The Bayh-Dole Act of 1980 and University-Industry Technology Transfer: A Policy Model for Other Governments?*

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I. Introduction

The research university plays an important role as a source of fundamental knowledge and, occasionally, industrially relevant technology in modern knowledge-based economies. In recognition of this fact, governments throughout the industrialized world have launched numerous initiatives since the 1970s to link universities to industrial innovation more closely. Many of these initiatives seek to spur local economic development based on university research, e.g., by creating “science parks” located nearby research university campuses, supporting “business incubators” and public “seed capital” funds, and the organization of other forms of “bridging institutions” that are believed to link universities to industrial innovation. Other efforts are modeled on a U.S. law, the Bayh-Dole Act of 1980, that is widely credited with improving university-industry collaboration and technology transfer in the U.S. national innovation system.

In some cases, these initiatives build on long histories of collaboration between university and industry researchers that reflect unique structural features of national university systems and their industrial environment. In other cases, however, these initiatives are based on a misunderstanding of the roles played by universities in national innovation systems, as well as the factors that underpin their contributions to industrial innovation. Many of these initiatives are based in the assumption that universities support innovation in industry primarily through their production of “deliverables” for commercialization (e.g., patented discoveries). Moreover, the most important channels through which university-industry interaction advances industrial innovation and economic growth, in this view, are the formal channels of patent licensing and in some cases, the formation of university “spin-off” firms. But for most industries university research aids innovation through its informational outputs, which in turn often reach industrial scientists and engineers through the channels of “open science,” such as publications, conference
presentations, or the movement of personnel between universities and industry (including the hiring by industry of university graduates).

This brief survey discusses the evidence on the origins and effects of the Bayh-Dole Act, focusing on the Act’s effects on U.S. universities’ contributions to industrial innovation since 1980. Based on that discussion, I consider the feasibility and advisability of the numerous initiatives in other industrial economies to emulate the “Bayh-Dole model” by adopting legislation with broadly similar goals and at least some similar provisions. The examination of efforts to emulate the Bayh-Dole policy framework in other OECD economies provides some basis for considering the advisability of implementing the “Bayh-Dole model” in developing economies. I do not discuss the effects of the Bayh-Dole Act per se or the effects of increased patenting by U.S. universities in general on the access by developing-economy citizens to products and inputs, such as pharmaceuticals and agricultural innovations, that are important to public welfare. This topic is not unimportant, but my expertise and access to the evidence do not allow an assessment of these issues.

II. Origins and Effects of the Bayh-Dole Act

In order to assess the effects of the Bayh-Dole Act on university research patenting, licensing, and technology transfer in the United States, one needs to consider the counterfactual: What would have happened in the absence of the Act? One basis for developing such a counterfactual is the long history of university-industry collaboration and technology transfer in the United States before 1980. This section provides a brief summary of this history, as well as a summary of the political origins and the effects on university patenting and technology transfer of the Act.

A. The pre-Bayh-Dole period

Collaboration between university and industrial researchers, combined with the focus of many U.S. university researchers on scientific problems with important industrial, agricultural, or
other public applications, meant that a number of U.S. universities patented faculty inventions throughout the 20th century. The pre-1980 patenting activities of U.S. universities built on research collaborations between university and industrial researchers that spanned many channels of technology and knowledge exchange, including publishing, training of industrial researchers, faculty consulting, and other activities. University-industry collaboration in turn was facilitated by the unusual structure of the U.S. higher education system (especially by comparison with those of other industrial economies) during the 20th century. The U.S. higher education system was significantly larger, included a very heterogeneous collection of institutions (religious and secular, public and private, large and small, etc.), lacked any centralized national administrative control, and encouraged considerable interinstitutional competition for students, faculty, resources, and prestige (See Geiger, 1986, 1993; Trow, 1979, 1991, among other discussions). In addition, the reliance by many public institutions of higher education on “local” (state-level) sources for political and financial support further enhanced their incentives to develop collaborative relationships with regional industrial and agricultural establishments. The structure of the U.S. higher education system thus strengthened incentives for faculty and academic administrators to collaborate in research and other activities with industry (and to do so through channels that included much more than patenting and licensing) long before the Bayh-Dole Act’s passage.

Despite the adoption by a growing number of universities of formal patent policies by the 1950s, many of these policies, especially those at medical schools, prohibited patenting of inventions, and university patenting was less widespread than was true of the post-1980 period. Moreover, many universities chose not to manage patenting and licensing themselves. The Research Corporation, founded by Frederick Cottrell, a University of California faculty inventor who wished to use the licensing revenues from his patents to support scientific research, assumed a prominent role as a manager of university patents and licensing. Even in these early decades of patenting and licensing, however, biomedical technologies accounted for a disproportionate share
of licensing revenues for the Research Corporation and other early university licensors, such as the Wisconsin Alumni Research Foundation.

Congress had debated the assignment of patents resulting from publicly funded research for decades before the passage of Bayh-Dole. These debates over federal patent policy largely ignored U.S. universities during the 1940s and 1950s. After all, U.S. universities have never accounted for more than one-third of overall federal R&D spending during the postwar period, and first exceeded 20% of federal R&D funding only in 1978.1 Moreover, U.S. universities historically had limited their direct involvement in patenting and licensing activities.

