Technology Transfer by Federal Agencies

Federal Guidelines for Technology Transfer

Between 1980 and 2003, the U.S. Federal research budget grew from $66.7 billion to $119.6 billion in real terms and represented nearly 30 percent of all R&D investments—public and private (table 1). More than half of the total was allocated to defense-related research. Of nondefense R&D spending, human health research represented 20 percent in 1980—growing to nearly 50 percent by 2003. NASA and the Department of Energy represent the next largest shares of nondefense R&D spending. Federal agricultural research spending grew from $1.4 billion (4.1 percent of nondefense R&D) to $2.37 billion (4.3 percent of nondefense R&D) in 2003.

What do these investments in research accomplish? Most of the research investments by the Federal Government are to support specific mission areas, e.g., military objectives, advances in basic health-related issues, and space exploration. Often there are scientific discoveries made in the process of carrying out the mission-oriented research that if made available to the private sector, with additional developmental research, may result in commercially viable products. Computed axial tomography (CAT) and magnetic resonance imaging (MRI) medical scanning technology, freeze-dried foods, and cordless power tools are examples of products derived from investments in the space program that benefited American consumers once the technology became commercially viable. These products are often

Table 1
Federal research and development (R&D) expenditures by agency, selected years, 1980-2003[1]

Agency	FY 1980	FY 1985	FY 1990	FY 1995	FY 2000	FY 2003
				$ millions		
Department of Defense	28,317	49,251	49,983	41,124	42,853	60,074
National Aeronautics and Space Administration	10,589	5,485	9,386	11,004	10,182	10,822
Department of Energy	11,651	9,208	9,223	7,464	7,460	8,565
Department of Health and Human Services	7,687	8,474	11,262	13,399	19,498	28,059
National Institutes of Health[2]	6,958	8,109	10,701	12,520	18,482	26,744
National Science Foundation	1,842	2,186	2,282	2,787	3,143	3,978
Department of Agriculture	1,444	1,543	1,615	1,730	1,904	2,373
Department of the Interior	828	599	701	777	663	652
Department of Transportation	802	676	467	775	651	709
Environmental Protection Agency	691	471	560	645	598	575
Department of Commerce	723	603	597	1,301	1,259	1,213
Department of Homeland Security	0	0	0	0	0	747
Department of Veterans Affairs	275	330	288	306	692	828
Other	1,888	854	1,336	1,227	931	1,078
Total R&D	66,735	79,678	87,700	82,539	89,834	119,672
Defense R&D	31,162	53,465	54,086	44,014	46,286	64,544
Nondefense R&D	35,573	26,213	33,614	38,525	43,548	55,127

Note: Constant dollar conversions based on OMB's gross domestic product deflators from the FY 2005 budget.
[1]Years are fiscal years (FY), from October 1-September 30.
[2]The National Institutes of Health are part of the Department of Health and Human Services; the HHS numbers include the NIH ones.

Source: American Association for the Advancement of Science Reports I through XXIX, based on Office of Management and Budget (OMB) and agency R&D budget data, including conduct of R&D and R&D facilities.

referred to as "spinoffs" from the space or other programs. Recognizing the potential benefits to business, industry, and consumers from federally funded scientific and technical advances, the government has developed considerable legislation over time to facilitate transfer of discoveries from the public to the private sector.

Federal involvement in technology transfer stems from several concerns. The government needs specific goods and services for its various missions, and those goods and services often cannot be purchased directly in the marketplace. Contracting, cooperation, and licensing arrangements between Federal labs and private industry facilitate the development of products the government needs. A key example is military equipment produced by private contractors. Cooperation between Federal labs and private firms also provides government researchers with access to state-of-the-art technical developments. But the chief reason for Federal involvement in technology transfer is to promote technological development and change that can spur economic growth. Technological change has been credited with responsibility for one-quarter of the economic growth in the U.S. economy during the last half of the last century and has been a major source of long-term economic growth and welfare (Jorgenson and Stiroh, 2000).

