Making the R&D Connection: A Perspective on the University Role

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WITHIN THE 35% OF THE U.S. science and technology community supported by federal tax dollars, much discussion centers on the proverbial budget ax poised to swipe across a mixed forest of research and development programs. These programs sprouted and then flourished in the post-World War II era of generous federal funding for academic R&D. If the ax does fall, just how radically will the research landscape be changed?

Looming constraints on federal R&D support are likely to spur self-preservation tactics aimed at securing alternative sources of funding. But as serious as this prospect is, it is only part of a larger set of issues demanding a strategic reassessment and response by the entire R&D community. The research landscape, as well as the relationships it sustains, cannot and should not be insulated against change — petrified, in effect, in its historic form — while all that lives and grows beyond its borders contend with relentless forces of change.

Over the last five decades, the U.S. university system has established itself as the world's premier performer of forward-looking, basic research. Industry, which performs and sponsors the lion's share of R&D — spending more than $100 billion annually, has concentrated on applied research and development, now devoting about 93% of its resources to these market-oriented tasks. With an R&D budget of about $70 billion, the federal government allocates the bulk of its resources for mission-oriented research, principally in the area of defense, and it is the primary funder of academic R&D.

Under this system of R&D responsibilities, academic researchers have made discoveries that broadened and deepened understanding of nature and human behavior. They also have laid the foundation for new technologies, new products and services, and even new industries. And in so doing, they have trained succeeding generations of scientists and engineers who fanned out to companies, governmental laboratories, and colleges and universities, here and abroad.

The outstanding performance of the U.S. university system has been sustained largely by growing federal support for academic research, which accounted for $13 billion, or 60%, of total R&D spending at colleges and universities in 1995.

In contrast to the widespread perception that federal research funding is declining, federal support of academic R&D has increased continuously since 1982. During the 1990s, it grew at an inflation-adjusted annual rate of 3.2%. Thanks in large part to this growing contribution, academe is the only R&D-performing sector not to have suffered a constant-dollar decline during this decade, according to the National Science Foundation.

Nonetheless, there are valid concerns that efforts to eliminate the budget deficit will lead to decreased federal support for academic research in the future. R&D is a significant portion of federal discretionary funding and, hence, is quite vulnerable to the budget ax. Many are now suggesting that U.S. industry should step into the anticipated breach in funding for universities. Annual company funding for university research is growing, to about $1.5 billion (or less than 2% of the total that industry spends), but now accounts for only about 7% of all academic R&D support.

Investment or Substitute Funding?

A strong argument can be made for increasing industry's investment in academic research, but not without qualification. Benefits touted as warranting a boost in private-sector outlays, such as speeding the transition from raw discoveries to real-world applications, may not be realized if the practical effect is simply to substitute one source of funding for another. Academic institutions must also respond to powerful forces, from intensifying international economic competition to the rapid diffusion of new knowledge to the increasing mobility of R&D personnel, capital resources, and capabilities that are buffeting the entire research enterprise. These forces are challenging many old ways of doing business, rendering them obsolete and ineffective, especially when viewed from the vantage point of the national economic interest.

With whatever funds are available, all sectors must work smarter and faster, more interactively, and more efficiently. This does not mean that the legitimate R&D roles of individual sectors and organizations should be distorted or subverted in the service of another. Universities, for example, must maintain a strong focus on long-term research and education, especially as industry narrows the focus of its R&D and moves it "closer to the customer."

Still, we as a nation can afford neither the luxury of leisurely harvesting the fruits of discovery and invention, nor the mistake of leaving them for others to harvest and market. Historically, as reported by Mansfield and others, the gestation period for academic research typically has spanned more than a decade, sometimes exceeding the patent life of inventions generated by early, ground-breaking studies. In many areas, long time frames and the attendant risks have deterred industry from following through on the breakthrough achievements of academic scientists. Today, we can point to important exceptions, examples in which the outmoded model of linear R&D has been replaced by a more dynamic, interactive style of working that transcends sector boundaries. Biotechnology and software are two particularly strong examples of fields where linkages between university research and the marketplace have worked in exciting new ways.

