PART 8

Research Universities and the Knowledge Economy

Globalization and the knowledge economy have caused many research universities to take on the new roles of innovator, entrepreneur, and business-partner, as well as educator. Most research universities now have technology transfer offices to facilitate the move of their inventions and innovations from the laboratory to the marketplace. The scramble for the Holy Grail of federal research dollars is steering the direction that university research is taking and often causing uneasy alliances between academe, government, and industry. Part 8 contains four chapters that explore effects that of these changes on research universities, including a federal government report on government-university research partnerships, and a discussion on increasing competitiveness in the EPSCoR program.

In Chapter 28, MIT president Charles Vest comments on the effects of globalization on R&D and research universities. He mentions changes such as the growth of offshore R&D, which many universities, companies and governments have begun to use. He also addresses an issue that has been broached several times in this *Yearbook*, Circular A-110. Vest raises concerns over the legislation and its impact on university research. He writes, "Many unintended consequences could obviously stem from the current version of A-110."

Vest believes that globalization generates several new challenges for universities, including forcing changes on curricula, and increasing the pressure to foster innovation and entrepreneurship while maintaining basic research. Forming partnerships with industry and government has become a common practice among universities. He states, "We are increasingly recognizing that our university research is a critical element in America's innovation system." Moreover, universities are seeing changes in the career paths of science and engineering graduates, with a growing number choosing jobs in the service, finance, and consulting industries.

Chapter 29 contains an excerpt from the National Science and Technology Council (NSTC) report, *Renewing the Federal Government-University Research Partnership for the 21st Century*. The report was commissioned "to assess and reaffirm the principles of the partnership, promote cost-effective university-based research, ensure fair allocation of research costs, and support the linkage between research and education... ." While the NSTC found that government-university partnership is effective, it identified several areas where the partnership can be strengthened. The report lists several guiding and operating principles for interactions between the government and research universities.

Irwin Feller of the Pennsylvania State University discusses the options for "enhancing the competitiveness of EPSCoR universities in securing external research support." In Chapter 30, Feller presents ten strategies that universities can follow. These strategies include increasing the number, size, and quality of research proposals, finding niche markets, emphasizing industrial and applied research, and building a medical school. Feller states that many of the strategies are not novel, but "are equally available to all universities, EPSCoR and non-EPSCoR." He believes that all universities are capable of improving their research, increasing the size of their programs, and bolstering their levels of federal academic R&D expenditures.

In Chapter 31, which originally appeared in *Issues in Science and Technology*, Richard Florida of the Carnegie Mellon University provides insight into the changing role of universities. He believes that universities are focusing far too much on developing commercial innovations and spurring regional development, and too little on knowledge creation and drawing talent. Universities are also making the mistake of shifting investment from basic science in favor of applied work. Florida says that universities must focus on attracting "the smartest people from around the world—the true wellspring of the knowledge economy." He asserts that the solution to these problems rests with policymakers. At the national level, a review of the Bayh-Dole Act, with the focus on attracting talent is needed. On the regional level, Florida believes policymakers must "reduce the pressure on universities to expand technology transfer efforts."

28 Science, Technology, and Innovation: Reflections on Change

Charles M. Vest

The context for science and technology policy is rapidly changing. Increasingly, we must think of it in terms of a global innovation system. This system is a chain of events that runs from the generation of new knowledge to the education of young men and women to do things with that knowledge, and ultimately, to the creation of new products, processes, and services in the commercial workplace.

My comments on this topic are divided into three parts: a few fables, a few observations, and some comments on the changing role of our research universities.

Fables

The first fable is titled "Racing to Sequence the Human Genome." We suddenly are in this rather strange race. On one hand is a group put together as an international collaboration of governments and a charitable trust (the Wellcome Trust, which supports public institutions such as Washington University, the Massachusetts Institute of Technology (MIT) Whitehead Institute, Baylor College of Medicine, the Sanger Center, and U.S. Department of Energy laboratories). They are working together to see how quickly they can come to a consensus sequencing of the human genome, and thus make their sequence fully available to anyone who wants this as they proceed. But they are racing against for-profit companies and organizations, such as Celera and Gensat. The

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bait in this race is a concern about how elements of the human genome might, in fact, become patented. (Of course, it is actually more complicated than this. A consortium of ten pharmaceutical companies also supports the public side). The argument can be described as whether you patent the dictionary or put the dictionary out there as a free good for use by everybody and worry about patents for the people who write the novels. The moral I draw from this fable is that we are rebalancing public and private responsibilities. This is just one example.

My next fable is titled "International Entanglements." I recently had a telephone conversation with the CEO of a major company, whom I respect very deeply and whose company is headquartered in the United States. The gist of the conversation was that he and his colleagues were not happy with the extent of MIT's technological collaborations with companies and, in some cases, even government entities outside the United States. It was not a hard push against us, but it was, indeed, a clear statement that they would be happier if we focused more on working with companies headquartered in the United States. This is not a new complaint, but it has not been very prominent since the balance between the United States and Japanese economies has changed rather dramatically during the last five years. I certainly did not totally agree with his perspective, however.

The very next day his Vice President for Research gave a speech in which he outlined that same company's strategies for locating R&D laboratories overseas in partnership with foreign universities. They are not alone in doing this. This is yet another important trend that we all need to be aware of and understand.

Many companies headquartered in the United States are increasingly performing some of their R&D functions offshore for several reasons. Generally, they want to help build local expertise. In some cases they even talk about creating the "world engineer," able to practice in any region of the world. They need access to differing cultural norms that may affect research and development functions. Way down the list is that some work can be done at a lower cost overseas. Of course, all of this drives the development of new customer bases for their products.

The Council on Competitiveness investigated this phenomenon in some detail and produced a report titled "Going Global." One of the things they discovered is that while a substantial amount of corporate R&D is moving offshore, apparently very little innovation that makes it into products is coming through offshore R&D. This raises the question of whether the movement of R&D offshore is a permanent or temporary trend. Whatever views we may have, we must work together to understand and consider the way in which we perform technological R&D on an international scale. (Fundamental science, of course, is international to the core of its very being. Here I am referring more to industrial applications).

The moral here is simply that we have not made up our minds about national versus global roles. This issue is going to be in a state of flux for some time.

Another fable is titled “Some Horses Want to Be Led to Water.” This is actually good news. Congress recently established a group called “The Technology and Innovation Forum,” or Tech Forum for short. This group was the brainchild of Senators John D. Rockefeller (D-WV) and Bill Frist (R-TN).

Senator Rockefeller reasoned that Senators and Representatives do not come to hearings on the future of R&D because they do not know what questions to ask and they do not want to embarrass themselves. This was also the situation several years ago in the area of health care. To address this situation, Senator Rockefeller established an informal bipartisan forum to increase Congressional understanding of the fundamental issues facing the U.S. health care system. They provided free bag lunches and brought in interesting expert speakers. The first time five or six staffers came, the next time 10 or 20, and a few years later typically 100-200 people came to these forums. Interestingly, the new Technology Forum has attracted this level of participants from its first meeting onward.

As senators and representatives came to understand the importance and complexity of health care issues, they began to hire staff with relevant health care expertise, and Congressional work on health care improved significantly. Senator Rockefeller believes there is a similar situation today regarding science and technology in the House and Senate. Note that many members of Congress, including himself, became more interested in S&T issues when they had AAAS fellows in their offices. As they began to learn more, some hired full-time staff who had expertise in the area.

It will take time to build Congressional expertise that matches what both of these senators believe is a very strong thirst for knowledge about science and technology within the membership of the House and Senate. This is the goal of the Technology Forum. So my moral to this fable is a very simple one: We need to better explain what we do, why we do it, and how we do it. We have a willing audience if we approach them in the right way.

Observations

I now want to offer a few additional observations The first stems from the following question: Why would the chambers of commerce across the United States orchestrate a letter-writing campaign supporting OMB Circular A-110? The issue has to do with access to fundamental data underlying any scientific research that is used to create federal policy or regulation. Last fall, during the authorization process, legislation was enacted to require that all such data be accessible to the general public through the Freedom of Information Act. The legislation required that the Office of Management and Budget translate this into regulatory language and implement it under OMB A-110.

The scientific and engineering community was a bit slow to respond, but respond it did with broad concern that considerable mischief could stem from such a regulation. The basic issues are fairly obvious. One is simply the daunting thought of having raw scientific data suddenly accessible without having passed through the normal routines of peer review and being communicated in a careful manner. There are also deep issues about personal privacy, particularly in medically related research.

Ironically, at the same time that many in the business community see A-110 as a way to gain access to research, such regulations could provide a disincentive for industry to work with universities. For example, MIT has two major research programs in which we follow about 20 companies, sharing data on their design process and how they translate designs into manufacturing practice. These are real trade secrets. Our role is to be the honest broker within a framework that all agree to. In this framework, we take the data, create a database, and give information back to people so they can understand best practice and evaluate their own work, all without giving away trade secrets. Government sponsorship is involved in at least one of the programs.

Many unintended consequences could obviously stem from the current version of A-110. But while we are pointing out the flaws and the possible inadvertent negative consequences, we also have to be reasonable and recognize that we do have a responsibility to the taxpayers and the government that supports our work to provide appropriate access to all we do. It is not a simple problem, and it does not have a simple solution. We need to make our voices heard as AAAS and many other organizations have done.

Another observation: We continually talk about the ubiquity of information technology and note that it is changing the way we all live, learn, work, and entertain ourselves. But who is "we"? Only about two percent of the world's population has access to the Internet. About 29 percent of the people in the United States and Canada are linked to the Internet, and about five percent of Europeans are. Anywhere else on the globe the number is less than one percent. We need to understand the dangers of creating a new kind of "have" and "have not" on the international scale. Those people involved in the development of information technology and its applications need to direct some attention to the lesser-developed nations and consider the appropriate development of information technology in this context. I hope we can find many positive ways of dealing with this. (In Costa Rica, for example, they are using modern telecommunications to dramatically improve access to information as well as to improve education. They are also using it to enhance environmental awareness and a very deep commitment to the concept of sustainable development).

Another random observation I call "Seeking Balance." Senator Arlen Specter (R-PA) called the proposed increases in NIH funding "a moral imperative." This is strong language, and very welcome. Both basic and applied research in life sciences are extremely important for the future. But we have to balance that against another imperative: the interconnectedness of science. This has been recognized by Vice President Gore and his colleagues in the Administration, particularly in the 1998 announcement of the Administration's R&D budget. This is an important message. We have a responsibility, whether we are life scientists, engineers, physicists, or mathematicians, to keep people aware of the way in which our different disciplines interact. The race to sequence the genome is an example. That, of course, involves biology, by definition. But, in fact, clever use of combinatorial mathematics, robotics, engineering, and automation is making the whole venture possible. We never know exactly what the next most important advance will be or where it will come from.

My next observation is actually a question: As we think about American innovation and entrepreneurship, should we think of ourselves in the United States (or even around the world) as a number of clusters, localities, cities, and states, or should we think of ourselves in a more common framework? For years this debate has generally been around discussions of Route 128 in the Boston area and of Silicon Valley in northern California. We often hear questions about how such clusters can be replicated in other states, cities, or districts.

Scholars such as Michael Porter at Harvard write quite convincingly about the importance of creating local clusters of expertise around a particular industry in order to gain a competitive advantage. In addition to the two well-established ends of the axis, Route 128 and Silicon Valley, other clusters are emerging. Consider the Georgia Alliance or work going on in wireless communication in the San Diego area, or Pennsylvania, or Austin, Texas, or in the District of Columbia. Increasingly this local cluster phenomenon and point of view is taking hold. It is very positive and it stems from strong public spirit and commitment. It comes from new organizations getting different sectors to work together to advance economic development.

But Regis McKenna, a great venture capitalist who is one of the fathers, as it were, of the Silicon Valley revolution, has said, "I think these things are being absolutely overstated and it is the wrong perspective. This is a modern network world. We should not think of ourselves as isolated clusters. We are all nodes on a great network and we should think about being able to interact all over that network. In the end that will serve this country much better."

