CONFERENCE PROCEEDINGS

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Technology Transfer of Federally Funded R&D

Perspectives from a Forum

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Executive Summary

The United States has long been a leader in creating and developing new technologies that advance understanding of the world around us, solve complex problems, keep the nation's industries competitive, and improve society's quality of life. By funding research, the federal government has played a major role in helping to create these new technologies. At the same time, the government has encouraged individuals and organizations to embrace and use knowledge that flows from federally funded research results to develop new products. This process is the essence of technology transfer. By understanding technology transfer, the government can increase the benefits it accrues from its investment in new technologies.

The President's Council of Advisors on Science and Technology (PCAST) was asked to examine the nature of technology transfer resulting from federally funded research and development (R&D). Generally speaking, technology transfer involves generating innovative ideas through the sharing of relevant knowledge and through the sharing of facilities among federal laboratories, universities, industry, and government, and commercializing those ideas in the form of goods and services. Often, the process of technology transfer uses technology, expertise, and facilities not only to solve a specific problem but also to facilitate its application to purposes not originally intended by the developing organization. In either case, these efforts can result in commercialization of a new product or process, or product and process improvements.

As part of its deliberations, PCAST asked RAND to host a one-day forum on the transfer of technologies developed with federal R&D funding. The forum, and in particular its open afternoon session for public comments, solicited input from participants on issues and best practices related to successful technology transfer. To attract a diverse set of participants with a wide range of viewpoints, announcements for the forum were posted in the Federal Register and distributed through e-mail to major groups involved in technology transfer, including universities, federal laboratories, government, industry, and the venture capital community. Additionally, for interested individuals and organizations who could not attend the forum, RAND developed an on-line questionnaire to collect information on their experiences with technology transfer and to solicit their thoughts on identification of best practices and the barriers to implementing those best practices.

Background

To help stimulate and structure discussion at the forum, RAND first presented an overview of technology transfer.

Overview of Technology Transfer

The overriding goal of any technology transfer is its successful adoption by a large majority of consumers who can use the technology. However, because every organization has its own goals and culture, there is no single technology transfer process that fits all organizations and occasions. Rather, there are several key steps or activities included in most technology transfer processes, and an individual process is tailored to fit organizational needs.

Figure S.1 presents a schematic overview of the main activities involved in the process of technology transfer.

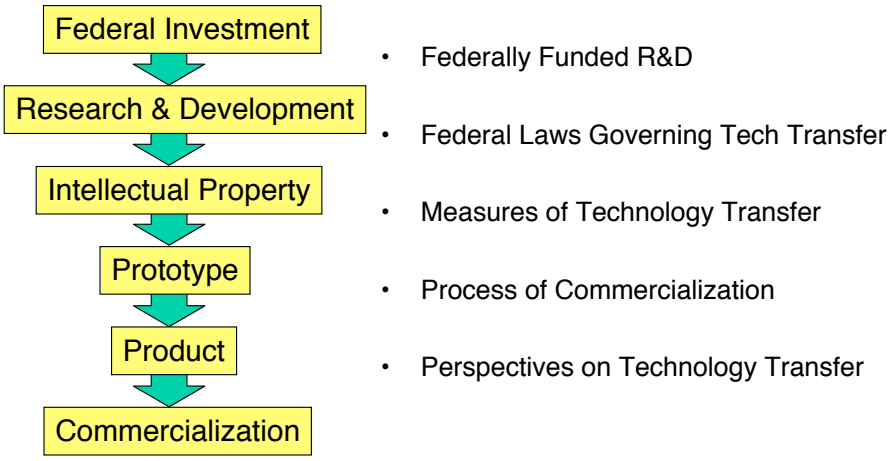

Figure S. 1—Schematic Overview of Technology Transfer Activities

This schematic view presents technology transfer in terms of its ultimate goal: commercialization, which involves taking intellectual property that derives from federally funded R&D at universities or federal laboratories, developing products, and then commercializing them. This chain of activities and the expectation that technology transfer will lead to commercialization is aimed at improving the nation's economic well-being and quality of life.

This framework is, of course, oversimplified. Innovation and insights on how to use old things in new ways, or how to use new ideas to solve old problems, may not be predictable or linear.

There may be evolutionary advances to existing technologies, or revolutionary technologies that displace or disrupt other technologies or existing ways of doing things.[1,2] There is also considerable iteration among the various activities. The process also typically involves a variety of players, from transferors who create the technology and prove the concept, to those who embed the technology in a useful product, service, tool, or practice, and finally to transferees who embrace it, further develop it, commercialize it, and ultimately use it.

