Discriminators Defining Development of High Technology—U.S. Experience
[Focus on Hungary]
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John Marburger
Director, Office of Science and Technology Policy
Executive Office of the President

Thank you for inviting me to speak this morning. Hungary has a long history of excellence in science and mathematics, from which the United States has greatly benefited. Hungarian-American scientists and engineers have contributed substantially to the foundations of today's technically intensive global economy, and are helping to maintain American competitiveness. I am pleased to have an opportunity to help sustain the well-spring of such creativity, if only in a small way through my remarks this morning. This forum seems ideally situated to provide Hungary's technology policy leadership with insights into America's complex system of innovation and entrepreneurship.

In his letter of invitation, George Handy, Director of CSIS's International Action Commissions Programs, asked me to share my view of American lessons learned to facilitate high technology development to applications and commercialization. I will sketch some background on U.S. science and technology policy that others may fill in during subsequent sessions today.

National science and technology facts and priorities

Investment in research is the first step along the technology transfer path. Funding long-lead time high-risk research is a key federal government responsibility, but we expect industry to invest in short-term lower-risk research consistent with their product sector. How this investment is determined and managed is complicated. For example, the United States does not fund science and technology through a single agency. Our National Science Foundation (NSF) expends only a small fraction of the total R&D investment of approximately $130 billion. About half of this amount is allocated to development projects within the Department of Defense. The remaining half is shared among five primary science agencies and numerous other agencies in which science is a small, but sometimes important, part of the agency mission.

Nor is the science budget appropriated by a single committee within Congress. Ten of the thirteen Congressional appropriations committees have a portfolio that contains science, and in none of these is science the dominant issue. The establishment of cross-agency priorities, the coordination among agencies of budget proposals, and the advocacy of the President's request on behalf of science are among the responsibilities of my Office of Science and Technology Policy.

Despite the complexity of the science funding process, the fraction of discretionary funds available to Congress that has been devoted to non-defense research has remained constant at about 11% for four decades (except for a peak during the Apollo space program in the 1960's and early 70's).

Of the roughly $60 billion in non-defense research funding, nearly half (47%) goes to the National Institutes of Health (NIH) for biomedical research. Most of the remainder is divided among NASA (16%), NSF (10%), DOE (9%), and DOD basic research (9%). These "big five" account for about 90% of non-defense science and technology funding. No other agency has more than 5%. Agriculture has 3%. It is clear from these figures that defense technology is a priority for our nation, followed by biomedical research and space programs. The Department of Energy operates major science user facilities for investigators funded by all other agencies – facilities such as research reactors, particle accelerators, and x-ray synchrotron light sources. About 40% of all funding for physical science is supported through DOE.

As for priority fields, they are similar to those of all other developed countries: biotechnology, nanotechnology, and information technology, and related areas of science, are all priorities. In more applied areas, certain topics in energy research (e.g. hydrogen fuel issues, renewable energy sources), environmental research (e.g. climate studies, environmental remediation), and space exploration are designated priorities. Technical workforce issues, including education, training, and retraining, of scientists and engineers at every stage, are also receiving attention. Improvement of science and math teaching at all grade levels is an important objective that we regard as essential for increasing the numbers of American students who seek and receive college degrees in science, mathematics, and engineering.

Research and development in the U.S. private sector is approximately twice the federal investment, bringing the total from all sectors to something over 2.7% of GDP. Private sector research is greatest in pharmaceutical and electronics industries, but is significant in others, including information technology, aerospace, and transportation sectors. The Administration favors industrial investments in research and development, and would like Congress to make the current R&D investment tax credit permanent.

U.S. researchers engage in many collaborations with researchers from other countries, and some agencies have offices specifically devoted to international research programs. The NIH Fogarty Center, for example, gives grants to foreign investigators exclusively. NSF also provides support for foreign researchers. Information on these programs is available on the agency websites. In general, however, the funds available for foreign research are small. The U.S. is making a significant contribution to the CERN Large Hadron Collider project, and has agreed to participate in the international fusion program ITER at the 10% level. Many other smaller programs exist in practically every field of science.

The U.S. Innovation Process

Economic analyses have shown that the U.S. innovation process depends upon federally sponsored basic and applied science that produces emergent technologies that are subsequently developed with private industry funds. A feature of this process that differs from many other countries is the joining of federally funded research with graduate level training in science and engineering at state and private universities. Most of this work is supported through competitive, peer reviewed proposals funded on their merits by the “big five” science agencies: DOD, NIH, NASA, NSF, and DOE. Even in the federal national laboratories, much of the research is funded on a competitive basis. Most American college students are enrolled in state-sponsored institutions, and the larger states have been generous in their support for facilities in which federally sponsored research can be conducted. Thus federal R&D funds are magnified by state contributions. Most private research universities, and some public ones, also receive substantial support for facilities from private donors, both individuals and corporations.

In general, the role of federal funding is to support long lead-time, high risk research, and the role of the industrial sector is to fund shorter term, lower risk research. There is a gray area where the two overlap, and this area is somewhat contentious. Agency programs are explicitly evaluated by the White House Office of Management and Budget on this criterion, and programs thought to be funding inappropriate types of research are rated down. Technology transfer from university and federal laboratories is encouraged, however, as a matter of policy. Congress passed laws in the 1980’s giving ownership to universities and federal laboratory operators of intellectual property developed with federal funds.