At a recent meeting in Michigan, the question was how to make that state as strong as possible economically in the new technological fields. A person who runs a small biotech company stood up and said, "I'm going to partner with whoever has the expertise I need to provide the best possible product and gain the greatest advantage. I don't care where they're located." Again, I point this out as an observation, not as a conclusion. It is something we all need to think about in our day-to-day work.

This issue leads to one last observation: Industry today, as we say over and over, is increasingly knowledge-based. It is global, and driven by innovation. It is digitally interconnected and created by entrepreneurs. I would like to consider the implications of this for our research universities in particular. Our research universities generate much of the knowledge that drives modern industry, and even more important, they educate the men and women who work in these industries.

Knowledge-based industry reminds us that basic research within our universities is needed more than ever because we are increasingly the only game in town when it comes to the creation of truly fundamental knowledge. We may not know where such knowledge will lead, but it has some likelihood of being used, whether two years from now or 100 years from now. I hope our system of financing research and our culture will always support first and foremost the conduct of truly basic research within our institutions.

The Changing Role of Universities

We in universities have many things to think about. What does globalization mean for our institutions? To what extent should we engage in partnerships, particularly those that cross national boundaries? What linkages should we develop with other universities and perhaps with other countries and companies? Above all, what does it mean for our curriculum? Do we have a responsibility to our students to somehow represent globalization in our curricula?

What about innovation-driven industry? What is the source of innovation? Our universities must be an important part of the chain of innovation, both in the creation of new knowledge and ideas and in the education of people. Do we need to recognize this more explicitly? Again, should it be reflected more in curricular development—and who should be part of that process?

We play a role in developing information technologies. What does that have to do with our curriculum? Is our responsibility to broadly educate people about information technology or to create more specialists?

And, finally, how do we respond to the pervasive phenomenon of entrepreneurship? Universities are trying to respond by creating entrepreneur clubs, contests, etc. People are starting companies in the first two or three years out of college, or sometimes while they are still in college. How much can you intellectualize this? What part of the responsibility for creating entrepreneurs does or does not lie with our institutions?

Universities are tugged and pulled by all these changes and questions. On the one hand, we need to work much more than we have with industry on fast-paced real-world projects. We have to do that if our faculty are to be able to provide up-to-date engineering and management curricula and experiences that will serve our students well. Simultaneously, we are being pulled in the other direction because we are literally the only basic research game left in town. We have to play both ends. Those institutions that succeed in doing both with a level of mutual respect and cooperation will be the strongest and will provide the best education, particularly for their engineering and management students.

Universities are, in fact, changing. We are conservative institutions because we have a lot of things that are very important to conserve.

Nonetheless, there are a number of changes underway that we may not even recognize today, but that will have profound consequences. They are the result of several trends.

First, we see changes in our finances. I speak, of course, primarily as a representative of a private institution that is predominately devoted to science and engineering. Endowments are up for private universities, which have benefited enormously from the increase in the stock market over the past five years. This is particularly fortunate because our federal support is leveling off. (If you look at most institutions on the surface, at least, our federal support is up a little bit. In a few places it is up dramatically. But, for the most part, particularly outside the life sciences, it is level to slightly up, but it is delivered with increasingly difficult cost-reimbursement policies attached).

The federal funding profile is also changing through dramatic growth in the NIH budget, which is understandable and sensible from many dimensions. We should keep pushing for this, but other agencies are growing much more modestly or declining. We hear calls from within Congress to double research funding but they all come with different time lines attached. Doubling in five years is a very different matter from doubling in twelve.

But there is good news, such as the increase in private support that has come with the strong economy. The economy also helps the tax base in our states and thus our public universities. But we have to face the fact that the fundamental laws of economics have not been repealed. We will ultimately have turbulence. We have already seen substantial volatility in the world economy.

More good news is that the tone in Washington is increasingly supportive of our institutions in a way that is much, much better than it was just a few years ago. But, of course, traditional political forces are always at work and we will always have to deal with them.

Other areas of change revolve around three new themes, three words frequently heard around research universities today. They are *innovation*, *partnership*, and *entrepreneurship*. We are increasingly recognizing that our university research is a critical element in America's innovation system. And we are increasingly looking to partnerships with other sectors (industry and government) and discovering new ways to work together in research and education. I think we are going to find dramatically successful partnerships in the years ahead. And we have to think through the proper role of entrepreneurship in the university context.

Technology is changing within our institutions, making innovation an exciting theme. New bases of science are beginning to undergird a variety of branches of engineering. For many years engineering has helped those in the life sciences, by creating instrumentation for example. We are now entering an era in which that flow is going to reverse. We will see a tremendous flowering of engineering capabilities based on all the developments in cell and molecular biology and other areas of the life sciences—particularly in the creation of new materials. (And I hope these methods will use less energy and create less waste).

We also see an increasing involvement of engineers in the academy in thinking about very large complex systems, whether it be the logistics of transportation or the complexity of electronic circuitry and networks. Large complex systems is a pervasive theme, as is so-called embedded intelligence. The integration of microprocessors in virtually every kind of mechanical device and element today is creating wonderful opportunities for advanced engineering research. We are beginning to move to the next generation where these various intelligent elements and systems interact with one another in new and different ways. It is going to be very exciting.

Finally, we are seeing a swing in the balance of experimentation and theory. As I look over the past 20 or 30 years, new advances, instrumentation, and capabilities have led to a movement back to lots of experimental work in addition to theory and computation.

But the more interesting and in some ways more profound changes have to do with people. The demographics of college-age young people in the United States are changing very rapidly. We are seeing increases in our minority populations. We also see, at long last, an increase in the number of women going into science and engineering. (This year's freshman class at MIT is 43 percent women. Since 85 percent of our students are in scientific or engineering fields, this is very significant). Add to this the increase in the number of international students, and first- and second-generation immigrants. Unfortunately, at the same time we continue to see an overall decline in the percentage of young Americans interested in science and engineering. That does not bode well for the future.

We are seeing dramatically changing career paths of science and engineering graduates. More and more students are moving into the service sector, finance, consulting, and so forth right out of science and engineering school. A recent survey found that 35 percent of recent engineering graduates have jobs completely "unrelated" to science and engineering (whatever "unrelated" means). In MIT's graduating classes in the late 1960s and early 1970s, two-thirds went directly into Ph.D. programs in a science or engineering discipline. Now that is a much smaller portion.

This is, of course, a reflection of changing student interests. We see an acceleration of interest in the life sciences, environmental matters, management, and economics (perhaps combined with science or engineering). For the last eight years or so, the number of students going into computer science and engineering has been diminishing. At MIT, though, over 20 percent of our incoming freshmen intend to go into computer science. But the national trend seems to be different.

Of course, there are changes in our faculty as well. A recent report by a committee of very distinguished MIT faculty members looked at the experiences, careers, and views of the senior, tenured women in our School of Science faculty. We learned some things that were not very pleasant, and we have begun working hard to correct them. Basically, we learned that our distinguished women faculty in the School of Science found themselves feeling increasingly marginalized, rather than gaining in stature, as they moved into the senior ranks. But what absolutely astounded me was the national resonance to the release of this report. I could not begin to describe the traffic of letters, e-mails, press, and editorials we have received. Most of the comments were positive about our articulating these things and facing up to them.

Another area of change is the increase in international initiatives and strategic collaborations. One example is the Association of Pacific Rim Universities (APRU) formed by Asian and Western U.S. universities. The exporting or perhaps re-exporting of the U.S. research university overseas, particularly to Europe and Asia, is extremely interesting. Government after government, city after city are coming to various public and private institutions around our country asking us to help them create U.S.-style research university institutions in their countries. Much of this, of course, involves large-scale experiments in distance learning, using technology between the U.S. and other countries. Despite all the exciting things we are going to do with new technologies and distance learning, I believe that the residential campus is going to remain uniquely important in the education of the very best and brightest young men and women.

Congressional and public support is much stronger than it was just five or six years ago, helping us to slowly but surely implement change. This is a very important time to undertake a variety of educational experiments in these changing contexts and to share the results of these experiments among our institutions so we can all improve. Of course, beneath all of this are the daunting problems in primary and secondary education—problems that simply must be addressed in this country. (Let us never forget that without education none of the innovation and economic development we celebrate can exist or moves forward). This is a time of great adventure, challenge and, of course, uncertainty.

Finally, let me comment briefly on science and technology policy. Technology continues to advance in exciting ways but it does so within a context in which the relationships among public, private, and academic institutions seem to be changing and becoming increasingly amorphous. Anything we call science and technology policy today must involve an understanding of both the public and private sectors. There was a time in which science policy indeed referred only to *science*. In fact, if you go back far enough, it essentially meant only physics. And it was entirely within the context of the federal government. We must now think broadly about both the public and private sectors. We must remember that innovation and economic development involve research, development, and business.

Another major message, which I hope our Tech Forum can help spread in Congress, is that technology means more than just information technology. It is astounding how many people today think about only that one dimension when you say "technology."

The scientific decades ahead will be fantastic. We will discover whether there are antimatter galaxies out there. We will have tremendous advances in neuroscience and brain research. We are going to learn how to manufacture materials in a greener way, with lower energy input. Whole new areas of biodiversity are going to take us along very different scientific routes and adventures. Where the Genome Project will ultimately lead, no one knows. The capabilities of truly advanced large-scale simulation are going to give us a third way of doing scientific and technological inquiry complementing experimentation and analysis. The fundamental nature of computing and what it means is also going to change radically in the decade or two ahead.

Finally, this new age—where science and technology are changing the way we do virtually everything—will bring with it many difficult ethical questions. In my own institution I do not believe we expose our students to enough of this dialogue. I hope that in public life as well as in institutional life, we can reflect more on what we do, why we do it, and how it fits into an ethical framework as we move forward.

29 Renewing the Federal Government-University Research Partnership for the 21st Century

National Science and Technology Council

Executive Summary and Recommendations

The partnership in science and technology that has evolved between the Federal government and American universities has yielded benefits that are vital to each. It continues to prove exceptionally productive, successfully promoting the discovery of knowledge, stimulating technological innovation, improving the quality of life, educating and training the next generation of scientists and engineers, and contributing to America's economic prosperity. As with all successful partnerships, it is occasionally appropriate to review and reaffirm the partnership and find ways to strengthen it.

At the urging of the President's Committee of Advisors on Science and Technology, state governors, industry leaders, elected officials, and leaders in education, the Assistant to the President for Science and Technology issued a Presidential Review Directive in September 1996, directing the National Science and Technology Council (NSTC) to review the government-university partnership in research and associated educational activities, and to recommend ways to strengthen it. The goal was to assess and reaffirm the principles of the partnership, promote cost-effective university-based research, ensure fair allocation of research costs,

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and support the linkage between research and education, all while maintaining appropriate accountability for expenditure of public funds. Where appropriate, the findings and recommendations emerging from this review also apply to nonprofit independent research institutes.

The review was carried out by a multiagency Task Force under the auspices of the NSTC Committee on Science. The Task Force solicited the views of universities, university associations, and the Federal research agencies regarding the issues they considered most pressing. These responses provided the basis for the interagency discussions and for the report's findings and recommendations.

The NSTC finds that the partnership is sound and continues to serve the nation in important ways. The NSTC identified a number of areas in which the partnership can be strengthened and will take action in three areas. First, the NSTC is issuing a proposed statement of the principles of the partnership to clarify the roles, responsibilities, and expectations of the parties and provide a framework for the development and analysis of future policies, rules, regulations, and laws. The principles will be finalized, in consultation with universities and other interested parties, including the Congress, within twelve months from the date this report is issued. Second, the NSTC reaffirms the importance to the nation, to the research enterprise, and to the future scientific and engineering workforce, of the linkage between research and education. The NSTC will take actions to strengthen this linkage, and urges universities to do likewise. Third, the NSTC, through the Federal agencies that fund university-based research, will implement a set of actions to help make the partnership more effective and efficient. Finally, the NSTC will establish a mechanism to provide for ongoing review of the partnership.

