Government Funding and Computing Research Priorities

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Much recent debate in both scientific and government policy circles has focused on the degree to which government should "steer" research, i.e., pick strategic priorities for funding. This debate was triggered by a general sense that the fundamental contact between government and science is being redefined. Even with the recent political trauma in Washington, this redefinition is likely to continue, for the simple reason that the underlying forces driving it are unchanged. Many in the research community have been concerned about possible negative effects of this change on the research agenda, seeing in it the intrusion of nonscientific political judgment into scientific decisions—bureaucrats assessing the quality of research results, politicians selecting research priorities, and lawyers designing research protocols. We suggest here, however, that while these changes are real, important, and long-lasting, they are also rooted in the long-standing interlock between government funding and research priorities, particularly for computing research.

The principal effect of these changes in policy direction is to make the research community responsible for engaging in a continuing dialogue with government, at many levels and in many ways. Researchers need to accept as a fact of life the inevitable and sometimes heavy-handed influence of government, while continuing to participate in scientific judgments. It will be a difficult balance for both politicians and researchers to maintain, yet it is necessary for the long-term health of the field.

THE MYTH OF "CURIOSITY-DRIVEN RESEARCH"

Scientific research is in theory a closed system, setting priorities, evaluating results, and policing processes according to its own internal standards and systems. In fact, these types of judgments are such an inherent part of the scientific process that the research community takes it as given that only those highly trained in the process (i.e. scientists) are qualified to make them. Part of the training of a scientist is in making such judgments.

In a perfectly closed world, that is how the system should operate: researchers, motivated purely by curiosity and scientific instinct, pursue the questions and directions they please, and their professional reputations rise

or fall on the judgment of their peers. However, the world in which research takes place is not closed, nor has it been for many years, because research is an expensive endeavor. Funders, whether governmental or private, rarely have purely philanthropic motivations. It is their money and, lacking sufficient funds to support all applicants, they must select among the contenders. It is not surprising that, in making those choices, funders express their own interests, values, and purposes. This fundamental disconnect of interests and perspectives between researchers and their funders creates a permanent tension that can be managed but never finally resolved, because it is inherent to their different respective roles and outlooks.

Thus, despite ebbs and flows in the rhetoric about the importance of basic versus applied research, politicians and U.S. government agency officials have for over a century assumed that the main purpose of funding science and technology has been to advance certain social purposes. Defense is just one example. It is no accident that the National Academy of Sciences was formed during the Civil War and the National Research Council during World War I. The agricultural research program, dating back over a century, was intended to improve U.S. agricultural production, to develop new techniques and bring them to American farms. The research institutes that comprise the National Institutes of Health were formed to fight disease, NASA to conquer space, NOAA to map the oceans and improve weather and climate prediction, and so on.

Of all the Federal agencies that fund research, only the NSF has an explicit mission to support science solely as science. But even the purity of that role can be overstated: the creation of the NSF was most certainly stimulated by the obvious contribution of scientists to the successful conclusion of World War II. And Vannevar Bush's famous report, considered to be the political manifesto that resulted in the creation of NSF, is filled with assertions of the importance of science and technology to society. NSF management has always been sensitive to this connection.

The author recalls how, as an NSF program director in the late 1960s, part of his job was to help convince both Executive Branch budget analysts and Congress that research in basic computer science and engineering had "payoff," albeit in the long term. And no one who was around NSF in the 1970s can forget the desperate scramble to show "energy relevance" of its research programs. (Of course, when not defending the long-term utility of CSE research, we were fending off arguments from the more traditional disciplines—and budgeteers—that it was not research at all, but just developmental work duplicating that done by computer manufacturers. We can guess that CSE programs at NSF are still caught in some version of that tension between claiming strategic social benefits to gain outside support but justifying its basic research identity to maintain respect within the scientific community.)

MECHANISMS OF INFLUENCE

Government funding programs deliberately or inadvertently affect the computing research agenda in several ways. We enumerate a few of the more important ones.

Funding Levels

Obviously, as government funds become more limited with respect to demand, proportionally less research can be externally funded. The assumption is that, since the most meritorious proposals are still funded, these limits have little effect on the research agenda itself. But, in fact, there can be subtle effects, the most important being a trend toward funding "safe" traditional research at the expense of risky new ideas.

The pressure comes from both ends. Funders have less discretionary money to direct to high-risk ventures and are certainly less motivated to do so when highly meritorious mainstream projects are at risk. The agencies also feel pressures to fund more senior experienced researchers who have a track record, are known in the field, and know how to write successful proposals. Researchers, facing stiffer competition, are also less likely to strike out in new directions, particularly when they have had past success in their current area. When even one negative peer review can shoot down a grant, why risk alienating a reviewer with a strange new idea?

Some agencies try to set up programs to correct these biases, earmarking funds for young investigators or high-risk projects, but worthwhile as those programs may be, they can be only palliatives. Pressures toward mainstream research are inevitable and hard for program managers to resist.

Mission Agency Support

The role of mission agencies in steering research agendas has already been mentioned. Even agencies that fund long-range (in their terms, "basic") research in pursuit of their missions clearly pick and choose among possible directions according to their beliefs on which will best advance their technological goals. This multiplicity of agency support is a unique characteristic of American science policy and has always been considered one of its strengths: since any particular mission agency needs to select among research directions, researchers have multiple chances to convince the government of the "fundworthiness" of their ideas.

