Debate

Readers and authors face off over HBR's last issue.

Whether it's tax cuts, collaboration, or hands off, U.S. technology policy needs a new twist.

Technology Policy: Is America on the Right Track?

Lewis M. Branscomb takes on the national debate about U.S. competitiveness in "Does America Need a Technology Policy?" (March-April 1992). In today's global economy, he argues, what matters is not creating new technology but absorbing and applying innovations quickly. Instead of concentrating on the "supply" of new technologies, the U.S. government should stimulate "demand" for innovative ideas by encouraging collaborative research, investing in technological infrastructure, emphasizing the importance of precompetitive research, and helping companies improve their capacity to adapt innovations to specific business needs.

W. Daniel Hillis
Chief Scientist
Thinking Machines Corporation
Cambridge, Massachusetts

I read Lewis M. Branscomb's "Does America Need a Technology Policy?" with mixed emotions. His suggestions for a "demand side" technology policy are a step in the right direction, but if we go no further than he suggests, the United States will continue its slide toward technological incompetence. These are painful words, but the painful reality is that the United States no longer leads the world in the exploitation of technology. Except for a few bright spots, such as computers, aircraft, and certain types of biotechnology, U.S. products must increasingly compete with technologically superior products from overseas.

What's most frustrating is that the United States is failing despite success. As Mr. Branscomb points out, America's de facto technology policy has been extremely effective in promoting the development of certain critical technologies. The United States has an excellent system for encouraging the creation of new technology through direct research funding; support for national laboratories; agencies such as NIH, NASA, NSF, and DARPA; public and private support for universities; and significant tax incentives. And both the public and private sectors have consistently attracted capable and dedicated people to run these programs. If the criterion of success is rapid technological progress, then we have succeeded.

The problem is not how well we invent new technology but, rather, how we turn our ideas into an economic advantage. It is tempting to blame our problems on competitors. The U.S. system of encouraging innovation and funding basic research has become so effective that the rest of the world has come to depend on it, which leaves countries such as Japan free to concentrate on the development and exploitation of ideas that have originated in the United States. Many business leaders argue that America pays the cost of an elaborate and effective system for encouraging technological innovation, yet its foreign competitors get most of the benefits for free. And U.S. companies that have paid directly or indirectly for the innovation are forced to compete with foreign corporations that have not.

As emotionally appealing as this argument may be, it is neither constructive nor entirely correct. Our most economically successful technological competitors, Japan and Germany, actually spend a much larger portion of their GNPs on commercial R&D. If U.S. companies bear an unfair burden, it is due to the cost of the U.S. military, not research. Even to the degree that the argument is true, whining about the unfairness of the situation won't help. To the degree that the United States provides the world with a service, the world will take advantage of the service in a rational, self-interested manner. That is human nature, and it is not likely to change.

The problem is not with the unfair world but with the expectations of leaders in U.S. industry. In the first decades following World War II, the U.S. economic and technological base was so much stronger than that of other countries it was safe to assume that economic success would follow naturally and painlessly from our technological innovations. How-

ever, in today's world, where many nations have the technological, educational, and economic infrastructure to exploit technology, success requires long-term investment and steady commitment. It requires years of building know-how, market share, and capabilities before a company will profit. When it comes to this long-term global perspective, U.S. industry falls short.

In high-technology industries, there is a particularly strong positive feedback between high volume and low cost. That favors the long-term investor. The startup costs for a new technology are inherently high and only justifiable by long-term volume. The best strategy for exploiting high technology, then, is to outspend your competition at the outset and outlast them during initial unprofitable market building–a strategy most U.S. investors find unattractive. It is difficult to imagine a U.S. appliance manufacturer, for example, announcing that it plans to lose money for the next five years in order to regain a technologically competitive position in consumer electronics. Yet that's what is required to compete successfully in that industry.