Introduction

American universities are a key component of our world-class research system, contributing to the development of knowledge and helping to advance societal goals. Our universities are the envy of the world, built as they are on a commitment to excellence. They have proven to be an exceptionally rich setting for the conduct of research because they are committed to the dual purpose of generating knowledge as well as educating the next generation of scientists and engineers.

Observers of the science and technology enterprise often look to Vannevar Bush's 1945 treatise *Science—The Endless Frontier*, to explain the origins of the Federal government's commitment to research and education. But the history of these endeavors goes back even further. The fact that the United States has flourished, notwithstanding profound internal and external challenges, is partly attributable to our willingness as a nation to invest significant public resources for public goods not readily attainable by the normal workings of the marketplace. Our earliest declaration of national purpose commits us to promoting "the progress of science and useful arts," a commitment which we honored immediately in 1790 with the first decennial U.S. Census. The census was followed by an historically unprecedented and nationally funded scientific reconnaissance of our landscape-its topography, geography, flora and fauna, wildlife, native peoples, land routes and waterways-which enabled citizens and entrepreneurs to realize the economic promise of our vast continent throughout much of the nineteenth century.

The manner in which we have chosen as a nation to invest in scientific and engineering research has, not surprisingly, reflected the pluralism of our communities and the decentralized structure of our governing institutions. The Federal government has relied on approaches as varied as the country itself to promote science and engineering. The advance of science and technology has often been coupled with other public objectives-especially education. The Johns Hopkins University and Clark University, our first explicitly research-oriented universities, were founded in 1876 and 1887. Since then, universities have served not only as critical research locations, but as a training ground for the next generation of scientists and engineers. The close coupling of research and education has become a hallmark of the U.S. system of higher education, producing the finest scientists and engineers prepared to perform cutting edge research and to manage high-technology enterprises across a broad range of disciplines and in multiple venues.

The partnership in research that has evolved between the Federal government and American universities has yielded benefits that are vital to each. It continues to prove exceptionally productive, successfully promoting the discovery of knowledge, stimulating technological innovation, improving the quality of life, educating the next generation of scientists and engineers, and contributing to America's economic prosperity.

While the wisdom of investments in research has proven itself repeatedly overtime, each era brings with it special challenges and opportunities. Neither universities nor the Federal government have remained immune from the historic shifts that have taken place in the last decade, including the globalization of the economy; the growing interdependence of the economy and scientific and technical advances; the increasing reliance of industry on universities for the performance of basic research; and the continuing importance of research universities to the economic prosperity of states and regions. The partnership between the Federal government and the nation's research universities must evolve along with these changes, making this an appropriate time to review the fundamental principles of the partnership, renew the government's commitment to it, and suggest how the partnership might be strengthened so that it can continue to be effective and efficient and serve the nation into the next century.

It was in this context that the Assistant to the President for Science and Technology, at the urging of the President's Council of Advisors on Science and Technology, state governors, industry leaders, elected officials, and leaders in education, issued a Presidential Review Directive in September 1996 directing the National Science and Technology Council (NSTC) to review the government-university partnership and recommend ways to strengthen it. As noted above, where appropriate, the findings and recommendations emerging from this review also apply to nonprofit independent research institutes. The NSTC was charged to assess the policies, programs, and regulations that shape the partnership, associated educational activities, and the administration of research. The goal was to review the principles of the partnership, promote cost-effective university-based research, ensure fair allocation of research costs, and support the linkage between research and education, all while maintaining appropriate accountability for expenditure of public funds.

The review was carried out by a multiagency Task Force chaired by the Associate Director for Science of the Office of Science and Technology Policy, with the support of a Working Group, under the auspices of the NSTC Committee on Science. The review findings and recommendations, documented in this report, are based on inputs from universities, university associations, and the Federal research agencies received in response to a Task Force solicitation. The Working Group reviewed over 40 university and university association responses, representing hundreds of universities. The Federal Demonstration Partnership (FDP), a cooperative agreement among 65 academic institutions (including administrators and faculty representatives), 11 Federal agencies, and six affiliate members designed to enhance research productivity and reduce administrative burden while maintaining appropriate stewardship of public funds, offered valuable input and is expected to assist in implementation of the recommendations. The Government-University-Research Roundtable of the National Academies of Sciences and

Engineering and the Institute of Medicine, is the official convener of the FDP. The Government-University-Industry Research Roundtable, with its record of inquiry into areas of concern to this review, also provided valuable input to this review. So did the National Science Board, particularly on the role of the Federal government in graduate and postdoctoral education.

Findings and Recommendations

The NSTC finds that the partnership is sound, that it continues to serve the nation in important ways, and provides a sound basis for the transition of the partnership into the twenty-first century. The partnership contributes to America's economic prosperity, enhances national security, and provides the means to improve the quality of life for our citizens. The integration of research with education, effective teaching and mentoring, and awards based on merit provide the underpinnings of the system.

Federally supported university-based research is a critically important investment by the nation in its future prosperity and wellbeing. Federal investments in university-based research are an integral component of the larger research and development enterprise that has enabled approximately half of the nation's productivity and growth in the last 50 years. In 1997, the Federal government provided $14.2 billion for academic research. These funds comprise more than 60 percent of support from all sources for university research, and account for more than half of Federal investments in basic research, and more than one-third of its investment in total research (basic and applied). Those fractions are more than are received by any other type of research performer. They reveal the extent of the nation's reliance on universities as the prime repository of core competency in basic research and underscore the importance placed by Federal agencies on coupling research and education in preparing the next generation of scientists and engineers. Federal agencies foster science and technology partnerships with universities in numerous other ways, such as providing university-based researchers access to unique, state-of-the art research facilities. These facilities provide essential research tools for a wide range of disciplines and foster collaborative research relationships between researchers in Federal laboratories, industrial partners, and university students and faculty.

The NSTC found great encouragement in the ongoing and dynamic partnership between government and universities. But while the NSTC concluded that the partnership remains productive, maintaining its vitality requires continued vigilance. The review identified a number of ways in which the partnership might be made more effective and is taking action in three areas outlined chapters 3-5. Chapter 6 addresses the need for ongoing review of the partnership. First, the NSTC concludes that mutual understanding and effectiveness would be enhanced by a clear articulation of the principles of the partnership. The NSTC will develop such a statement of principles in consultation with universities, and as a first step, is issuing a proposed set of principles, reproduced in chapter 3. To be effective, this process must be conducted in partnership with stakeholders, including the Congress. Second, the NSTC reaffirms the importance to the nation, to the research enterprise, and to the future scientific and engineering workforce, of linking education and research, and urges universities to do likewise. The vital and dual roles of students (undergraduates as well as graduates), as both researchers who contribute to the national research enterprise, and as students who gain research experience as part of their training, must be recognized and reflected in government and university policies and practices alike. Specific actions that the NSTC will take in support of this policy are outlined in chapter 4. Third, the NSTC, through the agencies that fund university-based research, will implement a set of actions that will help make the partnership more effective and efficient in areas identified by the review and discussed in chapter 5 of the report. Universities are likewise urged to examine their policies and practices for ways to improve the partnership. Finally, the NSTC will establish a mechanism to follow-up on issues that were identified by the review but which were not examined in detail and to provide for ongoing review of the partnership.

Principles of the Federal Partnership with Universities in Research

For the partnership to thrive, there must be a clear understanding on the part of both parties of the goals of the partnership and the responsibilities of the partners. Why does the Federal government invest in university research? What is the role of graduate students in the research enterprise? On what basis are the costs of research allocated among the parties? Federal laws, circulars, and regulations govern operational aspects of the government-university relationship in areas such as allowable costs, administrative procedures, compliance issues, and audit practices. Yet statements of the rationale, goals, and objectives of the public investment in university-based research remain implicit, or are dispersed in a variety of legislative and other documentation. As long as this is so, the government-university partnership risks being defined primarily in an ad hoc manner, by detailed accounting, administrative, and financial management requirements, and not by broader national goals.

A clearly articulated statement of the principles of the partnership would help clarify the roles, responsibilities, and expectations of each of the partners and establish a framework for addressing future issues as they arise. Ultimately, an agreed upon statement of principles would also serve to shape future discussions, formulate policies, and help guide decision making. The process itself of engaging the government and university partners in a dialogue would increase mutual understanding and provide a good foundation for resolving complex issues in the future.

The NSTC, in this report, is issuing a proposed statement of the principles of the government-university partnership. These were developed through interagency review and discussion that benefitted greatly from the input provided by the university community. It is imperative that a more extensive dialogue take place among all stakeholders before the principles are finalized. In particular, it is especially important that universities become directly involved in these discussions and that the Congress also become engaged. To this end, the NSTC encourages internal university discussions and inter-university deliberations, in addition to the dialogue that will be facilitated by the NSTC between the government and university partners and any congressional deliberations that might occur.

The goal of all those involved in these discussions should be to foster an environment that promotes scientific discovery, technological innovation, and the development of the next generation of scientists and engineers. Government actions should be guided by a recognition of the national importance of the American university and by a desire to sustain that special resource for maximum benefit to the nation. It is also important for universities to demonstrate their understanding of the responsibilities to the American public that accompany the acceptance of Federal funds for the conduct of research. Both partners must also be committed to streamlining administrative processes while maintaining effective stewardship of Federal funds.

Proposed Statement of Principles

The following are guiding principles that govern interactions between the Federal government and universities that perform research.

Guiding Principles

Research Is an Investment in the Future

Government sponsorship of university research—including the capacity to perform research and the training of the next generation of scientists and engineers—is an investment in the future of the nation, helping to assure the health, security, and quality of life of our citizens. Government investments recognize that the expected benefits of research often accrue beyond the investment horizons of corporations or other private sponsors. Investments in research are managed as a portfolio, with a focus on aggregate returns; investments in individual research efforts that make up the portfolio are based on the prospects for their technical success, though not on a presumption that those outcomes can be predicted precisely.

The Linkage Between Research and Education Is Vital

The integration of research and education is the hallmark and strength of our nation's universities. Students (undergraduates as well as graduates) who participate in Federally sponsored research grow intellectually even as they contribute to the research enterprise. Upon graduation, they are prepared to contribute to the advancement of national goals and to educate subsequent generations of scientists and engineers. Their intellectual development and scientific contributions are among the important benefits to the Nation of Federal support for research conducted at universities. There should be compelling policy reasons for creating or perpetuating financial or operational distinctions between research and education. Our scientific and engineering enterprise is further enhanced by the intellectual stimulation brought to campus by students from varying cultural, ethnic, and socioeconomic origins.

Excellence Is Promoted When Investments are Guided by Merit Review

Excellence in science and engineering is promoted by making awards on the basis of merit. Merit review assesses the quality of the proposed research or project and is often used in combination with a competitive process to determine the allocation of funds for research. Merit review relies on the informed advice of qualified individuals who are independent of those individuals proposing the research. A well-designed merit review system rewards quality and productivity in research, and can accommodate endeavors that are high-risk and have potential for high gain.

Research Must Be Conducted with Integrity

The ethical obligations entailed in accepting public funds and in the conduct of research are of the highest order and recipients must consider the use of these funds as a trust. Great care must be taken to "do no harm" and to act with integrity. The credibility of the entire enterprise relies on the integrity of each of its participants.

Operating Principles

The following operating principles are intended to assist agencies, universities, individual investigators, and auditing and regulatory bodies in implementing the guiding principles.

Agency Cost Sharing Policies and Practices Must be Transparent

As in any investment partnership, each partner contributes to the research endeavor. While the primary contribution of universities is the intellectual capital of the researchers' ideas, knowledge, and creativity, it is sometimes appropriate for universities to share in the costs of the research (and in some cases cost sharing is required by statute). Cost sharing can be appropriate when there are compelling policy reasons for it, such as in programs whose principal purpose is to build infrastructure and enhance an awardee's institution's ability to compete for future Federal awards. Cost sharing is rarely appropriate when an awardee is acting solely as a supplier of goods or services to the government since this would entail a university subsidy of goods purchased by the government. If agency funds are not sufficient to cover the costs of a research project, the agency and the university should re-examine the scope of the project, unless there are compelling policy reasons to require university cost sharing. Agencies should be clear about their cost sharing policies and announce when and how cost sharing will figure in selection processes, including explicit information regarding the amount of cost sharing expected.