Federal policy toward patents resulting from publicly funded university research became a topic of debate after the release in 1968 of critical reports on the NIH’s Medicinal Chemistry program by the U.S. General Accounting Office (GAO)2 and by Harbridge House,3 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 issue by the FCST itself.4 Both reports examined the effects of federal patent policy on research collaboration between U.S. pharmaceutical firms and academic researchers in medicinal chemistry. In 1962, the Department of Health, Education, and Welfare (HEW) notified universities that firms screening compounds in their research laboratories must sign formal patent agreements that prevented the firms from obtaining patents on technologies resulting from NIH funding (GAO, 1968, p. 10).

The GAO and Harbridge House reports criticized HEW's patent policy and recommended that HEW change its patent policy to clarify the circumstances under which rights reverted to the government, and those under which universities could retain title to patents and issue exclusive

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1 See also National Science Board (2002), Table 4-4. Universities and colleges (including Federally Funded R&D Centers) accounted for 10% of federal R&D spending in 1953, the first year for which the National Science Foundation has published data. This share had grown to more than 33% of federal R&D spending by 2000.
3 Harbridge House Inc. (1968), Vol. II.
4 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.
licenses to firms. HEW responded to these critical reports in 1968 by establishing Institutional Patent Agreements (IPAs) that gave universities with "approved technology transfer capability" the right to retain title to agency-funded patents. Though exclusive licensing was allowed under the terms of the IPAs, academic institutions were required to make good faith efforts to license inventions non-exclusively. 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.

Approximately one-quarter (49/212) of the Carnegie Research and Doctoral Universities had IPAs with either HEW or NSF during the 1970s. These institutions accounted for 73% of university patenting over the 1970s, and would continue to account for 55% of university patenting over the 1980s. Another 27 of these universities petitioned the government for title during the 1974-80 period (as indicated by acknowledgements in “government interest” section of patents). Together, institutions that either petitioned for rights or had IPAs accounted for 92% of patents during the 1970s, and 85% of university patents during the 1980s. That is, many of the most active patenters in the post-Bayh-Dole era were already patenting government funded research during the 1970s.

The number of universities establishing technology transfer offices and/or hiring technology transfer officers began to grow in the late 1960s, well before the passage of the Bayh-Dole Act. The decade of the 1970s, as much as or more so than the 1980s, represented a watershed in the growth of U.S. university patenting and licensing. U.S. universities expanded their patenting, especially in biomedical fields, and assumed a more prominent role in managing their patenting and licensing activities, supplanting the Research Corporation. Agreements

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5 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). Pharmaceutical companies also complained that these IPAs were ambiguous about the scope of exclusive rights that licensees could retain.
between individual government research funding agencies and universities contributed to the growth of patenting during the 1970s. Private universities also expanded their patenting and licensing during this decade. Although the Act was followed by a wave of entry by universities into management of patenting and licensing, growth in these activities was well-established by the late 1970s. Indeed, lobbying by U.S. research universities was one of several factors behind the passage of the Bayh-Dole Act in 1980. The Act is as much an effect as a cause of expanded patenting and licensing by U.S. universities during the post-1960 period.

B. Origins of the Bayh-Dole Act

The Bayh-Dole Patent and Trademark Amendments Act of 1980 provided blanket permission for performers of federally funded research to file for patents on the results of such research and to grant licenses for these patents, including exclusive licenses, to other parties. The Act facilitated university patenting and licensing in at least two ways. First, it replaced a web of Institutional Patent Agreements (IPAs) that had been negotiated between individual universities and federal agencies with a uniform policy. Second, the Act's provisions expressed Congressional support for the negotiation of exclusive licenses between universities and industrial firms for the results of federally funded research. Third, the Act reduced the power of federal funding agencies to oversee the terms of licensing agreements between research performers and licensees.

Although the Act reduced the power of federal funding agencies to influence the specific terms of licensing contracts covering patented inventions resulting from publicly funded research, Bayh-Dole contained three provisions affecting the ownership and licensing of this intellectual property. Federal funding agencies retained a nonexclusive, royalty-free license for all patents resulting from public funding and assigned to research performers. The Act also empowered federal agencies to deny patent rights to a non-U.S. research performer and to deny patent rights in circumstances under which denial of ownership of the invention will advance the goals of the Act. As Rai and Eisenberg (2003) point out, denial of patent rights to a contractor is subject to an elaborate process of appeal that extends to the federal U.S. Claims Court; they cite only one instance
in which patent rights have been denied to a contractor under this provision. Finally, the Act grants “march-in” rights to federal agencies, enabling a federal agency to mandate licensing of a patent if the patentholder or its licensee are not exercising due diligence in the development of the invention. This provision also includes procedures for administrative and judicial appeals, and the power has yet to be exercised by a federal funding agency.⁶

Supporters of Bayh-Dole asserted that university contributions to innovation were limited by difficulties in patenting the outputs of federally funded research and licensing the patents exclusively to industry. This argument was particularly salient during the competitiveness crisis in the U.S. during the 1970s, in spite of the fact that proponents of Bayh-Dole offered very little evidence supporting this argument, as Eisenberg (1996) points out (see also Mowery et al. 2003). Moreover, there was no discussion during the Bayh-Dole debates about any potentially negative effects of increased patenting and licensing on the other channels through which universities contribute to innovation and economic growth.