So how can we get U.S. industry to take the long view? Guarantee loans for plant constructions or process development? Give tax breaks to long-term investors? Allow banks to own voting shares? As a principal in a small technology company, I favor issuing publicly traded shares with voting rights that are proportional to the number of years an investor holds them. That means those investors who believe in the long-term future of the company would have more say in how it is run. I'd buy such stock in a second, but Wall Street would probably hate it, and the U.S. government probably would not allow it in any case. Unfortunately, the problem of long-term focus has no easy, short-term solution.

The United States is a young, impatient country, but its citizens have always believed in the future. Americans are not inherently shortsighted, but recently we've built up a set of habits, laws, and expectations that encourage us to act that way. We must break those habits to maintain our technological competitiveness. As an American, I am haunted by a vision of my children trading raw materials and agricultural products for technological marvels that are beyond their capacity to create. I hope my country has the courage and the patience to take the long road to something better.

Daniel F. Burton
Executive Vice President
Council on Competitiveness
Washington, D.C.

The key word in Lewis Branscomb's article is *absorb*. Mr. Branscomb is right to say that simply generating new technology is not enough; national security and international competitiveness depend on putting new technology to work in practical applications.

Since World War II, the United States has been the world's cornucopia of technology. America's rallying cry has been *basic research*. Matching this gigantic infrastructure and trying to beat the United States at its own game would have required other countries to make incredible investments in R&D and train several generations of researchers. Instead they took a shortcut, focusing on the absorption and application of existing ideas. For these countries, the watchwords were *engineering* and *manufacturing*.

The irony is that, in the process of strengthening their ability to borrow and adapt U.S. technology, other countries have also amassed the capital and created the intellectual talent to generate new technology on their own. Last year, the top four winners of U.S. patents were Japanese companies. And Japan is no longer simply copying and building on new U.S. breakthroughs; it leads the world in such technologies as advanced ceramics and optoelectronics.

Other countries have taken a shortcut, focusing on the absorption and application of existing ideas.

As a result, the United States is now faced with a serious challenge for the first time in over half a century. We will not meet this challenge simply by fueling our awesome engine of technology generation. Unfortunately, many U.S. managers and policymakers have tried to do just that. They have defined the challenge in ways that allow them simply to do more of what they already know how to do well–create new technology.

In industries that are driven by basic research, such as the life sciences, this renewed effort will serve us well. But in industries that are driven by incremental refinements and manufacturing process improvements, such as electronic components, new technology alone will not tip the scales in favor of U.S. industry in world markets. To win in these industries, we must also shore up our weakness in the absorption and application of technology. We must shift our attention to the absorption and application of ideas, which often involves teamwork and tight coordination. Our current system may win Nobel Prizes, but it does little to improve the efficiency of tool and die shops.

The tension between technology creation and the application of existing ideas is at the heart of the federal government's debate about technology policy, which has resulted in a profusion of lists of critical technologies. We should recognize such lists as only the first steps in a much larger process. The lists are not an end in themselves but a way of thinking about priorities and organizing for action. Moreover, they've begun to have an impact on U.S. public policy. The president's 1993 R&D budget, for example, focuses primarily on the importance of *applied* research.

Although Branscomb criticizes the Council on Competitiveness's report, "Gaining New Ground: Technology Priorities for America's Future," because it sets forth yet another list of critical technologies, a closer reading of the report reveals that we are both saying much the same thing. Almost all of the author's recommendations – focusing on precompetitive technology; promoting networks of collaboration; improving America's technology infrastructure;

creating a national industrial extension service for technology and manufacturing; and increasing DARPA funding for dual-use technology – are identical to Council recommendations. As is the case with technology, the most important task currently facing the policy community is not how to create a new series of recommendations but how to systematically implement an existing set of ideas.

Robert B. Costello
Adviser to Industry
Indianapolis, Indiana

Lewis Branscomb suggests that policies have not been carried far enough to make the impact on policymakers that's needed. But there is not just one U.S. technology policy; there are hundreds of them, at least one for every agency in the government. What we need is a set of consistent, complementary policies to enhance overall U.S. competitiveness. We also need to understand the nature and power of the buyer as the key catalyst for implementing new technologies in the industrial infrastructure. The U.S. government is the largest, most powerful buyer in the world and needs to use its power to its own advantage.