Partnerships: One Piece to the Puzzle

Close attention must be paid to the health and productivity of the nation's entire science and technology system. The amount of money allocated for R&D and how those dollars are distributed are important concerns, ultimately defining the breadth and depth of research efforts. Among many crucial system elements also warranting thoughtful study are the mechanisms that enable the R&D community to integrate its varied capabilities and to use them to the nation's full advantage. Unfortunately, there is no single prescriptive means for achieving this end.

Partnerships are an additional strategy — albeit a critical one — to strengthen the health and performance of the national science and technology system. They can be an antidote to the inertia that has plagued the middle stage of pre-market R&D, typically the longest period in what has been an awkward and sometimes haphazard progression from lab to marketplace. At this stage, raw research results are shaped into still rough technological form, enabling technical proof of concept, for example.

Working partnerships, by combining and integrating technical skills, resources, and perspectives, can compress the intermediate stage of a technology's metamorphosis and make the preceding and succeeding stages more productive, as well. Within the federal sector, the largest supporters of university research — the National Institutes of Health, NSF, the Department of Energy, NASA, and the Department of Defense — have instituted measures intended to foster partnerships and to blend R&D capabilities in ways that advance their particular missions and yield results useful to industry.

Crossing Organizational Boundaries

With the mission to work with U.S. industry to develop and apply technology, measurements, and standards, the National Institute of Standards and Technology is not a major funder of academic research. But we recognize the important role that universities can play in advancing our goals. In the case of the institute's advanced technology program, the incentive of matching federal taxpayers' funds to support competitively selected, industry-proposed R&D projects is proving to be a catalyst for collaboration. It is fostering intercompany and intersectoral cooperation during the early-stage development of technologies upstream from the market.

Of the 280 projects selected by the advanced technology program since 1990, 56% involve at least one university partner. One such project, for example, aims to overcome technical barriers obstructing commercial development and application of plasma source ion implantation, a promising but still highly experimental University of Wisconsin invention. In this collaborative effort, organized and led by a private sector research institute, 11 companies — from makers of locks and chrome-plated ornaments to a motorcycle manufacturer to electronic-device producers — are teaming with the University of Wisconsin and Los Alamos National Laboratory to demonstrate the technology's potential for uniformly depositing ultra-hard, wear-resistant surfaces on complex-shaped parts made from any one of a variety of materials. The barriers are steep: this invention has been demonstrated only in a laboratory treatment chamber, a very long way from the high-volume applications that are envisioned. Still, the potential utility and commercial benefits are great and recognized the world over. Of some 35 laboratories now pursuing the commercial promise of this U.S. technical advance, more than half are located overseas.

At NIST's laboratories, university collaborators have long been valued for their contributions, but the changing R&D climate is increasing that appreciation and, as a result, the level of interaction. More than 350 university staff members are working as guest researchers in these laboratories. University researchers are also key participants in institute-led consortia with industry. Consider an 18-organization effort to improve the precision casting of metal alloys commonly used in the aerospace industry. Spanning the spectrum from fundamental studies on materials properties to development of computer models and software incorporating the results of this research, the consortium is a distributed effort. Specific tasks are carried out in the laboratories of collaborating universities, companies, and federal agencies. The contributions of three particularly active universities — the University of Arizona, Auburn University, and the University of Illinois — have been especially critical. Their research is helping to guide efforts to enhance the aerospace industry's processing capabilities on the basis of new and deeper scientific understanding of casting variables.

Just as work conducted at the boundaries between disciplines can prove to be especially productive, often leading to leaps in understanding and to breakthrough accomplishments, collaborations that span organizations and R&D sectors present rich opportunities for progress on many fronts of science and technology. Recognizing and realizing these opportunities requires researchers and organizations in all sectors to think more broadly and more creatively. It also requires them to be more enterprising and to search aggressively for connections between fields and sectors — connections either created by new advances, capabilities, or needs, or previously obscured by compartmentalized ways of thinking and outdated concepts.

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