The passage of the Bayh-Dole Act was one part of a broader shift in U.S. policy toward stronger intellectual property rights.⁷ Among the most important of these policy initiatives was the establishment of the Court of Appeals for the Federal Circuit (CAFC) in 1982. Established to serve as the court of final appeal for patent cases throughout the federal judiciary, the CAFC soon emerged as a strong champion of patentholder rights.⁸ But even before the establishment of the CAFC, the 1980 U.S. Supreme Court decision in Diamond v. Chakrabarty upheld the validity of a broad patent in the new industry of biotechnology, facilitating the patenting and licensing of

⁶ One recent effort by a firm in 1997 to compel the National Institutes of Health to exercise the march-in rights and compel licensing of a patent involved CellPro’s attempt to compel licensing by Johns Hopkins University of a patent with broad claims to bone-marrow stem cell technology, a patent licensed exclusively by Baxter Healthcare. CellPro’s petition was denied, and the firm eventually filed for bankruptcy (Bar-Shalom and Cook-Deegan, 2002; McGarey and Levey, 1999).
⁷ According to Katz and Ordover (1990), at least 14 Congressional bills passed during the 1980s focused on strengthening domestic and international protection for intellectual property rights, and the Court of Appeals for the Federal Circuit created in 1982 has upheld patent rights in roughly 80% of the cases argued before it, a considerable increase from the pre-1982 rate of 30% for the Federal bench.
⁸ See Hall and Ham (1999) for an analysis of the effects of the CAFC and related policy shifts on patenting in the U.S. semiconductor industry.
inventions in this sector. The effects of Bayh-Dole thus must be viewed in the context of this larger shift in U.S. policy toward intellectual property rights.

Bayh-Dole has been modified twice since 1980. First, a 1983 Executive Memorandum extended Bayh-Dole’s benefits beyond non-profits, small businesses, and universities to cover large firms as well (this Memorandum was codified in a 1987 Executive Order). In 1984, the Act was amended to remove time limits on the term of exclusive licenses to large firms and the Commerce Department was granted authority to oversee Bayh-Dole.9 Since 1984, a variety of further amendments to the Act have been proposed, ranging from provisions that enable federal agencies to garnish a university’s licensing revenues on high-earning patents, to controlling the prices of products (primarily pharmaceuticals) produced from federally-funded research, to making it easier for government officials to waive the government’s right to procure a patent.

C. The Effects of Bayh-Dole

A number of scholars have documented the role of Bayh-Dole in the growth of patenting and licensing by universities since 1980 (Henderson et al 1998). But Bayh-Dole is properly viewed as initiating the latest, rather than the first, phase in the history of U.S. university patenting. And this latest phase is characterized by a higher level of direct involvement by universities in management of their patenting and licensing activities, in contrast to the reluctance of many U.S. universities to become directly involved in patenting prior to the 1970s.

Keeping in mind that we are unable to separate the effects of Bayh-Dole from those of other influences, how has U.S. university patenting changed since 1980? Since overall patenting in the United States grew during this period, indicators of university patenting need to be normalized by overall trends in patenting or R&D spending. Figures 1-2 present two such indicators that span the period before and after the Bayh-Dole Act. Figure 1 depicts U.S. research university patenting as a share of domestically assigned U.S. patents during 1963-99, in order to

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remove the effects of increased patenting in the United States by foreign firms and inventors
during the late 20th century. Universities increased their share of patenting from less than 0.3% in
1963 to nearly 4% by 1999, but the rate of growth in this share begins to accelerate before rather
than after 1980. Figure 2 plots the ratio of aggregate university patenting at time \( t \) to aggregate
academic R&D expenditures at time \( t-1 \), for application years 1963-1993.\(^{10}\) The Figure reveals
an increase in aggregate university "patent propensity" after 1981 (as pointed out by Henderson et
al. 1998), but this is the continuation of a trend that dates at least as far back as the early 1970s;
there is no evidence of a "structural break" in patent propensity after Bayh-Dole.\(^{11}\)

FIGURES 1-2 HERE (figures are provided at the end of the paper)

Another issue of interest in academic patenting is the distribution among technology
fields of university patents during the pre- and post-Bayh-Dole periods. Figure 3 displays this
information for U.S. research university patents during 1960-1999, and highlights the growing
importance of biomedical patents in the patenting activities of the leading U.S. universities during
the period.

FIGURE 3 HERE (figures are provided at the end of the paper)

Non-biomedical university patents increased by 90% from the 1968-70 period to the
1978-80 period, but biomedical university patents increased by 295%. This rapid growth in
biomedical patents also reflected growth of the major biomedical funding agency’s (HEW’s) IPA
program during the 1970s. The increased share of the biomedical disciplines within overall
federal academic R&D funding, the dramatic advances in biomedical science that occurred during

\(^{10}\) Data on total academic R&D were obtained from National Science Board (2000), Appendix Table 4-4.
\(^{11}\) As we have pointed out elsewhere (Mowery et al., 2001) The Bayh-Dole Act did not dramatically affect
the patenting and licensing activities of universities that had long been active in this area, such as Stanford
University and the University of California. Indeed, the biomedical patents and licenses that dominated
these institutions’ licensing revenues during the 1980s and 1990s had begun to grow before the passage of
the Bayh-Dole Act. Columbia University, an institution with little experience in patenting and licensing
before 1980 (and an institution that prohibited the patenting of inventions by medical faculty until 1975),
also had filed for its first “blockbuster” patent before the effective date of the Act. Nevertheless, the Act
did increase patenting of faculty inventions at both Stanford and the University of California, although
many of these patents covered inventions of marginal industrial value and did not yield significant licensing
royalties.
the 1960s and 1970s, and the strong industrial interest in the results of this biomedical research, all affected the growth of university patenting during this period.