Partners Should Respect the Merit Review Process

Excellence in science is promoted when all parties adhere to merit review as the basis for distributing Federal funds for research projects and refrain from seeking Federal funds through non-merit- based means. Federal investments in research are made with the expectation that the research community will select promising research paths more productively and wisely by relying on merit review than can a process that bypasses merit review to directly fund a specific individual or institution. Success in obtaining funds outside the merit review system can be discouraging to researchers who participate in the process.

Most significantly, bypassing merit review threatens to undermine research excellence. Merit review may be used in conjunction with other selection criteria to support agency or program goals.

Agencies and Universities Should Manage Research in a Cost-Efficient Manner

The goal of all those involved in sponsoring, performing, administering, regulating, and auditing university-based research and associated educational activities of the research enterprise should be to make maximum resources available for the performance of research and education. This goal can be accomplished by keeping agencies' and universities' costs of compliance with Federal requirements to the minimum required for good stewardship of Federal funds. For example, administrative requirements should rely on the least burdensome and least costly methods that can effectively provide needed stewardship. Universities should likewise manage their Federal grants as efficiently as possible.

Accountability and Accounting Are Not the Same

The principal measure of accountability must be research outcomes: have the researchers carried out a program of research consistent with their commitment to the government? Financial accountability is also important and should assure research sponsors that Federal funds have been used properly to achieve the goals of the research in a cost effective manner. Federal agencies must ensure that financial accountability requirements are limited to those that are reasonably required for good stewardship and that each measure adds sufficient value in terms of increased stewardship to justify the burdens and costs it imposes on universities and agencies.

The Benefits of Simplicity in Policies and Practices Should Be Weighed Against the Costs

The costs and benefits of simplicity in regulatory, administrative, cost accounting, and auditing practices should be assessed against the costs and benefits of accommodating diverse Federal programs and the multiplicity of university organizational structures in determining best policies and practices. "One size fits all," or uniformity for uniformity's sake, can unintentionally increase requirements and burdens, but a multiplicity of practices can also be costly. These tradeoffs should be carefully assessed whenever changes in government-wide or agency-specific policies and practices are proposed.

Change Should be Justified by Need and the Process Made Transparent

The process of change in the government-university partnership should be made as transparent as possible. Modifications in administrative, regulatory, or auditing requirements, or in cost sharing expectations, should be kept as infrequent as possible, consistent with the need to respond to changing circumstances. The impact of change in one part of the system should be understood relative to the whole. Reasonable time should be allowed for both agencies and universities to adapt to change.

30 Strategic Options to Enhance the Research Competitiveness of EPSCoR Universities

Irwin Feller

Introduction

This article outlines options for enhancing the competitiveness of the EPSCoR universities in securing external research support. Competitiveness occupies the center of the paper because the larger part of federal funds and substantial portions of the funds provided by industry and foundations for academic research are allocated primarily according to competitive review processes and criteria. A university's or state's share of federal or total academic research funding thus flows primarily from how well it fares in this competitive environment.

The dominant characteristics of the U.S. system of awarding federal funds to support academic research are open competition to all applicants, peer review of the quality of proposals, and emphasis on scientific merit as a proposal selection criterion. This system is widely held to have contributed to the U.S.'s preeminence in many fields of scientific research and to its distinctive integration of research and graduate student education and, increasingly, of undergraduate students (Clark, 1995). However, the system also has resulted in the concentration of academic research and development (R&D) funding, whether measured

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by the distribution of federal awards or by total academic R&D expenditures. In 1997, for example, the top ten university performers accounted for 19.2 percent of federally funded academic R&D expenditures, while the top 50 universities performed 51.0 percent and the top 100 performed 79.1 percent of this total. By state, the top five states accounted for 41.5 percent and the top ten states accounted for 59.7 percent of federally funded academic R&D. In contrast, the aggregate share of the top ten states with the smallest shares was two percent, while that of the lowest 20 states was six percent. EPSCoR universities fall mainly into this last group.

These patterns of concentration are longstanding. They have deep historic roots in the concentrated geographic location of the private universities that made the earliest and most intensive commitment to research, to differences in state populations and economic bases, and to state policies regarding support of higher education (Goldin and Katz, 1999). Moreover, patterns of concentration by institution or state have become somewhat less marked over the 1980–1997 period (Feller, 1999). Still, for many institutions and states, and certainly those within the lower portions of the distribution of federal academic research funds, increased dispersion (or decreased concentration) is a desired objective.

Contextual Factors

Although this article focuses on institution- and state-specific strategies to increase research competitiveness, its assessment of the likely effectiveness of these strategies is conditioned by an assessment of the forces affecting the larger external environment within which all universities compete for research funds.

Among the major national factors seen as likely to affect the efficacy of specific strategies are the following:

- Long-term trends in the external financing of academic research remain uncertain despite substantial increases in FY1999 appropriations for NIH and NSF and continuing congressional expressions of intent to substantially increase federal support for basic research. Existing caps on federal expenditures in the 1997 budget agreement and building pressures for some combination of tax reductions and shoring up of the social security system may limit the revenue available to fund discretionary domestic expenditures, which include non-defense R&D, in the future.

- Industrial support of academic research may be leveling off (as a percentage of total academic R&D). More pronounced is firms' tendency to concentrate their R&D funding in a smaller number of institutions.

- The portion of academic R&D financed from internal (institutional) sources has risen steadily since 1976, amounting to 18 percent in 1996. The sustainability—financially or politically—of this trend, especially for public universities, is problematic given current pressures and priorities for public universities to enrich the undergraduate experience.

- Beyond its size, the future structure of the academic research enterprise remains much in doubt and debated. Nationally, university presidents and academic leaders hold considerably divergent perspectives about future patterns of concentration/dispersion of the American research university system. They also differ about the desirability of national initiatives to substantially increase the number of research-oriented universities. The claims of EPSCoR institutions for any significantly larger share of total federal funding likely will be seen (and opposed) nationally as special pleading by non-EPSCoR university leaders unless sanctioned by competitive, merit-based procedures.

- The number of universities looking to maintain or enhance their research-competitiveness, national standing, or R&D funding share is increasing. For existing research institutions and an increasing number of aspiring universities, excellence means becoming a (more) research-intensive institution. Statements by EPSCoR universities of aspirations to "move up" in rankings as R&D performers or in state shares must take into account the same statements being made by aspiring non-EPSCoR universities. The strategies open to them most often differ more in degree than in kind for EPSCoR institutions. No established leader (university or state) is indifferent to competitive threats to its position; many have launched major new initiatives to buttress or enhance their positions. EPSCoR and non-EPSCoR institutions may each be seen as engaged in a continuing effort to sustain or achieve institutional excellence.

- Strategic thinking and language have become a standard part of university vocabularies, planning, and actions for well over a decade (Keller, 1983). Strategic planning at most universities today is primarily a matter of implementation and revision, not formulation. Few, if any, of the strategies presented below are thus likely to be new. This should not be surprising. For the most part, the strategies cited are those presented by university leaders, and they represent existing "best practice" or "conventional wisdom." Few strategies available to EPSCoR institutions are not available to non-EPSCoR institutions. In an arena of intense competition, the challenge for EPSCoR universities is not simply to achieve the average rate of increase in federal funding of academic R&D, but to accelerate their steps towards becoming nationally competitive.

Structural differences do exist between the EPSCoR and non-EPSCoR universities. EPSCoR universities, on average, have a relatively greater dependence on funding from state governments and USDA than do non-EPSCoR universities, and the latter have a relatively higher percentage of their funding from NIH. Federal funding of academic research has grown most rapidly in biomedical research, funded primarily by NIH. EPSCoR states are disproportionately represented among the states with small medical schools or without medical schools. EPSCoR universities also are typically public rather than private universities. Private universities in general have more latitude in allocating internal funds to underwrite modernization and expansion of research facilities than do public universities. Public universities by way of contrast must increasingly demonstrate to elected officials that state appropriations are directed primarily at instructional rather than research activities.

In addition to these characteristics of the external national environment, two other considerations affect the formulation of strategies to enhance the research competitiveness of EPSCoR institutions.

1. Eligibility to participate in the EPSCoR program is based on state- rather than institution-level measures of research performance. In fact, considerable differences—quantitative as well as qualitative—exist in research capacities and performance among EPSCoR universities and colleges. (For example, using the Carnegie Classification system, the 56 universities that participated in the EPSCoR program in 1995 ranged from Research I to Doctoral I institutions.) EPSCoR institutions differ significantly according to several structural variables that affect the research performance and competitiveness of universities. These include

institutional size and budgets, state-level variables such as level of appropriations, structure and governance of higher education systems, industrial base, rates of growth of population and economic activity, composition of sources of external research support, and internal histories and cultures.

2. EPSCoR universities vary considerably in measures of total and federal R&D expenditures. Five EPSCoR universities (University of Alabama-Birmingham [28], Louisiana State University [74], University of Kentucky [76], University of Kansas [93], and University of Oklahoma [94]) ranked among the top 100 institutions in total federally funded expenditures in 1997, with some of these institutions having achieved significant recent advances in total R&D awards and relative standing. Other EPSCoR institutions rank relatively low in total or federal R&D expenditures and have exhibited little increase (relative to national levels) in these expenditures during the past 15 years.

The obvious conclusion from a listing of these differences is that the strategies for different institutions likely will differ. Strategic options for EPSCoR institutions thus must take the form of a generic menu from which institutions and states select the most appropriate main choices, which must then be further seasoned to meet site-specific settings.

Strategic Options

University strategic planning is often predicated on what rivals or exemplars have done, and given the recent diffusion of benchmarking practices, on what they are doing. While engaging in this process, universities can lose sight of the interactions between their behavior and that of their rivals. If benchmarking, for example, on electronic research administration leads multiple universities to adopt the same innovative practices, the result may be more efficient internal procedures but not necessarily a lessening of the competitive scramble for external research funds. Strategic planning, in this example, simply leads to new requirements as to what constitutes a competitive minimum. To cite another current example, if multiple institutions seek to develop "niches" of excellence in biotechnology or information science, the short-term result can be a sharp increase in the cost of the scarce factors of production—namely, faculty salaries and start-up packages—needed to start these programs, but not necessarily a great leap forward for any single institution. Institutions that fail to make investments in these fields can be expected to be out of the running for any new stream of research funds flowing into the area, but institutions that make these investments cannot be assured that their expenditures (or "investments") will insure competitive successes. There may simply be too many institutions attempting the same strategy.

The account of strategies is predicated on consensus among university officials and faculty about the factors that shape research competitiveness. These factors include a research-productive faculty who are recruited in national markets and whose performance is vetted by national norms for research outcome; competitive salary levels and teaching loads; high-quality graduate students; state-of-the-art equipment and research facilities; flexible and supportive organizational arrangements and institutional policies (on purchases, personnel, and travel); and a supportive central administration which makes national standards of research performance a key institutional objective (Feller, 1996; Teich and Gramp, 1996).

Strategic options available to EPSCoR universities to enhance their competitiveness for external research funds are presented below. In each case the strategy is briefly described, followed by an assessment of its strengths and weaknesses. For purposes of presentation, the strategies are listed as discrete choices, or pure strategies. In fact, several of the strategies constitute specific refinements of other, more global strategies. More importantly, many (but not all) of the strategies may be combined into a "mixed" strategy. The mixed strategy approach more closely approximates the span and heterogeneity of research and graduate degree programs found on most campuses as well as the diversity of external funding opportunities and stakeholder interests in the composition and character of an institution's activities. A mixed strategy also permits an institution to select the strategy that is most effective to a particular discipline, college, or constituency.

