]

This vision was fulfilled in 1937, when the Massachusetts Institute of Technology (MIT) signed the first "invention administration agreement" with Research Corporation. Under the terms of the agreement, MIT would disclose to Research Corporation inventions that it deemed potentially patentable. Research Corporation agreed "to use its best efforts to secure patents on inventions so assigned to it and to bring these inventions into use and derive a reasonable income therefrom" and further to "use its best efforts to protect these said inventions from misuse and to take such steps against infringers as [it] may deem for the best interest of the parties hereto, but with the general policy of avoiding litigation wherever practicable."

Though MIT recognized that in some cases patents would be necessary to facilitate commercialization of university inventions, and was not averse to earning income from patenting, the institution decided to outsource it patent activities to Research Corporation to insulate itself from the business side of patent activities. This insulation was deemed necessary both to protect the institution from political embarrassment that might result from university involvement in commercial activities, and to prevent commercial interests from encroaching on the norms of open science (Fishman 1996, Mowery and Sampat 2001a, Etzkowitz 1994).

[7] In a 1911 speech before the American Chemical Society, Cottrell argued that without an entity charged with advertising, licensing, and developing academic inventions, such inventions might well fail to find any commercial applications: "a certain amount of intellectual by-products are going to waste at present in our colleges and technical laboratories all over the country. There is a great deal of work that is being developed to a practical or semi-practical standpoint that dies right there because the men . . . do not want to dip into the business side of technology and go out into practical fields and the work has not come to the point of economic usefulness that is desired" (quoted in Cameron, 1952, p. 166).

Over the post-war era, most universities signed comparable invention administration agreements (IAAs) with Research Corporation, for similar reasons. This is illustrated in Figure 1, which shows the proportion of Carnegie research universities[8] with such agreements, from 1940-1980.

FIGURE 1 HERE

While most major universities contracted with the Research Corporation before 1980, some (especially state schools) took another approach, establishing university-affiliated (but legally separate) research foundations to manage patents. The first and most prominent of these was WARF, the Wisconsin Alumni Research Foundation, founded by members of the University of Wisconsin in 1924. Steenbock demonstrated a method of increasing the vitamin D content of food and drugs via the process of irradiation. Despite the criticism of many in the medical community and his colleagues at the University, Steenbock wished to patent his findings, arguing that patenting was necessary for quality control, i.e. to prevent the unsuccessful or even harmful exploitation of the invention by unqualified individuals or firms. He believed that incompetent exploitation of the process, which might discredit the research results and possibly the university, could be avoided by patenting the process (Apple 1996). Once the decision to acquire the patent had been made, the question how to administer it remained. Steenbock offered to assign the patent to Wisconsin for management. However, the University was not convinced that creation of an administrative organ to handle patents was worth the necessary political and

[8] In its 1973 report, the Carnegie Commission on Higher Education classified the nation's 173 doctorate granting institutions as Research Universities and Doctoral Universities. Institutions that awarded at least 50 doctorates in 1969-1970 and were among the 50 leading recipients of federal financial support in at least two of the three years 1968-1969, 1969-1970, 1970-1971 were classified as "Research University I" (RU1). Institutions that awarded at least 50 doctorates in 1969-1970 and ranked in between 50th and 100th in federal financial support in two of the three years were classified as "Research University 2" (RU2). I treat the union of the RU1s and RU2s as "Carnegie Research Universities".

financial risk (Apple 1996). Thus a different solution was developed. Steenbock convinced several alumni to create the Wisconsin Alumni Research Foundation (WARF), a university affiliated but legally separate foundation that would accept assignment of patents from university faculty, would license these patents, and would return part of the proceeds to the inventor and the university. According to Apple (1996) the idea was that "[w]ith this structure, business matters would not concern or distract the university from its educational mandate; yet academe could reap the rewards from a well-managed patent whose royalties would pay for other scientific work" (42). Over the course of the twentieth century, a number of other universities established similar foundations.

While most universities employed one of these two options in the pre-Bayh-Dole era, there was considerable variance in their formal patent policies, e.g. in faculty disclosure policies and sharing rules (see Mowery and Sampat 2001b for specifics.) In the postwar era, many universities had "hands off" policies, refusing to take out patents as institutions but allowing faculty members to patent and retain title if they desired. Thus before 1980, Columbia University's policy left patenting up to the inventor and administration up to Research Corporation, stating that "it is not deemed within the sphere of the University's scholarly objectives" to hold patents. Some required faculty members to report inventions to university administration, which administration then typically turned over to Research Corporation or university research foundations. Notably, several major universities explicitly forbade the patenting biomedical research, evidently based on the belief that restricting the dissemination of health-related inventions was particularly undesirable. At Harvard, Chicago, Yale, and Johns Hopkins and Columbia, and Chicago, these prohibitions were not dropped until the 1970s.

Notwithstanding some variance in actual patent policies, by and large over the first three-quarters of the twentieth century American research universities were extremely reluctant to become directly involved in patenting and licensing. This reluctance reflected fears that such involvement could lead to political embarrassment, or might compromise--or at least be difficult to reconcile with--their commitments to "open science."

However, patents did occasionally result from university research efforts—a fact that is not surprising in view of the fact that American universities were never pure "ivory towers" but rather historically active in use-oriented basic and applied research (Rosenberg and Nelson, 1994). In such cases, they were typically held by faculty members or by third-party technology transfer agents, rather than the universities themselves. In many cases—like Cottrell's and Steenbock's—the reason for patenting was explicitly to protect the public interest. And though it is difficult to show this conclusively, it is likely that strong norms militating against academic patenting checked any ambitions universities may have had to patent in instances where publication or open dissemination would suffice for "technology transfer" (Mowery and Sampat 2001b).

All of this began to change in the 1970s, and identifying the sources of this shift remains an important topic for future research (see Mowery and Sampat 2001b and Sampat and Nelson 2002 for preliminary attempts). Certainly, one important development was the fruition of commercial applications resulting from the postwar growth of "use oriented" basic research (Stokes, 1997) in fields like molecular biology. This was occurring at the same time as federal and other sources of funds for university research were declining, leading some universities to become increasingly interested in patenting as a source of income. Moreover, as discussed in the following section, changes in government patent

policy during the 1970s—precursors to the Bayh-Dole act--made it easier for universities to patent publicly funded research.

Whatever the causes, many institutions began to reconsider their patent policies and procedures during the 1970s. Thus by the mid-1970s, Research Corporation's *Annual Report* noted that most major institutions were considering setting up internal technology transfer offices (Mowery and Sampat, 2001a), and patenting by universities began to grow in the decade before Bayh-Dole (see Section 5 below). Nevertheless, Bayh-Dole magnified and accelerated these changes, by providing strong congressional endorsement for the position that active university involvement in patenting and licensing, far from being ignoble, serves the public interest.

4. Patents, Public Funding, and the Bayh-Dole Act

Until the late-1960s, the vast majority of university patents, including those handled by the Research Corporation, were based not on federally funded research, but rather on research financed by institutional funds, industry, and state and local governments. Before this time, many federal funding agencies retained title to any patents resulting from research they funded, and others required universities to go through cumbersome petitioning processes to retain title to publicly funded patents. Several agencies became more liberal in allowing universities to retain title to patents during the late-1960s and 1970s, but there was considerable uncertainty about political commitment to these changes. Bayh-Dole erased this uncertainty, creating a uniform federal policy allowing universities to retain rights to patents resulting from publicly funded research.

4.1 Government Patent Policy: Historical Background and Intellectual Foundations

Though issues relating to university patenting provided the immediate impetus for the introduction of Bayh-Dole, and its effects on universities were more pronounced than those on other contractors, the long-standing historical concerns about the effects of patenting in academic environments were ignored during the Bayh-Dole hearings. Instead, the debates focused primarily on more general issues relating to whether the governments or private contractors should retain title to patents resulting from public funds, and the feasibility and desirability of a uniform federal patent policy across funding agencies.

As Forman (1957) shows, this is an old debate: Congress considered the issue of who should retain rights to patents resulting from publicly funded research at least seventy years before the passage of Bayh-Dole. However, government patent policy first became a prominent issue following the massive expansion of federal R&D during World War II, and was a central point of contention during the Bush-Kilgore debates over the shape of post-World War II science and technology policy.

One side of the debate over patent policy was represented by Senator Harley Kilgore (D-W.Va.), who argued that the federal government should retain title to patents resulting from federally funded research and place them in the public domain (Kevles 1973). According to Kilgore, allowing private contractors to retain patents represented a "giveaway" of the fruits of taxpayer-funded research to large corporations, reinforcing the concentration of technological and economic power. The opposing position was articulated by the Director of the wartime Office of Scientific Research and Development, Vannevar Bush, who argued that allowing contractors to retain patent

rights would preserve their incentives to participate in federal R&D projects and to develop commercially useful products based on government-funded research.[9]

The postwar debate highlighted the central issues in controversies over government patent policy for the next three decades. Supporters of the retention of intellectual property rights by government agencies argued that allowing contractors (rather than government agencies) to retain title to patents resulting from federally funded research favored large firms at the expense of small business. Moreover, they asserted, such a policy would harm consumers who would have to pay monopoly prices for the fruits of research they had funded through their taxes. Supporters of allowing contractors to retain title to patents resulting from federally funded research argued that failure to do so would make it difficult to attract qualified firms to perform government research and that absence of title would reduce incentives to invest in commercial development of these inventions.

