Aerospace Knowledge Diffusion Research Project

IN-82

Paper Fifty Seven

U.S. Scientific and Technical Information Policy

Chapter 10 in Federal Information Policies in the 1990s: Views and Perspectives. P. Hernon, C. R. McClure, and H. C. Relyea, eds. Norwood, NJ: Ablex Press, 1996, 211-232.

Thomas E. Pinelli
NASA Langley Research Center
Hampton, Virginia

Rebecca O. Barclay
Knowledge Transfer International
Portsmouth, Virginia

John M. Kennedy
Indiana University
Bloomington, Indiana

KNOWLEDGE DIFFUSION INNOVATION
NASA DoD AEROSPACE

National Aeronautics and Space Administration

Department of Defense

INDIANA UNIVERSITY

Chapter 10

U.S. Scientific and Technical Information Policy*

Thomas E. Pinelli, Rebecca O. Barclay, & John M. Kennedy

We begin this chapter by posing a modification of a question asked by Ergas (1987), "Does United States (U.S.) scientific and technical information (STI) policy matter?" We think it does. STI is an essential ingredient of technological innovation. After reviewing the available literature, Fischer (1980) concluded that STI is central to the process of technological innovation; the management of STI can improve the efficacy of the innovation process; and the ability of engineers and scientists to identify, acquire, and use STI positively correlates with technical performance at both the individual and group levels. Successful technological innovation results in economic growth and competitiveness within today's global economy. It contributes to increased productivity, growth in employment, real wage growth, and an increased standard of living. However, STI in and of itself does not make for successful innovation. Innovation-adoption decisions are seldom made on the basis of "advances in systemic knowledge of

* The views expressed in this chapter are those of the authors and not necessarily those of the National Aeronautics and Space Administration.

the useful arts," otherwise known as STI (David, 1986, p. 387). They are, for the most part, investment decisions and are influenced, to a large extent, by a variety of government policies, laws, and regulations. Conventional wisdom holds that a well-articulated and coordinated set of policies at the Federal level is needed to create a climate conducive to successful technological innovation within the United States. A coherent, integrated program derived from policies that emphasize the identification, acquisition, and utilization of STI resulting from the U.S. government's investment in science and technology should be included as a part of that coordinated set of Federal policies.

The U.S. government spent about $68 billion in FY1994 for science and technology (Office of Management and Budget, 1994, p. 131). There is general agreement among policy-makers that the results of this expenditure can be used to enhance technological innovation and improve economic competitiveness. Unfortunately, the United States has no coherent STI policy, and it lacks a coherent or systematically-designed approach to transferring the results of its investment in STI to the user (Ballard et al., 1989). What the United States does have, however, is many programs and numerous policies that cut across political jurisdictions, and the idiosyncratic missions and mandates of single agencies that are more or less responsive to a series of shifting political alliances and imperatives. Gold (1993) supports and expands this position by stating that the system which handles Federal STI is "uncoordinated, fragmented, and often ineffectual" (p. 222). Gold further states that the existing Federal STI system suffers from the absence of coherent policy guidelines.

The absence of a cohesive policy and STI policy framework means that the transfer and utilization of STI goes uncoordinated; there is no centrality concerning the identification and resolution of issues. Although the Office of Science and Technology Policy (OSTP) has a mandate to "promote the transfer and utilization of STI for civilian needs, to consider the potential role of information technology in the information transfer process, and to coordinate federal STI policies and practices," in general, OSTP has not fulfilled this legislative directive (Pinelli et al., 1992, p. 41).

This chapter examines the U.S. government's role in funding science and technology, reviews Federal STI activities and involvement in the transfer and use of STI resulting from federally-funded science and technology, presents issues surrounding the use of federally-funded STI, and offers recommendations for improving the transfer and use of STI. The term "federally-funded STI" includes data, information, and knowledge created by engineers and scientists working in the Federal (national) laboratories and research centers, and knowledge created by engineers and scientists employed in academia and industry who are working under Federal research grants or contracts. Finally, this chapter does not view science and technology as a continuous or normal progress from basic research (science) through applied research (technology) to development (utilization). We agree with Allen (1977) that the relationship between science and technology is not continuous but is perhaps best described as a series of interactions based on need rather than a normal progression. The idea of science and technology as a continuous process is based on the widely-held assumption that technology grows out of or is dependent upon science for its development. The belief that technological change is somehow based on scientific advance has, however, been challenged in recent years (see Kline, 1985; Shapley & Roy, 1985). This assumed relationship between science and technology is the foundation upon which U.S. science and technology policy is based. It has shaped much of the existing Federal science and technology policy and its framework and may help explain the use of the conventional phrase "scientists and engineers."

Technology may well be the critical factor in the long-term economic growth of the United States. It functions successfully, however, *only* within a larger social environment that provides an effective combination of incentives and complementary inputs into the innovation process. *Technology*, unlike science, is an extroverted activity; it involves a search for workable solutions to problems. When technology finds solutions that are workable and effective, it does not pursue the '*why*'. Moreover, the output of technology is usually a product, process, or service. *Science*, by contrast, is an introverted activity. It studies problems that are usually generated internally by logical discrepancies or internal inconsistencies or by anomalous observations that cannot be accounted for within the present intellectual framework (Landau & Rosenberg, 1986). Technology is a process dominated by engineers, rather than scientists, which leads to different philosophies and habits regarding the use and production of STI. U.S. STI policy should reflect that distinction.

THE U.S. GOVERNMENT AND SCIENCE AND TECHNOLOGY

The importance of science and technology to the nation was recognized by the framers of the Constitution. Specifically, the Constitution of the United States contains a provision (Article 1, Section 8, Clause 8) empowering the Congress to enact laws relating to patents:

> Congress shall have the power... to promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries.

Before the Constitution was adopted, the various colonies granted patents. The first United States patent was granted on July 30, 1790. The Patent Act of 1836 provided for the establishment of the Patent and Trademark Office under the direction of a Commissioner of Patents. A patent is a protection granted by a government to an inventor to prevent unauthorized exploitation of an invention and is distinguished from a trademark and a copyright. (Copyrights are registered with the Copyright Office in the Library of Congress.)

