11 Earmarking: The Expansion of Excellence in Scientific Research

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The title of this section rests on the fiction that we are already in an age of earmarking—a time when earmarking is the primary funding source of academic science. This viewpoint is reinforced by those who decry earmarking as unfair to research and development (R&D) and damaging to science. In fact, however, but for a few historical exceptions, only a small percentage of academic science is or ever has been funded by earmarking, and the recipients of earmarked funds have leveraged those grants many times over to demonstrate their value through the scientific advances they have made.

Critics of earmarking rarely distinguish between those funds earmarked for science and those earmarked for nonscientific purposes. I have no opinion, for example, concerning the merits of earmarked funds to restore the Lawrence Welk house, but I doubt that this example of earmarking poses a serious threat to academic science. Such examples have nothing to do with science and therefore are outside the subject of this section. I do not condemn those outside science in principle, however, because the Constitution of the United States gives citizens the right to appeal directly to Members of Congress. This establishes the legitimacy, although certainly not the wisdom, of all earmarking.

Earmarking for academic science has generally amounted to no more than one-half of one percent of all federal funding for R&D. In 1999, the total federal funding for R&D was $15.6 billion, and earmarked funds amounted to only $797 million.

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Congress engaged most heavily in earmarking when imperatives of the Second World War and, later, the Cold War required the development of an infrastructure of basic and applied scientific research to meet the needs of national defense. Universities were not only the obvious places for this research, but also the only places where persons most competent to engage in such research were available in large numbers. For this reason, Congress created a university-based infrastructure for advanced scientific research and technology development that has continued to expand to this day.

Congress earmarked massive funds for the Manhattan Project at Columbia University and the University of Chicago. It followed up by developing or enhancing national laboratories associated with the Universities of California and Illinois, the California Institute of Technology, the State University of New York at Stony Brook, and others. The location of Los Alamos in a desert close to the Universities of California was an obvious choice considering the nature of its research and availability of persons most qualified to contribute to it. The Fermi National Accelerator Lab was located in Illinois in large part because that is where Senator Everett Dirksen wanted it. But its location benefitted and was heartily applauded by the Universities of Illinois and Chicago, both key beneficiaries.

Congress also earmarked massive funds without peer review in establishing the National Science Foundation (NSF), the National Institutes of Health (NIH), the National Institute of Mental Health, and the National Aeronautics and Space Administration, agencies which then used peer reviewed funds to support academic science. But let us never forget—the funding of these agencies has not been won by peer review in competition from other agencies or proposals for agencies that perhaps have not yet been created.

One must wonder where academic science would be had Congress not earmarked funds necessary to produce a series of extraordinarily important and highly fruitful centers of advanced scientific research at major universities, along with national institutions and foundations to provide funding through peer review. Far from being threatened or compromised, scientific research has flourished as a consequence of these programs funded through congressional earmarking.

I do not recall a single protest being raised by the beneficiaries of this congressional earmarking—not by NSF and not by the Association of American Universities (AAU), or any of its members. I suspect that the true source of their good fortune has never crossed the minds of those beneficiaries of congressional earmarking. Like Pip in *Great Expectations*, who believed that the proper Miss Havisham was his beneficiary, rather than the murderer Magwitch, AAU and NSF seem to believe that their good fortune has resulted not from earmarking, but from a pure system of peer review. But it can be said of Pip that he was quite unaware of Magwitch's existence; while our modern-day academic Pips have known about earmarking. But they piously deny their own dependence on the Magwitch's of Capitol Hill while condemning new groups of universities which, by means of earmarked funds, create new, competitive centers of excellence in academic science. Of course, when new centers are introduced, and they rise in the rankings, some of the old establishments see a drop in their rankings. That does not mean that they have reduced their quality or success in peer review, it means only that their relative standing has declined as a consequence of increased competition.