Another contentious issue in these debates about government patent policy was the desirability of a "uniform" patent policy across all federal agencies. Each of the major federal R&D funding agencies had established its own patent policy following World War II, and the resulting mix of agency-specific policies created ambiguities and uncertainties for contractors and for government employees.[10] Despite numerous

[9] See e.g. Bush (1943) and also Bush's testimony on the Kilgore Bill, portions of which are reprinted in U.S. Department of Justice (1947). Most of the debate over this issue occurred during congressional hearings on Kilgore's proposal for postwar science policy. Interestingly, though Bush actively opposed the provisions in the Kilgore Bill that would give title to the government, his own proposal for postwar science policy (outlined in *Science, The Endless Frontier*) was rather vague, recommending only that "the public interest will normally be adequately protected if the Government receives a royalty-free license," i.e. if contractors retain title ("Letter of Transmittal" in Bush, 1945). One of the reasons that Bush was not more specific in his proposal was that he was awaiting the results of two studies on government patent policy that President Roosevelt commissioned during the war (Kevles, 1995, pg. 38).

[10] For example, NASA Administrator T. Keith Glennan, commenting on the differences between NASA and DOD policies, observed: “two such contradictory patent policies, followed by government agencies

congressional hearings on this issue, no legislation was adopted during the 1950-75 period, because of the inability of supporters of opposing positions outlined above to resolve their differences. The legislative deadlock was reinforced by statements on federal agencies' patent policies issued by Presidents Kennedy and Nixon in 1963 and 1971 respectively. Both Presidents' statements asserted that agency-specific differences in patent policy were appropriate, in view of the differences in their missions and R&D programs.[11]

Until the 1970s, very little of the deliberation and debate about the merits of "title" versus "license" policies, or the desirability of a uniform patent policy, focused on universities. After all, during the postwar era, most federal R&D funds went to private firms rather than universities, and universities themselves historically were reluctant to become actively involved in patenting and licensing.

Federal policy toward patents resulting from publicly funded university research became a topic of debate only after the release in 1968 of reports on the NIH's Medicinal Chemistry program by the U.S. General Accounting Office (GAO)[12] and by Harbridge House[13], a consulting firm that the Federal Council for Science and Technology (FCST) commissioned to conduct a study on government patent policy as part of a review of this

working in closely related fields of research and development, can be detrimental to the kind of cooperation that we must have from industry" (quoted in "Glennan Asks Review of NASA Patent Policy" 1959 p. 33).

[11] Memorandum and Statement of Government Patent Policy, 28 Federal Register 10,943-10946 (1963); and Memorandum and Statement of Government Patent Policy, 36 Federal Register 16,886 (1971).

[12] U.S. General Accounting Office (1968) *Problem Areas Affecting Usefulness of Results of Government-Sponsored Research in Medicinal Chemistry: A Report to the Congress*, Washington, D.C.: U.S. Government Printing Office.

[13] Harbridge House Inc. (1968a) 'Effects of Patent Policy on Government R&D Programs' Government Patent Policy Study, Final Report., Vol. II, Washington, D.C.: Federal Council for Science and Technology.

issue by the FCST itself.[14] Both reports examined the effects of federal patent policy on research collaboration between U.S. pharmaceutical firms and academic researchers in medicinal chemistry. During the 1940s and 1950s, these pharmaceutical firms had routinely screened compounds developed by NIH-funded university researchers[15] at no charge. In some cases (depending on the patent policies of particular universities), these pharmaceutical firms received exclusive rights to develop and market the compounds. In 1962, the Department of Health, Education, and Welfare (HEW) notified universities that firms screening compounds must sign formal patent agreements that prevented the firms from obtaining patents on any technologies that resulted from NIH funding or that were in the "field of research work" supported by the NIH grant (GAO, 1968, p. 10).

The GAO and Harbridge House reports criticized HEW's patent policy, arguing that pharmaceutical firms had stopped screening NIH grantees' compounds because of the firms' concern that the terms of the HEW policies meant that they could compromise their rights to intellectual property resulting from their in-house research (Harbridge House, 1968a, p. II-21; GAO, 1968, p. 11). Both reports recommended that HEW change its patent policy to clarify the circumstances in which rights reverted to the government, and those under which universities could retain title to patents and issue exclusive licenses to firms.

HEW responded to these critical reports in 1968 by establishing Institutional Patent Agreements (IPAs) that gave universities with "approved technology transfer

[14] President Kennedy's 1963 Memorandum on Government Patent Policy had charged the FCST with analyzing the effects of different patent policies on utilization and commercialization of government funded research.

[15] The firms screened these compounds for potential biological activity.

capability" the right to retain title to agency-funded patents.[16] In addition, the agency began to act more quickly on requests from universities and other research performers for title to the intellectual property resulting from federally funded research. Between 1969 and 1974 HEW approved 90% of petitions for title, and between 1969 and 1977 the agency granted IPAs to 72 universities and non-profit institutions (Weissman 1990). The National Science Foundation (NSF) instituted a similar IPA program in 1973, and the Department of Defense began in the mid-1960s to allow universities with approved patent policies to retain title to inventions resulting from federally funded research.

Thus, by the beginning of the 1970s, U.S. universities were able to patent the results of federally funded research via IPAs or similar programs at the Defense Department that were negotiated on an agency-by-agency basis, or via case-by-case petitions. These changes were likely partially responsible for the growth of university patenting during the 1970s.

4.2 Bayh-Dole

U.S. universities' concerns over potential restrictions on the HEW IPA programs provided the primary thrust for the introduction of the bill that eventually became the Bayh-Dole Act. In August 1977, HEW's Office of the General Counsel expressed concern that university patents and licenses (particularly exclusive licenses) could contribute to higher healthcare costs (Eskridge, 1978). The Department ordered a review of its patent policy, including a reconsideration of whether universities' rights to

[16] HEW had instituted an IPA program in 1953 and 18 universities had negotiated IPAs with the agency by 1958. But after 1958, no additional requests for IPAs were approved by HEW because "opinions of responsible agency officials differed concerning the value of such agreements" (GAO 1968, p. 24). In addition, pharmaceutical companies complained that the existing IPAs were ambiguous about the scope of exclusive rights that licensees could retain.

negotiate exclusive licenses should be curtailed.[17] During the ensuing 12-month review by HEW of its patent policies, the agency deferred decisions on 30 petitions for patent rights and 3 requests for IPAs. The reconsideration by HEW of its patent policies followed a similar review at the Department of Defense that had led to more restrictive policies toward university patenting.[18]

Reflecting their increased patenting and licensing activities, U.S. universities expressed concern over these restrictions to Congress (Broad, 1979a). In September 1978, Senator Robert Dole (R-Kansas) held a press conference where he criticized HEW for "stonewalling" university patenting (commenting, "rarely have we witnessed a more hideous example of overmanagement by the bureaucracy") and announced his intention to introduce a bill to remedy the situation (Eskridge, 1978, p. 605). On September 13, 1978, Senator Dole and Senator Birch Bayh (D-Indiana) introduced S. 414, the University and Small Business Patent Act. The Act proposed a uniform federal patent policy that gave universities and small businesses blanket rights to any patents resulting from government-funded research.[19] The bill lacked provisions that were typically included in IPAs, including the requirement that in order to receive title universities must have "approved technology transfer" capability. In contrast to the language of some

[17] The purpose of this review was "to make sure that assignment of patent rights to universities and research institutes did not stifle competition in the private sector in those cases where competition could bring the fruits of research to the public faster and more economically" according to the testimony of Elmer Staats during the Bayh-Dole hearings (United States Senate 1979a, p.37).

[18] "Under the new [DOD patent waiver] rules universities had to show and established technology transfer program in the particular field of technology of sponsored research, not merely an approved patent policy, in order to get prospective title retention clauses in contracts" (Eisenberg 1996, p. 1693).

[19] Identical legislation (H.R. 2414) was introduced in the House of Representatives by Rep. Peter Rodino (D-NJ) in 1979.

IPAs, the bill also lacked any language expressing a federal preference for non-exclusive licensing agreements.[20]

Since at least the Bush-Kilgore debates, there had been strong Congressional opposition to any uniform federal policy that granted rights of ownership of patents to research performers or contractors. But Bayh-Dole attracted little opposition, for several reasons. First, as its title suggests, the bill's focus on securing patent rights for only universities and small business weakened the argument (*a la* Kilgore) that such patent-ownership policies would favor big business.[21] Second, the bill included several provisions designed to defuse criticism that it would lead to "profiteering" at the expense of the public interest, including a recoupment provision (whereby institutions would have to pay back a share of licensing income or sales to funding agencies), and time limits on exclusive licenses (five years from commercial sale or eight years from the date of the license). Third, and most importantly, the bill was introduced in the midst of debates over U.S. economic competitiveness in the late 1970s. An article in *Science* discussing the debate on the Bayh-Dole bill observed that:

> The critics of such legislation, who in the past have railed about the 'giveaway of public funds' have grown unusually quiet. The reason seems clear. Industrial innovation has become a buzzword in bureaucratic circles … the patent transfer people have latched onto this issue. It's about time, they say, to cut the red tape that saps the incentive to be inventive (Broad 1979b, p. 479.)

[20] "Another IPA restriction dropped in the Dole-Bayh bill is the requirement that grantees and contractors try first to offer non-exclusive licenses. 'It's too hard and inefficient a process,' [a Bayh aide said]. 'Universities don't have the financial capability to beat the bushes and try to find someone who is willing to accept a license on a nonexclusive basis' (Henig, 1979, p. 281).

[21] A contemporary account noted that limiting the bill to universities and small businesses was "a tactical exclusion taken to ensure liberal support" (Henig 1979, p. 282). A Senate aide commented, "We'd like to extend [the policy] to everybody … but if we did the bill would never have a chance of passing" (Broad, 1979b, p. 474).