Over the years, Congress has enacted legislation affecting what is patentable. Under the Atomic Energy Act of 1954 (P.L. 83–703), inventions useful solely in the utilization of special nuclear material or nuclear energy for weapons cannot be patented (Subramanyam, 1981). The Government Research and Development Patent Policy Act of 1984 (P.L. 98–620) established uniform government policy regarding patent rights to inventions resulting from federally-funded science and technology. The Federal Science and Technology Transfer Act of 1986 (P.L. 99–502) amended the Stevenson-Wydler Innovation Act of 1980 (P.L. 96–480) and changed government policy on patent rights for inventions created in Federal laboratories and resulting from cooperative research and development (R&D) agreements with the Federal government. Passage of these acts reflected a recent but increasing involvement and growing interest in science and technology by the U.S. government. Prior to World War II, Federal involvement in science and technology was limited to specific agencies, departmental programs, and functions (e.g., national defense) that were considered to be the government's sole responsibility.

Pre-World War II

In detailing the involvement of the U.S. government in science and technology, it is important to understand that the present day involvement in and expenditures for science and technology represent a dramatic departure from earlier arrangements. World War II marked a sharp departure from the role previously played by the U.S. government with respect to financial support for science and technology activities that were not tied directly and explicitly to an existing Federal responsibility. Early examples of Federal involvement include the establishment of the Coast and Geodetic Survey, the U.S. Geological Survey, the Weather Bureau, the National Bureau of Standards, and a host of public works projects and medical programs conducted under the auspices of the military. (For additional information, see Dupree, 1986.)

To illustrate the issue of appropriate "Federal responsibility," we consider the creation of the Smithsonian Institution in Washington, D.C. The actual debate in Congress regarding the acceptance of James Smithson's 1829 bequest lasted for years. Congress founded the Smithsonian Institution in 1846. Support for agricultural research, perhaps the oldest Federal commitment to science and technology, was also subjected to protracted congressional debate. The Morrill Act, which established the nation's land-grant colleges, passed both houses of Congress in 1859 but was vetoed by President Buchanan. The Act became law in 1862 and the Department of Agriculture was established the same year. Little research was performed by the land-grant colleges until the Hatch Act, which provided Federal funding for agricultural experiment stations, was passed in 1887. Until the Second World War, agriculture continued to occupy its long-standing position of being the only sector of the economy to receive research-funding support from the Federal government. Although the Federal agricultural research establishment—with its land-grant colleges, agricultural experiment stations, and the state agricultural extension programs that bring research results to the farmer and the farmer's agricultural problems back to the research establishment—has been criticized in recent years, the system is widely regarded as "probably the most successful government effort to date in stimulating the innovation process" (Coles, 1983, p. 36).

With the creation of the National Advisory Committee for Aeronautics (NACA), the United States government created a Federal research laboratory (i.e., the Langley Memorial Aeronautical Laboratory) that began to "investigate the scientific problems involved in flight and to give advice to the military air services and other aviation services of the government" (P.L. 63–271, The Naval Appropriations Act, 1916). Considering the obvious connection to national defense, passage of this legislation did not come easily. After considerable debate, the legislation creating the NACA was passed as a rider to the Naval Appropriations Act of 1916. The NACA has been described as arguably the most important and productive aeronautical research establishment in the world. Between its creation in 1917 and its demise in 1958, the NACA published more than 16,000 technical reports that were sought after and exploited by aeronautical engineers and scientists throughout the United States and abroad (Roland, 1985). Many of these reports, classics in the fields of aerodynamics and aeronautics, are still used and referenced; the data contained therein are essential to understanding the fundamentals of aeronautical research (Anderson, 1974). The NACA has been cited by scholars as a model for Federal involvement in science and technology (Teich, 1985) and pre-commercial research cooperation between the public and private sectors (Nelson, 1982). Vannevar Bush (1945) proposed a similar model for the creation of his National Research Foundation that was based on a composite of the Federal agricultural research establishment and the NACA. Both offered science, applied science, technology, and a system for coupling the user with knowledge resulting from these programs.

World War II

Entry of the United States into World War II permanently transformed the Federal government with respect to financial support for science and technology. From 1940 to 1945, total Federal expenditures for science and technology rose from $83.2 million to $1,314 million, with the bulk of the funds being expended by the Department of Defense (Mowery & Rosenberg, 1989). Two events from this period are noteworthy. The first is the Manhattan Project. The successful completion of this project ushered in the age of "big science" and helped shape the postwar imagination about the "more constructive possibilities of science when it could be applied in an organized and systematic way to the pursuit of human goals" (Rosenberg, 1985, p. 5). The second is the Office of Scientific Research and Development (OSRD) under the direction of Vannevar Bush. OSRD entered into contracts with the private sector (i.e., academia and industry) for research. Prior to World War II, almost all federally-funded science and technology was performed by the government itself—by civil servants in Federal research centers and laboratories. The success of these contractual arrangements with the private sector dramatically influenced the organization of federally-funded science and technology in the post-World War II era. This arrangement effectively split the responsibility for the conduct of science and technology between the public and private sectors. Overall resource allocation decisions remained with the Federal government while academia and industry were given considerable autonomy in terms of problem formulation and approach.

Post-World War II

World War II marked a sharp departure from the role previously played by the U.S. government in science and technology with respect to financial support for research not directly or explicitly tied to a specific Federal agency or program. "In spite of the permissive implications of the *general welfare* clause of the U.S. Constitution, Federal support for science and technology prior to World War II had been limited sharply by a strict interpretation of the role of the government" (Teich, 1985). Rosenberg (1985) provides the following historical observation:

> What has emerged since the Second World War is a system in which the Federal government has become the dominant purchaser of R&D, but with-

> out, at the same time, becoming the dominant performer of R&D. Thus, the unique institutional development has been the manner in which the Federal government has accepted a vastly broadened financial responsibility for R&D without arranging simultaneously for its in-house performance. Rather, private industry has become the main performer of Federal R&D, and the university community the main performer of the basic research component. Thus, the enlarged role of the Federal government in the support of R&D has been carried out within an institutional framework dominated by contractual relationships between the Federal government and private performers. (p. 2)

From this policy emerged the concept of "spinoff and dual-use;" that is, science and technology that serves the immediate purpose(s) of the government can also be "commercialized" by the private sector. Commercialization would automatically occur as a by-product of Federal support for basic research in the academic community and agency (i.e., Department of Defense (DoD) and National Aeronautics and Space Administration (NASA) support for applied research in the private sector (Alic et al., 1992)).

