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The Research University: Doing Good, and Doing It Better

Academic research has been central to U.S. science policy and economic growth. With a bit of restructuring, and a little help from its friends, it should remain that way.

It is a remarkable fact that universities play such a dominant role in U.S. science policy. After all, universities employ only a little more than 10 percent of all scientists and engineers, and academia accounts for only 9 percent of all national R&D expenditures—private and public.

Witness, for example, the National Science Foundation's program for creating multidisciplinary Engineering Research Centers on university campuses. The centers are closely linked to industry and work in key areas of industrial technology judged to be vital to the U.S. economy in the future. Implicit in this program appears to be an expectation that the funding of university-based R&D will have much more economic leverage than equal amounts of money spent in other types of research institutions or on other kinds of technical activities.

The focus on higher education is by no means unique to the United States. Although it began here, it is in fact a worldwide trend. In other countries, where universities have not previously held such a central place in the formulation and implementation of national science policies, we find governments hastening to imitate the U.S. pattern. This is as true of the People's Republic of China and the Soviet Union as it is of Western Europe and Japan. Everywhere one sees movements to introduce U.S.-style grant making and peer review, not only in universities but in other types of research institutions as well.

Moreover, in almost every country, the mode of research support in universities is being gradually shifted away from institutional and block grants coming out of ministries of education toward competitive grants coming out of ministries of science or research. The Chinese, for example, have been trying to create a rough equivalent of NSF, to which university departments will submit applications for research funds that will be evaluated competitively by panels of prominent scientists. In Europe, each country is developing

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some kind of competitive grant program administered by national research councils. The fraction of total research support in foreign universities being allocated in this way is still modest in comparison to that of the United States, but the trend is unmistakable.

Even in the United States, the university component of national R&D is small, as noted. But this apparent smallness is partly an artifact of the enormous relative weight of the "D" in the national statistics, particularly the part arising from military R&D. Two-thirds of all federally supported R&D is development, but if defense work is subtracted, less than one-third of the civilian R&D remaining is development, and the balance is basic and applied research. When research only is considered, the universities account for about 25 percent of the total; and for "basic research," as defined in the NSF statistics, universities account for more than 50 percent.

This latter fraction represents a substantial growth in the relative role of universities, up from about 35 percent in the early 1960s. The increase is a by-product of the great expansion of universities and graduate education in the '60s resulting from the wave of the "baby-boom" generation; the size and research capacity of universities has been basically determined by student populations in combination with an average student/faculty ratio that has remained more or less constant. The political stimulus provided by Sputnik was also an important factor, though I personally think its role has been exaggerated.

The fountainhead of innovation

The U.S. science policy agenda was established quite firmly, in the years immediately following World War II, by Vannevar Bush in *Science, the Endless Frontier*. That report to the president, which has essentially remained the charter for national science policy up to the present day, has sometimes been called a "social contract" between the science community and society—a promise of social benefits in exchange for an unusual degree of self-governance and financial support free of strings. Universities were the centerpiece of this charter—indeed, the only institutions to which it seemed to apply explicitly—although some of the autonomy accorded to universities often rubbed off onto other institutions as well.

One could say that the scientific community—mainly the academic community—drew on the credit deriving from the wartime success of the Office of Scientific Research and Development (OSRD) to strike a new bargain with society. Even though most of the OSRD work had been applied R&D specifically directed to the war effort, much of it had been conducted at, or managed by, university centers in which academic scientists had played a leading role. The accomplishments under OSRD had shown, or were interpreted as showing, that "impractical" academic scientists were capable of attacking very practical problems and managing large coordinated efforts successfully. The atomic bomb in particular had shown how the most esoteric science could lead, under forced draft in the right circumstances, to spectacular technological developments, and the universities were the principal beneficiaries of this perceived accomplishment of science.

The implicit message of the Bush report seemed to be that technology was essentially the application of leading-edge science and that, if the country created and sustained a first-class science establishment based primarily in the universities, the generation of new technology for national security, economic growth, job creation, and social welfare would follow almost automatically without explicit attention to all the other complementary pieces of the innovation system.

The remarkable accomplishments of industrial production during the war led to all the activities complementary to R&D being taken for granted. As a result, the Bush report was interpreted as describing a linear picture—a one-way flow of ideas from fundamental research, through applied research and technological development, to commercialization and operational application—that was probably neither believed nor intended by its authors. Nevertheless, it was interpreted that way, and for many years nobody spoke up to contradict this simple and appealing model of the genesis of technological innovation. It provided a paradigm that still has political potency.