Perhaps the most familiar of these laws is the *University and Small Business Patent Procedures Act of 1980*, more commonly known as the *Bayh-Dole Act*. The provisions of *Bayh-Dole* created a uniform patent policy, permitting universities and small businesses to take title to inventions created with federal funds. The interests of the government and the public were, however, protected. The government retains the right to use the inventions for government purposes. And, if the owner of the intellectual property—the university, non-profit or small business—does not make an effort to commercialize the invention, the government may take back title. *Bayh-Dole* also applied to federally funded research laboratories that are operated by contractors, such as the Department of Energy’s Lawrence Livermore National Laboratory.

Bayh-Dole did not apply, however, to inventions made by federal employees working at federally operated laboratories. To encourage the transfer of technologies developed by federal employees Congress passed the *Technology Innovation Act*, also known as the *Stevenson-Wydler Act*, also in 1980. *Stevenson-Wydler* raised the bar by not only *allowing*, but also by *requiring*, federal agencies to take an active role in technology transfer. The Act made technology transfer a mission of every R&D agency.

In 1986, with the passage of the *Federal Technology Transfer Ac of 1986*, Congress added incentives to the mandates of Stevenson-Wydler. This *Act* allows the federal labs to keep all licensing royalties (which previously had gone to the Treasury’s General Fund) and requires that at least 15% of all royalties be shared with the lab employee inventors. This act also enhanced access by private industry to expertise, personnel and facilities resident at government labs when it authorized the federally operated labs (and subsequently in 1989 extended authorization to the contractor-operated labs) to enter into Cooperative R&D Agreements (or "CRADAs"). Under a CRADA, researchers at a federal lab and at a company, or other non-federal government organization, perform collaborative research of mutual benefit.

An Executive Order signed in 1987 by President Reagan extended *Bayh-Dole’s* provisions to large businesses doing federally funded research and also addressed the circumstances whereby CRADAs and license agreements might be entered into between federal labs and foreign owned companies.

As recently as 2000, Congress passed the *Technology Transfer Commercialization Act*, which attempts to make the transfer of technology from federal labs more streamlined by allowing licensing of relevant background inventions under the terms of a CRADA and by reducing the period for which an agency must advertise its intent to grant an exclusive license from 60 to 15 days. The government's continuing interest in fostering technology transfer, as indicated by the many pieces of legislation enacted over the years, speaks to its ongoing importance.

The success of *Bayh-Dole* can be measured, in part, by the patenting activity at U.S. universities. The number of patents issued to U.S. universities was approximately 250 per year before the passage of *Bayh-Dole*. In 1998, roughly 3,200 patents were issued. More recently, the Association of University Technology Managers (or AUTM) reported that among the 142 U.S. universities that responded to their survey, nearly 3300 patents were issued. This correlates to an increase in the percentage of all U.S. patents issued to U.S. entities from 1% in 1980 to ~2.5% in each year since 1998. This increase is due to (1) greater numbers of universities filing for and being awarded patents, and (2) individual universities obtaining more patents. In accordance with *Bayh-Dole*, any financial gains made by the university are directed back to the research and educational programs at the institution.

Obtaining patent protection is just one step in the technology transfer process. The university technology transfer offices also strive to commercialize their intellectual property. Based on responses from 167 U.S. universities and research hospitals to the 2000 AUTM survey, more than 4000 licenses, or options for license, were executed. The institutions reported nearly 20,000 active licenses and options, of which about half generated revenues totaling $1.24 billion. The respondents reported that roughly 350 new licensed products were made available in 2000 and 388 new companies were formed specifically for the commercialization of university or hospital technology. Over the last twenty years, among the universities participating in the AUTM surveys, a total of nearly 3300 start-up companies were formed as a result of technologies transferred from university R&D.

As for federal laboratories, the effect of the enactment of *Stevenson-Wydler* on technology transfer at these institutions was also dramatic. Beginning in 1986, the federal labs took full advantage of the ability to enter into cooperative R&D agreements (or CRADAs). Note that CRADAs are the equivalent of "industrially sponsored research" at universities. A CRADA is one of the few mechanisms by which private industry can pay for collaborative work to be done at a federal lab; however, neither the laboratory nor the individual researcher may make a profit under such agreements. Ten years after CRADAs were created in 1986, the number of active agreements soared to over 3500.

Efforts to promote the commercial utilization (or dual-use) of the technologies being developed for government use at the federal labs were also bearing fruit. In the decade following the amendment of *Stevenson-Wydler*, the number of license agreements that were executed in a given year nearly quadrupled (from 128 in 1987 to 487 in 1997 and reaching 577 in 2001).

Moreover, the amount of income received by the federal labs from their active license agreements increased more than 12-fold from approximately $6 million in 1987 to more than $80 million in 2001.

The innovation process is not completely defined or characterized. Important components include a business climate favorable to entrepreneurship, including access to venture capital and a society that does not regard business failure as a disgrace. Many successful entrepreneurs have a history of multiple failures before they succeed. Certainly the quality and availability of higher education in the U.S. is an important component of successful innovation, as well as the personal freedoms associated with American traditions and constitutional structure.

These brief remarks cannot do justice to a system of science-driven technology-intensive innovation that continues to drive the U.S. economy at an extraordinary pace. I would be glad to answer specific questions about any of these topics.