POLICY FORUM: SCIENCE PRIORITIES

Who's Balancing the Federal Research Portfolio and How?

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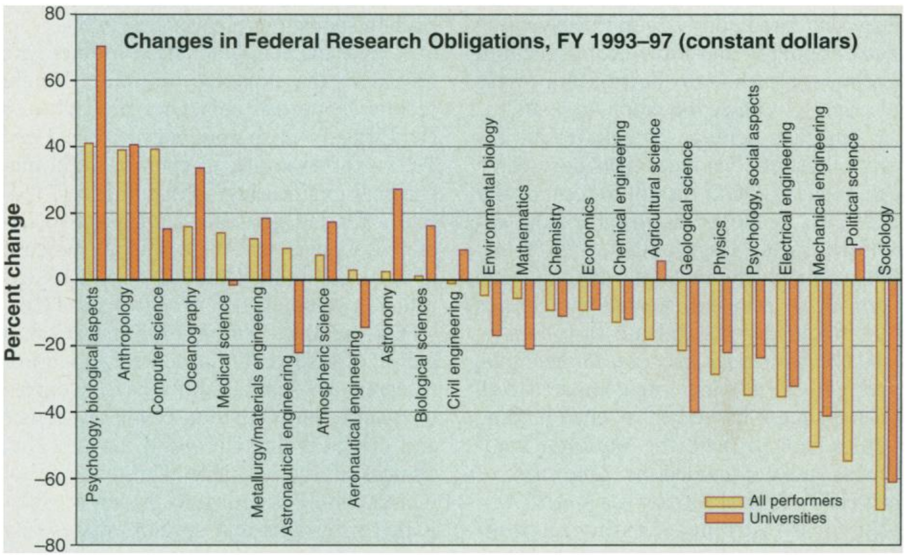
"Because of the interdependent nature of the scientific and engineering disciplines, the aggregate funding levels authorized [by this Act] assume that the Federal research portfolio will be well-balanced . . . ." So states the Federal Research Investment Act, which passed in the Senate and calls for a near doubling of U.S. government spending on civilian science and engineering research during the next decade (*1*). Likewise, the President's science adviser and budget director (in providing guidance to agencies for preparing FY 2001 budgets), asserted that the administration "will ensure that the government-wide portfolio of R&D investments establishes a desirable balance among fields of science" (*2*). And the 1998 House Science Committee report to Congress urged support of research "in a broad spectrum of scientific disciplines" and resistance to "overemphasis in a particular area or areas relative to others." (*3*).

Evaluating balance depends on one's program priorities and research field preferences. But any judgment should be informed by detailed knowledge of the changes in research support during the past decade, changes brought about by the end of the Cold War, new national security requirements, and efforts to reduce the federal budget deficit. We know a good deal about certain areas of science and engineering that have been congressional or administration priorities—biomedical, high-performance computing, and global-change research. Surprisingly little attention has been paid to the research fields that have not prospered, why they have lagged, and what the consequences might be.

Real growth in total federal R&D spending began to level off in the late 1980s, and between 1992 and 1997 it dropped by nearly 9% in constant dollars (that is, after inflation). Federal spending on the research part of R&D peaked in 1993 and by 1997 was 2.2% less in constant dollars. This much is well known. So, too, is the fact that the trend has not been uniform across agencies. Research budgets have increased at the National Institutes of Health (NIH), National Science Foundation (NSF), National Institute of Standards and Technology (NIST), and (because of an upturn in 1997) National Aeronautics and Space Administration (NASA) and have dropped at the Department of Defense (DOD), Department of Energy (DOE), and the Departments of Agriculture and Interior. The agencies with static or falling budgets turn out to be the primary funders of certain fields of research, the agencies with rising budgets the principal sources of support for other fields. So, inevitably, some fields' support shrank as other fields' support grew.



Why does this matter? One argument is that it is important to continue to invest across the range of scientific and engineering disciplines both to sustain cross-fertilization and because the sources of major advances are largely unpredictable. A related argument is that curtailing research constricts the supply of trained people capable of exploiting emerging research opportunities. With these rationales, successive Academy reports from the National Academies have recommended as an explicit goal of research policy maintaining U.S. parity with or superiority over other countries' capabilities in all major fields of science and engineering (*4*). The private sector Committee for Economic Development recently stated that "all fields require adequate support in an increasingly multidisciplinary, mutually reinforcing environment" (*5*).