U.S. government science and technology policy after World War II was based largely on the arguments advanced in *Science: The Endless Frontier* (Bush, 1945). Principally, government-funded research in science and technology serves as a means to improve health, defend the nation, fuel economic growth, and provide jobs in new industries (Smith, 1990). Events such as the Korean War and Sputnik, the increased use of science and technology by the Federal government to solve social problems in the late 1960s and 1970s, the energy crisis, the "War on Cancer," the Vietnam War, and, more recently, a widening concern in the late 1980s and 1990s over the apparent decline in U.S. international competitiveness have helped shape U.S. S&T policy and account for the growth of federally-funded science and technology (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 1986).

In recent years, however, members of Congress, citizens, and policy- and decision-makers have expressed concern that perhaps the results of the billions of dollars spent annually by the Federal government for science and technology may not be well-utilized. In other words, the American public may not be receiving an "adequate" return on their investment (Office of Technology Assessment, 1986). Other than during President Reagan's first term in office, the legitimacy of the United States in providing financial support for science and technology has gone virtually unchallenged. On the other hand, *Helping America Compete* (Office of Technology Assessment, 1990) is one of the latest in a series of studies, stretching over 30 years, which concludes that the United States should make better use of the knowledge resulting from federally-funded science and technology (Wood, 1991).

Competing in a Global Economy

During the Cold War, the focus of Federal science and technology policy was military superiority. During the 1960s, federally-funded science and technology was seen as a means of solving such pressing social problems as inadequate housing, declining environmental quality, and even poverty (Averch, 1985). The familiar refrain from this period was the question: "If we can put a man on the moon, why can't we...?" (Nelson, 1977). Beginning in the mid-1970s and continuing even today is the belief that federally-funded science and technology plays a major role in the economy and the competitiveness of the United States in a global economy. This position is based on the belief that science and technology are the underpinnings of technological innovation, which, in turn, has been seen as the key to economic growth and international economic competitiveness (Logsdon, 1986).

Economists like Mansfield (1968; Mansfield et al., 1982) have shown a positive correlation between the funding of science and technology and economic growth. Economists are also quick to point out, however, that the relationship between spending and economic growth is hard to predict, is often indirect, and is difficult to measure because the transformation of the results of that spending into economically successful technological innovation depends on a variety of factors such as government fiscal, domestic, trade, and national security policy, all of which fall outside the scope of science and technology policy. Furthermore, Federal science and technology policy is shaped by and must be responsive to many groups and constituencies. The goal of federally-funded science and technology is not profitability, but rather a means to achieving various social, political, and economic objectives; expanding the knowledge base; and supporting education and training.

Existing U.S. science and technology policy desires to increase technological innovation and increase the commercialization of federally-funded science and technology. Policy goals include improving domestic efficiency (i.e., productivity, wages, and jobs) and enhancing the international competitiveness of the United States. These goals have been justified in a political sense based on an economic concept known as *externalities* (Eads, 1974). Simply put, this concept holds that private firms underinvest in technological innovation which, the concept holds, constitutes a failure of the market. (For an explanation of *externalities* and market failures, see Baer, Johnson, & Merrow, 1977). It is the failure of the market that justifies intervention by the government in the form of financial support for science and technology. Action on the part of the government is meant to *supplement*, not *supplant*, the market through the creation (i.e., production) of data, information, and knowledge resulting from federally-funded science and technology.

Current U.S. science and technology policy is not without its critics, however. They argue that this policy does not take into account the factors and influences that motivate innovation. Doing so, they state, would increase the likelihood of successful technological innovation. Early on, Nelson and Winter (1977) and Pavitt and Walker (1976) and more recently Branscomb (1991) criticized this "supply-side" policy (i.e., producing knowledge) because it encourages innovation, not its adoption; knowledge transfer and utilization are very inadequately served by market forces. Further, they argue, this policy provides little incentive for knowledge transfer and utilization. They conclude that government would better serve public policy by formulating policies that encourage the diffusion (i.e., the production, transfer, and use) of knowledge. Mowery (1983) states that a theoretical economic framework for technological innovation that ignores or does not account for the effective transmission and utilization of complex research results and STI is inappropriate for developing Federal science and technology policy because it ignores the abilities and limitations of organizations engaged in technological innovation to exploit extramural research (i.e., the results of federally-funded science and technology), thus ignoring the relationship among the production, transfer, and utilization of knowledge as equally important components of the innovation process. Mowery (1985) further states:

> This theoretical [economic] framework focuses primarily on the putative undersupply of research and bases its recommendations for policy on this market failure. However, for policy purposes, the distribution and utilization of the results of research and development are crucial. An exclusive focus on the R&D support policies of the Federal government, without some cognizance of the substantial diffusion support component of the policy structure, yields conclusions that differ substantially from those of an analysis that attempts to incorporate both the technology supply and technology adoption incentives operating within the overall policy framework. (p. 34)

Commenting on technology diffusion, public policy, and industrial competitiveness in the United States, David (1986) concluded that attempts by the Federal government to promote successful technological innovation rest more with knowledge transfer and utilization and less with knowledge production. In concluding this point, David states that:

> Innovation has become our cherished child, doted upon by all concerned with maintaining competitiveness and renewing failing industries; whereas diffusion (i.e., transfer and utilization) has fallen into the woeful role of Cinderella, a drudge-like creature who tends to be overlooked when the summons arrives to attend the technology policy ball. (p. 377)

The apparent success of Federal involvement in agriculture and aviation contrasts sharply with the results of the government's attempts to stimulate technological innovation in the civilian economy. It appears that in the case of agriculture and aviation, the government utilized a long-term, holistic approach to technological innovation that emphasized the production, transfer, and use of federally-funded science and technology in a coordinated policy environment.