The system of distributing funds by peer review rather than congressional discretion is by no means a perfect one; it is, rather, a flawed system where the members of the "in" group are in a favored position to receive funds. There is nothing pure about the peer review process, even though peer review has been portrayed by its major beneficiaries as a pure, objective, competitive process. In fact, until competition was successfully enlarged by means of earmarked funds (creating additional centers of scientific excellence), the peer review process was almost exclusively dominated by a tight little network of established universities. They still crowd it, but less so than they used to.

In 1987, the General Accounting Office reported a remarkable correlation between the institutions that provided the peer reviewers and the institutions that received the funds.[1] It said: "For NSF, the top 20 institutions supplied approximately 25 percent of the peer reviewers. They received about 24 percent of the proposals awarded and about 46 percent of the NSF funds to universities." In other words, peer reviewers awarded the largest grants to their own or similar institutions, that is, to their buddies.

The scientific community as a whole never labored under any illusions about the purity or objectivity of the peer review system. According to a survey conducted in 1986 by Sigma Chi, 62.8 percent—nearly two-thirds of all scientists surveyed—agreed with the statement "Procurement procedures for grants to do governmentally sponsored research depend on 'who you know.' Many requests seem to be funded primarily because the researchers are already known to and supported by the granting institutions."

Under peer review, who gets the funding has largely depended on whom one knows, not which Members of Congress one knows, but which members of the review panels. By anybody's definition, that is an "old boy" network. The spokesmen for the institutions that benefit from the "old boy" network, of course, see it as the natural, perhaps even divinely ordained, way to allocate federal funds. The rich have always tended to see the system that made them rich as the best and the noblest.

In 1985, only ten research universities, or fewer than two percent of the 653 eligible research programs, received 25.9 percent of total federal R&D funding and 28.3 percent of NSF funding. Just 20 research universities received 40.8 percent of federal R&D, and 44 percent of NSF funding. The dense concentration of NSF funding is particularly inappropriate because NSF's statutory mandate explicitly requires it to avoid an undue concentration of resources.

This situation has hardly changed since that time. No one should be surprised to discover that in FY 1999 (when federal research funding totaled $15.6 billion), the top ten institutions receiving federal funding—all members of AAU—received 22 percent of the funding; the top 20 received 37 percent of the funding—all but one members of AAU. Fifty-nine of the 61 AAU members eligible to receive federal funds (excluding McGill University and the University of Toronto) received 60.4 percent of those funds.

NSF funding showed a similar pattern in FY 1999. The top ten, including nine from AAU, received 24 percent of the funding; the top 20, including 17 from AAU, received 39 percent.

We can conclude from this information that peer review is understandably and inevitably biased in favor of established programs whose faculty dominate the review process. This results in the narrow channeling of an excessive percentage of federal research support to only a handful of established universities.

James Savage in Chapter 10 of this volume discusses earmarking as the academic pork barrel. In his view, this process is used by universities who are incompetent to win competitive grants through a peer review process. But he knows that the University of Virginia, where he teaches, has received millions of dollars in earmarked funds, either directly or in a consortium of universities. Howard Gobstein of Michigan State University (see Commentary in Part 4 of this volume), knows that his institution participated, for example, in the Consortium on Animal Waste Management to secure through earmarking a major million-dollar grant.

So the “old boy” network has been strident in its righteous condemnation of earmarking while assiduously availing itself of that process. It has also proclaimed the superiority of peer review, a system by which its members continue to garner the highest percentage of funds by providing the highest percentage of reviewers.

This is why it has been necessary for Congress to serve the national interest by creating new centers of scientific excellence. Thanks to congressional earmarking, the allocation of funds by peer review is gradually becoming more fairly distributed as Boston University and many other institutions have created new and competitive centers of excellence in academic science. Congressional earmarking is vindicated by the emergence of these new centers of superb research in science and engineering, such as the Tufts School of Nutrition Science and Policy and the Center for Microelectronic and Computer Engineering and Center for Imaging Science at the Rochester Institute of Technology.

By offering earmarked challenge grants, Congress has assisted aspiring universities to build and equip state-of-the-art facilities. With these in place, they have been able to recruit scientists and engineers of outstanding quality who confirm the significance of the new centers by bringing to their institutions millions of dollars awarded through peer view.