Technology policy has been the subject of extensive analysis and review in Hudson Institute studies during the past two years. The primary recommendation of my 1992 report with Maurice Ernst, "An American Agenda for Manufacturing Leadership," is the establishment of a National Technology Agency, with technology defined in its broadest sense. We see the NTA as not just another bureaucratic level but as the means for integrating appropriate existing agencies and associated activities to enhance their effectiveness. A well-regarded precedent already exists – the director of the Central Intelligence Agency.

Why not use government buying power to get the industrial infrastructure we need for the future?

In addition, we cannot duplicate Japanese or German models without adopting much of their integrated parliamentary forms of government. The proposed director of the NTA would wear three hats: chief adviser to the president for science and technology, director of the NTA, and a critical new function, coordinator for the national science and technology community.

The resources for the new agency already exist. Obviously, they must include a strengthened National Institute of Standards and Technology and staff of the current Office of the Scientific Adviser to the President. Also included would be much of what is now the Defense Advanced Research Projects Agency (DARPA), which should become in the near future the National Advanced Research Projects Agency (NARPA), as the Carnegie Commission has recommended. The NTA would have close to $15 billion in research and development funding and unchallenged technical resources, enough to make a major impact.

The NTA's role would primarily be that of a catalyst for national R&D efforts. The director would have tenure, as do the directors of the Federal Bureau of Investigation and General Accounting Office. He or she would be supported by a board of directors, composed of a cross section of key individuals from industry, academia, and government, who would provide policy guidelines and monitor programs according to an explicit MILESTONE procedure previously proposed for DARPA.

The immediate benefits of establishing a National Technology Agency include:

1. More focused research in advanced, generic, precompetitive technologies, with manufacturing technologies given greater emphasis.
2. A more stable, strategic base for the management of government-industry teams with shared funding.
3. Cooperative R&D within federal agencies and activities.
4. Integrated and focused federal technology transfer.
5. Federal R&D shifted from mission orientation to technology diffusion orientation to stimulate U.S. competitiveness in manufacturing.

Robert M. White
Under Secretary for Technology
United States Department
of Commerce
Washington, D.C.

"Technology" is the application of knowledge to create solutions that satisfy human social needs. Our many Nobel Prizes indicate that the United States is very good at *creating* knowledge, and the Persian Gulf War demonstrated that the United States is very good at *applying* knowledge for military purposes. However, our declining market share in many industries points to a weakness in our ability to successfully commercialize new discoveries. By "successfully" I mean establishing a stable, profitable business. We actually did *develop* the technology in these industries, but gradually we fell behind as the markets grew. For example, the first industrial robot was built in 1961 by Joseph Engelberger, who founded Unimation, the first commercial producer. Yet today, about 75% of the robots purchased in the United States are imported.

Even when basic research in the United States does lead to commercial products, the journey is long and expensive and more often than not produces unexpected results. Corporations with specific markets become discouraged because they may not be able to capture benefits from their investments. So, up to now, the federal government has funded research – and development – in areas where industry has not. Nuclear fusion is one example.

But a technology policy should deal with the *process* of translating research into products. Lewis Branscomb argues for a demand-driven policy, and the Department of Commerce agrees with many of his points. In fact, U.S. technology policy already incorporates many of the features he suggests. In terms of his pipeline analogy, we would say technology policy should deal with the "pipe" itself. The ability to competitively commercialize technology is dependent on a complex mix of economic, trade, and regulatory policies, as well as on management and manufacturing skills. For this reason, a

technology policy cannot be stated as neatly as science policy. Also, the two should not be confused.

A technology policy should provide an environment that is conducive to the commercialization of technology. But what are the elements of such an environment? In this age of microscopic electronics and high-speed communications, physical measurement standards are critical. The federal government has long provided, through the National Institute of Standards and Technology, the measurement techniques that support new and emerging technologies.

Congress and the executive branch must eliminate or at least reduce obstacles to innovation.