There is another, more mundane reason to be concerned about the pattern of allocation of public research support. In the decentralized U.S. system of support for science and engineering, a great deal of research funding is tied to the missions of federal agencies. If a mission changes, research support in related fields may decline for reasons that are entirely defensible in terms of the agency's priorities, but are largely unrelated to research opportunities and productivity in particular fields, and that may ill serve some national need more broadly conceived. The unintended spillover effects of decisions dictated by agency mission needs are of much more concern when budgets are flat or declining than when spending in most fields is rising.

To find out in detail what has happened to research funding by field in the 1990s, we consulted the annual surveys conducted by the NSF of agencies' basic and applied research obligations to all research performers during the previous fiscal year in 26 fields of science and engineering (*6*). The six largest R&D-supporting agencies separately report obligations for research performed at universities and colleges (*7*). This information can be compared with data collected from university departments on sources of graduate student support to assess how fluctuations in research funding might be affecting training of scientists and engineers (*8*). As with any data set, there are limitations in quality, uniformity, detail, and currency that handicap analysis. But this is the only reasonably consistent, comprehensive, long-term (beginning in the early 1970s) data series bearing on

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the question of how the public research investment is allocated by field.

We compared support for fields in FY 1993, the peak funding year in most cases, and FY 1997, the last year for which data on actual obligations are available, with the following results (*9*):

The research fields with declining constant dollar support outnumber the fields with growing support by 15 to 11. Federal funding reductions range from less than 1% (civil engineering) to nearly 70% (sociology). Seven fields—electrical engineering, mechanical engineering, physics, geology, political science and social psychology as well as sociology—suffered a drop of 20% or more. The reductions are concentrated in the physical sciences and engineering, with the exception of computer science and materials engineering, whose overall support increased 39% and 12%, respectively. Most of the social sciences also fared poorly, with the exception of anthropology and biological aspects of psychology, although the funding levels are much lower (see the graph on p. 1679).

Computer science and materials research illustrate that reductions in research supported by DOD do not automatically mean cuts in the fields in which the department is the largest funder (57% and 73%, respectively, in 1993). By the same token, fields primarily funded by agencies with rising budgets did not fare equally well. The biological sciences, for example, experienced a 1% increase compared with a 14% increase in medical science funding even though in 1993 the National Institutes of Health provided the same share of each field's federal support—about 83%.

In the constrained funding environment that continues to prevail, there is no consistent pattern of protecting support of university research relative to in-house research and research performed in the corporate sector. Although total federally funded university research increased slightly from 1993 to 1997 and universities fared better than "all performers" in 17 of the 26 fields, there were more areas in which universities lost ground (15 fields) than gained it (11 fields). In three cases, aeronautical engineering, astronautical engineering, and medical sciences, university research actually declined even though overall federal support in those fields increased.

No single agency is serving as the "flywheel," to ensure some stability of funding in fields whose support is declining elsewhere. The NSF, with the broadest research portfolio, appears to be amplifying the changes in other agencies, boosting funding for most of the fields that prospered elsewhere and reducing funding for fields being cut elsewhere, with the exceptions of civil and aeronautical engineering. Of course, given the relatively modest size of the NSF budget, increases in NSF funding would not be sufficient to compensate for substantial cutbacks in most fields by DOD, for example.

In the 5 years covered by this comparison, changes in agency budgets resulted in significant changes in the structure of support of some fields. For example, NSF surpassed the Commerce Department (National Oceanic and Atmospheric Administration) as the leading supporter of research in oceanography, and DOE surpassed NSF as the second largest supporter of computer science research. Important changes also occurred in some declining fields. The Department of Commerce (through NIST) went from a marginal to a substantial (second only to DOD) source of electrical engineering research support, and NASA replaced DOD as the second leading sponsor of physics research.

The changes in graduate enrollment are mostly in the expected direction. Where federal support of university research in a field was down sharply between 1993 and 1997—for example, in chemical and mechanical engineering—the number of federally funded graduate students also declined. Conversely, there was an increase in federally funded graduate students enrolled in computer science programs (*10*).