But even if the simple linear model has been discredited, this does not mean that a strong scientific base is not essential to vigorous technological advance in the long term. Many of the most visible success stories of U.S. technology—microelectronics, computers, telecommunications, jet aircraft, high-performance materials, pharmaceuticals, space applications—have been heavily, though not exclusively, dependent on recent advances in science. And in the mid-1970s, just when public skepticism of the economic value of basic science was growing and the center of gravity of innovation in fields such as computers and microelectronics had clearly shifted to industry, biotechnology came along. This new field appeared as uniquely the product of a sustained national investment in the esoteric and seemingly "useless" field of molecular biology, an investment made almost entirely in academic or government laboratories. Thus the story of the atomic bomb appeared to be repeating itself in a civilian setting, and public faith in science as the fountainhead of innovation was revived.

Even while some U.S. scholars were questioning the importance of the nation's research universities, foreign observers were extolling them as a principal source of U.S. competitive strength in high technology. And thousands of foreign graduate students and postdoctoral trainees were voting with their feet, eagerly participating in the U.S. research university and often aspiring to remain in the United States as long as they could.

Trouble in paradise

The fundamental role of academic science does not mean, however, that all is well with the universities. Most noted is the steady deterioration of the research "infrastructure." Even in some of the most renowned academic centers, research equipment is decidedly below the state-of-the-art levels that the better corporate, government, and national laboratories can generally take for granted. This problem is being attacked, but at a snail's pace, and mostly by the Department of Defense, a fact that leaves a number of observers of the academic scene ambivalent and uneasy.

The question of the distribution of resources for academic science also remains a continuing and politically contentious issue. The debate is between those who contend that, in a time of stringency, resources need to be concentrated in "critical mass" efforts in fewer places (in order to avoid dispersion of limited funds and equipment among many claimants) and those who contend that existing research funds are already too concentrated in a few prestigious institutions (where well-known investigators understand how to "work the system").

Critics also contend that the system of selection of research proposals tends to reinforce the existing scientific "paradigms"—that truly novel and offbeat ideas and investigators, and investigations cutting across the existing disciplinary boundaries of universities, are discriminated against. Even within the rank and file of the working scientific community, there is increasing suspicion about the fairness and efficiency of the project-selection process that granting agencies apply to university research.

Although there is little, if any, evidence of any consistent bias against investigators who are young, embarking on a new field of research, or who come from institutions other than the best-known research universities, one must nevertheless acknowledge the "Mathew effect" (originally pointed out by the pioneer sociologist of science, Professor Robert Merton of Columbia University). This is the cumulative advantage accruing to scientists who have received financial support in the past, have thus been better able to establish a track record and acquire a reputation, and consequently enjoy a more favorable evaluation of their research proposals by peers.

Yet surely such self-perpetuating advantages are not confined to participants in academic science; on the contrary, they are inevitable in a society that stresses competition and individual achievement. The fact of the matter is that few, if any, of the critics of the present peer review system have been able to propose a convincing alternative that promises to be either fairer or more cost-effective for the advance of science. Nor are the critics able to point to alternative models in other countries that produce demonstrably superior outcomes in the academic research system.

Conditions for doing good science

A possibly superior mode of research support is evidenced outside academia—in a small number of corporate research laboratories of large high-tech companies, such as IBM and GE, and in the predivestiture Bell Telephone Laboratories. The latter is probably the ideal model for a stable institution that has produced fundamental research in direct competition with universities. I have had occasion to sit on "search committees" for academic appointments of young scientists, where individuals from corporate and academic laboratories were regarded as being in head-to-head competition. The research in a few of these corporate laboratories is just as "basic" (by any definition, except possibly the motivation of the sponsor) as that in universities, though it must be remembered that this type of research probably represents less than 5 percent of the total R&D expenditures of the parent organization.

When one of these corporate laboratories recruits a bright young scientist, it makes a commitment to provide him or her with a reasonable level of logistic support in the form of equipment, expendable supplies, and shop and technician services. This commitment usually continues as long as the researcher's work appears scientifically rewarding and important. Management takes the responsibility for defending its "relevance" to overall company interests and strategy in a general sense, while the individual's responsibility is largely to do "good science" as judged on a world standard by colleagues.