Committee hearings on the Bayh-Dole bill in both chambers were dominated by witnesses from small business, and various industry trade associations, and universities that were active in patenting and licensing (and groups representing these universities). Most of the testimony and commentary during these hearings focused on lagging U.S. productivity growth and innovativeness, suggesting that government patent policy contributed to these woes. [22] In their opening statements in the Senate Judiciary Committee hearings on the bill, Senators Bayh and Dole each pointed to two problems with federal patent policy as of 1979: the "policy" in fact consisted of more than 20 different agency-specific patent policies, and most federal agencies made it difficult for contractors to retain title to patents.

Most of the debate centered on whether publicly funded patents held by private contractors enjoyed higher rates of commercialization than those held be the government itself. Witnesses supporting the Bayh-Dole bill frequently cited results from the Harbridge House study that rates of utilization of government funded patents were higher when contractors rather than agencies held title to these patents.[23,24] Another frequently cited statistic was based on the 1976 FCST report that concluded that fewer than 5%: of the 28,000 patents owned by the federal government in 1976 were licensed.[25] Legislators and witnesses used this finding to argue that giving patent rights to

[22] For example, Dole opened the Senate Judiciary Committee's hearings on the bill by observing "The damaging impact of the Federal patent policy on the economy is dramatic. That we have lost our leadership role to Japan in the field of electronics and shipbuilding is no accident" (United States Senate Committee on the Judiciary 1979a, p. 28).
[23] See e.g. testimony of Howard Bremer of the Wisconsin Alumni Research Foundation (S. 1215 Hearings, 199, 203, 242).
[24] In addition to its analysis of the impact of NIH patent policy on academic-industry relationships in medicinal chemistry (discussed above), the Harbridge House report also presented broader statistical data of commercial utilization of patents resulting from federally funded research.
[25] See e.g. the testimony of Fredrick N. Andrews, Vice President for Research, Purdue University (S. 414 Hearings pg. 182), the Statement by Senator Dole (S.414 Hearings, page 28), and Walter Syniuta, President of Advanced Mechanical Technology (S. 414 Hearings, page 100).

contractors would create incentives for development and commercialization that were lacking under the current system. As Eisenberg (1996) points out, however, this inference was invalid. The patents cited in these studies were based primarily on research funded by the U.S. Defense Department (83% of the patents from the Harbridge House sample and 63% of those from the FCST sample), an agency that in fact readily granted patent rights to research performers. Patents derived from DoD-funded research for which contractors elected not to seek ownership rights almost certainly had limited commercial potential, and it is not surprising that they were not utilized or licensed.[26]

Moreover, the data in these reports were based primarily on patents resulting from government-funded R&D carried out by private firms. As such, they are of questionable relevance to the debate over the patenting by universities of inventions funded by the federal government. Several representatives from universities did make some points specific to the academic context, including an argument similar to that made by Cottrell in 1912: that university inventions are "embryonic" when first disclosed, requiring significant additional development before they can be commercially useful, and that firms would not invest in these costly development activities without clear rights to the relevant intellectual property (which, they argued, required university title to the patents and exclusive licenses).[27] Other witnesses suggested that giving title to universities would create incentives for inventors and institutions to become actively involved in the

[26] Importantly, Harbridge House itself concluded that the data in the report did not provide definitive evidence in favor of either a title or license policy. See also Eisenberg (1996), page 1681.
[27] See e.g. the testimony of Howard Bremer (S. 1215 Hearings, 243).

development and commercialization, anticipating arguments recently developed more formally by Jensen and Thursby (2000).[28]

However, beyond citing the Harbridge House or FCST statistics—which were of questionable validity and relevance--supporters of Bayh-Dole offered little systematic evidence that university inventions were being "under-utilized" because of difficulties universities faced in retaining title or granting exclusive licenses. More importantly, none of the witnesses discussed the potential risks created by university patenting and licensing for the norms of academic science, or any potentially detrimental effects of patenting and licensing for other channels of university-industry technology transfer considered. A journalist covering the hearings observed that "although the Dole-Bayh bill is receiving nearly unprecedented support, some congressional aides point out that it still leaves unanswered fundamental questions about patents in general and patents on university campuses in particular" (*Bioscience* 29(5), page 284).

Bayh-Dole was passed overwhelmingly in both the House and the Senate in the winter of 1980, with minimal floor debate.[29,30] The final version of the bill omitted the recoupment provision and the time limit on exclusive licenses for small firms (although it

[28] See e.g. the testimony of Howard Bremer (S. 1215 Hearings, 270) and Leland Clark, Professor of Pediatrics, Children's Hospital Research Foundation (S. 414 73-4).

[29] The House did not pass the companion bill to Bayh-Dole (H.R. 2414), but rather a bill (H.R. 6933) that contained the same provisions as Bayh-Dole but also allowed large firms to obtain "field of use" exclusive licenses to inventions they had developed with government funds. However, the Senate amended this bill, replacing it with the text of Bayh-Dole (S. 414). The House subsequently passed H.R. 6933 as amended, i.e. a bill identical to Bayh-Dole. Rep. Kastenmeier (D-WI), one of the main advocates for the version extending rights to large business contractors, noted that "rather than hold hostage [the] non-controversial areas [i.e. allowing universities and small business to retain title], I think we have no real option but to move forward with this [the bill as amended] and send it to the White House" Congressional Record - House (11/21/80) pg. 30560.

[30] Most of the floor debate focused on whether the bill should be extended to large businesses as well as universities and small business.

retained time limits on exclusive licenses for large firms).[31] President Carter signed the Bayh-Dole Act into law in 1980, and the Bayh-Dole Act became effective in 1981.

Bayh-Dole created a uniform federal patent policy for universities and small businesses that gives them the rights to any patents resulting from grants or contracts funded by any federal agency.[32] As discussed above, universities began to increase their involvement in patenting and licensing before Bayh-Dole, and the growth of university patenting and licensing probably would have continued in its absence. As such, one of the most important effects of Bayh-Dole on universities was normative: by endorsing university involvement in patenting and licensing, it assuaged any remaining fears about the reputational costs of involvement in the "business-side" of patenting and licensing. University patenting, licensing, and even licensing revenues would no longer be seen as potential sources of political embarrassment—as they were throughout much of the twentieth century—but rather as indicia of the "entrepreneurialism" and "economic dynamism" of research universities.

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[31] According to a recent NIH report the recoupment provision was dropped from Bayh-Dole in conference committee "because there was no agreement on whether the funds would be returned to the agencies or to general revenue, or how the collection and auditing functions would be conducted" and "fears that the costs of the infrastructure required to administer such a program would exceed the amounts collected." See http://www.nih.gov/news/070101wyden.htm.

[32] The federal government retains a non-exclusive royalty-free license to any such patents and retains "march in" rights to license or practice the invention when contractors' licensing policies are not promoting utilization or where doing so is necessary for public health or safety. The Act and subsequent implementing regulations also incorporate regulations governing the timetable for disclosures of invention to the funding agency and for filing patent applications. These regulations also require that universities share any licensing royalties with inventors and mandate a preference for small businesses in the award of licenses by universities and other research performers. The Bayh-Dole Act as passed also limited the duration of any exclusive licenses negotiated with large businesses. Interestingly, the Act's limitations on the rights of large firms to obtain title to patents resulting from federally funded research and its limits on duration of exclusive licenses were each nullified by subsequent executive and legislative actions. In 1983, President Reagan circulated a Memorandum to agencies instructing them to allow large businesses as well as universities and small businesses to retain title to federally funded patents and issued an Executive Order to this effect in 1987. In 1984, an amendment to Bayh-Dole removed the time limits on the length of exclusive licenses universities could offer to large businesses.

5. The Effects of Bayh-Dole

5.1 The Growth of University Patenting and Licensing

In the wake of Bayh-Dole, universities increasingly became directly involved in patenting and licensing, setting up internal technology transfer offices to manage licensure of university patents. Figure 2 shows the distribution of years of "entry" by universities into patenting and licensing, defined as the year in which the universities first devoted .5 FTE employees to "technology transfer activities" (AUTM, 1998). Consistent with the discussion above, few universities were involved in patenting and licensing early in the century. Entry began during the 1970s, but accelerated after Bayh-Dole.

FIGURE 2 HERE

University patenting exhibits a similar trend. Figure 3 shows the total number patents issued to Carnegie research universities over the 1925-1995 period.[33] Here again, growth began during the 1970s, but accelerated after 1980.

FIGURE 3 HERE

Time series on license revenues are more difficult to obtain, as they were not systematically collected until the early 1990s. In 1991, according to a survey by the Association of University Technology Managers (AUTM), universities earned nearly $200 million in license revenues, and this figure has increased nearly seven-fold since that time, as seen in Figure 4:

FIGURE 4 HERE

Though the growth rate is impressive, license revenues still only account for less than 5% of all research funds at AUTM universities (AUTM 2002). Note also that this

[33] These counts do not include Research Corporation patents.

figure was calculated before subtracting the inventors' share of royalty income (typically 30-50%) and before subtracting costs of patent and license management, which can be significant.[34]

In addition, a handful of universities account for the lion's share of licensing revenues. Figure 5 shows the distribution of licensing revenues in 1998 across the Carnegie research universities. Note that few universities are making large revenues: in fact, 10% of these universities account for over 60% of total licensing revenues. Moreover, the numbers in Figures 4 and 5 are gross revenue figures, and do not include costs of patent and license management. It is likely that after taking costs into account, the majority of American research universities are losing money on their patenting and licensing activities (cf. Trune and Goslin 1997).