After Bayh-Dole, universities increased their involvement in patenting and licensing, setting up internal technology transfer offices to manage licensure of university patents. Figure 4 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). “Entry” accelerated after 1980, but growth in this measure of direct involvement by universities in patenting and licensing predates Bayh-Dole.

FIGURE 4 HERE (figures are provided at the end of the paper)

Longitudinal data on university licensing activities are less complete, but the available data indicate that in FY2000, U.S. universities signed more than 4000 license agreements, representing more than a doubling since FY1991 (AUTM, 2000).

Based on these trends in university patenting and licensing, many observers have argued that Bayh-Dole stimulated university-industry technology transfer. During the late 1990s and early 21st century, many commentators and policymakers portrayed the Bayh-Dole Act as the critical catalyst to growth in U.S. universities’ innovative and economic contributions. Indeed, the OECD argued that the Bayh-Dole Act was an important factor in the remarkable growth of incomes, employment, and productivity in the U.S. economy of the late 1990s. Implicit in many if not all of these characterizations is the argument that university patenting and licensing were necessary to these asserted increases in the economic contributions of U.S. university research. Similar characterizations of the effects of the Bayh-Dole Act have been articulated by

12 “Regulatory reform in the United States in the early 1980s, such as the Bayh-Dole Act, have [sic] significantly increased the contribution of scientific institutions to innovation. There is evidence that this is one of the factors contributing to the pick-up of US growth performance...” (OECD, A New Economy?, 2000, p. 77).

13 “Possibly the most inspired piece of legislation to be enacted in America over the past half-century was the Bayh-Dole Act of 1980. Together with amendments in 1984 and augmentation in 1986, this unlocked all the inventions and discoveries that had been made in laboratories throughout the United States with the help of taxpayers’ money. More than anything, this single policy measure helped to reverse America’s
the President of the Association of American Universities,¹⁴ and the Commissioner of the U.S. Patent and Trademark Office.¹⁵

These characterizations of the positive effects of the Bayh-Dole Act cite little evidence in support of their claims beyond counts of university patents and licenses, and none has attempted to assess the relative importance of Bayh-Dole and other factors. But growth in both patenting and licensing predates Bayh-Dole and is rooted in internationally unique characteristics of the U.S. higher education system. Nor does evidence of increased patenting and licensing by universities by itself indicate that university research discoveries are being transferred to industry more efficiently or commercialized more rapidly, as Colyvas et al. (2001) and Mowery et al. (2001) point out. Indeed, current research provides mixed support at best for a central assumption of the Bayh-Dole Act, i.e., the argument that patenting and licensing are necessary for the transfer and commercial development of university inventions in all fields of academic research.

Evidence cited in Mowery et al. (2004), for example, reveals that the gross licensing revenues for Columbia University, Stanford University, and the University of California system were dominated by a small number of patents. For each of these three universities, the “top 5” patents accounted for more than 65% of gross licensing revenues. These “top 5” patents were mainly biomedical inventions. Universities lacking a major biomedical research program may precipitous slide into industrial irrelevance. Before Bayh-Dole, the fruits of research supported by government agencies had gone strictly to the federal government. Nobody could exploit such research without tedious negotiations with a federal agency concerned. Worse, companies found it nigh impossible to acquire exclusive rights to a government owned patent. And without that, few firms were willing to invest millions more of their own money to turn a basic research idea into a marketable product.”

¹⁴“In 1980, the enactment of the Bayh-Dole Act (Public Law 98-620) culminated years of work to develop incentives for laboratory discoveries to make their way to the marketplace promptly, with all the attendant benefits for public welfare and economic growth that result from those innovations. Before Bayh-Dole, the federal government had accumulated 30,000 patents, of which only 5% had been licensed and even fewer had found their way into commercial products. Today under Bayh-Dole more than 200 universities are engaged in technology transfer, adding more than $21 billion each year to the economy.”

¹⁵“In the 1970s, the government discovered the inventions that resulted from public funding were not reaching the marketplace because no one would make the additional investment to turn basic research into marketable products. That finding resulted in the Bayh-Dole Act, passed in 1980. It enabled universities, small companies, and nonprofit organizations to commercialize the results of federally funded research. The results of Bayh-Dole have been significant. Before 1981, fewer than 250 patents were issued to universities each year. A decade later universities were averaging approximately 1,000 patents a year.”
not produce such “home run” patents and therefore may reap lower gross revenues. The high costs of establishing and operating technology licensing offices (costs that include the legal expenses associated with patent prosecution and litigation) also depress net revenues. Even the University of California system, one of the leading recipients of licensing revenue during the “post-Bayh-Dole” era, reaps surprisingly small net revenues from licensing activities. During fiscal 1999 – 2003, average annual gross licensing revenues for the UC system were roughly $75 million.\textsuperscript{16} The net contribution to UC operating expenses, however, a figure that subtracts the operating expenses of the technology licensing office and payments to the faculty inventor, averaged slightly more than $15 million annually. This amount represents a small fraction (less than 1\%) of the annual research budget for the UC system of more than $3 billion.