The availability of capital to develop technology is another crucial element. During the 1970s and the early 1980s, venture capital fueled entire new industries, such as semiconductors and biotechnology. Over the past five years, venture funding has steadily declined. Also, during the 1980s, the assets of institutional investors, such as pension funds and mutual funds, tripled. Unfortunately, these investors are not known for taking the long-term view that technology development requires. Labor Department statistics show that the annual turnover of pension-fund portfolios is more than 50%. The estrangement between capital providers and technology developers poses a serious challenge to the rapid commercialization of new technologies.

One approach to the lack of capital is to make better use of the investments that are made. In particular, the federal government invests $76 billion a year in research and development. Much of this supports objectives in defense, space, energy, transportation, and so on. These technical objectives have become increasingly based on the same generic or "critical" technologies that drive commercial applications: semiconductors, advanced materials, and manufacturing processes. Legislation enacted over the past few years encourages better utilization of this federal investment for commercial applications, and these changes are now beginning to have an impact.

Another approach is to provide direct support for the development of technologies that are beyond the capabilities of certain industries. Just as science grants are awarded to universities based on peer review of proposed research, Advanced Technology Program grants are awarded to corporations in response to proposals reviewed for their technical merit and commercial potential. The ATP satisfies Branscomb's call for more commercially relevant research, but it has two very important features: *industry* not only identifies what should be supported, but it also contributes at least 50% of the funding.

Murray Weidenbaum
Director and Mallinckrodt
Distinguished University Professor
Center for the Study
of American Business
Washington University
St. Louis, Missouri

Lewis Branscomb's article, while filled with many useful insights, is ultimately disappointing. Mr. Branscomb makes a valuable contribution by showing the shortcomings in the current way in which U.S. industry uses R&D, but, unfortunately, instead of pursuing that vital point, he veers off and proposes yet another set of federal subsidies.

As the studies he reviews demonstrate, there is little in the history of federal support of technology to justify the optimism that underlies his proposals. Government – at least in the United States – is not good at choosing which areas of technology to support and which organizations to do the work. We are much better off when private enterprise risks its own capital in selecting technological activities and carries through.

When a company's own laboratory comes up with a product or process advance, there are far fewer barriers to using it than when government takes on that role. The pathetic efforts of the Department of Commerce to interest private business in the research it has financed reminds me of a forlorn street corner vendor trying to peddle his wares to preoccupied passersby.

Government can play an important role in promoting technology, but Branscomb touches on this role all too briefly. Congress and the executive branch need to eliminate or at least reduce the obstacles to innovation that they have erected over the years. Numerous regulatory restrictions inhibit the growth of corporate R&D. It is futile for the federal government to pour vast sums into high-tech enterprises if, at the same time, it erects statutory and administrative roadblocks to the application of new technologies.

The deregulating trend of the late 1970s and early 1980s has been replaced by expanded government regulation of business. Because many federal agencies exempt existing facilities, products, and processes from such directives, the main burden of expanding regulation falls on new enterprises, new undertakings, and new technology. Consider America's world-class pharmaceutical industry, which generates substantially more exports than imports. Congressional committees are responding to that positive situation by cracking down on the industry via proposed new legislation (the pending Food, Drug, Cosmetic, and Device Enforcement Act) that would grant the Food and Drug Administration unprecedented police powers, such as the authority for inspectors to carry guns.

In a large number of cases – chemicals, pharmaceuticals, and biotechnology – the supply of venture capital is substantial. The major constraint on commercializing technology arises from government itself. Consider the hysterical reaction to the use of the protein BST in increasing the production of milk. "Consumer advocates" vehemently opposed the move because it would *reduce* the price of milk, and state legislatures followed their lead by preventing the use of this advance in biotechnology.

Many reforms are needed in the government's current policy of supporting commercially oriented technology. In addition to regulatory changes, a simpler, more effective patent system would encourage the

creation and diffusion of technology. Such a change would ensure that smaller inventors are not overwhelmed by the costs of obtaining patents and defending them against legal challenges. Larger companies would be encouraged to seek patents rather than protecting their new products and processes by maintaining secrecy.