FIGURE 5 HERE

5.2 Effects of Bayh-Dole on "Technology Transfer"

Of course, the primary purpose of the Bayh-Dole act was not to make universities rich, but rather to promote "technology transfer". And a number of observers in the United States and abroad have looked to the patenting and licensing trends displayed above (or similar figures) and pronounced Bayh-Dole a resounding success.[35] Implicit in this interpretation is the assumption that the commercialization and development underlying these trends would not have occurred absent Bayh-Dole, or more generally absent university patenting and licensing.

[34] Mowery and Sampat (2001a) show that the high costs of patent management made it difficult for the Research Corporation to generate positive net income from patenting and licensing university inventions.
[35] See, for example, the recent assessment of Howard Bremer, available online at http://www.cogr.edu/Bremer.htm.

This assumption is bound to be valid in some cases, but certainly not in all. The importance of patents and licensing for development and commercialization of university inventions was not well understood during the Bayh-Dole hearings, and is not well understood today. Universities can patent any inventions developed by their faculty members, and certainly do not limit their patenting to cases where commercialization would go forward even absent patenting and licensing.[36] For example, the Cohen-Boyer recombinant DNA technique was being used by industry even before the University of California and Stanford began to licensure; patenting (and licensing widely) allowed the universities to generate income, but did not facilitate technology transfer. In a recent oral history, Neils Reimers, the manager of the Cohen-Boyer licensing program, made this point explicitly, noting that

> [W]hether we licensed it or not, commercialization of recombinant DNA was going forward. As I mentioned, a nonexclusive licensing program, at its heart, is really a tax ... [b]ut it's always nice to say "technology transfer" (Reimers, 1998).

Another invention that fits this bill is Richard Axel's co-transformation process, patented and licensed by Columbia University. In this case, firms were using the technology shortly after it was described in the scientific literature, and before a patent was granted. The university compelled firms to license the invention by threatening to sue the firms if they continued to use the technology without a license.

In these two cases, technology transfer happened in spite of, not because of, university patenting and licensing activities. These are just two cases, but two important ones: together they account for close to 15% of cumulative royalty revenues earned by *all*

[36] According to a recent survey of 76 major university technology transfer offices, licensing incomeis the most important criterion by which technology transfer offices measure their own success (Thursby, Jensen, and Thursby 2001).

research universities in the post-Bayh-Dole era. Here, the university revenues are "taxes" on industry (to use Reimers' language) and ultimately consumers, rather than indicators of the extent of technology transfer.

In cases such as these, where universities are patenting inventions that would have been utilized or developed even absent intellectual property rights, society suffers the standard losses from non-competitive pricing. Further, restrictive access to university inventions may result in too few sources of further experimentation and development, in a context when multiple, rivalrous development efforts may be more socially desirable (see Merges and Nelson, 1990). The share of these cases and the extent of these costs are unknown: because they involve counterfactuals they are difficult to identify and measure. But a proper evaluation of the effects of Bayh-Dole on "technology transfer" would have to take these costs into account.

5.3 Effects on "Open Science"and Other Channels of Technology and Knowledge Transfer

More importantly, a complete assessment of the effects of Bayh-Dole requires analysis of its effects on other channels of knowledge and technology transfer. As indicated in Section 2, universities contribute to technical change in industry and economic growth through a number of channels. We have little understanding of whether and how increased academic patenting and licensing, and increased enthusiasm for these activities as sources of revenue, are affecting these other channels. Yet these issues have been the cause of much concern, and rightly so in view of the relative importance of these other channels. In particular, the surveys cited in Section 2 suggest that the most salient economic contribution of universities is via production of information which helps

increase the efficiency of applied R&D. Traditionally, this information has been disseminated via publications and conferences, informal communication, and via graduate students. Do these channels of knowledge transfer co-exist with increased patenting and licensing, and pursuit of commercial gain? Unfortunately, at this point we do not know, and this remains an important topic for future research.

Another concern is that academics and universities are limiting disclosure and availability of information and materials that are inputs into scientific research itself, reminiscent of Cottrell's concerns that university interest in patenting may foster "growing commercialism and competition between institutions and an accompanying tendency for secrecy in scientific work." Unfortunately, apart from anecdotal evidence there is little systematic evidence on this front either. But given the importance of communication and information disclosure for the advance of science, this concern too deserves to be taken seriously.[37]

5.4 Are Universities Increasingly Patenting "Science"?

Related to each of the worries above is the belief (see e.g. Nelson 2002, Eisenberg and Nelson 2002) that universities are increasingly patenting "scientific" research outputs rather than just embryonic new technologies. Recall that the intent of Bayh-Dole was to facilitate utilization of patents resulting from university research, not to change the range

[37] A related concern is that in pursuit of commercial gain, academics have shifted from "basic" to "applied" research after Bayh-Dole. In a previous paper with colleagues (Mowery et al. 2001), I argued that since much of the growth of commercial activity is concentrated in fields of "use-oriented basic research" like biotechnology, it would be difficult to identify such a shift. Perhaps the most systematic attempt to assess this issue is the paper by Henderson et al. (1998), which shows a decline in the "quality" of university patents after Bayh-Dole. Some observers have interpreted this result as evidence of a post-Bayh-Dole shift to "applied" research. Sampat et al. (2002) question this interpretation, and also show that the "quality decline" is driven by truncation bias, and is not robust to using a longer stream of citation data.

of outputs that universities patent. Since the passage of Bayh-Dole, several court decisions and other changes in the U.S. patent system have led to an increasingly broad definition of patentable subject matter.[38] Given that they now can do so, are universities increasingly patenting scientific outputs of their research?

Trends in the references cited in university patents may shed some light on this question.[39] Several scholars have suggested that, all else equal, a higher number and proportion of non-patent references indicates that the invention is based more in "science" than "technology" (e.g. Trajtenberg et al. 1997). Thus trends in non-patent references in university patents may signal the degree to which academic institutions are increasingly patenting scientific outputs, rather than embryonic technologies.[40]

To examine these trends, I collected information on the non-patent references in all university patents granted between 1976 and 1996 (N=19,115) and a 1% random sample of all U.S. patents granted over the same period (N=16,543). Following Trajtenberg et al. (1997), for each patent I constructed two variables, NPCITES, the number of non-patent citations, and SCIENCE, the share of non-patent citations in all

[38] The most important of the court rulings was the Supreme Court's 1980 decision in Diamond v. Chakrabarty, which effectively extended patentability to "anything under the sun that is made by man"(447 U.S. 303 1980). Another Supreme Court decision in the same year, Diamond v. Diehr, allowed for the patentability of applications of laws of nature and mathematical formulae.

[39] In order to assess whether an invention disclosed in a patent application satisfies the requirements for patentability, the patent examiner compares the claims in the application to the "prior art", which can be loosely defined as knowledge and information that is related to the claimed invention. Granted patents include lists of references to two types of prior art against which patentability was assessed: previous patents, and non-patent references.

[40] Several recent papers have used patent-patent references to evaluate the effects of Bayh-Dole, including Henderson et al. (1998), Mowery and Ziedonis (2002), Mowery, Sampat and Ziedonis (2002), and Sampat, Mowery, and Ziedonis (2002). A common complaint about this line of work—and the use of patent citation data more generally--is that many citations are inserted by the patent examiner for purely legal reasons (e.g. Ahoranian 1999), and may not provide useful information about the characteristics of the knowledge embodied in the patent. In current work (Sampat 2002) based on an analysis of over 150,000 patents granted in 2001, I show that while patent examiners do insert 43% of the citations to previous patents, they insert only 5% of the citations to non-patent prior art. As such, indicators based on non-patent prior art are much less subject to the criticism above.

(patent and non-patent) references in the patent. Each of these variables is used as a proxy for the degree to which the knowledge embodied in the patent is related more to "scientific" rather than "technological "sources (Trajtenberg et al. 1997).

The data on non-patent references are taken directly from the front-page of U.S. patents, and do not discriminate between non-patent references from "scientific" journals and those from other sources.[41] As such, the analysis below rests on the assumption that the non-patent references to items other than "science" are random noise, and thus that counts and shares of all non-patent references in a patent accurately signal the degree to which the relevant prior art is based in science.

If universities are increasingly patenting "science", the number and share of references to non-patent citations in university patents should be increasing over time. To isolate the effects of Bayh-Dole (and related changes in norms, policies, and procedures at universities) from more general developments that could affect trends in non-patent references (e.g. better search capabilities at the USPTO), I compare trends in non-patent references in university patents to those in the control sample: i.e. I employ a "difference-in-differences" approach.

Specifically, I estimate two regressions, the first with the number of non-patent citations in a patent as the dependent variable, and the second with the share of non-patent citations. The independent variables in each regression include grant year dummies, patent class dummies for each patent class, and grant year dummies interacted with a dummy variable indicating whether the patent is a university or control sample patent. More formally, I estimate equations of the form:

[41]CHI Research (www.chiresearch.com) has created and maintains a cleaned and standardized non-patent reference database, including information on which non-patent references are "scientific" (i.e. reference scientific journals and conferences).

$$NPCITES_i = \sum_t \left[\alpha_t APP_t + \beta_t (APP_t * UNIV)\right] + \sum_c \lambda_c CLASS_c + \varepsilon_i$$

$$SCIENCE_i = \sum_t \left[\alpha_t APP_t + \beta_t (APP_t * UNIV)\right] + \sum_c \lambda_c CLASS_c + \varepsilon_i$$

where $NPCITES_i$ and $SCIENCE_i$ are respectively the number and share of non-patent citations in patent *i*, APP_t is a dummy variable taking on the value of 1 if patent was granted for in year *t* (*t* = 1976, … ,1996), UNIV is a dummy variable taking on the value of 1 if patent *i* is assigned to a university, $CLASS_c$ is dummy variable taking on the value of 1 if the patent class is *c*, and ε_i is the error term. The coefficients on the interaction terms, β_t, are estimates of the mean differences in the number of citations to university patents and patents from our random sample for a given grant year, controlling for technological field effects.