The present environment of the research university may be selecting against a certain type of scholarly individual—one with a truly long-range agenda and vision but a relatively nonaggressive personality and a distaste for self-promotion.

In the modern research university, by contrast, faculty appointments (at least in the natural sciences and engineering) are more like "hunting licenses" that authorize the individuals to sally forth and persuade some potential external sponsor in government, industry, or a private foundation that they have a worthwhile research program in mind. Depending on its internal resources, the academic institution may sweeten the pot by providing some basic infrastructure, such as remodeling a laboratory to the researcher's requirements or perhaps purchasing some basic equipment (if the institution is very affluent or particularly anxious to recruit the individual), but for the most part the young scientist is on his or her own in a highly competitive world with, at most, startup support from the institution.

There is disturbing evidence that this situation places the young assistant professor in a university at a serious disadvantage compared to a young scientist at a similar career stage in one of the best corporate laboratories. Too much of a premium is placed on short-term publishable results, which encourages even the most entrepreneurially minded young investigator to stick too long with lines of work in which he or she has already acquired an external reputation. The performance of the corporate researcher often reveals a willingness to make much longer-term gambles on new lines of investigation, and greater novelty is exhibited than in the work of the peer of comparable intellectual ability from a university background.

In the search committees I mentioned, I have been struck by how often, in comparing the promise and accomplishments of a young physicist from academia with another from industry, we found ourselves making allowances for the much greater difficulty involved in launching a novel research program in a university setting. Furthermore, because the environment of the industrial laboratory allows much more time for the gestation of a novel approach, some very creative industrial researchers tended to be ruled out as candidates for university posts because of a feeling that their rather retiring personalities would make it difficult for them to function in the competitive grant-selling milieu of the research university.

Thus, I believe that the present environment of the research university may be selecting against a certain type of scholarly individual—one with a truly long-range agenda and vision but a relatively nonaggressive personality and a distaste for self-promotion. This is hard to prove, of course, but a number of senior scholars have reported similar observations. The situation is likely to worsen, moreover, as the competition for limited funds in universities continues to intensify.

Reintegration of the disciplines

One may well ask, if conditions for pioneering research in the universities are so bad, how can they continue to recruit or retain first-class research faculty? There are probably three reasons. First, there are only a few fields in which universities are in direct competition with the handful of industrial laboratories engaged in high-quality basic science and that recruit only a small proportion of the outstanding PhDs turned out each year. But these fields, among which advanced engineering is one of the most important, are exactly the ones most directly related to future U.S. industrial competitiveness, and there is considerable evidence that the universities are becoming less successful in recruiting the best people.

Second, the opportunity to teach and work with graduate students is still a very important drawing card for the most creative minds. The need to organize a subject for presentation to bright but relatively inexperienced (and open-minded) young people is perceived as a great stimulus to creative thought about one's own research.

Finally, the universities may enjoy some advantage just out of sheer tradition. In theory, it is universities that embody most completely and firmly the values of science. If these values are under threat, perception may not yet have caught up to reality in the minds of young people who are making career decisions.

Meanwhile, there has been considerable experimentation in universities. More sustained types of federal support, built around a coherent area of research in a single institution, are being made available to groups of investigators. Faculty members who belong to such groups have much more local control and determination of research directions and priorities; and such "core support" in a programmatic area puts them in a better position to test out new ideas in a preliminary way before putting forward more concrete and documented competitive proposals. This kind of core support has been especially valuable to young investigators starting out in a new institution, as well as to senior scientists wishing to start a wholly new research field. It enables the direction of research to be guided much more immediately by the evolution of findings; while the competitive grant system tends to ensure that new research ideas and directions are carefully thought out in advance, it also tends to slow the process of redirection of the research agenda.

Such core support programs have been difficult to defend politically because of the privileged position in which their members seemed to be placed in the competition for normal project grants. Combined with this is the fact that broad programmatic grants tend to be located mostly in the larger and more prestigious universities. Thus these programs are continually on the defensive in the internal battle for funding within federal agencies that also administer more traditional project grant programs.

Nevertheless, I believe that programmatic research programs will have to assume greater importance in the future if the research universities are to remain major players on the U.S. research scene. Not only have these programs helped some institutions to better compete with industrial laboratories, they have also enabled universities to overcome some of the barriers separating the disciplines. Major advances are becoming more and more dependent on bringing together the tools and insights of several specialties, a trend that Lewis Branscomb (director of the Science, Technology, and Public Policy Program at Harvard University) has characterized as "the reintegration of the disciplines."