THE U. S. GOVERNMENT AND STI

The U.S. government has been producing STI for over 200 years. Traditionally, the Federal government has limited the distribution of this STI to activities either directly or explicitly tied to an existing responsibility of a specific government agency, to an activity that supports a specific government agency (i.e., government contractor or grantee), or to a group of citizens identified by the legislation that created the specific government agency. Under this policy, such Federal entities as agriculture would be justified in distributing the results of federally-funded science and technology to farmers and members of the agricultural community. Historically, STI activities were limited; they were organized to support specific agencies and departmental programs, not to carry out the coordinated distribution of Federal STI. For most of its history then, the United States has had no overall, coordinated Federal policy for STI. (For a history of Federal STI activities, see Adkinson, 1987.) Although the U. S. government has been involved in creating, supporting, and distributing STI virtually since the founding of the nation, this chapter concentrates on the post-World War II period, the creation of the STI clearinghouses, and the U.S. government technical report.

U.S. Government Clearinghouses for STI

If World War II marked a significant departure from the Federal government's role with respect to financing science and technology, it also signaled the beginning of an era in which it was assumed the U.S. government had the primary responsibility to provide access to the results of its investment in science and technology (Ballard et al., 1989). The primary argument for this assumption stems from the role of the government as a major funder of science and technology and the corresponding need for a uniform approach to disseminating the results of its investment in science and technology (Pinelli & Henderson, 1989). U. S. government funding for science and technology during this period focused on the applied or, as Bush

(1945) would say, "the purposeful nature of science and technology," with the majority of Federal funds for science and technology being allocated to DoD, the Department of Energy (DoE), the Department of Health and Human Services (HHS), and NASA. With the exception of HHS, each of these agencies created information clearinghouses and supporting specialized information services to acquire, reproduce, announce, and distribute the results of government-funded science and technology. The National Technical Information Service (NTIS) was established as the central source for public sale of technical reports containing the results of research performed or sponsored by the U.S. government and for the sale of "war time [i.e., Axis countries] reports" captured by the Allies. (See Richards, 1994, for a discussion of this topic.) At the same time, advances in computer technology were applied to indexing and abstracting and to the creation of a variety of Federal online databases. (For information on Federal STI from 1945 to 1990, see Pinelli, Henderson, Bishop, & Doty, 1992.) Policy concerning access to, and the distribution of, federally-funded STI during the post-World War II period focused primarily on "free and open vs. restricted access" for reasons of national security. (See Relyea, 1994, for a discussion of this issue.)

The U.S. Government Technical Report

The technical report has become synonymous with documenting and reporting the results of federally-funded science and technology (Pinelli, Barclay, & Kennedy, 1993). According to Adkinson (1987), "distribution of printed results of federally funded science and technology changed from almost complete reliance on traditional journals and monographs to widespread use of the government technical report" (p. 29). The development of the U.S. government technical report, according to Godfrey and Redman (1973), dates back to 1941 and the establishment of the OSRD. Further, the growth of the U.S. government technical report coincides with the expanding role of DoD in science and technology during the post-World War II era and the classification of research results for reasons of national security. U.S. government technical reports have, however, existed for several decades. The Bureau of Mines *Reports of Investigation* (Redman, 1965/1966), the *Professional Papers of the United States Geological Survey*, and the *Technological Papers of the National Bureau of Standards* (Auger, 1975) are early examples of U.S. government technical reports. Perhaps the first U.S. government publications officially created to document the results of federally-funded science and technology were the technical reports first published by the National Advisory Committee for Aeronautics (NACA) in 1917.

McClure (1988) concludes that "we know very little about the role, importance, and the impact of this literature vis-à-vis the transfer of federally-funded STI, technological innovation, and productivity" (p. 42). Our analyses of the literature support the following conclusions regarding U.S. government technical reports (Pinelli, Barclay, & Kennedy, 1993).

- Although the U.S. government technical report has been variously reviewed, compared, and contrasted, there is no real knowledge base regarding the role, production, use, and importance of this information product in terms of knowledge diffusion, technological innovation, and productivity.
- The body of available knowledge is simply inadequate and non-comparable to determine the role played by the U.S. government technical report in transferring the results of federally-funded science and technology.
- Further, most of the available knowledge is largely anecdotal, is limited in scope and dated, and is unfocused in the sense that it lacks a conceptual framework.
- The available knowledge does not lend itself to developing "normalized" answers to questions regarding U.S. government technical reports.

U. S. Government STI Policy

The early enthusiastic support for increased financial support for science and technology also carried over into Federal STI. That initial enthusiasm has degenerated to produce a system that is passive, fragmented, and unfocused, and is largely unresponsive in a user context (Ballard et al., 1989). In making this statement, we recognize that, unlike the Soviet Union, the United States made a conscious decision not to build a single, centralized system or facility for STI. It did, however, intend the Federal STI enterprise to be coordinated and purposeful. Much of the reason for the fragmented and unfocused nature of the existing Federal STI system can be attributed to politics. The COSATI (Committee on Scientific and Technical Information) was created in 1964 under the auspices of the Federal Council for Science and Technology ostensibly to provide leadership and to coordinate Federal STI activities. COSATI was transferred in 1971 from the Office of Science and Technology (OST) to the National Science Foundation (NSF), where it was abolished the following year. The abolition of the Office of Science Information within NSF essentially ended government-supported research for STI. These two events, coupled with the failure of OSTP to fulfill its congressional mandate with respect to STI, have contributed to a Federal system with no coherent, policy-oriented, systematically-designed approach to STI. Through the years, the role of various government agencies involved in STI has become increasingly passive and blurred. The basic infrastructure created by the Federal government to collect, distribute, and disseminate STI has changed little since its creation, although the Cold War has ended, dramatic advances in computer and information technology have occurred, and the ability of the United States to compete effectively in a global market has been questioned. One effort to remedy the STI leadership void has been the formation of CENDI (Commerce, Energy, NASA, and Defense Information), a loose federation of Federal entities working together to develop standards and solve STI problems common to CENDI agencies. Although the efforts of CENDI are admirable, they fall short of the leadership and coordinated policy that is needed to improve the Federal STI enterprise (Gold, 1993).