The coefficients on the interaction terms from these regressions are plotted in Figures 6 and 7. Clearly, there has been a dramatic increase in both the number and proportion of citations to non-patent prior art in university patents, relative to the controls.

FIGURES 6 AND 7 HERE

Though these results are consistent with the hypothesis that universities are increasingly patenting "scientific" rather than "technological" outputs of their research, they should be interpreted with caution for several reasons. First, non-patent citations are noisy measures of "science" citations, as mentioned above. If this noise is correlated with any variables of interest (e.g. if university patents are increasingly citing articles from *Newsweek* in their non-patent references and the control patents are not), the estimates of the differences will be biased. Second, though the results are what we would expect if universities were increasingly patenting science, there could also be alternative

explanations for these trends. Finally, the lines between “science” and “technology” are often blurry and the distinctions subtle (Dasgupta and David 1994, Stokes 1997), and crude patent citation based measures of the “scientific” content of patents may be misleading or, at the very least, too blunt.

Moreover, even if universities are increasingly patenting "science" the actual effects of these changes are unclear. Even though the intent of the Bayh-Dole act was not to change the composition of university patenting, there may be no significant negative effects even if this is in fact occurring. For example, based on interviews, Arora et al. (2002) find that even though universities are increasingly patenting and licensing inputs into future research, this is rarely a stumbling block to future research or product development. And though the Cohen-Boyer and Axel patents each were each based more in “science” than “technology,” each were licensed widely and non-exclusively, and there is no evidence that the mere fact that they were patented significantly limited their use or dissemination.

This raises an important point, that the social costs and benefits of the post-Bayh-Dole regime depend less on whether university research outputs are patented than on how they are licensed. Indeed, many of the important policy issues surrounding patenting of publicly funded research revolve around this issue, as I discuss in more detail in the concluding section below.

6. Policy Options and Conclusions

This paper shows that the "private parts" of academic science have certainly expanded over the past quarter century. Universities' historical reluctance to become involved in patenting and licensing has disappeared, and appears to have been replaced

with enthusiasm. This change was supported in part by the passage of the Bayh-Dole of 1980, which not only made it easier for universities to patent federally funded research, but also engendered a change in norms about the appropriateness of university involvement in the business-side of patenting and licensing activities.

The political history of Bayh-Dole in Section 4 revealed that it was passed based on little solid evidence that the status quo ante resulted in low rates of commercialization of university inventions. More remarkably, the hearings completely neglected the economic importance of the public aspects of university research, and ignored the possibility of potential negative effects of increased patenting and licensing on open science and on other channels of technology and knowledge transfer.

Nevertheless, the discussion in Section 5 suggests that the net effects of Bayh-Dole (and the rise of university patenting and licensing activity more generally) on innovation, technology transfer, and economic growth remain unclear, and much more research in necessary on this front. As such, while current efforts to emulate Bayh-Dole type policies in other OECD countries (see OECD 2002) are misguided (or at least premature), we also do not have enough evidence to suggest that major changes to the Bayh-Dole act are necessary in the United States.

However, some tinkering could help protect the public domain--and the public interest--especially important in the context of taxpayer funded research. Note that from a social welfare perspective, we would want universities to patent publicly funded research outputs only when *absent* patents, these research outputs would not be effectively utilized. Similarly, we would want universities to issue exclusive licenses on patented inventions only when non-exclusive licensing fails to promote use or commercialization.

However, under the Bayh-Dole act as currently written, universities have complete latitude in making decisions about what to patent and how to license, and typically make patenting and licensing decisions based on their own self-interest rather than public interest (see footnote 36), though the two are often correlated.

This can be thought of as a principal-agent problem.[42] Via Bayh-Dole, principals (funding agencies) delegated to agents (universities) the authority to make decisions about patenting and licensing, based on the belief that doing so would facilitate "technology transfer" and social returns from university research. But the agents make patenting and licensing decisions based on their own self-interest—including concern for licensing revenues--and in some cases may make choices that hinder, rather than facilitate, technology transfer and social returns. Because it is difficult and costly for principals to monitor the decisions of their agents (e.g. because knowledge of the "right" licensing regime requires specialized knowledge about the university technology and industry of use), agents can "get away with" making choices contrary to the public interest.[43]

This principal-agent analogy suggests some possible alternatives available to policymakers that could help assure that universities patent and license only when it serves the public interest, consistent with the intent (if not the letter) of Bayh-Dole.

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[42] See Guston (2000) for a more general discussion of principal-agent problems in science and technology policy.

[43] Thus Eisenberg and Rai (2002), writing about the effects of Bayh-Dole on biomedical research, note "The policy challenge is to devise a system that does the best job of distinguishing the cases in which patenting makes sense from the cases in which it does not. The complexity of biomedical research makes this a formidable task, and the public interest in getting these determinations right demands assigning this task to an appropriate decisionmaker. Ideally, decisions about what to patent and what to place in the public domain should be made by institutions that are in a position to appreciate the tensions between widespread access and preservation of commercial incentives without being unduly swayed by financial interests that are not aligned with the overall public interest" (161).

One standard solution to principal-agent problems is to better inform principals about the actions of agents, i.e. to improve monitoring. In a sense, recent moves by the NIH and other agencies to improve disclosure and reporting requirements by universities are a step in this direction, though not far enough. It may make sense for funding agencies to require universities to keep more detailed information on what criteria they use in deciding whether to patent federally funded inventions, and criteria used to decide how and to whom to license these patents. Though it would be infeasible for funding agencies to actually review all of this information, random (low probability) audits could suffice to curb opportunistic behavior on the part of universities. Moreover, such a system would also remind universities at each step of the process of their responsibility to promote "technology transfer" rather than their own private interests.

Another solution to principal-agent type problems is to increase costs agents face if it is discovered that their actions deviate from the actions desired by principals. Interestingly, throughout much of the twentieth century, universities avoided involvement in patenting and licensing precisely because of fears of political embarrassment and repercussions if they were found to be "profiteering" at public expense (see above, and also Sampat and Nelson 2002). I have argued above that these fears may have disappeared--in part because of Bayh-Dole's congressional endorsement of university involvement in technology transfer--and norms about how a university should behave in these arenas may no longer be checking their financial ambitions. However, in specific instances funding agencies may still be able to induce patenting and licensing consistent with the public interest via hortative statements basically making it clear that "in research area X, the public interest is generally served via broad dissemination." The NIH recently

followed such an approach with respect to research on single-nucleotide polymorphisms and human genetic DNA sequences (Rai and Eisenberg 2002). Because such statements clearly define the public interest, they could serve to create political and reputational costs for institutions whose patenting and licensing strategies deviate from it. Along the same lines, Nelson (2002) has suggested an amendment to Bayh-Dole emphasizing that in most instances the presumption should be wide dissemination of publicly funded research (via publication or non-exclusive licensing), though it is recognized that in specific instances patenting and licensing may be necessary.

However, such exhortations may not be enough, and others have suggested strengthening the ability of funding agencies to take corrective actions in instances where patenting and licensing decisions made by universities are contrary to the public interest. Under Bayh-Dole, funding agencies can revoke title to publicly funded patents in "exceptional circumstances," or "march in" to compel broader licensure in cases where licensees are not taking appropriate steps to commercialize the invention. However these provisions are extremely cumbersome, and consequently have not been exercised since the passage of Bayh-Dole. Recognizing this, Eisenberg and Rai (2002) have proposed amending Bayh-Dole by lowering the bar for ex post intervention by funding agencies. An attractive feature of this proposal is that even the threat of such actions by principals ex post could curb opportunistic behavior by agents ex ante. However, this proposal may be limited its by potential for "capture" by interest groups, and is also complicated by the informational constraints facing funding agencies discussed above.

Each of the policy suggestions discussed above is based on the recognition that patenting and restrictive of public research licensing facilitates commercialization in

some cases, but not all: a recognition not embodied in current government patent policy. In addition to these changes, several observers (Eisenberg and Rai 2002, Nelson 2002) have suggested that many of the potential problems associated with the growth of university patenting and licensing (see Section 5 above) could be ameliorated by more general changes in the patent system, e.g. strengthening of the utility and non-obviousness requirements and implementation of a formal research exemption.

Finally, it is advisable for universities themselves to exercise greater responsibility for managing patenting and licensing with a view towards the public interest rather than their own financial interests. Universities are society's best vehicles for advancing fundamental knowledge and disseminating it widely: this is their comparative advantage. Over the long-run, if they stray too far from this mission and start behaving like profit-maximizing firms, political will for extensive financial support of academic research will surely diminish. Given this risk, and the fact that over 20 years since the passage of Bayh-Dole only a handful of universities are earning significant net licensing revenues, aggressive pursuit of royalty income is probably not worth it.

Even absent any interventions by policymakers, if American research universities reaffirm their commitment to creating economically and socially useful "public knowledge," we can expect that their spectacular achievements over the past century will be repeated in the next.

References

References

"Innovation's Golden Goose." *The Economist* 365, no. 8303 (2002): T3.

Agrawal, Ajay, and Rebecca Henderson. "Putting Patents in Context: Exploring Knowledge Transfer From MIT." *Management Science* 48, no. 1 (2002): 44-60.

Association of University Technology Managers (AUTM). *AUTM Licensing Survey 1998, Survey Summary*. Norwalk, CT: AUTM, 1998.

Association of University Technology Managers (AUTM). *The AUTM Licensing Survey: FY 2001*. Norwalk, CT: AUTM, 2002.