There are three hypothesized goals of Federal technology transfer policy:

(1) To bring the benefits of public R&D to potential users. One of the motivating factors behind technology transfer policy was concern that too many publicly developed technologies were useful, but unused. The Bayh-Dole Act "constituted a congressional endorsement of the argument that failure to establish patent protection over the results of federally funded university research would limit the commercial exploitation of these results" (Mowery et al., 2001).

(2) To draw on private sector resources when possible, as the public sector shifts resources to areas in which it has a comparative advantage. In U.S. agriculture, for example, the public agricultural research system has been characterized by a decentralized State-led structure, which fosters geographically specific applied research (Schultz, 1971; Huffman and Evenson, 1993). Public and private entities cooperated closely, with the public sector playing a strong applied research role. However, influential reports published by the National Academy of Sciences (1972) and by the Rockefeller Foundation (1982) argued that agricultural research had become overly focused on applied research, and had moved too far from the cutting edge of biological research. Since that time, many public agricultural research institutions have sought to pass more applied work to the private sector, and focus instead on basic research and applied research with strong public-good characteristics. Technology transfer has offered public research institutions an opportunity for private firms to assume certain forms of applied research and development.

(3) To allow public institutions to influence the development of new technologies. Like other industries, agricultural production offers benefits to society, but it may also impose certain externalities. Technology transfer offers public institutions an opportunity to promote the development of technologies that increase agriculture's benefits to society or mitigate the costs of agricultural production (Fuglie et al., 1996).

Key Legislation

Prior to the 1980s only about 5 percent of federally owned patents were being licensed and used by the private sector. While many patented technologies held by the public sector are specific to Federal mission needs and may have no commercial potential, it was nonetheless felt that there were unexploited discoveries within the public sector that could benefit the private sector and, as a result, the general public. Also, most Federal agencies would take title to discoveries made with Federal funds—regardless of who made the discovery—and then would only license the patents with nonexclusive licenses. Without ownership of the technology, or at least a partially exclusive license, private firms had little incentive to develop and commercialize the technologies. To remedy these concerns, two key pieces of legislation were enacted with the explicit purpose of getting Federal research from the lab into the market: The Patent and Trademark Act (P.L. 96-517), referred to as the Bayh-Dole Act, and the Stevenson-Wydler Technology Innovation Act (P.L. 96-480). The purpose of the Bayh-Dole Act was to create a uniform national policy (out of the 26 different agency policies) to minimize bureaucratic inconsistency and encourage private industry to invest in the commercial development of federally produced research. The legislation would allow universities, nonprofit institutions, and small businesses to obtain patents arising from research that was funded with Federal funds. This law allowed these entities to derive royalties from their patents, which then would support further research and enhance the return on their investment. The Stevenson-Wydler Act was similarly designed to encourage the use of federally funded research through technology transfer. Transfer is achieved by transferring legal rights (licensing), assigning patent title to private contractors, or through personal interactions. Both Acts also encouraged the licensing of technologies to small businesses.

The Federal Technology Transfer Act of 1986 (P.L. 99-502), which amended the Stevenson-Wydler Act, permitted the use of cooperative research and development agreements (CRADAs). A CRADA is a legal document that defines a collaborative venture between a government lab and another entity, e.g., a university or private firm.[14] The Bayh-Dole Act permits nongovernment cooperators in a CRADA to receive title to an invention. The Federal Technology Transfer Act also increased employee incentives by including technology transfer in performance evaluations (see box, "U.S. Legislation Governing Patenting and Transfer of Federally Funded R&D").

[14]Throughout this report, the term CRADA is used to refer to the specific legal mechanism described in the Stevenson-Wydler Act, and not to more general cooperative research efforts.

U.S. Legislation Governing Patenting and Transfer of Federally Funded R&D

Since 1980, Congress has enacted a series of laws to promote technology transfer and to provide technology transfer mechanisms and incentives. These laws and related executive orders encourage the dissemination of new knowledge and foster the development of commercial technologies. Sharing between federal laboratories and private industry can include not only technologies, but personnel, facilities, methods, expertise, and technical information in general.