Federal R&D Funding and Performers

To understand the earliest stages of technology transfer, it is useful to first understand the nature of federal investment in R&D. Annually, the U.S. government invests roughly $80 billion in federally funded research and development. Funding is dominated by the Department of Defense (DoD) and the Department of Health and Human Services (HHS), which includes the National Institutes of Health (NIH). Together with the National Aeronautics and Space Administration (NASA), the Department of Energy (DOE), and the National Science Foundation (NSF), these top five agencies fund 95 percent of the annual federal investment in R&D. Federally funded R&D is performed by many types of institutions. The federal laboratories together perform about 30 percent of the funded R&D, followed by universities which account for about 25 percent. Large and small businesses perform about 40 percent of federally funded research and development.

Figure S.2 displays a breakdown of the federal investment by funding agency and by the entities performing the research and development. The nonU.S. government operated federal laboratories (nonintramural laboratories) are represented by the top bar in the figure, which shows the DOE was the most significant R&D funding agency in that area. The second bar displays the government-owned government-operated (GOGO) federal labs (intramural labs). There, roughly half the funding comes from the DoD. Funding at large businesses and small businesses also largely comes from the DoD. Funding at universities and colleges is predominantly from the HHS. Note that the only sizable portion of research funded by the NSF is performed at universities.

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[1] See Schumpter (1942) for a discussion of his concept of "creative destruction."

[2] Christensen (1997).

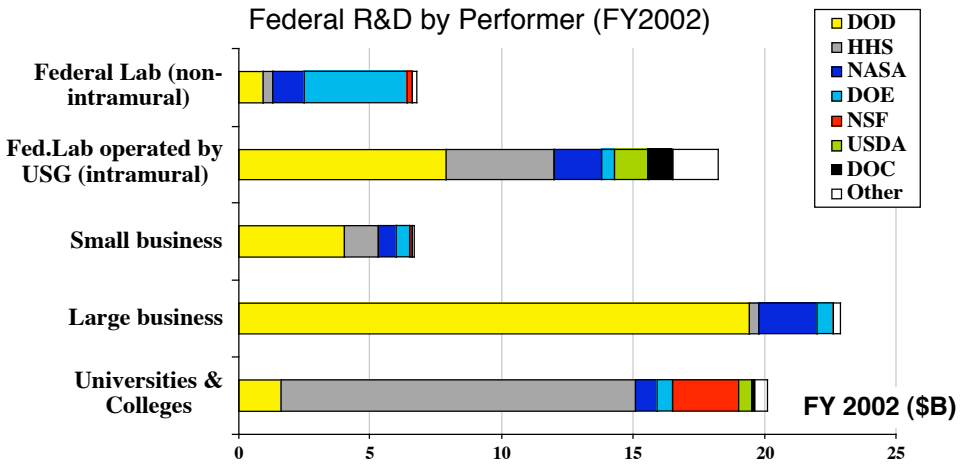

Figure S.2—Federal R&D by Funding Agency and by Performer (FY2002 $B)

Federal Laws Governing Technology Transfer

Concerns about U.S. global competitiveness and a rising Japan in 1980 motivated Congress to pass legislation intended to increase the movement of university knowledge and ideas into commercial innovations and products. Prior to 1980, universities and other research institutions had little incentive to commercialize their research, given that the patent rights belonged to the federal funding agency. The federal policies that increase technology transfer to the private sector are set forth in a collection of legislation and Executive Orders (EOs). These laws and EOs are primarily concerned with intellectual property rights but also govern other aspects of the larger process of transferring technology created with federal funds. This collection of laws includes three pieces of legislation cumulatively known as the Bayh-Dole Act: the University and Small Business Patent Procedures Act, the Trademark Clarification Act, and Executive Order 12591. Another important piece of legislation, the Stevenson-Wydler Act, gives federal agencies responsibility for transferring intramural federal R&D results to the private sector. Two important R&D agencies, NASA and the DOE, are covered by separate acts, but federal policy guidance has in effect brought them in line with Stevenson-Wydler.

Measures of Success

Because technology transfer involves so many different individuals and organizations and their diverse needs, it is difficult to define universally appropriate measures of transfer activity or effectiveness. Indeed, it is unlikely that all federal laboratories, universities, and corporations

perform equally well with respect to any given measure of success. However, there has been meaningful work on defining metrics for and success in technology transfer. The Interagency Committee of Federal Technology Transfer, chaired by the Department of Commerce (DOC), has identified key mechanisms for successful transfer. These include licensing, Cooperative Research and Development Agreements (CRADAs), technical assistance and consulting, reimbursable work for nonfederal partners, the use of facilities, exchange programs and collegial interchange, publications, and conferences.

Beyond anecdotal information, practitioners and scholars of technology transfer have developed and used diverse metrics that are usefully described in seven categories: (1) science, technology, engineering, and medical school graduates taking jobs in the technology sector; (2) patents; (3) manufacturing innovations; (4) innovation networks; (5) Web hits to a science database; (6) transfer mechanisms; and (7) knowledge spillovers.