The problems associated with the Federal STI system are not entirely new. Numerous government-sponsored studies concerned with Federal STI have been conducted over the past 30 years. The major studies of Federal STI policy in terms of content, the analysis of the context in which they were produced, and the results they generated were analyzed by Bishop and Fellows (1989). From their analysis, these researchers concluded that "today's imperfect federal STI system is not due to a lack of informative studies... but rather the failure of the studies' producers to influence policy makers" (p. 3). Perhaps this conclusion is a bit harsh considering that the individuals who conducted the studies were hired to analyze the present state of Federal STI and not to influence policy-makers. Instead, we find ourselves agreeing with Gold's (1993) conclusion that much of the blame for the current state of the Federal STI enterprise rests with the lack of Executive Branch leadership and the lack of coordination with respect to Federal STI.

Existing Federal STI policy is not tied to Federal science and technology policy. Rather, it is derived from the generic government information policy that is binding on Executive Branch agencies through Office of Management and Budget's (OMB) Circular No. A-130, "Management of Federal Information Resources." OMB Circular No. A-130 sets standards and guidelines as to how Federal agencies should manage their information and information technology. Critics argue that Circular No. A-130 is generic and does not distinguish according to "type" of information. In effect, OMB holds that Federal STI does not exhibit unique characteristics that would warrant its being considered in a separate policy framework. Critics also content that Circular No. A-130 gives precious little attention to the dissemination of Federal STI. After examining the relationship between government information and Federal STI, Sprehe (1995) concluded that the Federal government should develop special government-wide policies, similar to OMB Circular No. A-130, for Federal STI. What Executive Branch agency or department would have the oversight for Federal STI policy? The natural candidate for issuing Federal STI policy would seem to be OSTP. However, Brown (1987) states that OSTP has such a mandate but has never shown either the interest or the ability to carry out its mandate under P.L. 94–282, The National Science and Technology Policy, Organization and Priorities Act of 1976.

The Dissemination of Federal STI

Three paradigms—appropriability, dissemination, and diffusion—have dominated the dissemination of Federal STI (Ballard et al., 1989; Williams & Gibson, 1990). Whereas variations of them have been tried within different agencies, overall Federal STI dissemination activities continue to be driven by a *supply-side*, dissemination model. Scholars such as Branscomb (1991) argue, however, that this approach and the *trickle-down* benefits associated with the funding of basic research and mission-oriented (i.e., applied) research are inadequate in terms of stimulating technological innovation and competitiveness. Branscomb (1992) advocates the adoption of a *diffusion-oriented* policy for U.S. science and technology to gain a competitive advantage in the emerging global economy.

The *appropriability model* emphasizes the production of knowledge by the Federal government that would not otherwise be produced by the private sector, and competitive market pressures to promote the use of that knowledge. This model emphasizes the production of basic research as the driving force behind technological development and economic growth and assumes that the Federal provision of science and technology will be rapidly assimilated by the private sector. Deliberate transfer mechanisms and intervention by information intermediaries are viewed as unnecessary. Appropriability stresses the supply (production) of knowledge in sufficient quantity to attract potential users. Good technologies, according to this model, sell themselves and offer clear policy recommendations regarding Federal priorities for improving technological development and economic growth. This model incorrectly assumes that the results of federally-funded science and technology will be acquired and used by the private sector, ignores the fact that most basic research is irrelevant to technological innovation, and dismisses the process of technological innovation within the firm.

The *dissemination model* emphasizes the need to transfer information to potential users and embraces the belief that the production of quality knowledge is not sufficient to ensure its fullest use. Linkage mechanisms, such as information intermediaries, are needed to identify useful knowledge and to transfer it to potential users. This model assumes that if these mechanisms are available to link potential users with knowledge producers, then better opportunities exist for users to determine what knowledge is available, acquire it, and apply it to their needs. The strength of this model rests on the recognition that STI transfer and use are critical elements of the process of technological innovation. Its weakness lies in its passive nature, for the model does not take users into consideration except when they enter the system and request assistance. The existing Federal STI system is based on a *dissemination model* and employs one-way, source-to-user transfer procedures that are seldom responsive in the user context. User requirements are seldom known or considered in the design of information products and services.

The overall problem with the total Federal STI system is that "the present system for transferring the results of federally funded STI is passive, fragmented, and unfocused" (Bikson, Quint, & Johnson, 1984, p. 22); effective knowledge transfer is hindered by the fact that the Federal government "has no coherent or systematically designed approach to transferring the results of federally funded research to the user" (Ballard et al., 1989, p. 4). In their study of issues and options in Federal STI, Bikson, Quint, and Johnson (1984) found that many of the interviewees believed "dissemination activities were afterthoughts, undertaken without serious commitment by federal agencies whose primary concerns were with [knowledge] production and not with knowledge transfer;" therefore, "much of what has been learned about [STI] and knowledge transfer has not been incorporated into federally supported information transfer activities" (p. 23).

The existing Federal STI system has informal and formal components. Problematic to the *informal* part of the system is that knowledge users can learn from collegial contacts only what those contacts happen to know. Ample evidence supports the claim that no one researcher can know about or keep up with all the research in his/her area(s) of interest. Like other members of the scientific community, engineers and scientists are faced with the problem of too much information to know about, to keep up with, and to screen. Further, information is becoming more interdisciplinary in nature and more international in scope.

Two problems exist with the *formal* part of the system. First, it employs one-way, source-to-user transmission. The problem with this kind of transmission is that such formal one-way, "supply side" transfer procedures do not seem to be responsive to the user context (Bikson, Quint, & Johnson, 1984). Rather, these efforts appear to start with an information system into which the users' requirements are retrofitted (Adam, 1975). The consensus of the findings from the empirical research is that interactive, two-way communications are required for effective information transfer (Bikson, Quint, & Johnson, 1984).

