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A Scientific Method For Money; We Need Smarter -- not Bigger -- Spending for Tomorrow's Research

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Society has come to expect that American science and engineering will contribute to the general economic and social welfare of the nation across a wide spectrum -- from atomic energy to molecular biology to microelectronics to zoology. In the 1990s and beyond, the ability of U.S. scientific enterprise to meet these expectations will depend largely on how well the federal government allocates resources and administers programs. We rely on the federal government to support basic research because private industry cannot be expected to make investments that lead to substantial, but unpredictable, public benefits.

I believe the government is performing these key management functions poorly and significantly less well than in the past. The shaping of basic research programs in many federal agencies is more like looting by mobs than disciplined pursuit of reasoned priorities.

Consider the following troubles faced by major agencies that support science:

The National Institutes of Health (NIH), despite ever growing budgets, is giving inadequate support to new individual investigators, and instead is putting money into continuing projects.

The Department of Energy (DOE) has embarked on an unaffordable number of projects -- giga-projects, not simply mega-projects -- which will be built, if at all, on delayed and therefore even more costly schedules.

The Department of Defense (DOD) is allocating an increasing fraction of its technology budget to its in-house laboratory system, denying opportunities for universities,

The National Science Foundation nonprofit institutes and industry to compete for the work. (NSF), in its eagerness for expansion, favors institutions that agree to supplement federal funds with their own. Such "cost-sharing" sacrifices scientific excellence on the altar of cash and forces universities to take money from undergraduate education to support NSF-sponsored projects.

The National Aeronautics and Space Administration (NASA) is pursuing major projects that either have little demonstrated scientific merit, e.g., the space station; or don't work as planned, e.g., the Hubble Space Telescope.

Why is faltering federal stewardship so serious now? First, changing world political and military relationships mean that the United States must redirect defense research. We must support new information technologies that have dual military and civilian applications, rather than exotic technologies to defend against massive ballistic missile attack. We can and should place increased research emphasis on other pressing societal needs -- understanding global environmental

problems and improving health, for example.

Second, there is increasing interest in directing federally sponsored research toward technologies that will improve U.S. industrial competitiveness in international markets by manufacturing better quality products. The nation does not lack the creativity to design a new chip, for example, but rather the ability to produce the chip at low cost and integrate it into a competitive product. Shifting research emphasis from technology creation to technology application (in terms of production, design for quality performance and cost) is a major challenge for the U.S. scientific community. Progress requires reorienting some of our research and education effort toward learning how to make things well.

Finally, the severely constrained budget climate inhibits the historic pattern of adding, never eliminating research programs. The scientific community enjoyed significantly larger research budgets throughout the Reagan and Bush years, but the curve is likely to remain flat in the future. Resources to undertake new programs in manufacturing technology, material science, software engineering and earth sciences will have to come from more efficient use of current research expenditures.

Today, more than in the past, agencies are funding projects in response to pressure from scientific interest groups, research and development contract performers, and congressional supporters. Since all projects have some merit, advocates feel justified in wielding political clout that both the federal bureaucracy and Congress find difficult to resist. DOE, for example, has undertaken a stunning list of projects, all of which cannot conceivably be funded.

A typical example is DOE's plan to construct the $ 10 billion-plus superconducting particle collider in Texas rather than collaborating with the Europeans on a less ambitious, cheaper, high energy physics project at the international laboratory (CERN) near Geneva.

NASA's estimated $ 30 billion space station project illustrates the sorry state of affairs. In this case, the political process has culminated in a decision to proceed with the program instead of meritorious scientific projects. This decision was taken despite advice from two prestigious review panels -- the Augustine NASA review panel and the Space Board of the National Academy of Sciences -- that the project has no clear purpose.

It is no surprise that such giga-projects have the support of their user communities, contractors and the congressional delegations of the project districts. In addition, several agencies -- notably DOD and NASA -- spend a large fraction of their technology resources at government labs, allocating funds without competition from outside researchers in industry and universities. Currently, the in-house labs soak up more than two-thirds of the $ 21 billion spent per year on the federal laboratory system.

Contractor-operated labs such as Lincoln Laboratory (operated by MIT for the Air Force) and Oak Ridge (Martin Marietta for DOE), have greater flexibility than government laboratories because they can perform technical work without the constraints of Civil Service personnel rules and federal procurement regulations. Thus, converting some federal labs to contractor-operated facilities would lead to a more effective research-and-development system. However, political resistance to change remains strong.

DOD and other agencies should shrink the size and upgrade their in-house labs and use any money left over to fund more competitive research at universities, industry, and federally funded private labs.

The nation has relied on a capable and dedicated cadre of technologists in the federal bureaucracy to set research priorities and manage programs. But in the '90s, attracting good scientists to federal career service has proven difficult, because of lower pay and burdensome post-employment restrictions. But most importantly, federal researchers have repeatedly seen their judgments and authority undermined by special interests. Congress is more responsive to scientific or industry pressure than to federal research managers, a strong disincentive to federal service.

What is needed is smarter spending, not more spending. The way to reach this goal is to pay attention to the recommendations of experts, instead of making decisions based on political considerations, such as the supercollider

project.

Some would place greater reliance on the president's science adviser. But this individual's most important task is to counsel the president on the technical aspects of such pressing national issues as defense, the environment, health and productivity. The science adviser is not in the White House to butter the bread of the scientific community, nor to take responsibility for the planning or implementation of agencies' programs. The adviser should work for the appointment of the most competent technical individuals. The recent appointments of Walter Massey as director of the National Science Foundation, Bernadine Healey as director of the National Institutes of Health, and Will Happer as DOE director of energy research are excellent examples.

I believe the most promising way to restore faltering federal stewardship is for the scientific community to play a larger, formal advisory role in assisting Congress and the Executive Branch to set priorities for projects and fields that compete for available resources. The advisory function should enhance the process of making choices within available resources, not advocate more resources for science. Physicists, for example, must reach a consensus on the value of the supercollider relative to condensed matter physics.

The role of scientific advice in the allocation process is often constrained by scientists themselves, who are reluctant to pass judgments across fields for the understandable reason that an astronomer has little standing to choose among chemistry or computer science alternatives. In the past, the scientific community has been willing to rely upon the wisdom of the sponsoring agency and the random legislative process to allocate resources. But the need for the scientific community to intervene becomes more critical because even as the complexity of the scientific process grows and becomes more costly, technical competence within federal agencies declines, and Congress increasingly views big science as big pork.

The best mechanism for providing this advice is the federal advisory committee structure, where scientists help decision-makers appreciate new scientific opportunities and gauge the consequences of alternative courses of action. For many years, NSF has had advisory committees organized by established disciplines to help set priorities within fields. We need to add a more formal structure at a higher level. At NSF, this would mean establishing a stronger advisory role for a committee with authority over all physical and mathematical sciences. Other agencies can have their priority-setting mechanisms similarly strengthened.

Congress and executive agencies should welcome a system in which the scientific community has greater responsibility to state priorities. Currently, scientific interest groups are pressing their cause to weakened agencies and to Congress. There is no voice to rank competing demands against objectives; the result is too many projects amid too little money. The nation would be better off if in each agency's budget-setting process, an independent and qualified group of scientists came forward with a statement of research objectives and an evaluation of the relative value of competing programs in meeting those objectives. This scientific advice would not replace the political process but instead would encourage our political leaders to use better limited scientific resources.

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