No particular metric is appropriate for all applications, nor is any particular analytical tool correct for answering every question. Yet, the principal findings from academic research of technology transfer, even from a field barely 20 years old, are already varied and useful. They point in some instances to patterns worthy of close attention from practitioners of technology transfer and from policymakers.

Key Perspectives from the Technology Transfer Forum

In order to identify important issues and best practices, a Technology Transfer Forum was held at RAND's Washington, D.C., office on December 12, 2002, to raise as many issues and perspectives as possible on the topic of technology transfer. This forum included a roundtable discussion featuring the participation of technology transfer experts representing research universities, federal laboratories, the U.S. government, and various industries. A significant portion of the agenda was devoted to an open forum session at which attendees could make public comments. An open discussion period also provided an opportunity for additional comments. Many individuals who were unable to attend the forum could submit comments from an on-line questionnaire-and-comments form.

Several themes emerged from discussions at the forum and subsequent questionnaire submissions. The discussion that follows represents RAND's summary of the main issues and perceptions that emerged at the forum. Note that these are perceptions only and not necessarily fact, although the opinions expressed here may help to suggest where further research may be most valuable.

Technology Transfer: Adjusting to the Policy Environment

- Participants generally agreed that improving technology transfer involves a steep learning curve. It has taken decades for organizations to learn how to operate successful transfer programs.
- In part because of the length of this learning curve, many forum panelists and attendees expressed the belief that technology transfer legislation should not be altered.
- There is a broad perception that the U.S. R&D landscape has changed in the past two decades. For instance, the relative share of R&D funded by government is believed to have shifted, altering the balance of basic versus applied research, and a short-term focus versus a long-term focus.

General Views of Technology Transfer

- Panelists and attendees noted that technology transfer should be viewed broadly. A framework including federal investment, legislation, and commercialization seemed useful.
- Many forum attendees discussed technology transfer within a global context. U.S. competitiveness and an increasingly global economy spurred these comments. Industry partnerships with foreign research institutions was also a recurring point of discussion.
- Successful commercialization requires significantly more than a good idea or new technology. Developing a successful product requires, among other things, effective management, strategy, timing, and marketing. Coordinating among many organizations, some with widely varying missions, is a significant challenge.

Implementation of Technology Transfer

- Many attendees urged that recommendations to improve technology transfer, particularly of implementation issues, be tailored to specific circumstances. The processes that work for one industry or institution may not be applicable to another.
- Employees at the federal laboratories feel less incentive than their counterparts in universities or in industry to contribute to technology transfer. Lack of consulting time, royalties, and equity in startups were among the issues raised.
- The implementation of technology transfer is not uniform: Technology licensing offices operate in diverse ways and do not apply Bayh-Dole uniformly.
- The increase in interdisciplinary and jointly sponsored research sometimes creates confusion when ownership of intellectual property is not clear.
- Resources early in the technology transfer process are sought by all parties. Lack of these early resources hinders technology and market development, and hinders patent and licensing processes.

Steps for the Future

- Many attendees recommended the development of training tools and education courses on technology transfer, including explanations of the use of various technology transfer mechanisms.
- Homeland security issues were raised by some forum participants, in the context of planning for increased research and development and moving technologies into public use.
- Some attendees suggested examining how technology transfer is accomplished in other countries. In the U.K., for example, many companies are invited to bring their R&D efforts into university settings where they can be nurtured by universities.
- Many attendees agreed that technology transfer, and the many issues that were raised, require further research to develop and improve metrics, especially those that measure benefits to the end user.

Directions for Future Research

Based on the themes that emerged from the forum, RAND identified a range of areas in which increased knowledge might help improve federal technology transfer. In assessing the government's return on its technology investments, much of the current discussion has focused on existing legislation and how it affects the success of technology transfer. However, no set of best practices has been proposed or adopted. Interesting observations and anecdotes give some clues as to what works well and give some basis for deliberations, but they do not constitute a body of systematic knowledge from which best practices can be derived. A clearer conceptual framework, supported by carefully conceived and collected data, is needed to support a more rigorous study of which transfer practices have been effective and in which contexts. Four issues in particular stand out for future research:

- First, given the various ways in which technology can be transferred and the numerous organizations involved in those transfers, what measures or combinations of measures are best for evaluating, advancing, and monitoring progress of technology transfer? For those metrics or combinations of metrics, what goals would be reasonable?
- Second, using the metrics developed as described above, how do the various federal agencies compare in their ability to transfer technology, and which practices can and should be emulated by others?
- Third, foreign universities and laboratories have active programs to license intellectual property and transfer technology. What might we learn from an examination of foreign technology transfer practices, and which ones might be profitably adopted by the United States?
- Fourth, what can we learn from the private-sector experience with technology transfer and what might be applicable for federal-to-private technology transfer?