Revenues are of course not the only motive for university licensing activities. Other important motives include retention of faculty who wish to see their inventions patented and licensed; the transfer of university inventions to commercialization; regional or state-level economic development, and (in the wake of the 2003 \textit{Madey v. Duke} decision of the Court of Appeals for the Federal Circuit, which eliminated the informal “experimental use” defense against claims of patent infringement) the preservation of freedom of academic scientists to conduct research. This array of potential goals for patenting and licensing activities, however, creates some challenges for management. First, these goals are not entirely compatible—for example, support for regional economic development may entail an acceptance of lower royalty rates on licenses for firms active in the vicinity of the university. Technology licensing thus will involve some tradeoffs among these goals. Second, in spite of these tradeoffs, as well as the evidence above on the relatively modest scale of net revenues at many university technology licensing offices, a recent survey of technology licensing officers (Jensen et al., 2001) indicates that these individuals cite licensing revenues as the most important goal of their activities.

\textsuperscript{16} This calculation covers fiscal years 1999-2003, but omits fiscal 2000, since the “licensing revenues” data reported for that year include a $200 million payment to the University of California under the terms of settlement of a patent dispute over human growth hormone.
U.S. universities have long been important sources of new firms, many of which are founded to commercialize faculty inventions. In other cases, university faculty work closely (e.g., as members of scientific advisory boards, as consultants, or as individuals who guide students into employment) with technology-based firms located nearby. Intellectual property rights can play an important role in the formation of startups. Here as elsewhere, however, we lack sufficient data to opine with confidence on the role of increased university patenting in the relationship between universities and the formation of new firms (nor can we speak with confidence about the specific effects of Bayh-Dole on this relationship). Whether and how increased university patenting affects the interaction between universities and knowledge-based “startup” firms is unclear.

Although many evaluations of the economic effects of the Bayh-Dole Act highlight the role of small-firm startups as beneficiaries of these licensing transactions, the data compiled by the Association of University Technology Managers (AUTM, 2001, 2002) suggest that firms founded specifically to commercialize the licensed technology account for a minority of licensees. The AUTM annual reports for 2001 and 2002 indicate that 14 – 16% of university patent licensees in these years were startup firms founded to exploit the licensed inventions. More than one-half (50 - 54%) of academic licensees during this period were small (fewer than 500 employees) firms already in existence, while roughly one-third (32 – 33%) of licensees were large firms. The emphasis in recent academic research (DiGregorio and Shane, 2003) on the role of university “spinoffs” in the licensing activities of U.S. universities thus needs to be qualified by a recognition that such startups account for a minority of academic licensees. Nor do we have reliable data on the rate of formation of academically linked startup firms since 1980 that are not licensees, or the rates of formation of startups before 1980 that were or were not licensees.

One important development in the management by many U.S. universities of their patenting and licensing activities has been an increase during the 1990s in the acquisition by universities of equity stakes in small firms that license faculty inventions. In many cases, university licensing
officers believe that equity positions may provide a larger “upside potential” than a licensing contract alone, especially for a small firm with little if any cash flow. The limited financial resources of startup-firm licensees also mean that universities may accept equity stakes in lieu of licensing fees or other “upfront” payments. The fiscal 2002 AUTM survey reports that a total of 443 licenses negotiated during that year included the grant to licensor universities of equity in the licensee firm. Of these 443 licenses, 313 were negotiated with new firms founded specifically to commercialize the university invention. The total of 443 licenses with equity represented an increase over fiscal 2001 of almost 52. Interestingly, the share of licenses with equity negotiated with existing small firms nearly tripled during 2002 (the number grew from 43 to 130), an increase that the survey’s analysis interpreted as an indication of increased financial pressures on existing small firms.

As was previously noted, the growth in U.S. university patenting and (to an even greater degree) licensing has been concentrated in the biomedical sciences, where patents have considerable economic value and the number of patents associated with significant commercial innovations (e.g., a new pharmaceutical product) often is smaller than is true of commercial innovations in fields such as information technology. And in at least some of these nonbiomedical fields, anecdotal evidence suggests that the emphasis by many universities on negotiating the status of intellectual property rights for industry-supported research projects has been a source of friction, rather than something that facilitates collaboration. R. Stanley Williams of Hewlett Packard stated in testimony before the U.S. Senate Commerce Committee’s Subcommittee on Science, Technology and Space that

Largely as a result of the lack of federal funding for research, American Universities have become extremely aggressive in their attempts to raise funding from large corporations….. Large US based corporations have become so disheartened and disgusted with the situation they are now working with foreign universities, especially the elite institutions in France, Russia and China, which are more than willing to offer extremely favorable intellectual property terms.” (September 17, 2002; statement reproduced at http://www.memagazine.org/contents/current/webonly/webex319.html; accessed April 2, 2005).
In the biomedical field, the NIH Director’s Working Group on Research Tools stated in its report that

If there was one point on which virtually every private firm that we spoke to was in agreement, it was that universities take inconsistent positions on fair terms of access to research tools depending on whether they are importing tools or exporting them. Over and over again, firms, complained to us that universities “wear the mortarboard” when they seek access to tools developed by others, yet they impose the same sorts of restrictions when they enter into agreements to give firms access to their own tools. As one lawyer for a small biotechnology firm put it,

“Universities want it both ways. They want to be commercial institutions when it comes to licensing their technology, but to be academic environments when it comes to accessing technology that others have developed…They throw the same things in the way of small companies.” (National Institutes of Health, 1998, p. 15).