The risk of the mixed as compared to the pure strategy is that the former may dilute the resources or level of commitment needed to effectively implement a pure strategy. A mixed strategy also may be more difficult to describe to faculty, students, or relevant stakeholders, such as state officials, industrial leaders, and parents of students. Difficulties in communicating the strategy may cause the institution to emit mixed signals as to its purposes or priorities, leading to opposition or inefficiencies as the strategy is implemented.

Ten strategies are considered: Increase the Number, Size, and Quality of Research Proposals; Niche Markets; Interdisciplinarity; Catch a

New Wave; Collaboration; Emphasis on Industrial and Applied Research; Build a Medical School; Bootstrap; Political Leverage; and Strategic Redefinition of Objectives.

Increase the Number, Size, and Quality of Research Proposals

Abstracting from formula-based funding (say, for state Agricultural Experiment Stations under Hatch funding) or specific congressional earmarks, the amount of externally funded research support received by a university is primarily the product of the number of proposals submitted by its faculty, the percentage of these proposals that are funded, and the average size of the awards. Enhanced institutional research competitiveness entails improving performance with respect to each and all of these three variables.

a) Increasing the number of proposals submitted relates to the institutional commitments of universities and their faculty to research and to the necessity, criticality, or convenience provided by external research support. A strategy to increase the number of faculty writing proposals is likely redundant in universities, colleges, or departments already committed to national standards of research or where external support is necessary for the conduct of research. Faculty likely are fully employed in this activity, and so strategy moves on to focus on other parts of the university or to b) and c) below.

The strategy of increasing the number of research proposals likely has more relevance in universities and units that have made new or more intensive commitments to research performance. Some faculty, particularly in the science and engineering disciplines, are socialized to seek external research support and thus to write proposals early in their graduate or post-graduate training; other faculty are not (or are less so). What the first set needs or is most likely to need, as indicated by the Teich–Gramp findings, is infrastructure support—ranging from secretarial and budget assistance to service-oriented sponsored research offices.

Proposal writing also often means rewriting, whether it be revisions or new proposals. How a unit treats those who have tried but failed can be an important element in determining future endeavors.

Evident in these observations is the recognition that proposal writing is neither a spontaneous process nor a costless endeavor. Academic administrations exhorting faculty to write more proposals may squeeze some more work from faculty—the WTBH strategy, as it has been called—but are unlikely to find this a viable (or productive) long-term strategy.

b) The goal of "bigger" proposals, as one EPSCoR project director has described it, is to move the size of the budget over by first one and then two zeros—from $50,000 to $500,000 to $5 million. Strategic planning to increase the average size of proposals (and awards) entails setting new sights or standards about the complexity, scale, or intellectual stretch of individual or institutional research aspirations.

Underlying this strategy is the premise that the scale of research a faculty member undertakes is not fixed but rather can be shaped by organizational cultures and resources. Given modest institutional norms, faculty may be satisfied with reasonably assured success in securing external funds involving modest amounts to address modestly interesting research problems. They may eschew higher-risk endeavors that entail seeking major awards to address more fundamental, complex, or significant research questions because of doubts about whether a) they will be given serious attention in peer review processes; b) they can satisfactorily perform the research; and c) their institution will provide the resources required to complement those obtained from external sources.

To elevate faculty aspirations, institutional strategy needs to be directed at b) and c). Its most significant potential role may rest in encouraging risk-taking behavior directed at major research undertakings. A specific element of this strategy includes recruiting faculty with demonstrated experience in leading major research groups. Such individuals may or may not be "stars" in the conventional sense with which this term is used in academic circles. Rather, it focuses on individuals who have a penchant for collaborative work often organized around program or center-like thrusts.

c) The strategy of improving the quality of proposals is intended to increase the likelihood that proposals will be funded. Phrased differently, it is intended to prevent what could evolve into a process of proposal generation but limited success into success ratios that approximate those achieved by faculty at nationally ranked institutions.

Improvements in the quality of proposals require first that faculty and institutions understand what the quality standards are for success in those agencies, particularly NIH and NSF, where scientific merit strongly affects peer-review recommendations. Strategic action here is directed at developing processes that enable faculty to course through an equivalent internal review process prior to formal submission of a proposal to an agency. In effect, this strategy extends and systemizes to a wider number of proposals; elements of a strategy have already been incorporated into the activities of EPSCoR universities, particularly as they have prepared their proposals to NSF and other federal agencies.

The strategy, to be effective, requires that a) the reviews truly approximate those likely to be administered by panels; b) faculty understand that criticism is an essential part of enhanced competitiveness; and c) faculty accept the hard work associated with revision.

Competitiveness, in short, is hard on the ego. It also can be a time-demanding undertaking that requires institutional flexibility in released time from other activities. Various methods exist to implement this strategy, including reviews by a university's own faculty or by external experts brought in as a pre-screening panel.

This strategy of more, bigger, and better proposals implies that a university has essentially all the critical elements—resources, leadership commitments, policies, and organizational forms—needed to be a nationally competitive research university. It also means that the university has a sufficiently large number of nationally competitive faculty distributed over several disciplines and/or academic units to support an already sizeable research and Ph.D. degree program.

The downside to this strategy is its mirror image: overreaching, or attempting to move too rapidly or on too many fronts without the necessary resources or broad-scale institutional commitments (by deans, department heads, and even faculty). Both internal and external constituencies may continue to champion other institutional missions—undergraduate education, outreach, applied research relevant to local industries—that drain both resources and leadership from the inspiring but difficult-to-achieve objectives of enhanced national research standing.

Niche Markets

The concept of niche markets pervades current strategic thinking in American higher education. These precepts of selectivity, strategic areas of emphasis, and concentration have been voiced by presidents of America's major private research universities—Yale, Chicago, Rochester—and are widespread across public research universities. The strategy is a logical corollary to the repeated refrain that no university has the resources or existing expertise to be all things to all people, but must focus its resources instead on a small, select number of research areas.

A strategy of niche markets would appear to have even greater relevance and attraction for EPSCoR institutions, which, on average, operate with smaller resource bases and lower (NRC) ranked programs than those of the universities with which they seek to compete. A strategy of niche markets indeed is implicit in NSF's EPSCoR program's features: promotion of research clusters; intra-institutional and intra-state competitive processes to identify the research thrusts to be included in a state's proposal to NSF; and de facto institutional provision of funds to match NSF and other federal agency EPSCoR awards.

A niche strategy also plays to existing institutional strengths and unique research opportunities. A combination of geographic and climatic settings, proximity to federal laboratories or major industrial firms, or serendipitous concentrations of outstanding faculty in selected research fields may provide an institution with a springboard to national research competitiveness. Careful attention to the linkages between these fields and complementary fields of knowledge can be used to leverage external support and enhanced quality in others. The rise to national standing of the University of Arizona—initially in meteorology, then in astronomy, and then in the related field of optics—fits this model (Geiger, 1993).

Despite its widespread appeal, there are limitations and drawbacks to the niche strategy. It is generally presented as meaning choices among research areas and graduate degree programs, but in fact the costs of selectivity and concentration may be higher than suggested. For example, Geiger describes the niche approach—or "building steeples of excellence," following the oft-cited example of Frederick Terman's strategy at Stanford—as "implying a kind of institutional triage in which many units will be relegated to teaching or service roles" (1996, p. 125). More than just selected graduate degree programs may be sacrificed in the process. Leslie, for example, presents the implied costs of the steeples of excellence strategy as follows:

> Do not waste time with the undergraduate programs, Terman advised, for they never pay big dividends no matter what kind of resources are devoted to them… . (P)ut the effort into the graduate programs, where national reputations are forged. Do not deviate from the guiding principles of the 'mainstream' theory and the 'steeple' concept. There was no point in creating excellent programs in fields no one cares about (Leslie, 1973, p. 45).

A niche strategy that involves such costs on the undergraduate program may be politically untenable in public universities that draw substantial portions of their revenues from parents and taxpayers. At a state level, the strategy implies selectivity and concentration of resources in those state universities that have stronger research programs, a policy that can run counter to institutional and state government interests in pursuing a broad distribution of resources among institutions (Lambright, 1996).

In addition, successful implementation of the niche strategy implies identifying a niche that is sufficiently wide and deep to have a meaningful impact on an institution's research reputation and level of external funding, but is sufficiently narrow that other established research universities or competitors from other aspiring institutions do not seek to fill the same area. This task is not easy. A niche, by definition, is a narrow area: if too many aspirants seek to fill the niche, the immediate result is that some will not fit in or will be squeezed out. In practice, the prevailing penchant for niche strategies in university strategic planning is more effective in defining the areas that an institution will cut back on or not go into than it is in guaranteeing that the investments in research areas to be strengthened or entered will prove worthwhile.

Interdisciplinarity

A generally high correlation exists among size (as defined by number of faculty, enrolled students, and number of graduates) and measures of the scholarly quality of program faculty (National Research Council, 1995, p. 34). Interdisciplinarity seeks to overcome the limitations of institutional size by configurations of faculty about research thrusts rather than academic cost centers—that is, departments. Rather than attempt to achieve research competitiveness along traditional disciplinary lines, the strategy seeks to build competitiveness at the boundaries of disciplines through supporting interdisciplinary efforts. These efforts include established techniques such as championing the creation of interdisciplinary research institutes and centers on campus, and perhaps more importantly, organizing fields of study and hiring faculty along interdisciplinary lines.

Interdisciplinarity has been a winning strategy for a small number of universities, primarily in engineering-oriented institutions such as Carnegie Mellon. This strategy gains support from the findings from the Stahler and Tasch study (1992) that fast-growing research universities conducted more of their research in institutes than did slower growing universities. It also draws strength from specific programmatic initiatives and general statements from NIH and NSF that major funding will be directed at cross-disciplinary approaches to scientific and engineering research.

The downside to this strategy is the challenges it presents to the traditional disciplinary and departmental structure of most universities, the tendency of faculties and university administrators to employ disciplinary-based reference groups in promotion and tenure decisions, and—unintentionally perhaps—the "conservative" consequences of benchmarking techniques, which favor established academic fields. These challenges are not easily overcome. Indeed, only a few technology-oriented universities may be said to have successfully used this strategy to achieve national research competitiveness. For most institutions, adoption of this strategy would require a fundamental rethinking and restructuring of the institution.

Catch a New Wave

The strategy here is to identify and implement research programs that address the most intellectually exciting scientific and technological questions of the next major wave of federal and other external sources of funding. A variant of that strategy is to reinforce existing niches of research expertise in the hope that they become the hot, mainstream area of scientific research in the near future. In either case, the goal is to so concentrate institutional resources as to be at the forefront of the new wave rather than a niche or distant performer of pre-existing mainstream research.

Seeking to identify a new wave—a paradigm-shifting line of research—is a high-risk, high-return strategy. The vaunted mainstream of scientific research often is visible (and navigable) only after revolutionary, breakthrough advances have been made (Cohen, 1985). Prior to that time, however, the channels by which new scientific knowledge is to be communicated are imperfectly perceived and frequently disputed (Horgan, 1996). (Howard Temin's work in the 1960s on viruses as a cause of cancer was "widely held to be scientifically bizarre and wrongheaded"; in 1975, Temin shared a Nobel Prize with David Baltimore and Renato Dulbecco for their research [Kelves, 1995].) Although each decade typically yields a list of new wave topics (information technology and neurosciences, for example, being cited as the successor to recombinant DNA research as a "hot" field of research), considerable uncertainty exists about which lines of research will prove productive and thus lead to sustained federal government and other external research support.

EPSCoR institutions confront not only these "scientific risks" but also what may be termed "economic" or "retention risks"—namely, that if they recruit and support researchers capable of generating breakthrough findings, these researchers, when successful, will be bid away by established research universities.

Collaboration

Collaboration involves combining the expertise of several institutions to overcome the shortcomings of a lack of critical mass in faculty and equipment. It offers opportunities for faculty and institutions to participate in important and large-scale research undertakings that they could not successfully pursue themselves.