The Stevenson-Wydler Technology Innovation Act (1980) required Federal laboratories to facilitate the transfer of federally owned and originated technology to State and local governments and the private sector. The act required offices of technology transfer in Federal agencies and established budgeting and reporting requirements.

The Bayh-Dole University and Small Business Patent Act (1980) permitted government grantees and contractors to retain title to federally funded inventions and encouraged universities to license inventions to industry. The act is designed to foster interactions between academia and the business community.

The Small Business Innovation Development Act (1982) established the Small Business Innovation Research (SBIR) program within the major Federal R&D agencies to increase government funding of research that has commercialization potential within small high-technology companies.

The National Cooperative Research Act (1984) encouraged U.S. firms to collaborate on generic, precompetitive research by establishing a rule of reason for evaluating the antitrust implications of research joint ventures.The act was amended in 1993 by the National Cooperative Research and Production Act (NCRPA), which let companies collaborate on production activities as well as research activities.

The Federal Technology Transfer Act (1986) amended the Stevenson-Wydler Technology Innovation Act to authorize cooperative research and development agreements (CRADAs) between Federal laboratories and other entities, including state agencies.

The Omnibus Trade and Competitiveness Act (1988) established the Competitiveness Policy Council to develop recommendations for national strategies and specific policies to enhance industrial competitiveness. The act created the Advanced Technology Program and the Manufacturing Technology Centers within the National Institute for Standards and Technology to help U.S. companies become more competitive.

The National Competitiveness Technology Transfer Act (1989) amended the Stevenson-Wydler Act to allow government-owned, contractor-operated laboratories to enter into CRADAs.

The National Cooperative Research and Production Act (1993) relaxed restrictions on cooperative production activities, enabling research joint venture participants to work together in the application of technologies they jointly acquire.

The Technology Transfer Commercialization Act (2000) amended the Stevenson-Wydler Act and the Bayh-Dole Act to improve the ability of government agencies to monitor and license federally owned inventions.

Source: Science and Engineering Indicators 2004, National Science Foundation.

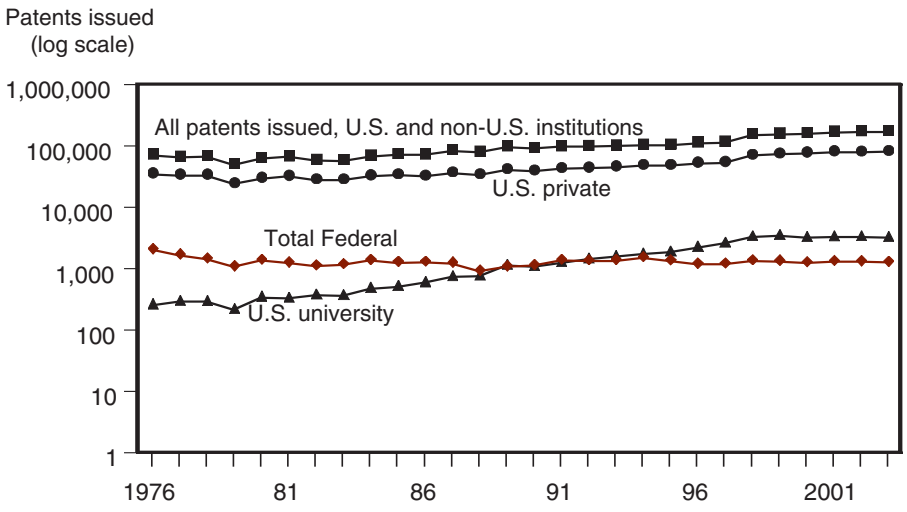
Federal Agency Use of Intellectual Property