Revisions in the antitrust laws are also needed to encourage joint ventures for developing new technology. Often the capital requirements to develop "generic" or "precompetitive" technologies are beyond the financial capabilities of a single company. Amending antitrust statutes would be more effective than direct financial support from the federal government.

If government goes the subsidy route instead, it will probably favor powerful companies, which are usually older and slower growing. Over the years, these companies have invested substantial amounts of resources into enhancing their political presence in Washington. They are the "squeaky wheels," those companies that suffer most from competitive forces, and they wind up the recipients of the largest subsidies.

New and growing companies may be economically strong, but they are politically weak. They possess neither a record of extended financial contributions to political candidates nor a detailed knowledge of lobbying techniques nor a large group of agitated employees and voters. The result is a very uneven contest for federal money.

Many policymakers are concerned that society as a whole ends up underinvesting in applied R&D because of imperfections in the market economy. The government should make it easier for the private sector to invest in R&D, provided that the entrepreneurial nature of individual companies is maintained. For example, the federal government could provide more generous and permanent tax incentives, available to all private companies that pay U.S. income taxes, for private-sector investment including such vital activities as R&D. Companies receiving the incentive would choose the projects they wish to undertake and would bear most of the financial risk.

Reducing the existing obstacles that face high-tech companies in the United States is a far more satisfying alternative than what Branscomb proposes. Many of the barriers to commercializing technology have been erected inadvertently by the U.S. government's tax, regulatory, and antitrust policies. My advice to the federal policymaker attempting to administer a dose of subsidy to the all-too-willing industrial patient is "Physician, heal thyself."

Luke Georghiou
Executive Director and
Professorial Fellow
Programme of Policy Research in
Engineering Science & Technology
The University
Manchester, England

Lewis Branscomb argues eloquently that the current implicit supply-oriented technology policy in the United States has been rendered obsolete by a competitive environment in which continuous incremental improvements in product quality and process efficiency are critical to success. He rightly points out the inability of governments either to pick technology "winners" or to bring large-scale integrated technologies to the market. Mr. Branscomb is correct, but in his prescription for a demand-oriented technology policy, he fails to follow his arguments to their logical conclusions and hence risks repeating the shortcomings he identifies.

Separating R&D and engineering from core business decision making creates barriers to opportunities.

Take the main elements of his "capability enhancing" technology policy. The first of these, support for collaborative, precompetitive R&D in generic technologies, is one that was tried in Europe throughout the 1980s. The European Community's Framework Programmes and national initiatives such as the United Kingdom's Alvey Programme for Advanced Information Technology have directed several billion dollars toward restoring the competitiveness of industries that, despite individual successes, continued to lose market share and were subject to takeovers and closures. While successful in achieving their technological goals and in stimulating collaborative behavior, the initiatives have not achieved their strategic aim of improving industrial competitiveness. The reasons for this include internal factors such as poor communication between R&D and production divisions; but the overriding lesson to be learned is that such programs *could never* have achieved this aim. Access to generic R&D may be a necessary condition for these industries to exist, but it is certainly not sufficient to restore competitiveness.

The precompetitive model itself was borrowed from a misreading of what had happened in earlier Japanese government programs, notably the VLSI project. Foreign observers correlated the spectacular success of Japanese chip producers with their participation in this collaborative scheme, which was then followed by fierce competition in the market. Hindsight shows that Japanese companies, like their counterparts elsewhere, were averse to collaborating in key areas and did much of the relevant work in their own laboratories. In Europe, the "precompetitive" umbrella became a convenient label for state support in an era when governments were steering away from market intervention. Of course, collaboration can be beneficial, but in most European projects, participants were very positive about this aspect but also emphasized that it is driven by complementarity rather than cost sharing.