Bremer, Harold. *The First Two Decades of the Bayh-Dole Act as Public Policy (http://www.nasulgc.org/COTT/Bayh-Dohl/Bremer_speech.htm)*, *Presentation to the National Association of State Universities and Land Grant Colleges*, 2001.

Broad, William. "Patent Bill Returns Bright Idea to Inventor (in News and Comment)." *Science* 205 (1979a): 473-476.

Broad, William. "Whistle Blower Reinstated at HEW." *Science* 205 (1979b): 476.

Bush, Vannevar. "The Kilgore Bill." *Science* 98, no. 2557 (1943): 571-577.

Cohen, W.M., R.R. Nelson, and J.P. Walsh. "Links and Impacts: The Influence of Public Research on Industrial R&D." *Management Science* 48, no. 1 (2002): 1-23.

Crane, Diana. *Invisible Colleges: Diffusion of Knowledge in Scientific Communities*. Chicago: University of Chicago Press, 1972.

Dasgupta, Partha, and Paul David. "Towards a New Economics of Science." *Research Policy* 23, no. 5 (1994): 487-521.

de Solla Price, Derek. *Little Science, Big Science*. New York: Columbia University Press, 1963.

Eisenberg, R. "Public Research and Private Development: Patents and Technology Transfer in Government-Sponsored Research." *Virginia Law Review* 82 (1996): 1663-1727.

Eskridge, N. "Dole Blasts HEW for 'Stonewalling' Patent Applications." *Bioscience* 28 (1978): 605-6.

Federal Council on Science and Technology. "Report on Government Patent Policy,1973-1976." Washington, D.C.: U.S. Government Printing Office, 1978.

Forman, H.I. *Patents: Their Ownership and Administration by the United States Government*. New York: Central Book Company, 1957.

Gambardella, Alfonso. *Science and Innovation*. New York: Cambridge, 1995.

Guston, David. *Between Politics and Science: Assuring the Integrity and Productivity of Research*. New York: Cambridge University Press, 2000.

Harbridge House Inc. "Effects of Government Policy on Commercial Utilization and Business Competition." In *Government Patent Policy Study, Final Report*. Washington, D.C.: Federal Council for Science and Technology, 1968a.

Harbridge House Inc. "Effects of Patent Policy on Government R&D Programs." In *Government Patent Policy Study, Final Report.* Washington, D.C.: Federal Council for Science and Technology, 1968b.

Henig, R. "New Patent Policy Bill Gathers Congressional Support." *Bioscience* 29, no. May (1979): 281-284.

Henig, R. "New Patent Policy Bill Gathers Congressional Support." *Bioscience* 29, no. May (1979): 281-284.

Kevles, D. "The National Science Foundation and the Debate over Postwar Research Policy, 1942-45." *Isis* 68 (1977): 5-26.

Kitcher, Philip. *The Advancement of Science*. New York: Oxford University Press, 1993.

Merges, Robert, and Richard Nelson. "On Limiting or Encouraging Rivalry in Technical Progress: The Effect of Patent Scope Decisions." *Journal of Economic Behavior and Organization* 25 (1994): 1-24.

Merton, Robert King. *The Sociology Of Science : Theoretical And Empirical Investigations*. Chicago: University of Chicago Press, 1973.

Mowery, David, and Bhaven Sampat. "Patenting and Licensing University Inventions: Lessons from the History of the Research Corporation." *Industrial and Corporate Change* 10 (2001a): 317-355.

Mowery, David C., and Bhaven N. Sampat. "University Patents, Patent Policies, and Patent Policy Debates,1925-1980." *Industrial and Corporate Change* 10 (2001b): 781-814.

Mowery, David, Richard Nelson, Bhaven Sampat, and Arvids Ziedonis. *The Ivory Tower and Industrial Innovation: University Patenting Before and After Bayh-Dole*. Palo Alto: Stanford University Press, 2003.

Nelson, Richard. "The Market Economy and the Republic of Science." *Draft* (2002).

OECD. *Benchmarking Science-Industry Relationships*. Paris: OECD, 2002.

Polanyi, Michael. "The Republic of Science: Its Political and Economic Theory." *Minerva* 1 (1962): 54-74.

Rai, A.T., and R.S. Eisenberg. "The Public and the Private in Biopharmaceutical Research." *Paper Prepared for the Conference on the Public Domain, Duke University* (2002).

Reimers, Niels. *Stanford's Office of Technology Licensing and the Cohen/Boyer Cloning Patents, An Oral History Conducted in 1997 by Sally Smith Hughes, Ph.D., Regional Oral History Office*. Berkeley, CA: The Bancroft Library, 1998.

Rosenberg, N., and R.R. Nelson. "American Universities and Technical Advance in Industry." *Research Policy* 23 (1994): 323-348.

Sampat, B.N., and R.R. Nelson. "The Emergence and Standardization of University Technology Transfer Offices: A Case Study of Institutional Change." *Advances in Strategic Management* 19 (2002).

Stokes, D.E. *Pasteur's Quadrant: Basic Science and Technological Innovation*. Washington, D.C.: Brookings Institute, 1997.

Thursby, J., R. Jensen, and M. Thursby. "Objectives, Characteristics and Outcomes of University Licensing: A Survey of Major U.S. Universities." *Journal of Technology Transfer* 26 (2001): 59-72.

Trune, D. , and L. Goslin. "University Technology Transfer Programs: A Profit/Loss Analysis." *Technological Forecasting and Social Change* 57 (1998): 197-204.

U.S. General Accounting Office. *Problem Areas Affecting Usefulness of Results of Government-Sponsored Research in Medicinal Chemistry: A Report to the Congress*. Washington, D.C.: U.S. Government Printing Office, 1968.

U.S. Office of Management and Budget. "Memorandum and Statement of Government Patent Policy." *Federal Register* 28 (1963): 10943-10946.

U.S. Office of Management and Budget. "Memorandum and Statement of Government Patent Policy." *Federal Register* 36 (1971): 16886.

Ziman, J. M. *Public knowledge: an essay concerning the social dimension of science*. London,: Cambridge U.P., 1968.

Figure I: Proportion of Carnegie Research Universities with IAAs with Research Corporation: 1940-1980