The cost of the necessary infrastructures means that whole institutions may have to specialize—in a programmatic sense—while facilitating access to and participation in these programs by people who are not part of those institutions. This is already the practice to a considerable extent with respect to centers that are built around major, one-of-a-kind machines such as accelerators, optical telescopes, and supercomputers, but it may be necessary to adopt it as well for interdisciplinary research centers: An increasing number of research topics, engineering design projects, and even laboratory training courses require the coordinated use in a single investigation of several complex and expensive tools.

Such arrangements will be assisted by the marriage of modern telecommunications and data processing, which permits use of facilities by remote access and thus reduces the need for travel or disruption of teaching schedules. The full exploitation of such networks by dispersed groups of scientists may require a great deal of imagination, but it is likely to come as the movement of information and the massaging of data become ever cheaper and more transparent to the user.

College for public knowledge

Universities are uniquely the locus of both the generation and the diffusion of publicly shareable knowledge, whereas industry naturally tends to be the locus of proprietary and competitive research. Under some circumstances—in fields that are still relatively distant from commercial application and where no one group or investigator has the capability to achieve a monopoly on potentially relevant knowledge—the state of knowledge advances more rapidly if it is widely shared in an open environment, a fact that is well recognized by industry and is the main justification for the maintenance of corporate research laboratories with a university-like atmosphere. This occurs with basic research and, to an increasing degree, with "generic" technology development in its early stages—prior to crystallization into specific product designs or the emergence of a dominant design. Even some kinds of specific industrial knowledge are better treated as "public goods."

The question is, where does the balance lie? As innovation becomes increasingly based on recent science, I believe that the balance tends to shift in favor of public research. That is one of the reasons why governments are so much more involved in industrial innovation than they were in the nineteenth century. Yet there is still a good deal of room for disagreement about the boundary between public and proprietary research, and the future of the research universities in the United States has a great deal to do with just how it is drawn in the next few decades.

In Japan, the balance between private and public knowledge has been struck at a point much closer to proprietary knowledge than in the United States. This is reflected in the fact that nearly 75 percent of the total Japanese R&D budget is paid for by private industry, as compared to something in the neighborhood of 50 percent in the United States and Europe. It may also be reflected in the fact that in Japan the universities are much weaker players in the research game. A great deal of advanced training beyond the bachelor's level, especially for engineers, goes on within industry and on the job, and it is much more company-specific than in the United States. This situation is facilitated by the practice of lifetime employment in large firms, which assures the firm that proprietary information communicated in training will remain proprietary.

There is a serious question, however, whether this approach can continue to be viable as Japan makes the transition from a follower to a leader in advanced technology. It appears that the Japanese have hitherto drawn heavily on the open research system of the United States, but they may well be forced to move toward greater dependence on their university system for public research.

But although a strong and vital university research system is an essential ingredient in technological innovation and long-term competitiveness—at least for a large country at or near the world technological frontier, such as the United States or Japan—it cannot be the prime solution. The universities have few competitive advantages in the conduct of proprietary research, and if they did they would cease to be universities as we have known them. Although cooperation between universities and industry is desirable and beneficial to both sides up to a point, it needs to be constrained within the fundamental notion of public knowledge that lies at the basis of science.

Thus the research universities would do well to avoid capitalizing too enthusiastically on the present political concerns about economic competitiveness, for this could create unwarranted and unrealizable expectations that could later lead to public disillusionment. In my view, the competitiveness problem in the United States does not arise primarily from its performance in R&D, and cannot be cured just by increased R&D support or by the restructuring of its R&D system. The present emphasis on university research is not necessarily misplaced, but I question the implicit assumption that if we just get university research right, and properly supported, everything else will take care of itself. The application of the output of research to the economy depends on too many complementary investments, institutions, and private and public policies—and on actions having little to do with R&D.

In their own long-range self-interest, therefore, the universities need to address the competitiveness problem not just as an opportunity to enhance public support for university research but as an intellectual challenge in its own right—to be attacked in the traditional mode of objective scholarship, letting the chips fall where they may. Only in that way will they be able to retain credibility for the part they must play in a healthy national innovation system for the future.

Recommended reading

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