Branscomb's second element, industrial extension, is an appealing concept but notoriously difficult to implement on a large scale. Government can promote awareness of new technologies, but such messages are necessarily general and usually insufficient to persuade the individual company to adopt the technology in question. Experience in this area suggests that conditions for diffusion require companies to perceive benefits

for their own specific circumstances. In the United Kingdom, schemes such as awareness clubs for new technologies have worked well but do not reach large groups. Timing is also an important consideration: At what stage in the maturity of a technology should the message be broadcast?

In his third element, DARPA-style support in the civilian sphere, Branscomb moves a long way from a demand orientation. Nevertheless, DARPA's successful record shows that a leading-edge technology can benefit from an initial financial push. But what happens when that "push" is spent? Without the incentive of military procurement to stimulate subsequent investment in commercial products, a competitive nation needs a dynamic industry with many resources that is capable of absorbing the technology and willing to take risks and stay in the market long enough to reap the benefits. But was not the lack of such an industry the problem we started with? And so we are left with the big exceptions: national strategic programs. Putting aside the question of who chooses what these should be, Branscomb himself concedes that they are dependent on a raft of complementary measures – and amount to a full-scale industrial policy.

Of course, it is easy to emphasize the problems of technology policy and much harder to offer positive guidance. Benefits exist in all of the prescriptions Lewis Branscomb offers, but, even taken together, they should not be sold as a cure. In Europe, we are learning the dangers of overselling such solutions.

So what can be done? One clue lies in Branscomb's citation of Fumio Kodama's analysis of Japanese companies that articulate demand and absorb the new technologies needed to shift into new markets. The conditions required are (1) an organization's ability to perceive the need for change in its technology base and (2) an ability to implement that change. Together they constitute a technology strategy.

The European collaborative programs carry a lesson for the implementation of technology acquisition. The complementarity that characterized the successful projects was sometimes horizontal: different technology bases were combined, which corresponds to Kodama's fusion model. But more often, the connections were made vertically, bringing together users and suppliers to produce technologies that were ready for the market. Japanese companies also receive constant technological feedback from their users, which drives the continual improvements Branscomb refers to. A true demand-oriented technology policy should seek to strengthen such links.

Ultimately, however, the barriers that prevent companies from identifying technology opportunities and moving toward them lie deeper than short-term policies can reach. They are rooted in organizational practices and cultural attitudes within the company that separate the R&D and engineering functions from core business decision making. Companies can be encouraged to develop explicit technology strategies, but, in the long-term, the solution lies in measures designed to shift cultural attitudes, beginning with management education.

Umberto Colombo
Chairman
ENEA (Italian National Agency for New Technology, Energy, and the Environment)
President
European Science Foundation
Rome, Italy

In a famous lecture to the Royal Society in 1971, Sir Eric Ashby pointed out an apparent paradox besetting science and technology policy in the West. Disillusionment with science and technology had become commonplace on the heels of its greatest achievement: the landing of man on the moon. The lack of relevance to the ordinary man and woman of the goals set by science was the principal source of this soured vision. Today another paradox has appeared: doubts are expressed about the way America's science and technology policy, based for so long on serving primarily the high-tech needs of the military-industrial complex, is oriented and managed – just when victory in the Cold War and the disintegration of the Soviet empire has been achieved.

This victory comes in no small way from the inability of the Soviet system to match the American, despite the sacrifices and single-mindedness a totalitarian state demands. We must therefore pay tribute to the role U.S. science and technology has played in bringing about the end of a long period of confrontation, even if we agree that now is the time to consider a different policy structure.

Global problems will not only affect the poor nations of this planet; the rest of the world will also suffer.

Lewis Branscomb's article is a major contribution to the technology policy debate in the United States and elsewhere. Many of his criticisms and arguments could also be applied here in Europe. Even so, some aspects of his analysis might benefit from a European-oriented critique.

Mr. Branscomb correctly identifies the supply side-demand side dichotomy in the approach to science and technology policy. It would be useful to follow this with a critical analysis of the actual results these approaches have obtained, which I will try to do from a European perspective.