Second, it relies heavily on information intermediaries to complete the knowledge transfer process, but a strong methodological base for measuring or assessing the effectiveness of the information intermediary is lacking (Beyer & Trice, 1982). In addition, empirical data on the effectiveness of information intermediaries and the role(s) they play in knowledge transfer are sparse and inconclusive. The impact of information intermediaries is likely to be strongly conditional and limited to a specific institutional context.

According to Roberts and Frohman (1978), most Federal approaches to knowledge utilization have been ineffective in stimulating the diffusion of technological innovation. They claim that the numerous Federal STI programs are "highest in frequency and expense yet lowest in impact" and that federal "information dissemination activities have led to little documented knowledge utilization" (p. 36). Roberts and Frohman also note that "governmental programs start to encourage utilization of knowledge only after the research results have been generated" rather than during the idea development phase of the innovation process (p. 36). David (1986), Mowery (1983), and Mowery and Rosenberg (1979) conclude that successful [Federal] technological innovation rests more with the transfer and utilization of knowledge than with its production.

The *knowledge diffusion model* is grounded in theory and practice associated with the diffusion of innovation and planned change research and the clinical models of social research and mental health. Knowledge diffusion emphasizes "active" intervention as opposed to dissemination and access; stresses intervention and reliance on interpersonal communications as a means of identifying and removing interpersonal barriers between users and producers; and assumes that knowledge production, transfer, and use are equally important components of the innovation process. This approach also emphasizes the link between producers, transfer agents, and users, and seeks to develop user-oriented mechanisms (e.g., products and services) specifically tailored to the needs and circumstances of the user. It makes the assumption that the results of federally-funded science and technology will be underutilized unless they are relevant to users and ongoing relationships are developed among users and producers. The problem with the knowledge diffusion model is that (1) it requires a large Federal role and presence, and (2) it runs contrary to the dominant assumptions of established Federal science and technology policy. Although U.S. science and technology policy relies on a "dissemination-oriented" approach to STI transfer, other industrialized nations, such as Germany and Japan, are adopting "diffusion-oriented" policies that increase the power to absorb and employ new technologies productively (Branscomb, 1991, 1992).

SUMMARY AND RECOMMENDATIONS

There is general agreement among policy-makers that Federal STI can be used to enhance technological innovation and improve the economic competitiveness of the United States. This agreement is based on the results of studies that show a positive relationship between STI and successful innovation, technical performance, and increased productivity. However, the United States lacks a coherent or systematically-designed approach to transferring federally-funded STI to the user. Policy instruments such as the Stevenson-Wydler Technology Innovation Act of 1980 (P.L. 96–480), the Federal Technology Transfer Act of 1986 (P.L. 99–502), the Japanese Technical Literature Act of 1986 (P.L. 99–382), the American Technology Preeminence Act of 1991 (P.L. 102–245), Executive Order (E.O.) 12591, "Facilitating Access to Science and Technology" (April 10, 1987), E.O. 12881, "Establishing the National Science and Technology Council (NSTC)" (November 23, 1993), and OMB Circular No. A-130 have shaped the legislative and regulatory environment for Federal STI policy.

Excluding OMB Circular No. A-130, the intent of these instruments is to (1) develop a predominant position for the United States in international markets by facilitating technology transfer from government laboratories, and (2) provide the inducements for Federal engineers and scientists to nurture the transfer process. In addition, some of these instruments provide a mechanism for the collection and dissemination of foreign STI in the United States. The scope of Circular No. A-130, which is concerned with the management of information as a resource, includes Federal STI. According to Circular No. A-130, STI conforms to a standard information life cycle and does not exhibit any unique attributes calling for the formation and implementation of a separate information policy framework. Attempts by OMB to regulate STI with a single policy instrument fail to recognize the linkages between Federal science and technology policy and federally-funded STI; thus, from a policy standpoint, OMB Circular No. A-130 does not contribute to congressional attempts to promote innovation and competitiveness (Hernon & Pinelli, 1992).

A holistic approach to technological innovation and economic competitiveness must be adopted at the Federal level. The current "supply-side" STI dissemination policy emphasizing knowledge production and the "trickle-down" benefits associated with the funding of basic research and mission-oriented, applied research are inadequate for developing a much-needed U.S. science and technology policy. The current approach will simply not restore the United States to a more competitive footing with other industrialized countries. A new approach to U.S. science and technology policy should be based on the assumption that the production, transfer, and use of STI is inextricably linked to successful technological innovation;

that a positive relationship exists between Federal attempts to stimulate technological innovation and federally-funded STI; that the process of technological innovation is best served by a "knowledge diffusion"-based model; and that an STI transfer infrastructure, funded and coordinated as a partnership among American industry, academia, and the Federal government, is required for the nation to become competitive in the global marketplace of the 1990s and beyond. Consequently, Federal policy with respect to technological innovation and economic competitiveness would, by definition, include an STI component. In other words, U.S. STI policy would be tied to U.S. science and technology policy, not to a generic information policy instrument such as OMB Circular No. A-130 or to a particular computer and information processing technology.

This approach recognizes the need to maximize the diffusion of federally-funded STI and to coordinate Federal STI activities using a mechanism similar to the now-defunct COSATI. A strong science and technology policy would commit the United States to building and maintaining a technology infrastructure that includes an STI transfer component based on a knowledge diffusion model. This model should have an "activist" component that emphasizes both domestic and imported STI, and it should be responsive in a "user" context. U.S. science and technology policy would view the structure, organization, and management of STI as a strategic resource. The need for more frequent and more effective use of STI characterizes the strategic version of today's competitive marketplace. STI policy should also reflect this same strategic vision for the following reasons:

- Information technology is making the same STI available at the same time to all competitors.
- The marketplace is increasingly characterized by a growing number of stakeholders whose numbers and positions are constantly changing. This implies that a broader array of STI will be needed for decision-making, and that simply providing STI retrieval and access without providing interpretation and analysis is meaningless.
- The need to provide STI interpretation and analysis is critical because less time is available for making decisions and the half-life of information is getting shorter.