Collaboration may take several forms. It can involve employing the unique research facilities or settings of an EPSCoR university, as in Montana and Nevada, to attract the collaboration of faculty at more research-intensive universities. It can entail appointments between an EPSCoR university and a non-university research laboratory, an arrangement that serves to apportion the salary costs of a faculty member while providing opportunities for him or her to work at research organizations with state-of-the art facilities lacking in the EPSCoR university. It may involve accepting supporting roles in terms of specification of principal investigator(s) or lead institutions to more established researchers. Whether as a transitional or permanent arrangement, the net outcome is higher productivity and reputation for a university and its faculty than would otherwise be the case. In some states, collaboration means bringing together two (or more) essentially autonomous units of a university—especially a main campus and a medical center—to form a larger research team.

Criteria contained within select federal research awards—that institutions demonstrate commitment to broadened participation of historically underrepresented groups in research, teaching, and related programmatic objectives—also offer singular opportunities for historically black universities and colleges and other minority institutions in EPSCoR states (as well as in non-EPSCoR states) to leapfrog existing institutional constraints on research competitiveness by collaborative arrangements that enable them to participate in major research projects.

Collaboration, however, is a strategy that takes considerable time and effort to implement. It requires building information and communication linkages where none may have existed before. It requires substituting negotiation, trust, and a positive sum perspective for what at times may have been contentious, zero-sum relationships within universities in a state.

Emphasis on Industrial and Applied Research

Universities in EPSCoR states, on average, receive a higher percentage of their funding in the fields of agriculture and engineering than do the more research-intensive universities in non-EPSCoR states. This pattern follows from the predominant role of public universities in EPSCoR states, many of which, like public universities in non-EPSCoR states, had their research programs arise about applied research topics of relevance to the state's industries (Feller, forthcoming).

Within this historical context, efforts at enhancing research competitiveness for several EPSCoR universities have been directed at strengthening basic science and engineering fields. This strategy has sought to capitalize on the increased role of NIH as a source of academic research funds, to be more competitive for peer-reviewed individual investigator and non-sheltered program competitions from NSF, and to compete for the more basic research programs of mission agencies such as DoD and NASA.

An alternative strategy is to concentrate on the institution's historical strengths in applied research, focusing on industrial sponsors, state agencies, and the applied research programs of mission agencies. This concentration of emphasis includes not only research competencies, as reflected in faculty and research facilities, but formulation of institutional policies on intellectual property rights, technical assistance, and curricular content to enhance the value of the institution to the "customer." The strategy also seeks to capitalize on linkages between key state economic sectors and state government, using improved relationships with the state's industries as a means of obtaining supplemental state support.

The downsides to this strategy include the small size of the industrial sector in several EPSCoR states, which limits the revenue potential from focusing on intra-state sponsors; and the loss in intellectual and economic synergies that can come from too sharp a separation of basic and applied research within an institution. The strategy also runs counter to industry's interest in establishing longer-term relationships with a small number of institutions that are capable of performing the fundamental research that underlies the firm's core technologies. The strategy also may involve a move away from the largest (and fastest growing) source of federal funds for academic research—NIH.

Build a Medical School

Recent experiences of research universities and projected trends in the composition of federal academic research point to the possibilities of building institutional research competitiveness about an academic medical center. During the 1980s, academic medical institutions—either as free-standing institutions or as schools within larger comprehensive research universities—increased their relative shares of federal funding (Geiger and Feller, 1995). They were able to capitalize on the openings of new scientific and technological frontiers associated with breakthrough advances in molecular biology and the life sciences; the increased funding for NIH, both in absolute terms and relative to that of other federal agencies; and the organizational and staffing patterns of academic medical centers, which permitted the hiring of additional research personnel essentially independent of undergraduate enrollment patterns.

The rapid rise to national standing of the University of Alabama-Birmingham from a branch campus to a nationally ranked, Research I institution based first on development of an academic medical center, and then leveraging of this strength to develop arts and sciences degrees highlights the potency of this strategy (Graham and Diamond, 1997, pp. 151–152). One can indeed find similar strategies underway at EPSCoR universities—as in the case of Marshall University, West Virginia, which has used the EPSCoR-supported enhancement of its biomedical research capabilities as an institutional template in seeking comparable improvements in its science and engineering programs.

Underpinning this strategy have been recent trends in the external funding of academic research. Between 1973 and 1996, the share of academic R&D directed to the medical sciences increased by over five percentage points, from 22.4 to 27.6 percent (National Science Foundation, 1999). This shift, using 1996 as the base, represents $1.2 billion in research support to the medical sciences relative to other fields. Recently enacted increases in NIH's budget for FY1999, coupled with still active congressional proposals to achieve a doubling of NIH's budget in five years, attest to continuing strong political support for increases in medical and life science research. Even if the rosiest of scenarios for NIH funding increases fails to materialize, it still appears likely that biomedical research will be treated at least as well if not better than most other scientific fields in congressional appropriations.

This strategy has two downsides. First, academic medical centers are expensive to establish and operate, making efforts to increase research competitiveness—even if successful—a financially questionable proposition for a university. Revenues from academic medical centers accounted for approximately 15 percent of total revenues for Research I and Research II universities in 1993, but were as high as 40 percent of revenues for universities with medical schools. The largest source of these revenues was medical services; indeed, "(b)y 1993, medical-service revenues accounted for over two and a half times more money than federal research grants to medical schools" (Cohen, 1997, p. 363).

However, cost control policies associated with the rise of managed health care and increased competition and changes in federal policies for reimbursing medical schools for their educational missions have had a twofold deleterious impact on the finances of academic medical schools. They have weakened the overall financial position of medical schools and closed off a channel by which clinical service income was used to subsidize research activities. Both trends are seen as serious threats to the ability of academic medical centers to maintain their existing levels of research (Association of American Medical Colleges, 1996).

Second, in many states, perceptions of excessive competition among existing hospitals—university-affiliated and non-university affiliated—may lead to a political gauntlet of opposing interests in securing state approval.

Bootstrap

Bootstrapping is a more austere form of a niche strategy. It involves finding the resources from within the university to build research expertise. The strategy implies greater sacrifice in other institutional missions (e.g., educational programs) than the other strategies, and a longer time horizon before institutional expertise is built to nationally competitive levels. On the other hand, it yields greater self-determination in areas of research expertise to be developed, being somewhat less geared to short-term funding opportunities available from federal, state, or industrial sponsors.

Bootstrapping has two manifest shortcomings as a strategy. Even with concentrated focus, the institution may not be able to generate the internal resources necessary to achieve threshold levels of faculty and facilities to achieve research competitiveness. In addition, bootstrapping may not have the institutional staying power (in terms of leadership or faculty dedicated to both the objective of research competitiveness and the effectiveness of this strategy) to hew to the course of action implied by this strategy. Widespread and persistent austerity felt across many parts of a campus in the hopes of eventually making a few programs nationally competitive is a difficult strategy for an academic leader to implement.

Political Leverage

Political leverage involves increased emphasis by university officials and state officials on using the influence of key members of the U.S. Congress to introduce explicit geographic distributive criteria into the allocation of federal academic research funds by federal agencies. This strategy converts episodic efforts to earmark selective federal research awards and the incremental building of requirements for EPSCoR programs among federal agencies into a broad-scale effort to introduce formula-based or quota-based criteria in lieu of peer-reviewed, merit-based scientific criteria into the allocation of federal academic research awards. The strategy essentially seeks to change the rules of competition.

The appeal of this strategy is heightened by the key leadership positions in the U.S. Congress currently held by representatives from EPSCoR states. Its appeal also may be enhanced over time if other strategies for increased competitiveness and excellence fail. In turning to political redress, EPSCoR institutions would be behaving like many other groups who find their interests not well served by competitive market processes and thus turn to government for regulatory or financial relief.

The drawbacks to this strategy are that it may stunt impetus for the reforms in policies, structures, and behaviors necessary to succeed in competitive environments. Earmarks also may deaden initiative within the university; they can become the antithesis of better and bigger. The strategy also is likely to create opposition from members of Congress who represent states with universities that receive relatively large shares of federal academic R&D awards, from the scientific community, and from industrial and other communities which perceive that both their own sectors' and the national interests lie in insuring that the return from the public investment in academic R&D is maximized. Despite criticism of its shortcomings as well as expressions of unhappiness about the "distributively unfair" outcomes that it can produce (Chubin and Hackett, 1990), review by scientific peers is still regarded as the most effective resource allocation method to accomplish this end.

Strategic Redefinition of Objectives

What if all the above strategies fail to enhance the research competitiveness of an institution? What if the impediments to improvement in research performance—low faculty salaries, inadequate equipment, indifferent political and financial support from state government or other stakeholders, competing institutional visions and priorities—are too formidable to overcome?

This possibility must be considered. Recent exegesis on the hierarchical structure of American research universities highlights this scenario. Geiger, for example, has recently observed that those universities with "good" rather than excellent research programs (as measured by NRC rankings) increased their share of external research funding during the 1980s, with promising prospects for the future; those institutions with programs ranked as adequate or below face "formidable hurdles as they seek to rise in the research hierarchy" (Geiger, 1996, p. 132). Moreover, he concludes, "Most will probably not succeed" (loc. cit.).

Essentially similar assessments are offered by Graham and Diamond (1997). The fourth tier of their four-tier ranking of the research and doctoral quality of institutions contains 51 institutions, many of which are "institutions of modest size and ambition that by dint of their history and location are unlikely to develop major research agendas" (Graham and Diamond, 1997, p. 161). Included in this group are the flagship universities in several EPSCoR states.

Graham and Diamond's history of the post-World War II period also points to unrealized aspirations by several universities that were unsuccessful in their efforts to make quantum quantitative and qualitative advances in research standing. Their lowest ranked quality tier contains a cluster of "relatively new urban branch campuses," as in Milwaukee, St. Louis, Dallas, Arlington, and New Orleans. These are institutions "where ambitions soared in the expansive 1960s, when service to urban constituencies was high on the national agenda" (p. 160).

What strategy(ies) exist for this possibility of unattained or unattainable objectives? One strategy, of course, is to work harder on any or all of the above strategies, or on finding a new, more potent approach. Another, however, is to engage in a strategic redefinition of objectives. Wildavsky, for example, in reviewing the course of public policy in areas such as crime, health, and education, has observed that when public objectives are unobtainable, agencies engage in a strategic retreat from objectives. Government agencies engage not only in trying to achieve objectives, but as these efforts fall short, in changing the objectives themselves. Agencies "negotiate between what they would have liked and what they can get, by finding either new objectives they can achieve for former clients or a new clientele that can use old objectives, or as a last resort, by transferring responsibility to other levels of government" (Wildavsky, 1979, p. 43).

Either purposively, based on analysis of the low probabilities of significantly enhancing research competitiveness or reactively, based on a period of unsuccessful endeavors to achieve such an enhancement, universities may seek to redefine their objectives. For many institutions (in both EPSCoR and non-EPSCoR states), this redefinition would likely take the form of increased attention to undergraduate education, master's level and professional education, and outreach. Significantly, such a redefinition would accord with calls from national leaders for an end to "research drift" and institutional compulsions to move up the Carnegie Classification hierarchy, and for public universities in particular to reemphasize undergraduate education and public service (Kellogg Commission, 1997).

The downside to this strategy is obvious. It requires institutions to accept lesser standings as research institutions on a permanent basis. For some, it may in fact constitute a retreat, pulling back from a beachhead of recent advances in research standing to a toehold as something other than a strictly teaching and service institution. Academic administrators also must be wary about expressly articulating such a redefinition of objectives so that their institutions lose fewer research-active faculty to other more research-intensive institutions, and thus find themselves with even lower levels of research competitiveness.

Conclusion

Strategy is a means of focusing attention and resources towards attainment of an objective. The objective considered in this paper is that of increased research competitiveness for federal research funds, the overarching objective of the NSF EPSCoR program. Each of the strategies presented (except, of course, the last one of strategic redefinition of objectives) singly or in combination holds some prospect of contributing to attainment of this objective. As noted, there is little that is novel in the strategies themselves; in fact, they are based primarily on information gathered during interviews with university presidents and other senior university administrators.