Other assessments of the effects of the Bayh-Dole Act cite potentially negative effects of the Act on U.S. university research or innovation in the broader economy, although in most cases these potentially detrimental effects are not solely the result of the Bayh-Dole Act. Some scholars have suggested that the “commercialization motives” created by Bayh-Dole and the associated increase in university patenting could shift the orientation of university research away from “basic” and towards “applied” research (Henderson et al., 1998), but there is little evidence of substantial shifts in the content of academic research since Bayh-Dole.

A second negative effect of increased university patenting and licensing cited by some observers is the potential weakening of academic researchers’ commitments to “open science,” leading to publication delays, secrecy, and withholding of data and materials (Dasgupta and David, 1994; Liebeskind 2001). Although some work on this issue suggests that the “disclosure norms” of academic research in specific fields have been affected by increased faculty patenting (see Campbell et al., 2002), findings thus far are not conclusive, and more work is needed.

Moreover, the Bayh-Dole Act is not solely responsible for any such changes in disclosure norms. Nonetheless, given the importance assigned by industrial researchers to “nonpatent” channels of interaction (faculty publications, hiring of students, informal interactions with faculty, conferences, faculty consulting) with universities in most industrial sectors other than
pharmaceuticals (See Levin et al., 1987; Cohen et al., 2002), it is important that these channels not be constricted or impeded by the intensive focus on patenting and licensing in many universities.

Finally, the effects of increased patenting by institutional and individual inventors of inputs to scientific research have only begun to receive serious scholarly attention. Patenting and restrictive licensing of inputs into future research (“research tools”) could hinder downstream research and product development (Heller and Eisenberg 1998; Merges and Nelson 1994),

17 but quantitative evidence on this point remains scarce. Some preliminary evidence, however, suggests that the issue of patents on biomedical research advances that are also the subject of published papers diminishes future citations to these papers, a result that indicates that the issue of a patent on a particular finding does seem to produce some revision in the research agenda of other scientists (Murray and Stern, 2004; Sampat, 2005).

Increased patenting of biomedical research advances in universities and industry also appears to have influenced the conditions under which research materials are exchanged among university and industrial researchers. The National Institutes of Health Director’s Advisory Group on Research Tools also expressed concern over the growing complexity of the “Materials Transfer Agreements” (MTAs) used by many academic and nonacademic research performers to govern the conditions under which biological materials, cell lines, and other research inputs could be shared by researchers. Increased academic and industrial patenting of biomedical discoveries, as well as the higher perceived value of biological and genomic materials used in biomedical research have expanded the number and diversity of the institutions seeking to obtain or being asked to supply these materials, making the negotiation of satisfactory terms among the parties to

17 The NIH responded to growing concerns about access to research tools, by issuing its Research Tool Guidelines, supporting the use of non-exclusive licenses on enabling technologies. According to the NIH 1998 report, enforcement of the guidelines is “constrained by the Bayh-Dole Act,” giving recipients of federal funds “considerable discretion” in licensing inventions (NIH, 1998).
a given MTA more difficult, according to Eisenberg (2001). In many cases, these MTAs included “reach-through” provisions claiming a share of royalties on any patented inventions resulting from research using the materials, and university technology licensing offices were involved in the negotiation and approval of the agreements. The NIH issued Research Tool Guidelines and advocated greater use of the “Uniform Biological Materials Transfer Agreement” that it had developed in 1995 to facilitate cooperation among academic researchers, but the administration of MTAs remains a sore point among many academic researchers. Eisenberg (chair of the NIH Advisory Committee) argues that MTAs may impede the progress of research (Eisenberg, 2001), but no systematic analysis has yet been conducted on the extent of use or effects of MTAs on biomedical research. A contrasting view of the effects of patents and MTAs on biomedical research is provided by Walsh et al. (2003), a study that is based on interviews rather than quantitative data.

Although there is little compelling evidence as yet that the Bayh-Dole Act has had negative consequences for academic research, technology transfer, or industrial innovation in the United States, the data available to monitor any such effects are limited. It also is impossible to separate out the effects of Bayh-Dole from the effects of the broader shift to stronger patentholder rights that has occurred simultaneously in the United States. Moreover, such data are necessarily retrospective, and in their nature are likely to reveal significant changes in the norms and behavior of researchers or universities only with a long lag.

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18 The implications of a more diverse array of parties to these exchanges are complex, as the NIH Working Group on Research Tools pointed out in its 1998 report: “The very term ‘research tool’ connotes a user perspective rather than a provider perspective. What a user sees as a research tool, a provider may see as a valuable end product for sale to customers.” (NIH, 1998, p. 4).