Since its inception under the inspiration of Étienne Davignon in the early 1980s, European Community science and technology policy has been based on the notion that programs should focus on upstream – premarket or precompetitive – phases of R&D. Financing of phases downstream should remain primarily within the domain of the market and, in special cases, of the public sector. But it has become clear in Europe that market forces cannot sustain unaided the effort that's needed in certain critical areas. While Branscomb appears to advocate greater reliance on the precompetitive approach for America, many Europeans believe that we should be moving away from it as unduly restrictive of public policy.

Branscomb mentions the pivotal role played by the U.S. government in funding defense-related R&D. Pre-

competitive research is a component, but most R&D has been goal oriented – a new bomber, a man on the moon, a new weapons system – rather than bottom-up. It will be fascinating to see how much will now spill out of the U.S. national laboratories and defense establishments to shape R&D policy for the rest of the economy as a new phase, in which initiative rests largely within individual enterprises, gets under way.

Through fertile exchanges in recent years in Europe, there has been considerable success in raising the quality of science across Europe, but we have seen that excellence does not automatically translate into innovation that generates competitive advantage. The best illustration is Britain, where a highly regarded scientific system is married to a sluggish, conservative economy. But the same problem is widespread in other European countries as well.

For a long time, it was identified as a problem of diffusion, a market problem that cannot be defined, understood, or pursued in the same manner as large-scale projects or specified high-tech objectives. Diffusion also focuses attention on the policy issue of what balance to strike between the interests of the producers and the users of high technology. Traditionally, Europe has favored producers, although attempts have been made to sustain certain categories of users with some success.

European policymakers have much to learn from the EUREKA initiative, which was developed largely independent of the Community and links industrial enterprises and centers of research across Europe in market-oriented projects specifically aimed at commercial exploitation. The intention is now to focus Community resources on fewer, better targeted goals and objectives. Coherence and selectivity have become the watchwords; the overall aim is to improve the industrial competitiveness of the European economic system.

While Community-sponsored research is but a small fraction of the R&D conducted in Europe, it does play a significant role as a catalyst. In the individual EC member states, where most of the R&D is done, technology policy comes in various shades – from a very supply-side-oriented approach in France to a more demand-side strategy in Germany. Even Britain has followed its own variant of technology policy in stimulating the emergence of technologically sophisticated markets more readily able to absorb innovation.

My own country, Italy, has adopted a more flexible policy, which recognizes the recent industrialization of the country and the dynamic small and midsize business sector. The aim has been to help clusters of these businesses assimilate high technology and to maintain a climate that is conducive to innovation. A state R&D agency plays the key role.

What unites all of these approaches is the belief that, if technology "push" is no longer adequate, given the pace and cost of innovation, any refocusing of policy on stimulating market "pull" must challenge R&D to come up with more advanced solutions for wider problems affecting the common good. Certain parallels are emerging in the Japanese approach, which is also long-range and broad, and in U.S. policy, as Branscomb suggests. However, attempts at replicating the Japanese experience are likely to encounter serious obstacles.

The author is correct to say that picking winners only within one's own borders is doomed. Strong multinational corporations set world standards and dominate markets. It is as difficult to identify an effective policy for stimulating innovation in the United States today as it is in Europe. The problem is deeply rooted. U.S. and European companies lack team mentality, and there is real concern that the best performers may actually be shackled by a centrally orchestrated technology policy.

Global and domestic problems already provide market pull that can rejuvenate R&D and generate value-added jobs.

Another element of market pull shouldn't be underestimated: the use of emerging technologies to obtain major improvements in societal welfare and, as a result, in the quality of life. In Europe, we stress this aspect. The market here is, to varying degrees, institutional, infrastructural, socioenvironmental, and biomedical.

Furthermore, just as competition is now global, so are so many of the problems afflicting people. Global problems demand global solutions, and the contribution advanced technology can make is immense. But unless the private sector is encouraged by appropriate public policies, it is unlikely that it can respond in sufficient depth. I am referring to such issues as development of the Third World, where the potential for political disruption is enormous; complex environmental problems such as ozone depletion and global warming; the urgent necessity of helping the new democracies rising from the rubble of the Soviet system; the need for radical revitalization of our educational and training systems, health care provision, and care for the elderly (all issues that are particularly acute in the United States); and restoration of the social and economic infrastructure on which any truly civilized advanced society must rest. Here enlightened public policy must intervene to support and extend what more myopic market forces might find difficult to achieve.