More important than the novelty or lack thereof of the listed strategies is that most, if not all, of them are equally available to all universities, EPSCoR and non-EPSCoR. Having an institutional strategy to enhance research competitiveness thus may be more effective than not having one (which itself is a "strategy," purposively or by default, of leaving essentially in place existing university objectives, resource allocation algorithms, policies, practices, etc.). But having a strategy is no guarantee that it will lead to the attainment of the desired objective(s).

Here, clarification and specification of objectives become critical. All universities can improve the quality of their research, graduate, and undergraduate programs. All can increase the size of their research programs and, given continuous increases in federal funding of academic research, their absolute levels of federal academic R&D expenditures. Not all universities, however, can increase their relative shares (or rankings) of federal R&D expenditures. Whatever the care, thoughtfulness, or leadership exercised in selecting (and implementing) strategies to increase research competitiveness, it is not possible for all current and aspiring research-oriented universities to achieve their objectives of relative improvement.

Bibliography

Association of American Medical Colleges, *The Financing of Medical Schools, Report of the AAMC Task Force on Medical School Financing*. Washington, DC: 1996.

Chubin, Daryl E., and Hackett, Edward J. *Peerless Science*. Albany, New York: State University of New York Press, 1990.

Clark, B. *Places of Inquiry*. Berkeley, CA: University of California Press, 1995.

Cohen, I. B. *Revolution in Science.* Cambridge, MA: The Belknap Press of Harvard University Press, 1985.

Cohen, Linda. "Biomedical Research Support and the Decline of Medical-Services Research Subsidies at Medical Schools." *1998 AAAS Science and Technology Policy Yearbook*. Edited by Albert H. Teich, et al. Washington, DC: American Association for the Advancement of Science (1997): 355–374.

Feller, Irwin. "Elite and/or Distributed Science: An Analytical and Empirical Guide to Public Policy on the Distribution of Federal Academic R&D Funds." Paper presented at the American Association for the Advancement of Science's 1999 Annual Meeting, Anaheim, California, 1999.

_____ (1999). "The American University System as a Performer of Basic and Applied Research, and More." In Branscomb and Florida (eds.), *Industrializing Knowledge: University-Industry Linkages in Japan and the United States*. Cambridge, MA: MIT Press.

_____ "The Determinants of Research Competitiveness Among Universities." *Competitiveness in Academic Research*. Edited by Albert H. Teich. Washington, DC: American Association for the Advancement of Science (1996): 35–72.

Geiger, Roger. *Research and Relevant Knowledge.* New York: Oxford University Press, 1993.

_____ "Making the Grade: Institutional Enhancement of Research Competitiveness." *Competitiveness in Academic Research*. Edited by Albert H. Teich. Washington, DC: American Association for the Advancement of Science (1996): 113–136.

Goldin, Claudia and Katz, Lawrence. "The Shaping of Higher Education: The Formative Years in the United States, 1890 to 1990." *Journal of Economic Perspectives* 13 (1999): 37–62.

Graham, Hugh, and Diamond, Nancy. *The Rise of American Research Universities.* Baltimore, MD: The Johns Hopkins University Press, 1997.

Horgan, John. *The End of Science*. Reading, MA: Addison-Wesley Publishing Company, 1996.

Keller, George. *Academic Strategy*. Baltimore, MD: The Johns Hopkins University Press, 1983.

Kellogg Commission on the Future of State and Land-Grant Universities. *Returning to Our Roots: The Student Experience*. Washington, DC: National Association of State Universities and Land-Grant Colleges, 1997.

Kelves, Daniel. "Pursuing the Unpopular: A History of Courage, Viruses, and Cancer." *Hidden Histories of Science*. Edited by Robert Silvers. New York: A New York Review Book (1995): 69–112.

Kerr, Clark. *Troubled Times for American Higher Education*. Albany, NY: State University of New York Press, 1994.

Lambright, W. Henry. "Developing Science: Notes from the States." *Competitiveness in Academic Research*. Edited by Albert H. Teich, et al. Washington, DC: American Association for the Advancement of Science (1996): 137–190.

Leslie, Stuart. *The Cold War and American Science.* New York: Columbia University Press, 1993.

National Research Council. *Research Doctorate Programs in the United States*. Washington, DC: National Academy Press, 1995.

National Science Foundation, Division of Science Resource Studies. "How Has the Field of Academic R&D Changed." Issue Brief 2 (December 1998).

Stahler, G., and Tash, W. "Success in External Funding at the Fastest Growing Research Universities: Contributory Factors and Impediments." *Research Management* 6 (1992).

Teich, Albert H., and Gramp, Kathleen. "Competitiveness in Research: Perceptions of Practioneers." *Competitiveness in Academic Research*. Edited by Albert H. Teich. Washington, DC: American Association for the Advancement of Science (1996): 73–110.

Wildavsky, Aaron. *Speaking Truth to Power*. Boston, MA: Little, Brown and Company, 1979.

31 The Role of the University: Leveraging Talent, Not Technology

Richard Florida

During the 1980s, the university was posed as an underutilized weapon in the battle for industrial competitiveness and regional economic growth. Even higher education stalwarts such as Harvard University's then-president Derek Bok argued that the university had a civic duty to ally itself closely with industry to improve productivity. At university after university, new research centers were designed to attract corporate funding, and technology transfer offices were started to commercialize academic breakthroughs.

However we may well have gone too far. Academics and university officials are becoming increasingly concerned that greater involvement in university research is causing a shift from fundamental science to more applied work. Industry, meanwhile, is growing upset over universities' increasingly aggressive attempts to profit from industry-funded research, through intellectual property rights. In addition, state and local governments are becoming disillusioned that universities are not sparking the kind of regional growth seen in the classic success stories of Stanford University and Silicon Valley in California and of MIT and the Route 128 beltway around Boston. As John Armstrong, former IBM vice pres-

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ident for science and technology, recently noted, policymakers have overstated the degree to which universities can drive the national and regional economies.

Universities have been naively viewed as "engines" of innovation that pump out new ideas that can be translated into commercial innovations and regional growth. This has led to overly mechanistic national and regional policies that seek to commercialize those ideas and transfer them to the private sector. Although there is nothing wrong with policies that encourage joint research, this view misses the larger economic picture: Universities are far more important as the nation's primary source of knowledge creation and talent. Smart people are the most critical resource to any economy, and especially to the rapidly growing knowledge-based economy on which the U.S. future rests. Misdirected policies that restrict universities' ability to generate knowledge and attract and produce top talent suddenly loom as large threats to the nation's economy. Specific measures such as the landmark Bayh-Dole Act of 1980, which enable universities to claim ownership of the intellectual property rights generated from federally funded research, have helped universities commercialize innovations but in doing so may exacerbate the skewing of the university's role.

If federal, state, and local policymakers really want to leverage universities to spawn economic growth, they must adopt a new view. They have to stop encouraging matches between university and industry for their own sake. Instead, they must focus on strengthening the university's ability to attract the smartest people from around the world—the true wellspring of the knowledge economy. By attracting these people and rapidly and widely disseminating the knowledge they create, universities will have a much greater effect on the nation's economy as well as regional growth. For their part, universities must become vigilant against government policies and industry agreements that limit or delay the intellectual property researchers can disclose. These requirements, which are mounting daily, may well discourage or even impede the advancement of knowledge, which retards the efficient pursuit of scientific progress, in turn slowing innovation in industry.

The Partnership Rush

In the new economy, ideas and intellectual capital have replaced natural resources and mechanical innovations as the raw material of economic growth. The university becomes more critical than ever as a provider of talent, knowledge, and innovation in the age of knowledge-based capitalism. It provides these resources largely by conducting and openly publishing research and by educating students. The university is powered in this role by generating new discoveries that increase its eminence. In this way, academic research differs markedly from industry R&D, which is powered by the profit motive and takes place in an environment of secrecy.

In order to generate new discoveries and become more eminent, the university engages in a productive competition for the most revered academics. The presence of this top talent, in turn, attracts outstanding graduate students. They further enhance the university's reputation, helping to attract top undergraduates, and so on. The pursuit of eminence is reflected in contributions to new knowledge, typically embodied in academic publication.

Universities, however, like all institutions, require funding to pursue their objectives. There is a fundamental tension between the pursuit of eminence and the need for financial resources. Although industry funding does not necessarily hinder the quest for eminence, industry funds can and increasingly do come with restrictions, such as control over publishing or excessive secrecy requirements, which undermine the university's ability to establish academic prestige. This phenomenon is not new: At the turn of the century, chemistry and engineering departments were host to deep struggles between faculty who wanted to pursue industry-oriented research and those who wanted to conduct more basic research. Rapidly expanding federal research funding in the decades after World War II temporarily eclipsed that tension, but it is becoming more accentuated and widespread as knowledge becomes the primary source of economic advantage.

University ties to industry have grown extensively in recent times. Industry has become more involved in sponsored research, and universities have focused more on licensing their technology and creating spin-off companies to raise money. Between 1970 and 1997, for example, the share of industry funding of academic R&D rose sharply from 2.6 percent to 7.1 percent, according to the National Science Foundation (NSF). Patenting by academic institutions has grown exponentially. The top 100 research universities were awarded 177 patents in 1974, then 408 in 1984, and 1,486 in 1994. In 1997, the 158 universities in a survey conducted by the Association of University Technology Managers applied for more than 6,000 patents. Universities granted roughly 3,000 licenses based on these patents to industry in 1998—up from 1,000 in 1991—generating roughly $500 million in royalty income.

Furthermore, a growing number of universities such as Carnegie Mellon University (CMU) and the University of Texas at Austin have become directly involved in the incubation of spin-off companies. Carnegie Mellon University hit the jackpot with its incubation of Lycos, the Internet search engine company; it made roughly $25 million on its initial equity stake in Lycos when the company went public. Other universities have joined in the startup gold rush, but this puts them in the venture capital game, a high-stakes contest where they don't belong. Boston University, for example, lost tens of millions of dollars on its ill-fated investment in Seragen. These activities do little to advance knowledge per se and certainly do not help attract top people. They simply tend to distract the university from its core missions of conducting research and generating talent. The region surrounding the university may not even benefit if it does not have the required infrastructure and environment to keep these companies in the area; Lycos moved to Boston because it needed high-level management and marketing people it could not find in Pittsburgh.

Joint university-industry research centers have also grown dramatically, and a lot of money is being spent on them. A 1990 CMU study of 1,056 of these U.S. centers (those with more than $100,000 in funding and at least one active industry partner), conducted by CMU economist Wesley Cohen and myself, showed that these centers had total funding in excess of $4.12 billion—and that was nine years ago. The centers involved 12,000 university faculty and 22,300 doctoral-level researchers—a considerable number.

Academic Entrepreneurs

In recent years, a debate has emerged over what motivates the university to pursue closer research ties with industry. The "corporate manipulation" view is that corporations seek to control relevant research for their own ends. In the "academic entrepreneur" view, university faculty and administrators act as entrepreneurs, cultivating opportunities for industry and public funding to advance their own agendas. The findings of the CMU survey just mentioned support the academic entrepreneur thesis. Some 73 percent of the university-industry research centers indicated that the main impetus for their formation came from university faculty and administrators. Only 11 percent reported that their main impetus came from industry.

This university initiative did not occur in a vacuum, though. It was prompted by federal science and technology policy. More than half of all funding for university-industry research centers comes from government. Of the centers in the CMU survey, 86 percent received government support, 71 percent were established based on government support, and 40 percent reported they could not continue without this support.

Three specific policies hastened the move toward university-industry research centers. The Economic Recovery Tax Act of 1981 extended industrial R&D tax breaks to research supported at universities. The Patent and Trademark Act of 1980, otherwise known as the Bayh-Dole Act, permitted universities to take patents and other intellectual property rights on products created under federally funded research and to assign or license those rights to others, frequently industrial corporations. And NSF established several programs that tied federal support to industry participation, such as the Engineering Research Centers, and Science and Technology Centers. Collectively, these initiatives also encouraged universities to seek closer research ties to business by creating the perception that future competition for federal funds would require demonstrated links to industry.