19 Still another problem associated with the growing use and complexity of MTAs is the increased burden on university technology licensing office staff. The director of the University of Pennsylvania technology licensing office noted in 1997 that that number of MTAs reviewed by his office had more than doubled during the previous 12 months from 197 to 425, even as the provisions of many of them had become more complex (Marshall, 1997). The NIH Working Group on Research Tools reported that the University of Washington’s technology licensing office was dealing with an average annual volume of “incoming” MTAs (dealing with materials being requested by their institution’s researchers) in the mid-1990s of roughly 1,000.
III. International Emulation of the Bayh-Dole Act

Recent discussions by OECD governments on the desirability of “Bayh-Dole-type” policies reveal little awareness of the research discussed above that highlights the variety of channels through which universities contribute to innovation and economic growth. The “emulation” of Bayh-Dole in other industrial economies also tends to overlook the importance and effects on university-industry collaboration and technology transfer of the many other institutions that support these interactions and the commercialization of university technologies in the United States.

The evidence discussed thus far suggests that the asserted “catalytic” effects of the Bayh-Dole Act itself on university-industry technology transfer have been overstated. Nevertheless, a number of other industrial-economy governments are considering or have adopted policies emulating the Act’s provisions. In Denmark, a 1999 law gave public research organizations, including universities, the rights to all inventions funded by the Ministry for Research and Technology. Under Denmark’s previous policy (established in 1957), all such rights had reverted to employees (OECD 2003). The German Ministry for Science and Education in 2002 altered the “professor’s privilege,” which gave academic researchers primary responsibility for the decision to file for patent protection on inventions and granted them the rights to any resulting patents. The new policy requires that academic inventors inform their employers of potentially patentable inventions two months before papers disclosing such inventions are submitted for publication, and grants universities four months to determine whether they wish to file for patent protection.

In France, a 1999 law authorized the creation of technology transfer offices at universities, and in 2001 the Ministry of Research “recommended” that universities and public research organizations

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20 This section draws on Mowery and Sampat (2005).
21 A recent OECD report (2003) argues that these initiatives “echo the landmark Bayh-Dole Act of 1980” (11).
22 The new policy aims to ensure that “more inventions are brought to patent offices before they get published” and “is supposed to lead to active licensing transfer from university to industry and to more companies being founded on the basis of intellectual property conceived within the university environment” (Kilger and Bartenbach, 2002).
establish policies to assert their rights to employee inventions (OECD 2003). The Canadian Prime Minister's “Expert Panel on the Commercialization of University Research” recommended in 1999 that universities retain ownership of inventions resulting from publicly funded research, and “be held accountable for maximizing returns to Canada,” noting that “the proposed IP policy framework will inspire a transformational shift in culture within Canadian universities, as happened in the United States with the passage of the Bayh-Dole Act in 1980” (Public Investments in University Research, p. 28).\(^\text{23}\)

In varying degrees all of these initiatives cite Bayh-Dole as one justification. Nevertheless, they in fact differ significantly from the Act, which sought to transfer ownership for publicly funded inventions from government agencies to universities and other nonprofits. In contrast to Bayh-Dole, all of the policies described in the previous paragraph, along with similar new policies in other European countries (e.g. Austria, Ireland, and Spain) “have focused on changing employment laws so that university professors are no longer exempted from legislation that gives employers the IP generated by employees” (OECD 2003, p. 11).\(^\text{24}\) Similarly, the “Japanese Bayh-Dole Act” of 1999 shifted ownership from individual inventors to universities (http://www.nsftokyo.org/rm04-05.html).

In addition to changes in intellectual property policy and employment regulations, a number of related initiatives aim to stimulate the organization and activity of technology licensing offices. Thus the Swedish, German, and Japanese governments (among others) have encouraged the formation of external “technology licensing organizations,” which may or may not be affiliated with a given university (See Goldfarb and Henrekson, 2003, for a comparison of Bayh-Dole and Swedish initiatives to enhance university-industry technology transfer).

\(^{23}\) Although no uniform government policy governs the treatment of university inventions in the United Kingdom, “there is now an increasing trend for Universities to claim ownership” over academic inventions (Christie et al, p. 71).

\(^{24}\) In contrast to these initiatives, Italy passed legislation in 2001 that shifted ownership from universities to individual researchers. According to Breschi et al. (2004), this policy change has “the declared intention of finally providing the right economic incentives for individual scientists to undertake “useful” (that is “patentable”) research” (2).
As this discussion suggests, these initiatives to emulate Bayh-Dole differ from one another and from Bayh-Dole itself. The policy proposals and initiatives represent a selective “borrowing” from another nation’s policies for implementation in an institutional context that differs significantly from that of the nation being emulated. Nonetheless, these initiatives are based on the belief that university patenting was an essential vehicle for effective transfer of technology from universities to industry and that Bayh-Dole was essential to the growth of university-industry interaction in science-based industries in the United States during and after the 1980s. They focus narrowly on the “deliverable” outputs of university research, and ignore the effects of patenting and licensing on other channels through which universities contribute to innovation and economic growth.