The changes in technology transfer policies for federally funded, as well as federally performed research, outlined in the previous section, were one of four major changes in U.S. intellectual property policy that began in the 1980s.[15] The economic effects of these policy changes have been complex and not always well understood, although it is clear that both private and public sector institutions have responded to shifts in policy (Jaffe, 2000). Public data on patents are available from the U.S. Patent and Trademark Office (PTO), and more detailed information on invention disclosures, patenting, and licensing is available from the U.S. Department of Commerce. Available data suggest that although the level of patenting by Federal agencies has remained essentially unchanged for the past 25 years or more, the incidence of technology transfer from the Federal Government to the private sector has increased markedly with the passage of the Bayh-Dole, Stevenson-Wydler, and other technology transfer amendments.[16]

From 1976 through 2003, the number of patents issued each year to all Federal agencies and laboratories remained essentially unchanged (fig. 1). The total number of patents granted in all sectors grew about 140 percent over this period. The most striking change was for U.S. universities, for which issued patents increased 1,164 percent over this period. During this entire period, it should be noted that U.S. private sector patents consistently averaged 95 percent of the total issued to all U.S.-based institutions (fig. 1; USPTO). Patenting by the U.S. Department of Agriculture shrank from over 6 percent of the Federal total to about 3 percent by the mid-1980s, but has risen back to 5 or 6 percent today (figs. 2 and 3).

Issued patents are only one measure of the disclosure of research information by Federal entities. In recent years, Department of Commerce technology transfer data show positive trends for many indicators for the 10 largest government research agencies (unfortunately, in this source, issued patents were only recorded from 1997 and active licenses from 1999.)[17] For

Figure 1
Patents issued to U.S. assignees



Source: ERS calculations based on U.S. Patent and Trademark Office (USPTO) data.

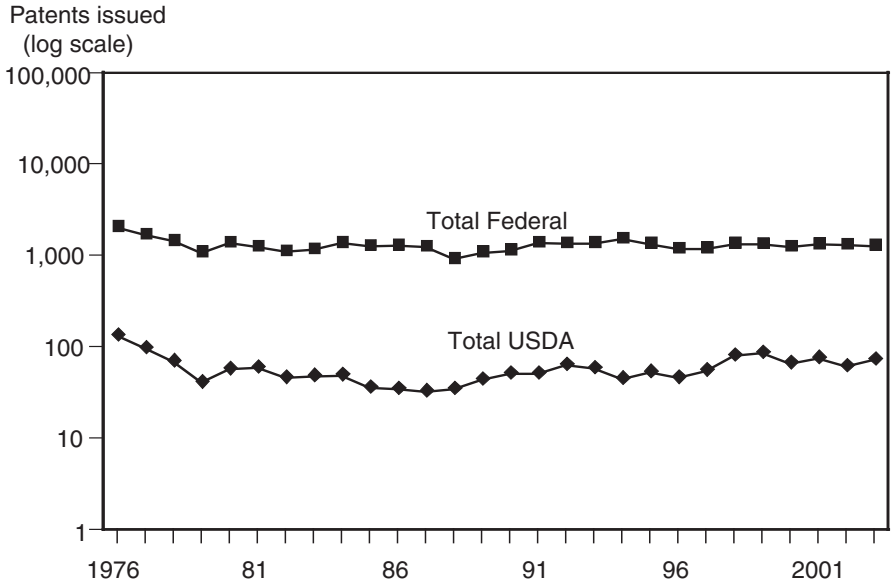
[15]The others were the creation of the Court of Appeals for the Federal Circuit (CAFC) specifically to review patent decisions; the extension of patent rights to new technological areas; and agreements under the General Agreement on Tariffs and Trade (GATT) to harmonize IP policy worldwide.

[16]Market structure in the relevant industries likely to license technologies may differ from Federal agency to Federal agency. For example, the pharmaceutical industry, a likely recipient of National Institutes of Health (NIH) research, consists of large firms but is less consolidated than the agricultural biotechnology sector. Although USDA licenses relatively little to the narrowly defined agricultural biotechnology industry, agricultural markets are sometimes niche markets, served by relatively few firms, even if the firms are not large.