The rush to partner with industry has caused uncomfortable symptoms to arise. Industry is becoming more concerned with universities' overzealous pursuit of revenues from technology transfer, typically at the hands of technology transfer offices and intellectual property policies. Large firms are most upset that even though they fund research up front, universities and their lawyers are forcing them into unfavorable negotiations over intellectual property when something of value emerges. Angered executives at a number of companies are taking the position that they will not fund research at universities that are too aggressive on intellectual property issues. One corporate vice president for industrial R&D recently summed up the sentiment of large companies, saying, "The university takes this money, then guts the relationship."

Smaller companies are concerned about the time delays in getting research results, which occur because of protracted negotiations by university technology-transfer offices or attorneys over intellectual property rights. The deliberations slow the process of getting new technology to highly competitive markets, where success rests on commercializing innovations and products as soon as possible. Some of the nation's largest and most technology-intensive firms are beginning to worry aloud that increased industrial support for research is disrupting, distorting, and damaging the underlying educational and research missions of the university, retarding advances in basic science that underlie these firms' long-term future.

Critics contend that growing ties to industry skew the academic research agenda from basic toward applied research. The evidence here is mixed. Studies by Diane Rahm and Robert Morgan at Washington University in St. Louis, found a small empirical association between greater faculty involvement with industry and more applied research. Research by Harvard professor David Blumenthal and others showed that industry-supported research in biotechnology tended to be "short term." But National Science Foundation statistics show that overall, the composition of academic R&D has remained relatively stable since 1980, with basic research at about 66 percent, although this is down from 77 percent in the early 1970s.

The larger and more pressing issue involves growing secrecy in academic research. Most commentators have posed this as an ethical issue, suggesting that increased secrecy contradicts the open dissemination of scientific knowledge. But the real problem is that secrecy threatens the efficient advancement of scientific frontiers. This is particularly true of so-called disclosure restrictions, which govern what can be published and when. Over half of the centers in the CMU survey said that industry participants could force a delay in publication, and more than a third reported that industry could have information deleted from papers prior to publication.

Some have argued that the delays are relatively short and that the withheld information is of marginal importance in the big picture of science. But the evidence does not necessarily support this view. A survey by Harvard's Blumenthal and collaborators indicated that 82 percent of companies require academic researchers to keep information confidential to allow for filing a patent application, which typically can take two to three months or more. Almost half (47 percent) of firms report that their agreements occasionally require universities to keep results confidential for even longer. The study concludes that participation with industry in the commercialization of research is "associated with both delays in publication and refusal to share research results upon request." Furthermore, in a survey by Rahm of more than 1,000 technology managers and faculty at the top 100 R&D-performing universities in the United States, 39 percent reported that firms place restriction on information-sharing by faculty. Some 79 percent of technology managers and 53 percent of faculty members reported that firms had asked that certain research findings be delayed or kept from publication.

These conditions also heighten the chances that new information will be restricted. A 1996 *Wall Street Journal* article reported that a major drug company suppressed findings of research it sponsored at the University of California San Francisco. The reason: The research found that cheaper drugs made by other manufacturers were therapeutically effective substitutes for its drug, Synthroid, which dominated the $600-million market for controlling hypothyroidism. The company disallowed publication of the research in a major scientific journal even though the article had already been accepted. In another arena, academic economists as well as officials at the National Institutes of Health have openly expressed concern that growing secrecy in biotechnology research may be holding back advances in that field.

Despite such troubles universities continue to seek more industry funding, in part because they need the money. According to Pennsylvania State University economist Irwin Feller, the most rapidly increasing source of academic research funding is the university itself. Universities increasingly believe that they must invest in internal research capabilities by funding centers and laboratories in order to compete for federal funds down the road. Since most schools are already strapped for cash and state legislatures are trimming budgets at state schools, more administrators are turning to licensing and other technology transfer vehicles as a last resort. CMU is using the $25 million from its stake in Lycos to finance endowed chairs in computer science and the construction of a new building for computer science and multimedia research.

Spurring Regional Development

The role of the university as an engine for regional economic development has captured the fancy of business leaders, policymakers, and academics, and led them astray. When they look at technology-based regions such as Silicon Valley in California and Route 128 around Boston, they conclude that the university has powered the economic development there. A theory of sorts has emerged that assumes that there is a linear pathway from university science and research, to commercial innovation to an ever-expanding network of newly formed companies in the region.

This is a naïve, partial, and mechanistic view of the way the university contributes to economic development. It is quite clear that Silicon Valley and Route 128 are not the only places in the United States where excellent universities are working on commercially important research. The key is that communities surrounding universities must have the capability to absorb and exploit the science, innovation, and technologies that the university generates. In short, the university is a necessary but not sufficient condition for regional economic development.

Michael Fogarty and Amit Sinha of Case Western Reserve University in Cleveland have examined the outward flow of patented information from universities and have identified a simple but illuminating pattern: There is a significant flow of intellectual property from universities in older industrial regions such as Detroit and Cleveland to high-technology regions such as the greater Boston, San Francisco, and New York metropolitan areas. Their work suggests that even though new knowledge is generated in many places, it is only those regions that can absorb and apply those ideas that are able to turn them into economic wealth.

In addition to its role in incubating innovations and transferring commercial technology, the university plays an even broader and more fundamental role in the attraction and generation of talent—the knowledge workers who work in and are likely to form entrepreneurial high-tech enterprises. The labor market for knowledge workers is different from the general labor market. Highly skilled people are also highly mobile. They do not necessarily respond to monetary incentives alone; they want to be around other smart people. The university plays a magnetic role in the attraction of talent, supporting a classic increasing-returns phenomenon. Good people attract other good people, and places with lots of good people attract firms who want access to that talent, creating a self-reinforcing cycle of growth.

A key and all too frequently neglected role of the university in the knowledge economy is as a collector of talent—a growth pool that attracts eminent scientists and engineers, who attract energetic graduate students, who create spin-off companies, which encourages other companies to locate nearby. Still, the university is only one part of the system of attracting and keeping talent in an area. It is up to companies and other institutions in the region to put in place the opportunities and amenities required to make the region attractive to that talent in the long run. If the region does not have the opportunities or if it lacks the amenities, the talent will leave.

Focus groups I have recently conducted with knowledge workers indicate that these talented people have many career options and that they can choose where they want to live and work. They want to work in progressive environments, frequent upscale shops and cafes, enjoy museums and fine arts and outdoor activities, send their children to superior schools, and run into people at all these places from other advanced research labs and cutting-edge companies in their neighborhoods. Researchers who do leave the university to start companies need quick access to venture capital, top management and marketing employees, fast and cheap Internet connections, and a pool of smart people from which to draw employees. They will not stick around the area if they cannot find all these things. Moreover, young graduates know they will probably change employers as many as three times in ten years, and they will not move to an area where they do not feel there are enough quality employers to provide these opportunities. Stanford did not turn the Silicon Valley area into a high-tech powerhouse on its own; regional actors built the local infrastructure this kind of economy needed. The same was true in Boston and, more recently, in Austin, Texas, where regional leaders undertook aggressive measures to create incubator facilities, venture capital, outdoor amenities, and the environmental quality that knowledge workers who participate in the new economy demand.

It is important to note that this cycle has to not only be triggered by regional action, but also sustained by it. Over time, any university or region must be constantly repopulated with new talent. More so than industrial economies, leading universities and labor markets for knowledge workers are distinguished by high degrees of "churning." What matters is the ability to replenish the talent stock. This is particularly true in advanced scientific and technical fields, where learned skills (such as engineering degrees) tend to depreciate rather quickly.

Regions that want to leverage this talent, however, have to wake up and realize that they must make their areas attractive to this talent. In the industrial era, regions worked hard to attract factories that spewed out goods, paid taxes, and increased demand for other local businesses. Regional authorities built infrastructure and even offered financial inducements. But pressuring universities to develop more ties with local industry or expand technology transfer programs can have only a limited effect in the knowledge economy, because they fail to recognize what it takes to build a truly vibrant regional economy that can harness innovation and retain and attract the best talent the knowledge economy has to offer.

The Path to Prudent Policy

The new view of the university as fueling the economy primarily through the attraction and creation of talent as well as by generating innovations has important implications for public policy. To date, federal, state, and local public policy that encourages economic gain from universities has been organized as a giant "technology push" experiment. The logic is: If the university can just push more innovations out the door, those innovations will somehow magically turn into economic growth. Clearly, the economic effects of universities emanate in more subtle ways. Universities do not operate as simple engines of innovation. They are a crucial piece of the infrastructure of the knowledge economy, providing mechanisms for generating and harnessing talent. Once policymakers embrace this new view, they can begin to update or craft new policies that will improve the university's impact on the U.S. knowledge economy. We do not have to stop promoting university-industry research or transferring university breakthroughs to the private sector, but we must support the university's role in the broader creation of talent.

At the national level, government must realize that the United States has to attract the world's best talent and that a completely open university research system is needed to do so. It is probably time for a thoroughgoing review of the U.S. patent system and federal laws such as the Bayh-Dole Act, which incorporates a framework for protecting intellectual property that is based on the model of the university as an innovation engine. It must be reevaluated in light of the framework based on a university as a talent magnet.

Regional policymakers have to reduce the pressure on universities to expand technology transfer efforts in order to bolster the area's economy. They can no longer slough off this responsibility to university presidents. They have to step up themselves and ensure that the infrastructure their region has to offer will be able to attract and retain top talent and be able to absorb academic research results for commercial gain.

Meanwhile, business, academic, and policy leaders need to resolve thorny issues that are arising as symptoms of bad current policy, such as disclosure restrictions, which may be impeding the timely advancement of science, engineering, and commercial technology. Individual firms have clear and rational incentives to impose disclosure restrictions on work they fund to ensure that their competitors do not get access. But as this kind of behavior multiplies, more and more scientific information of potential benefit to many facets of the economy is withheld from the public domain. This is a vexing problem that must be solved.

Universities need to be more vigilant in managing this process. One solution, which would not involve government at all, is for universities to take the lead in establishing shared and enforceable guidelines limiting disclosure restrictions. In doing so, universities need to reconsider their more aggressive policies toward technology transfer and particularly regarding the ownership of intellectual property.

Since we are moving toward a knowledge-based economy, the university looms as a much larger source of economic raw material than in the past. If our country and its regions are really serious about building the capability to prosper in the knowledge economy, they will have to do much more than simply enhance the ability of the university to commercialize technology. They will have to create an infrastructure that is more conducive to talent. Here, ironically, policymakers can learn a great deal from the universities themselves, which within their walls have been creating environments conducive to knowledge workers for a very long time.

Recommended Reading

Blumenthal, David et al., “Withholding Research Results in Academic Life Sciences: Evidence from a National Survey of Faculty,” *Journal of the American Medical Association*, vol. 277 (April 16, 1997); 1224–1226.

Blumenthal, David et al., “Relationships between Academic Institutions and Industry in the Life Sciences: An Industry Survey,” *New England Journal of Medicine*, vol. 334, no. 6 (February 8, 1996); 368–373.

Cohen, Wesley, Richard Florida, and W. Richard Goe, “University-Industry Research Centers in the United States,” report to the Ford Foundation, Carnegie Mellon University, 1994.

Cohen, Wesley, Richard Florida, Lucien Randazzese, and John Walsh, “Industry and the Academy: Uneasy Partners in the Cause of Technological Advance,” in Roger Noll (ed.) *Challenges to Research Universities*, Washington D.C.: Brookings Institution Press, 1998; 171–199.

Geiger, Roger, *Research and Relevant Knowledge: American Research Universities since World War II*. New York: Oxford University Press, 1993.

Rosenberg, Nathan and Richard Nelson, “American Universities and Technical Advance in Industry,” *Research Policy*, vol. 23, no. 3 (May 1994); 323–48.