Increasing U.S. collaboration with foreign producers will result in a more international manufacturing environment. These alliances will result in a more rapid diffusion of technology, and increasing pressure on U.S. companies to push forward with new technological developments and to take steps designed to maximize the inclusion of recent technological developments into the innovation process. Empirically-derived knowledge is needed to formulate an appropriate model for developing a holistic and conceptual U.S. science and technology and STI policy. Policy research is needed to understand the process of technological innovation and the relationship between STI and technological innovation. The existing Federal STI transfer mechanism should be studied, and descriptive and analytical data regarding the producer, information intermediary, and end-user interfaces should be collected and analyzed.

CHAPTER BIBLIOGRAPHY

Adam, Ralph. "Pulling the Minds of Social Scientists Together: Towards a Science Information System," *International Social Science Journal*, 27 (1975): 519–531.

Adkinson, Burton W. *Two Centuries of Federal Information.* Stroudsburg, PA: Dowden, Hutchinson, and Ross, 1987.

Alic, John A., Lewis M. Branscomb, Harvey Brooks, Ashton B. Carter, & Gerald L. Epstein. *Beyond Spinoff—Military and Commercial Technologies in a Changing World.* Boston, MA: Harvard Business School Press. 1992.

Allen, Thomas J. *Managing the Flow of Technology: Technology Transfer and the Dissemination of Technological Information within the R&D Organization.* Cambridge, MA: MIT Press, 1977.

Anderson, Jean. "Not a Half-Life for NACA Reports," *Sci-Tech News*, 28 (4) (October 1974): 24.

Auger, Charles P. *Use of Reports Literature.* Hamden, CT: Archon Books, 1975.

Averch, Harvey A. *A Strategic Analysis of Science & Technology Policy.* Baltimore, MD: Johns Hopkins University Press, 1985.

Baer, Walter S., Leland L. Johnson, & Edward W. Merrow. "Government-Sponsored Demonstrations of New Technologies," *Science*, 196 (4293) (May 27, 1977): 950-977.

Ballard, Steven, Thomas E. James, Jr., Timothy I. Adams, Michael D. Devine, Lani L. Malysa, & Mark Meo. *Innovation through Technical and Scientific Information: Government and Industry Cooperation.* New York: Quorum Books, 1989.

Beyer, Janice M. & Harrison M. Trice. "The Utilization Process: A Conceptual Framework and Synthesis of Empirical Findings," *Administrative Science Quarterly*, 27 (1982): 591–622.

Bikson, Tora K., Barbara E. Quint, & Leland L. Johnson. *Scientific and Technical Information Transfer: Issues and Options.* Washington, D.C.: National Science Foundation, 1984. (Available from NTIS: PB-85-150357; also available as Rand Note 2131.)

Bishop, Ann & Maureen O. Fellows. "Descriptive Analysis of Major Federal Scientific and Technical Information Policy Studies," in *United States Scientific and Technical Information Policies: Views and Perspectives*, edited by Charles R. McClure & Peter Hernon. Norwood, NJ: Ablex, 1989, pp. 3–55.

Branscomb, Lewis M. "Toward a U.S. Technology Policy," *Issues in Science and Technology*, 7 (4) (1991): 50–55.

Branscomb, Lewis M. "U.S. Scientific and Technical Information Policy in the Context of a Diffusion Oriented National Technology Policy," *Government Publications Review*, 19 (1992): 469–482.

Brown, George E. "Federal Information Policy: Protecting the Free Flow of Information," *Government Information Quarterly*, 4 (1987): 349–358.

Bush, Vannevar. *Science: The Endless Frontier*. Washington, D.C.: Government Printing Office, 1945.

Coles, John S., ed. *Technological Innovation in the '80s*. Englewood Cliffs, NJ: Prentice-Hall, 1983.

David, Paul A. "Technology Diffusion, Public Policy, and Industrial Competitiveness," in *The Positive Sum Strategy: Harnessing Technology for Economic Growth*, edited by Ralph Landau & Nathan Rosenberg. Washington, D.C.: National Academy Press, 1986, pp. 373–391.

Dupree, A. Hunter. *Science in the Federal Government: A History of Policies and Activities*. Baltimore, MD: Johns Hopkins, 1986.

Eads, George. "US Government Support for Civilian Technology: Economic Theory versus Political Practice," *Research Policy*, 3 (1974): 2–16.

Ergas, Henry. "Does Technology Policy Matter?," in *Technology and Global Industry: Companies and Nations in the World Economy*, edited by Bruce G. Guile & Harvey Brooks. Washington, D.C.: National Academy Press, 1987, pp. 191–245.

Fischer, William A. "Scientific and Technical Information and the Performance of R&D Groups," in *Management of Research and Innovation*, edited by Burton V. Dean & Joel L. Goldhar. New York: North-Holland, 1980, pp. 67–90.

Godfrey, Lois E. & Helen F. Redman. *Dictionary of Report Series Codes*. 2nd ed. New York: Special Libraries Association, 1973.

Gold, D. "Improving the Impact of Federal Scientific and Technical Information: A Call for Action," *Government Information Quarterly* 10 (1993): 221–234.

Hernon, Peter & Thomas E. Pinelli. "Scientific and Technical Information (STI) Policy and the Competitiveness Position of the U.S. Aerospace Industry." Paper presented at the 30th Aerospace Sciences Meeting and Exhibits of the American Institute of Aeronautics and Astronautics (AIAA), Bally's Grand Hotel, Reno, NV, January 9th, 1992. AIAA-92-0796. (Available from AIAA as 92A28233.)

Kline, Stephen J. "Innovation Is Not a Linear Process," *Research Management*, 27 (July/August, 1985): 36–45.

Landau, Ralph & Nathan Rosenberg, ed. *The Positive Sum Strategy: Harnessing Technology for Economic Growth*. Washington, D.C.: National Academy Press, 1986.