Boston University offers a demonstration case. In describing our success, I am not trying to brag; my point is to show how earmarking leads not to bad science but to an explosion of first-rate science.

In 1971, when I came to Boston University, we received less than $10 million in federal funds. Most of that came from NIH and went to our medical school. Federal funding for science and engineering was negligible. By 1975, federal funding for research in physics, biology, chemistry, and engineering was only $1.2 million and growing slowly.

We then asked Congress to earmark funds to assist us in acquiring facilities and equipment necessary to attract a first-rate faculty. In 1985, we received $19 million to build a science and engineering center. In 1988, we received $8.5 million for a physics and biology research center. In 1991, Congress appropriated $29 million to create a center for photonics research. In 1999 and 2000, it sent an additional $6.3 million to support technology development in the Photonics Center. Earmarked funds totaled $62.8 million, of which $41.8 million was for construction. Boston University matched those construction funds with a contribution of $156 million, leveraging the congressional investment by 3.7 to 1. We matched the $2.5 million for equipment with $35 million, a 14 to 1 match.

Boston University's Photonics Center, although comparatively recent, provides a dramatic example of how carefully targeted earmarked funds can produce extraordinary results. It was established in 1994 as a focal point for photonics research and photonics technology development, education, and commercialization. Donald Fraser—former director of the Draper Laboratory at the Massachusetts Institute of Technology and former Undersecretary of Defense for Procurement—was appointed to direct this program. The center is housed in a new, specially designed building of 235,000 square feet. It includes world-class laboratories, new business incubation facilities, a core photonics and systems engineering staff, and internationally known faculty and research fellows in a wide variety of scientific, computer, and management fields. Research facilities include an optical fiber draw tower and lathe to produce optical fiber and optical fiber devices and lasers.

Congress earmarked the funds for the development of the Photonics Center on the same principles it used when it funded the Manhattan Project. It recognized that photonics will have an impact on the next generation, especially on national defense and economic development at least as profound as that of electronics in the generation just past. Boston University was selected for the development of photonics research because of the strength of our proposal and the strength of the faculty and facilities available for photonics development. The grant was made with the explicit understanding that Boston University would match congressional funds many times over. The grant was seed money for an exploding technology.

Since 1999, the Photonics Center, under contract to the Army Research Laboratory, has accelerated the development of photonics technology in direct support of the Army mission with the goal of eventually commercializing the most promising technologies for availability to the Department of Defense. Virtually every weapons system now uses photonics technology in some way, from displays to sensors to command and control. Thus far, the Photonics Center has developed devices already in production or prototype for a small sensor to warn pilots of an incoming missile from the direction of the sun (not detectable without photonics) and for the "Smart Shoe," a distributed sensor system placed inside a soldier's boot to allow every soldier to be fitted with appropriate footwear and thus improve performance. The Center is incubating a company to facilitate the commercialization of this technology. One application is for use by hospitals. The technology can be used to determine the position of patients so they can be moved to avoid bedsores or so staff can be alerted if the patient falls out of bed or moves in a way that is dangerous.

The Center has also developed a prototype of a lightweight portable device that detects and identifies harmful chemicals and biological pathogens in water, air, or fuels that may threaten military personnel or the civilian population.

These are only a few of the products already prototyped or manufactured as a result of research at the Photonics Center, and this center is just one of the outcomes of earmarking at our university.

By 2000, the federal grant and contract support for physics, biology, chemistry, and engineering at Boston University had risen from $1.2 million in 1975 to $31.2 million. Every dollar of this increase came through peer review. By acquiring state-of-the–art facilities and equipment we were able to recruit faculty and research associates of the very highest quality, many of whom brought peer-reviewed grants with them.

With new facilities in biology, we added ten outstanding faculty of international reputation. We also added new junior faculty, all of whom have established well-funded research programs with major peer reviewed grants from NSF, NIH, the Department of Agriculture, and the American Cancer Society. In the last four years, grant funding in the biology department has doubled to more than $10 million.