[17]In contrast to the patent data in the preceding paragraph, which were derived directly from the U.S. PTO, these data come specifically from technology transfer reporting by the Department of Commerce.

Figure 2

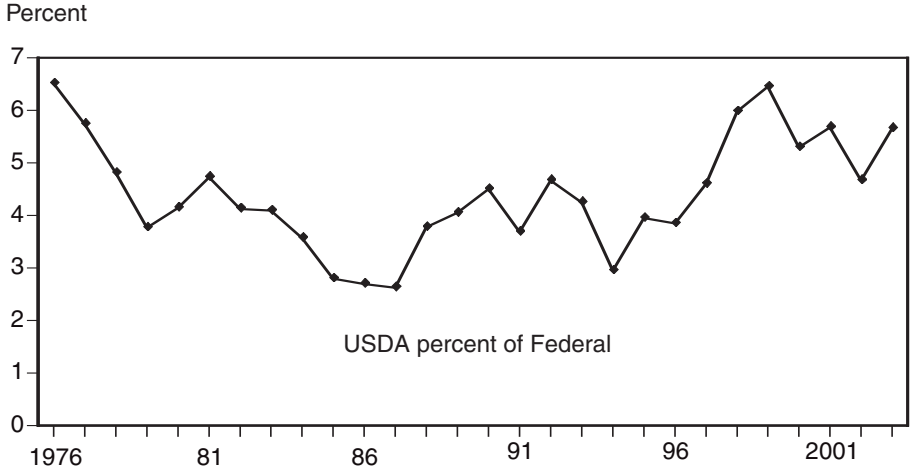
USDA and Federal patenting



Source: ERS calculations based on USPTO data.

Figure 3

USDA patenting as a percentage of all Federal patenting



Source: ERS calculations based on USPTO data.

these agencies, the number of inventions disclosed grew from 2,662 in 1987 to 3,909 in 2001 (table 2).[18] Patent applications grew from 848 in 1987 to 2,172 in 2001. More than half of all inventive activity as measured by invention disclosures arises from the Departments of Energy and Defense. USDA invention disclosures have been more modest, with 83 in 1987, 260 in 1997, and 118 in 2001. The licensing of patents by Federal agencies also grew considerably over this period. The number of new licenses issued by all agencies grew from 128 in 1987 to 578 in 2001. The number of active licenses was 3,142 in 2001.[19] The number of new licenses from the USDA each year was around 20 to 30 over this period. The total number of active USDA licenses was 255 in 2001. The use of CRADAs by all agencies also

[18]An invention disclosure contains information about new inventions and discoveries that help intellectual property managers determine if a patent application is necessary.

[19]License terms, including the length of the license, are subject to negotiation. Furthermore, licenses are sometimes abandoned (see below). A theoretical limit for the license of a patented technology is the patent term of 20 years.

grew over this period, from 34 active CRADAs for the 10 major agencies in 1987 to 3,603 in 2001. The number of active USDA CRADAs grew from 9 to well over 200 during the same period.

These indicators suggest that although changes in IP policy have not led to a rapid upsurge of patenting by the Federal Government, in contrast to the trends for the private sector and particularly universities, the incidence of technology transfer from the Federal Government to the private sector has increased with the passage of the Bayh-Dole, Stevenson-Wydler, and other technology transfer amendments. As we have noted, the purpose of these laws is to transfer technology—not to raise funds for the Federal Government through licensing. Licensing income for the whole Federal Government was $5.8 million in 1987 and grew to $69.5 million in 2000—the last year for which we have data on Federal licensing revenue. The total Federal R&D budget in 2000 was $89.8 billion, which overshadowed the income from licenses. USDA license income grew from $133,000 in 1987 to $2.5 million in 2000, only about 0.3 percent of the total ARS R&D budget of $885 million. In both cases, license income is not a complete measure of the benefits of public sector investments in science and technology; it is merely a reflection of the amount of technology being transferred through licensing agreements.[20] Licensing patents to firms is often desirable for agencies because the contracts bind the firms to developing and utilizing the technology, thus diffusing it into the marketplace. License fees also serve as a way to screen out firms with insufficient ability or interest to develop the licensed technology. License fees impose costs that a successful firm can expect to recoup in product sales, while discouraging unsuccessful firms from going forward. If the technology is successfully commercialized, the firm's resulting profits and the consumer benefits from the technology are the major direct economic benefits from the original research. This aspect of licensing is an important incentive that furthers the technology transfer mission, outweighing the importance of the total licensing revenues collected relative to the Federal R&D budget.