Logsdon, John M. "Federal Policies towards Civilian Research and Development: A Historical Perspective," in *Technological Innovation: Strategies for a New Partnership*, edited by Denis O. Gray, Trudy Solomon, & William Hetzner. New York: North-Holland, 1986, pp. 9–26.

Mansfield, Edwin. *Industrial Research and Technological Innovation*. New York: Norton, 1968.

Mansfield, Edwin, Anthony Romeo, Mark Schwartz, David Teece, Samuel Wagner, & Peter Brach. *Technology Transfer, Productivity, and Economic Policy*. New York: Norton, 1982.

McClure, Charles R. "The Federal Technical Report Literature: Research Needs and Issues," *Government Information Quarterly*, 5 (1988): 27–44.

Mowery, David C. "Economic Theory and Government Technology Policy," *Policy Sciences*, 16 (1983): 27–43.

Mowery, David C. "Federal Funding of R&D in Transportation: The Case of Aviation." Paper commissioned for a workshop on *The Federal Role in Research and Development*, November 21–22, 1985, held in Washington, D.C., and sponsored by the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine.

Mowery, David & Nathan Rosenberg. *Technology and the Pursuit of Economic Growth.* New York: Cambridge University Press, 1989.

Mowery, David & Nathan Rosenberg. "The Influence of Market Demand upon Innovation: A Critical Review of Some Recent Empirical Studies," *Research Policy*, 8 (1979): 102–153.

National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. *The Federal Role in Research and Development: Report of a Workshop.* Washington, D.C.: National Academy Press, 1986.

Nelson, Richard R. "Government Stimulus of Technological Progress: Lessons from American History," in *Government and Technical Progress: A Cross-Industry Analysis*, edited by Richard R. Nelson. New York: Pergamon Press, 1982, pp. 435–463.

Nelson, Richard R. & Sidney G. Winter. "In Search of Useful Theory of Innovation," *Research Policy*, 6 (1977): 36–76.

Nelson, Richard R. *The Moon-Ghetto Metaphor: An Essay on Public Policy Analysis.* New York: Norton, 1977.

Office of Management and Budget. *Budget of the United States Government: Analytical Perspectives.* Washington, D.C.: Government Printing Office, 1994.

Office of Technology Assessment. *Helping America Compete: The Role of Scientific and Technical Information.* OTA-CIT-454. Washington, D.C.: Government Printing Office, 1990.

Office of Technology Assessment. *Research Funding as an Investment—Can We Measure the Return?* OTA-CIT-454. Washington, D.C.: Government Printing Office, 1986.

Pavitt, Keith & W. Walker. "Government Policies toward Industrial Innovation," *Research Policy*, 5 (1976): 11–97.

Pinelli, Thomas E., Rebecca O. Barclay, S. Hannah, B. Lawrence, & John M. Kennedy. "Knowledge Diffusion and U.S. Government Technology Policy: Issues and Opportunities for Sci/Tech Librarians," *Science & Technology Libraries*, 33 (1992): 33–55.

Pinelli, Thomas E., Rebecca O. Barclay, & John M. Kennedy. "The U.S. Government Technical Report and the Transfer of Federally Funded Aerospace R&D," *Government Publications Review*, 20 (1993): 393–411.

Pinelli, Thomas E. & Madeline M. Henderson. "Access to Federal Scientific and Technical Information through U.S. Government Technical Reports," in *United States Scientific and Technical Information Policies: Views and Perspectives*, edited by Charles R. McClure & Peter Hernon. Norwood, NJ: Ablex, 1989, pp. 109–138.

Pinelli, Thomas E., Madeline M. Henderson, Ann P. Bishop, & Philip Doty. *Chronology of Selected Literature, Reports, Policy Instruments, and Significant Events Affecting Federal Scientific and Technical Information (STI) in the United States: 1945-1990.* Washington, D.C.: National Aeronautics and Space Administration, 1992. NASA TM-107658. (Available from NTIS; 92N27170.)

Redman, Helen F. "Technical Reports: Problems and Predictions," *Arizona Librarian*, 23 (1965/1966): 11–17.

Relyea, Harold C. *National Security Controls and Scientific Communication.* Norwood, NJ: Ablex Publishing Corp., 1994.

Richards, Pamela S. *Scientific Information in Wartime: The Allied-German Rivalry, 1939-1945.* Westport, CT: Greenwood Press, 1994.

Roberts, Edward B. & Alan L. Frohman. "Strategies for Improving Research Utilization," *Technology Review*, 80 (March/April, 1978): 32–39.

Roland, Alex. *Model Research: The National Advisory Committee for Aeronautics 1915–1958* Vol. 1. NASA SP-4103. Washington, D.C.: National Aeronautics and Space Administration, 1985. (Available from NTIS; 85N23683.)

Rosenberg, Nathan. "A Historical Overview of the Evolution of Federal Investment in Research and Development since World War II." Paper commissioned for a workshop on *The Federal Role in Research and Development*, November 21–22, 1985, held in Washington, D.C., and sponsored by the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine.

Shapley, Debora & Rustom Roy. *Lost at the Frontier: U.S. Science and Technology Policy Adrift.* Philadelphia, PA: ISI Press, 1985.

Sprehe, J. Timothy. "Does the Federal Government Need an A-130 for STI?," *Government Information Quarterly*, 12 (1995): 213–223.

Subramanyam, Krishna. *Scientific and Technical Information Resources.* New York: Marcel Dekker, 1981.

Smith, Bruce L. R. *American Science Policy since World War II.* Washington, D.C.: The Brookings Institute, 1990.

Teich, Albert H. "Federal Support of Applied Research: A Review of the United States Experience." Paper commissioned for a workshop on *The Federal Role in Research Development*, November 21–22, 1985, held in Washington, D.C., and sponsored by the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine.

Williams, Frederick & David V. Gibson. *Technology Transfer: A Communication Perspective.* Newbury Park, CA: Sage, 1990.

Wood, Fred B. "Helping America Compete through More Effective Use of Scientific and Technical Information: An Opportunity for Office of Science and Technology Policy Leadership," *Government Information Quarterly*, 8 (1991): 105–112.