Earmarking has also transformed the physics department. With new facilities, we attracted Larry Sulak and four outstanding young physicists from the University of Michigan, and later, our fourth Nobel Laureate, Sheldon Glashow, formerly of Harvard University. With these scientific stars in place, the university added 12 new faculty and 38 new postdoctoral positions. Annual research funding from peer review has risen over fourfold in the past 15 years, from $1.5 million to $6.8 million. The yearly number of refereed papers is up almost sixfold, from 34 to 184. The number of citations is up sixfold, ranking Boston University 10th among independent universities! The number of Ph.D. candidates is up more than threefold from 30 to 100, despite a drop of 25 percent in the United States over the same time span. And the number of research associates has soared 20-fold, from 2 to 40.

Although a substantial lag exists between objective accomplishments of a department and their reflection in the reputation polls, the most recent National Research Council (NRC) ratings taken in 1992—nine years ago and only six years into our expansion following earmarking—demonstrated a rise in the stature of the physics department from 74th to 38th. This was the largest jump by any institution in that evaluation, and we are regularly queried on the keys to our success. Our goal for the NRC review anticipated in 2002 is to break into the top 25: the objective measures more than justify this jump.

The NRC reports that external peer reviewed funding per physics faculty member at Boston University is higher than that at Harvard and several other AAU member universities, including Yale, San Diego State, Rutgers, Minnesota, Ohio State, Brown, Carnegie Mellon, Rockefeller and Purdue.

The faculty has garnered over 70 national awards and fellowships over the last decade. It has also played seminal roles and provided critical technology for major discoveries, including the fourth most highly cited physics experiment of the century (the Super-K discovery of neutrino mass) and the first possible indication of physics beyond the standard model (the *g-2* experiment). In addition, as a part of the $19 million appropriated for the Center for Science and Engineering, we have a state-of-the-art scientific instrument facility that is used by Harvard, the Massachusetts Institute of Technology, the Fermi National Accelerator Lab, Brookhaven National Laboratory, and the European Organization for Nuclear Research (CERN). Recently, our scientific instrument facility constructed the first and only telescope at the South Pole, and machined most of the components of the *g-2* ring, the world's largest and most accurate superconducting magnet. The electronics facility in the center designs and produces state-of-the-art chips and circuit boards for major forefront projects at Fermilab, Brookhaven, CERN, among many others.

Measured by the peer review funding per faculty member, the total number of refereed papers per year, or the annual number of citations for their work, our physics department now ranks in the top ten universities of the nation.

Developments in the College of Engineering are equally impressive. The Dean of Engineering, Charles DeLisi, was recently honored with the Presidential Citizens Medal for his seminal work in initiating the Human Genome Project. He has attracted leading researchers in several aspects of genomics, photonics, and quantum optics. Ph.D. degrees granted by the College of Engineering have risen from one in 1988 to five in 1992 to 29 in 1998; and the total number of Ph.D. candidates is now nearly 200. Over the past decade, the engineering faculty have improved their success in peer review competition from $4.9 million in 1990 to $20.5 million in 1999.

The University's overall ranking in federal research and development funding for science and engineering has moved from insignificance in 1970, to 50th in 1995 (with $83.5 million) to 33rd in 1999 (with $131.2 million).

This review of the programs in academic science and engineering at Boston University refutes the disingenuous claim that earmarked funds have resulted in bad science and damage to the best interests of our nation. Rarely has Congress made better investments than those through earmarking to Boston University. And Boston University is not unique. We and others have won the ear of Members of Congress not because of some nefarious, underhanded effort by unscrupulous lobbyists, but because we have had projects so clearly in the national interest that Congress has seen fit to support them. Far from threatening the purity of peer review, earmarking has increased its fairness. Earmarking has created new centers of academic excellence in which scientists and engineers of the highest quality now successfully compete for support through the traditional process of peer review. By this process, they substantially enhance academic science in our nation.

Endnote

1. U.S. Congress. General Accounting Office. *University Funding: Patterns of Distribution of Federal Research Funds to Universities*. Washington, DC: February 1987.