[20]The benefits to investment in R&D are difficult to measure and have been the subject of considerable research, (see Mansfield, 1977, 1991, or Alston et al., 1995 for excellent expositions on this research). Nonetheless, estimates of the rate of return to public agricultural research have had a wide range, with medians of around 50 percent to 60 percent. Even after adjusting for potential biases, the U.S. rate of return has likely been around 35 percent, indicating large public benefits (Fuglie et al., 1996; see also Alston et al., 2000 and Evenson, 2001 for worldwide estimates).

Table 2

Federal technology transfer indicators, by selected U.S. agencies, FY 1987-2001[1]

Agency	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Invention disclosures and patenting								*Numbers*							
All 10 agencies															
Inventions disclosed	2,662	3,047	3,168	3,772	4,213	3,901	3,538	3,753	4,001	4,153	3,842	3,503	3,646	3,564	3,909
Patent applications filed	848	1,131	1,466	1,727	1,940	1,867	1,838	1,724	1,803	1,723	1,850	1,894	2,089	2,083	2,172
Patents issued	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1,265	1,466	1,448	1,391	1,608
USDA															
Inventions disclosed	83	144	127	158	127	83	110	111	133	129	260	208	162	109	118
Patent applications filed	44	50	71	76	110	70	68	40	80	91	56	64	84	78	83
Patents issued	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	45	75	74	64	64
Invention licenses															
All 10 agencies															
Active invention licenses	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2,736	3,009	3,142
New invention licenses	128	129	150	164	206	239	260	337	408	462	487	492	596	511	578
USDA															
Active invention licenses	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	218	225	255
New invention licenses	30	24	23	33	29	31	28	9	21	26	22	23	29	24	32
Income from licenses of patented inventions								*Thousands of current dollars*							
All 10 agencies	5,875	6,346	7,304	9,413	18,163	14,070	18,570	26,641	27,922	36,969	50,234	57,563	60,174	69,498	NA
USDA	133	120	420	559	836	1,044	1,483	1,450	1,635	2,091	2,300	2,400	2,377	2,555	NA
Cooperative research and development								*Numbers*							
research agreements (CRADAs)[2]															
All 10 agencies															
Total active CRADAs	34	98	271	460	731	1,078	1,628	2,471	3,121	3,530	3,078	3,038	3,227	3,133	3,603
USDA	9	51	98	128	177	172	172	208	229	244	273	288	298	257	219

NA = Data not requested or not available.

[1]The 10 agencies are the Department of Commerce, the Department of Defense, the Department of Energy, the Department of the Interior, the Department of Transportation, the Environmental Protection Agency, the Department of Health and Human Services, the National Aeronautics and Space Administration, the Department of Agriculture, and the Department of Veterans Affairs.

[2]Data for CRADAs are for agreements established under the authority of 15 U.S.C Sec. 3710a. Nontraditional CRADAs are agreements for special purposes, such as material transfer or technical assistance. Before 1999, NASA performed all of its technology transfer activities under the authority of the 1958 Space Act.

Source: U.S. Department of Commerce, Office of the Secretary, *Summary Report on Federal Laboratory Technology Transfer: 2002 Report to the President and the Congress Under the Technology Transfer and Commercialization Act* (Washington, DC, 2002); and *Science & Engineering Indicators—2004, Appendix table 4-38.*