For all its strengths, mission agency support does have some drawbacks. For example, agency research programs, answerable to their management's own views of their own agency needs, tend to go their own way even when funding research in the same area as other agencies. At worst, this process can create pressures in the research community by sending conflicting signals about funding priorities or by creating splits in the community among scientists loyal to one agency or another. Multiple agency support can also suboptimize Federal research investment in a field by making it difficult to direct programs to important national needs that transcend particular agency missions. In the past, occasional attempts to coordinate have been made through the office of the President's Science Advisor, the Office of Science and Technology Policy (OSTP), but the Advisor has very little authority or influence over agency missions and budgets.

Special Initiatives (HPCC)

In the 1980s, computing research was at the center of a new attempt to create a true multiagency initiative—the High-Performance Computing and

Communications Program (HPCC). Established both by Presidential directive and a new law, this and a few related initiatives attempted to create a new government-wide research initiative by more tightly coordinating existing agency programs. Now five years old, HPCC illustrates both the benefits and dangers of more centralized government control of research priorities. For example:

Increased funding: One result of the HPCC, of course, has been an influx of Federal funds into computing. There has been some debate about whether this benefit has flowed to computing research itself as much as it could or should have. We do know that basic research funding grew substantially over the last several years of the program. But we also can expect that a highly publicized, multibillion-dollar program such as HPCC may well attract claimants from a wide range of fields, not all of them computing research—and, in fact, that the support of those claimants was an important factor in generating political support for the program.

Tighter control: Another result, for better or worse depending on perspective, has been a more centralized government setting of research priorities, and hence influence on the field, particularly in areas such as architecture. Tighter focus may move the field along faster, but it also risks missing opportunities by putting too many eggs in too few baskets. Not surprisingly, some of the harshest criticism of the HPCC program has arisen over the foci of the research programs, particularly those of ARPA.

Loss of interest: The key danger now faced by the HPCC program is that loss of political favor and momentum may bring down support for a field of research across the entire government, not just in one agency or office. If HPCC funding is cut, many existing agency research programs put into the HPCC hopper will be at risk.

Politicization: The good news is that the President and Vice-president really like the HPCC program. Personal interventions by Vice president Gore last year managed to protect HPCC funding from some serious Congressional attacks. The bad news, if Republicans control funding in Congress, may also be that the President and Vice president really like the program. HPCC has been by and large a bipartisan program, passed unanimously by a Democratically controlled Congress and signed by a Republican President, George Bush. Even then, though, some hint of the strain between bipartisan and partisan pressures appeared as some White House staff reportedly encouraged the President to veto the so-called "Gore Bill." Some in both the administration and the Congress may be tempted to make "technology policy," and with it HPCC, a partisan issue, which could be very dangerous to the future of the program.

Strategic "Choices"

Over the last two years the term "strategic research" has become commonplace in science policy discussions, particularly with respect to NSF. Although associated with a Democratic Congress, one suspects that, in the Senate at least, the pressures represented under the term will continue, though per-

haps in different language. The term reflects nothing more than a restatement of the old political desire to prioritize research funding according to its potential to serve social goals.

Although the debate over NSF's role in funding "strategic research" has engendered some controversy, especially in the basic science community, it is important to understand that "strategic" was never intended to imply "applied" as opposed to "basic." Committee language clearly indicated that the term was simply intended to refer to priority choices among and within fields. That is to say, one could argue that computer science research, no matter how basic, seems more strategic, and hence should receive a greater increase in funding than, say, cosmology. More problematic is the question whether within computer science one could or should choose among subfields on other than purely intrinsic scientific grounds.

CONCLUSIONS

We have argued that, for government-supported science, the idea of priority setting purely on the basis of intrinsic scientific merit is and always has been to some extent a myth, and that research priorities are the result of an ongoing and never-ending dialogue between the scientific community and the political and bureaucratic institutions. This thesis has significant implications for computing researchers. In particular, it suggests that engagement in this dialogue is an inherent part of the profession. It calls for leadership of the community and active participation by its members in the debate at many levels and in many ways. Just a few examples.

Peer review: Although NSF's process may be more formal than most, all science agencies conduct some form of formal or informal peer review of the scientific content of the research proposals they receive. Thoughtful, expert reviews not only help the program staff select the best projects for funding, they also form a collection of evaluative material that is used by the agency to plan future program growth, shrinkage, or changes in orientation.

Priority setting: Increasingly, the computing research community, working through its own organizations and quasi-governmental groups such as the Computer Science and Telecommunications Board of the National Research Council, is being called on to help set research agendas and priorities. These ad-hoc efforts became even more important in light of the elimination a few years ago of division-level NSF advisory committees in CISE and congressional pressures on the HPCC programs to consult more widely with the academic and industrial research communities.

Service: Most importantly, service in Washington, often on temporary detail to science agencies, has become the most direct and critical conduit for dialogue between the research community and the government bureaucracy. Partly, of course, this is because it places trained senior scientists at the key decision points for funding, but it is also because it involves those same senior scientists in the longer-term planning and program development activities in the government. It is hard to overstate the importance for a discipline that those positions be occupied by knowledgeable and experienced scientists.

Research priorities in disciplines heavily dependent on government support, like computing research, are neither set internally to the field nor imposed by a heavy-handed bureaucracy but are, instead, the result of ongoing dialogue and negotiation between the two communities. Although government agencies constantly solicit advice and help in various forms from the scientific community, decisions will be made whether or not that help is received. Thus, the burden is on the research community to engage actively in the dialogue at all possible levels, especially through service in Washington.