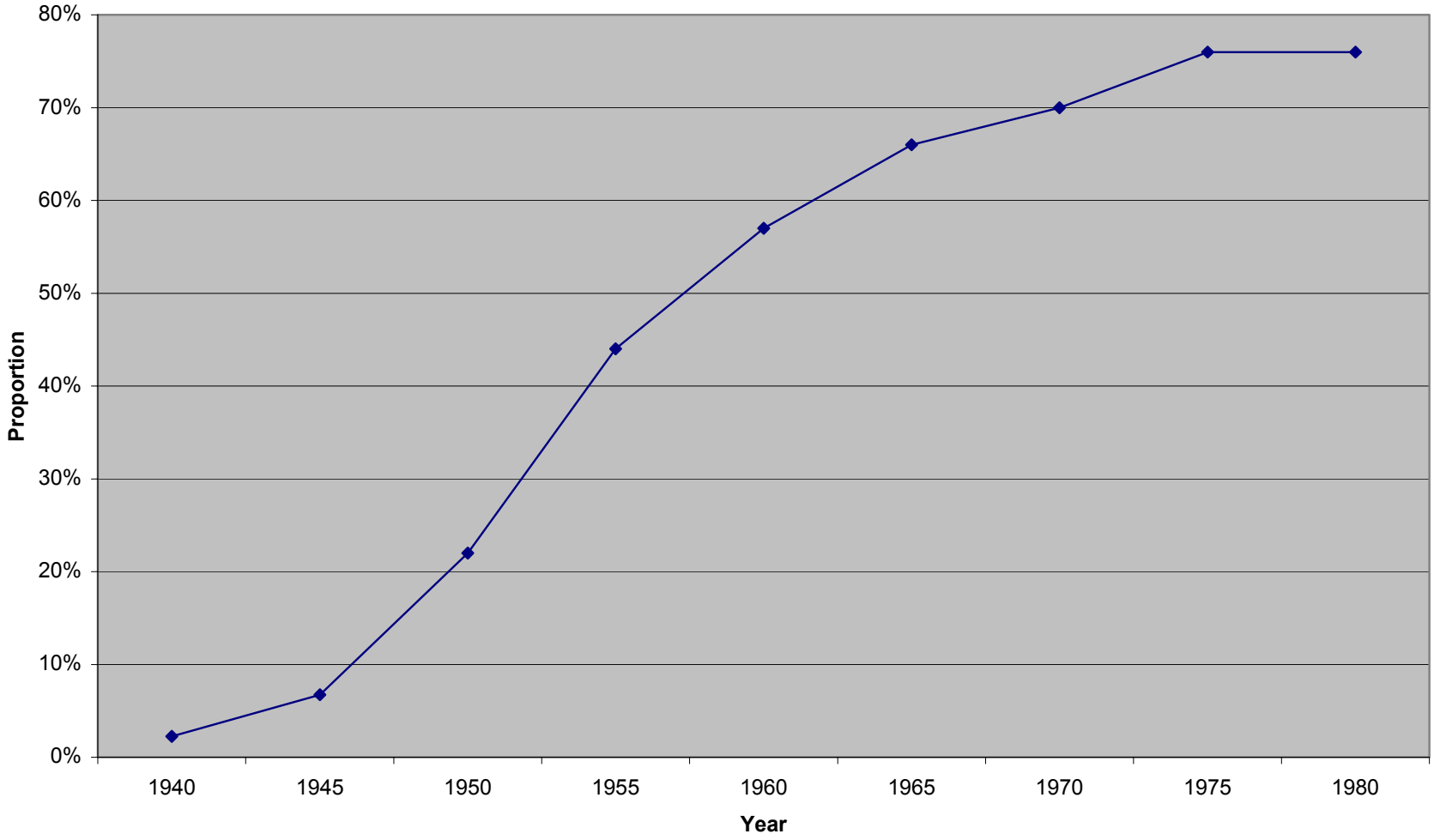

Figure 2: Year of "Entry" into Technology Transfer Activities

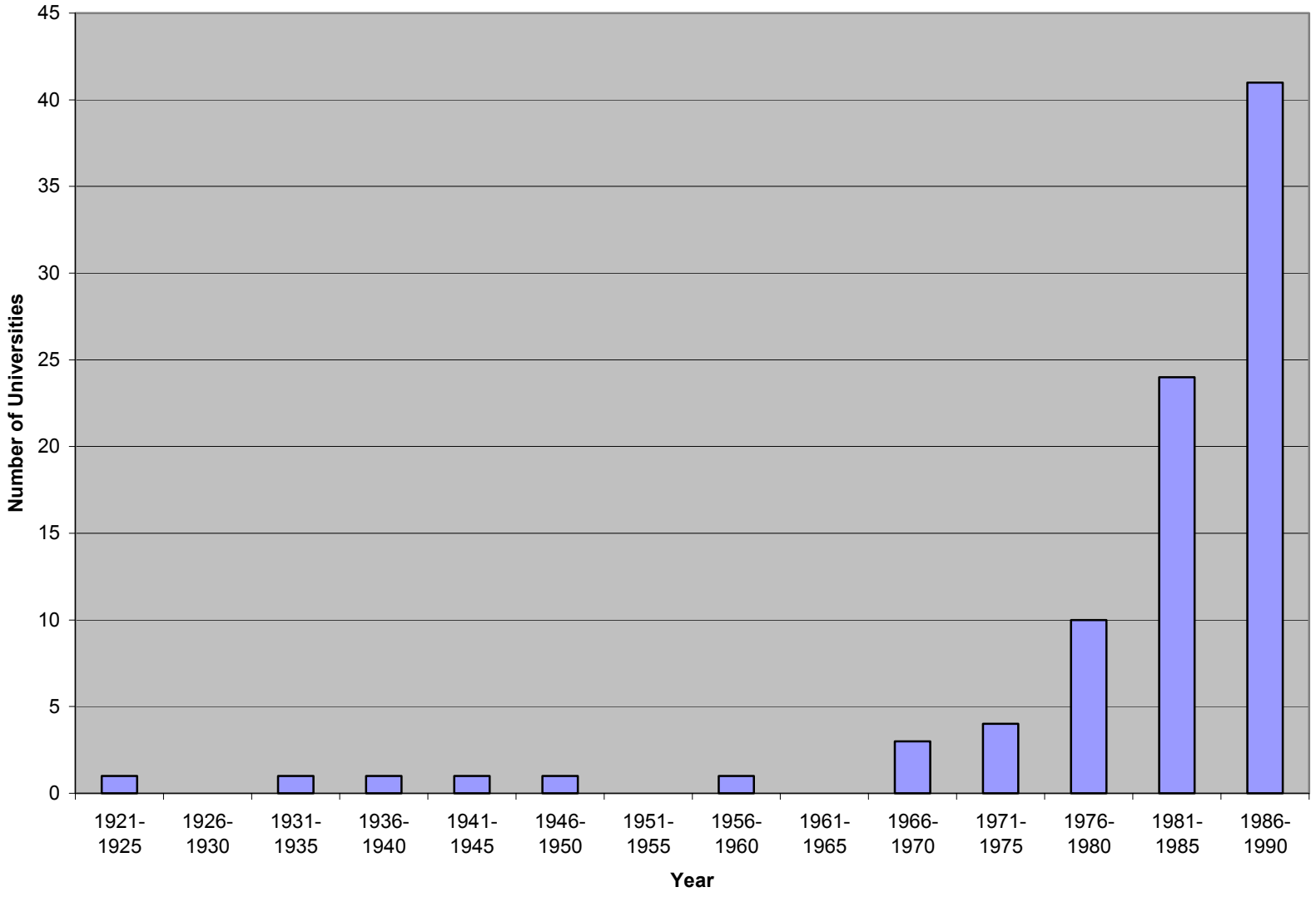

Figure 3: Patents Issued to Research Universities, By Year

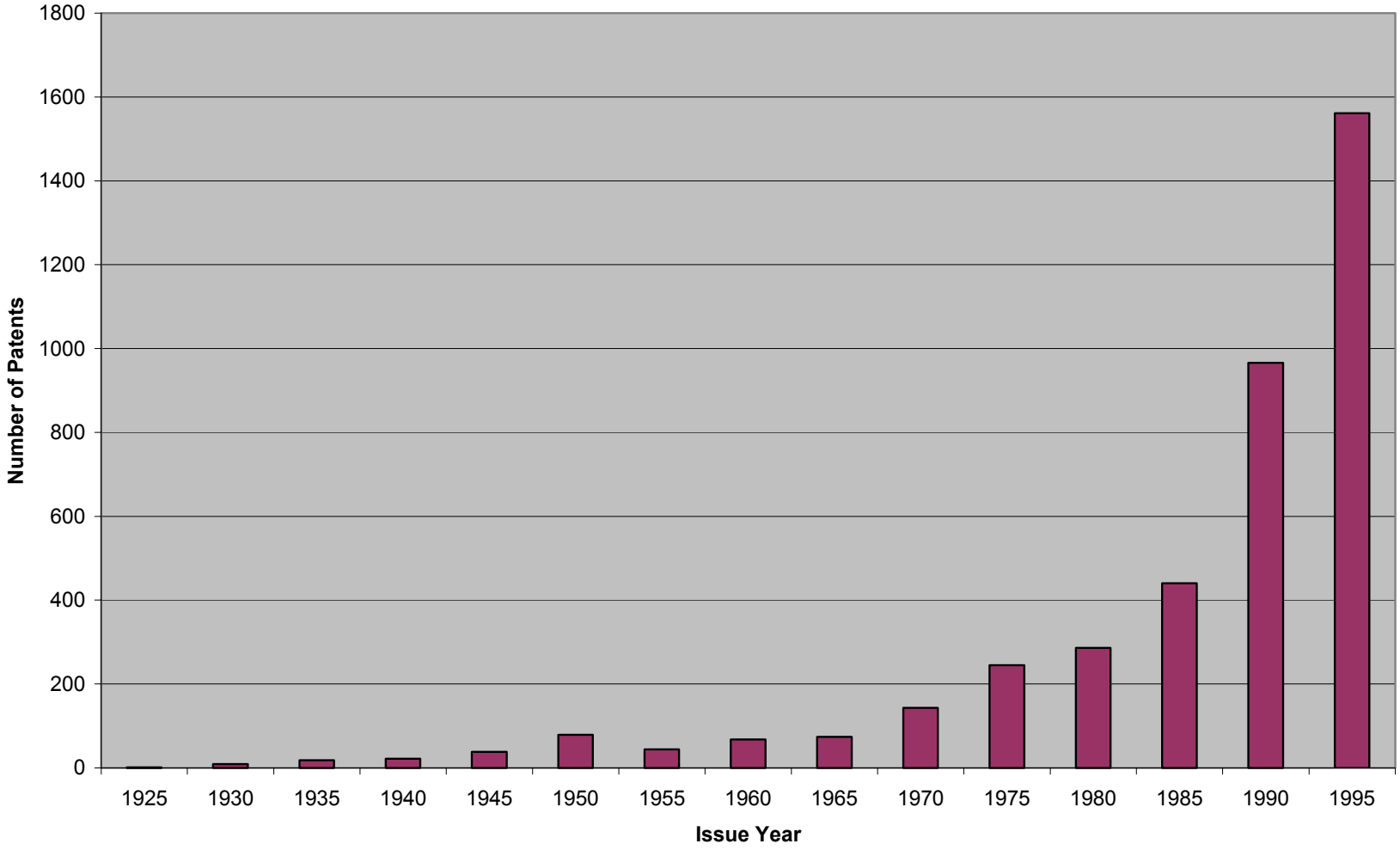

Figure 4: Gross University Licensing Income, 1991-2000
(Source: AUTM 2002)