During the Clinton administration, a period of essentially flat federal support of research, substantial shifts have occurred in funding levels among fields of science and engineering. The good news is that choices are being made. The tendency of incremental budgeting to preserve established programs and spread cuts evenly among performers has, apparently, been avoided (*11*). And the system has managed to respond to some new societal demands and research opportunities (in medicine, computation, and materials engineering, for example) by shifting resources to them. But many of the reductions seem to have occurred with little forethought or consideration of how the health of key disciplines will be affected. In the absence of any explicit public discussion of the cuts and their implications, it would be foolish to assume that the result is a "well-balanced" research portfolio.

Three steps are needed. First, research fields undergoing substantial reductions in funding should be subject to a bottom-up evaluation to assess whether the cuts are justified or jeopardize national interests in the broadest sense. Second, there needs to be an open, explicit discussion of national science and technology priorities of the kind advocated by some policymakers over the past decade—a discussion involving the scientific and engineering communities. Finally, the Office of Science and Technology Policy, Office of Management and Budget, and Congress should be prepared to make adjustments when this process points to a serious shortfall in desirable investment. Only then can we be confident that shifts in priorities of the magnitude we have recently experienced are ones from which the nation will benefit.

References and Notes

1. S. 296, 106th Cong., 1st Sess., § 6 (1999).
2. N. Lane and J. Lew, Memorandum for the heads of executive departments and agencies: Regarding FY 2001 interagency research and development priorities, 22 April 1999.
3. U.S. Congress, House of Representatives, Committee on Science, *Unlocking Our Future: Toward a New National Science Policy* (Government Printing Office, Washington, DC, 1998).
4. Committee on Science, Engineering, and Public Policy, *Science, Technology, and the Federal Government: National Goals for a New Era* (National Academy Press, Washington, DC, 1993); National Research Council, *Allocating Federal Funds for Science and Technology* (National Academy Press, Washington, DC, 1995).
5. Committee for Economic Development, *America's Basic Research: Prosperity Through Discovery* (New York, 1998).
6. National Science Foundation, *Federal Funds Survey, Fields of Science and Engineering Research Historical Tables, Fiscal Years 1970–99* (NSF 99-345, National Science Foundation, Arlington, VA, 1999). Available online at www.nsf.gov/sbe/srs/nsf99345/start.htm. Obligations are commitments to spend money although actual payment may be made later, for example, under multiyear contracts. "All performers" include government and contract laboratories and industry, as well as universities, colleges, and other nonprofit institutions. The 26 fields are grouped into major areas—engineering, physical sciences, life sciences, mathematics and computer sciences, environmental sciences, social sciences, psychology, and "other sciences"—for which obligations estimates are reported for two fiscal years beyond the year for which actual obligations are known. In addition, each major area of science and engineering has a residual, "not elsewhere classified" or "n.e.c." category of research.
7. National Science Foundation, *Federal Funds Survey, Fields of Science and Engineering Research to Universities and Colleges Historical Tables, Fiscal Years 1970–99* (NSF 99-346, National Science Foundation, Arlington, VA, 1999). Available online at www.nsf.gov/sbe/srs/nsf99346/start.htm.
8. National Science Foundation, *Graduate Students and Postdoctorates in Science and Engineering: Fall 1997* (NSF 99-325, National Science Foundation, Arlington, VA, 1999). Available online at www.nsf.gov/sbe/srs/nsf99325/start.htm.
9. M. McGeary and S. Merrill, Appendix A, in *Securing America's Industrial Strength*, National Research Council (National Academy Press, Washington, DC, 1999). This source reports 1990–97 constant dollar research obligations for all performers and for work performed in universities in 19 selected research fields. Research obligations in current dollars in all 26 research fields on which data are collected are available online at www4.nationalacademies.org/pd/step.nsf "R&D Data."
10. Over time, these effects may not be very large because federal funding is not the principal source of support for graduate training in most fields, and research grants are only one way the government supports graduate education.
11. P. M. Smith and M. McGeary, *Issues Sci. Technol.* **13**(3): 33 (1997).

12. The authors thank C. Hill, P. Smith, and N. Metzger for comments and C. Schultz for preparing the data presentation in this article, in the report (*9*), and on the Web site listed above.