But patenting and licensing were only one of many channels through which U.S. universities contributed to industrial innovation throughout the 20th century, and surveys of industrial managers suggest that these channels are not the most important ones in most technological fields. Inasmuch as patenting and licensing are of secondary importance in most fields, emulation of the Bayh-Dole Act is insufficient and perhaps even unnecessary to stimulate higher levels of university-industry interaction and technology transfer. Instead, reforms to enhance inter-institutional competition and autonomy within national university systems, as well as support for the external institutional contributors to new-firm formation and technology commercialization, appear to be more important.

Indeed, emulation of Bayh-Dole could be counterproductive in other industrial economies, precisely because of the importance of other channels for technology transfer and exploitation by industry. A narrow-minded focus on licensing as the primary or only channel for technology transfer can have a chilling effect on the operation of other important channels. There are potential risks to the university research enterprise that accompany increased involvement by university administrators and faculty in technology licensing and commercialization, and
uncritical emulation of Bayh-Dole in a very different institutional context could intensify these risks.

**IV. Is Bayh-Dole a policy model for developing economies?**

It is difficult to make general statements about the role of universities in the innovation systems of developing economies, a fact that impedes statements about the desirability of a “Bayh-Dole model” for developing-economy university systems. The university and innovation systems of nations such as Brazil and Mexico more closely resemble those of lower-income European economies than they do the institutional and policy landscape of some sub-Saharan African economies. Nevertheless, if the arguments made in this paper are valid, the fruitful interactions between industry and academia that have long characterized the United States and that have contributed to innovation and growth in the U.S. economy have much deeper roots than the Bayh-Dole Act. And the mere “import” of the “Bayh-Dole Act model” is likely to have modest effects on the contributions of university research to economic growth or public welfare in even middle-income developing economies such as Brazil or Mexico. Some or all of the following initiatives are essential (and minimal) preconditions to serious consideration of a “Bayh-Dole model” for developing-economy university systems:

a. Shifting funding of university research toward competitive allocation (including peer review by academic and potentially, government or private-sector researchers) of a larger pool of public research funds

b. “Devolution” of management and (to the maximum extent possible) financial responsibility for university operations to individual campuses that have greater administrative autonomy.

c. Development of a more differentiated landscape of institutions of post-secondary education, including greater reliance on two-year training programs and technical institutes, privately funded universities, and other institutional forms that may be more
responsive to the demands of prospective students, employers, and industrial or agricultural research collaborators.

V. Conclusion

The relationship between U.S. university research and innovation in industry is a long and close one. Indeed, organized industrial research and the U.S. research university both first appeared in the late 19th century and have developed a complex interactive relationship. The unusual structure of the U.S. higher education infrastructure, which blended financial autonomy, public funding from state and local sources with federal research support, and substantial scale, provided strong incentives for university faculty and administrators to focus their efforts on research activities with local economic and social benefits. Rather than being exclusively concerned with fundamental scientific principles, much of U.S. university research throughout the late 19th and 20th centuries focused on understanding and solving problems of agriculture, public health, and industry.

U.S. universities have made important contributions to industrial innovation throughout the past century, not least through by providing both advanced research and education. The strong links between education and research sustained a close relationship between the evolving scientific research agenda and problems of industry or agriculture, while at the same time providing a powerful and effective channel (in the form of trained students) for the transfer and application of much of this knowledge to industry and other economic sectors. In addition, many university researchers in engineering and medical schools maintained close ties with the users of their research and their graduates in industry, medical practice, and agriculture. The important role of universities in industrial innovation, particularly during the post-1945 period, also relied on institutions external to the university, including venture capitalists, equity-based financing of new firms, and high levels of labor mobility between academia and industry.
Based on these considerations, it seems likely that much of the growth in licensing and university-based “spinoffs” that has occurred since the passage of the Bayh-Dole Act almost certainly would have occurred in the absence of this piece of legislation. After all, U.S. universities were active patenters and licensors for decades before 1980, and much of their patenting and licensing activity since 1980 has been concentrated in a few fields, at least some of which also have benefited from rapid growth in public research funding and significant advances in basic science.

For these and other reasons, the Bayh-Dole Act may have been neither necessary nor sufficient for the post-1980 growth in university patenting and licensing in the United States. Moreover, given the very different institutional landscape in the national higher education systems of much of Western Europe and Japan, as well as most developing economies, the “emulation” of Bayh-Dole is far from sufficient to trigger significant growth in academic patenting and licensing or university-industry technology transfer. Indeed, there is some question as to the necessity of a “patent-oriented” policy to encourage stronger research collaboration and technology transfer. And the potential risks associated with such policy changes have received too little attention.

Instead, the adoption of policies based on the Bayh-Dole Act in the treatment of the results of publicly funded university research in the OECD or developing economies must be preceded by structural reforms in national systems of post-secondary education. These reforms are costly in terms of resources and political capital. But in their absence, it is hard to see how the emulation of the Bayh-Dole Act in these economies can have positive effects that will more than offset the risks associated with such a policy shift.
References


Figure 1: US research univ. patents % of all domestic-assignee US patents, 1963 - 99
Figure 2: University Patents Per R&D Dollar, 1963-1993
Figure 3: Technology Field of Carnegie University Patents, 1960-1999

- Chemicals and Chemical Processes (Excluding Drugs)
- Drugs and Medical Technology
- Electronic, Optical, and Nuclear
- Mechanical
- Other
Figure 4: Year of “Entry” into Technology Transfer Activities