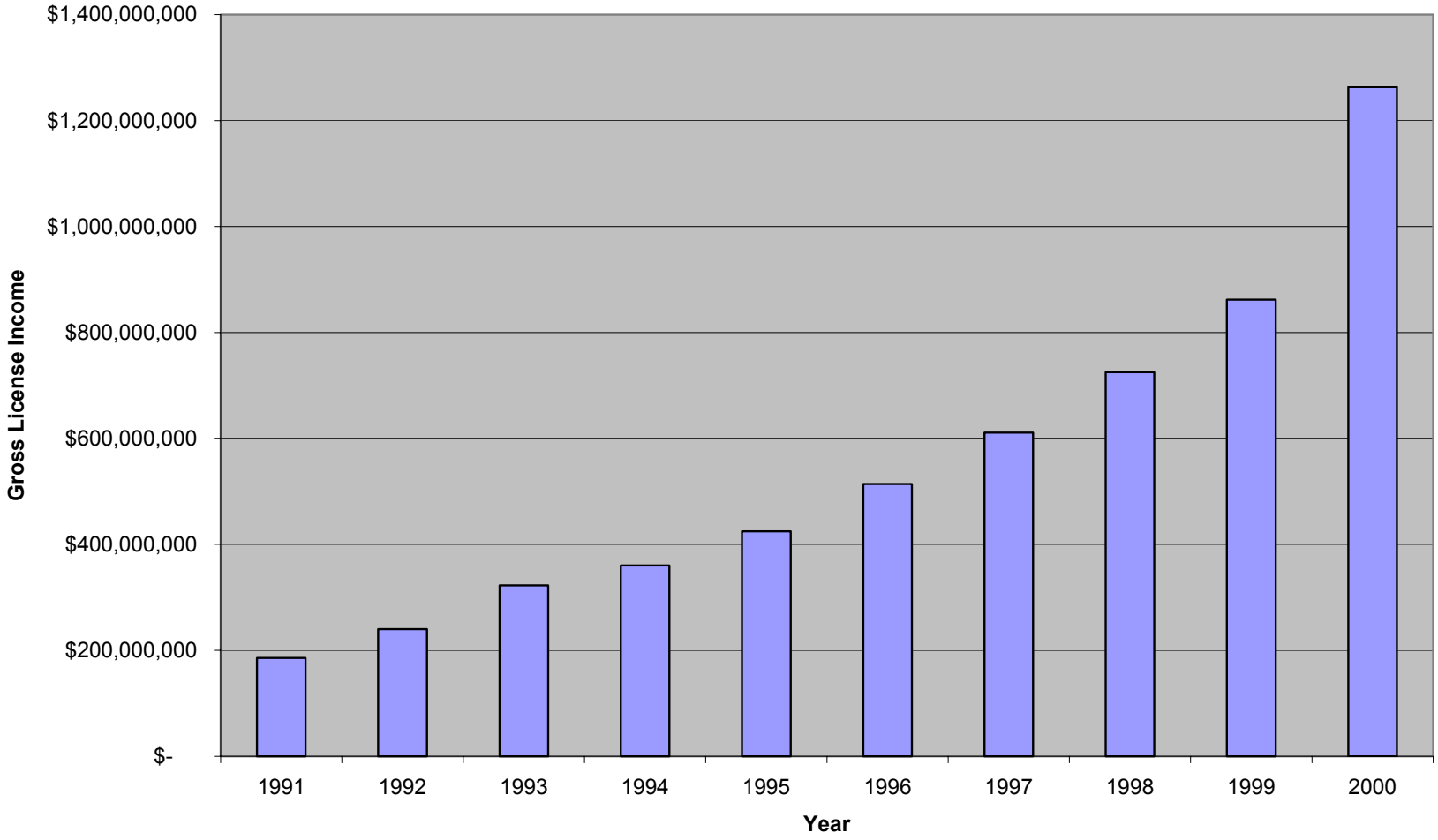

Figure 5: Distribution of University License Revenues

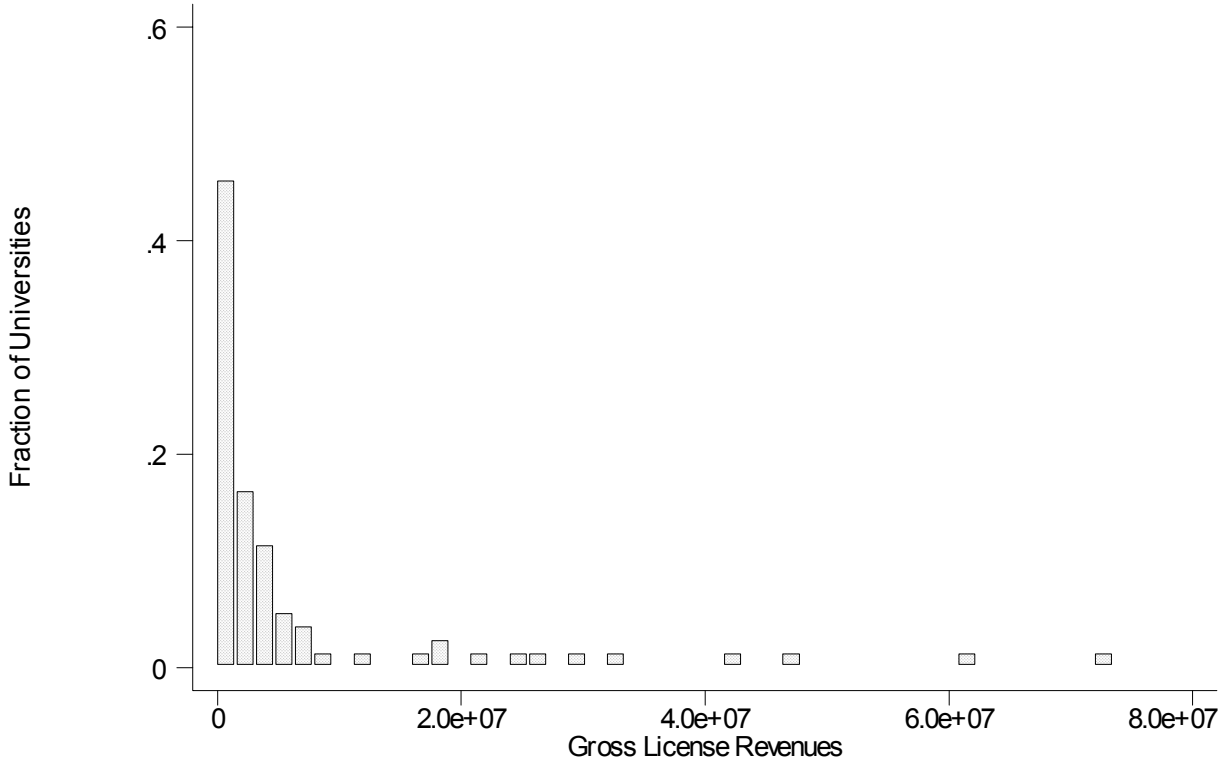

Figure 6: Number of Citations to Non-Patent Prior Art, University-Random Sample Difference

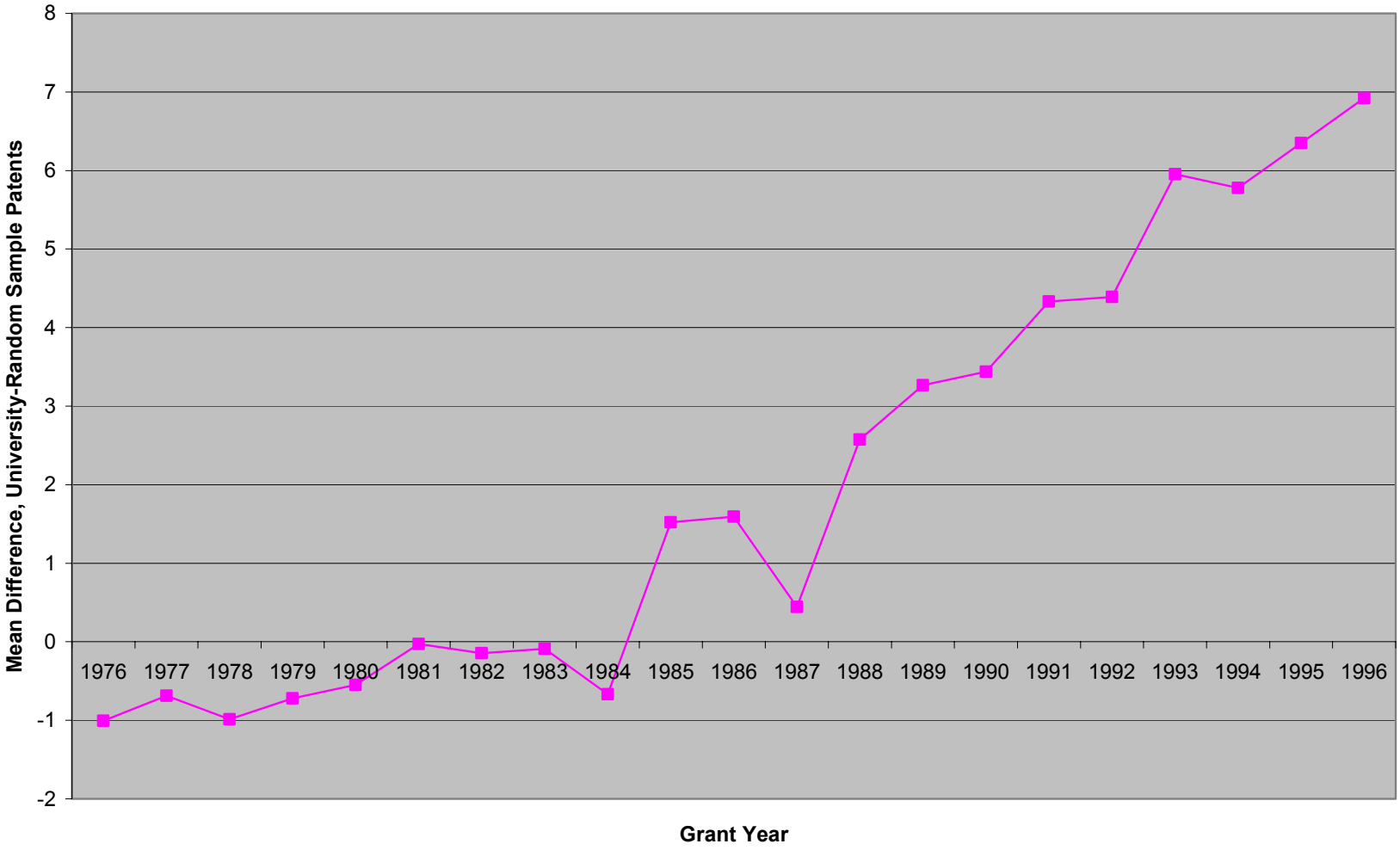

Figure 7: Proportion of Citations to Non-Patent Prior Art, University-Random Sample Difference