I believe there is a definite need for a new U.S. technology policy that is capable of harnessing the superb quality of U.S. science. But the cuts in defense spending could constitute a poisoned apple for America's continued primacy in science and technology. Global problems will not affect only the poor nations of this planet: the rest of the industrialized world may suffer badly as well. Many domestic problems in the United States seem directly linked to a steady decline in quality of life. Global and domestic problems together already constitute forces of market pull capable of reorienting and rejuvenating R&D and of generating high-value-added jobs for U.S. citizens.

Getting this to happen will not be easy. It will demand institutional change, radical reorientation of human as well as financial resources from the defense sector to the civil-

ian economy, and new priorities in career paths. The unparalleled knowledge possessed by U.S. scientists must be redirected to serve perhaps more mundane goals, linked to the actual needs of society. Big science macroprojects, in turn, should now find their way within a wider international cooperation, sharing resources to attain long-term or highly speculative objectives.

The return to competitiveness in global markets is one aspect, but it should not be considered the whole story. The United States otherwise could risk overlooking areas where it can make an immeasurably greater contribution to both its own welfare and the general good.

Leslie Schneider
Director
Technologies for Effective Cooperation Network
Tufts Manufacturing Resource Center
College of Engineering
Tufts University
Medford, Massachusetts

I support Lewis Branscomb's call for a government technology policy that emphasizes demand-side programs to help companies incorporate new technologies into their products and manufacturing processes. But I also believe his article, through no fault of his own, suffers from a major limitation that colors the entire technology policy debate. In the United States, proponents of technology policy (or its close cousin, industrial policy) spend so much time arguing for its legitimacy that they almost never get around to considering what it will take to implement such a policy effectively in the real world of companies and managers.

Success will depend on addressing the nuts-and-bolts issues of implementation.

I speak as a practitioner in the field of industrial extension, a major component of Branscomb's demand-side alternative. As director of the TECnet program, I receive grants from the state of Massachusetts and the federal government (including the NIST manufacturing technology program that Branscomb mentions), as well as matching funds from private sources such as companies, universities, and foundations.

TECnet's mission is to assist small and midsize manufacturing companies in Massachusetts to improve their competitiveness by building their capacity to compete in the global economy. The companies TECnet services are usually quite small, with annual sales of $10 million or less, and they often employ fewer than 100 people. In this, they are typical of manufacturing establishments throughout the state. (In 1989, almost 90% of the 10,735 manufacturing establishments in Massachusetts employed fewer than 100 workers.) Often they are first- and second-tier suppliers to large companies in the region, such as General Electric, AT&T, Digital Equipment, Raytheon, Hewlett-Packard, and Polaroid. The best are often quite advanced technologically (at least compared with most small U.S. manufacturing companies), but they are struggling to develop the new capabilities their large customers want – for example, advanced quality methods or expertise in product design.

These companies don't just need technical assistance in incorporating new process technologies. They need an integrated approach to systems improvement across a wide range of organizational disciplines: defining new markets, training human resources, gaining access to capital, coping with increasingly stringent and necessary environmental standards, and forging long-term relationships with customers and suppliers.

The problem is that few service providers, whether in the private or public sector, know how to provide such an integrated approach. Private consultants rarely offer the broad range of services companies need at prices they can afford. Those small companies fortunate enough to do business with a forward-looking big company can get a great deal of help, but the help is usually based on that customer's specific needs. And, unfortunately, even most public programs that already embrace the demand-side approach have a narrow focus on technology transfer at the expense of the often more important transfer of soft, managerial expertise and skills.

At TECnet, we are trying to address this problem by creating a manufacturing industry "service center" that can help companies look at the broad range of challenges they face. Our approach is to help companies organize either vertical networks with their suppliers and customers or horizontal networks with other companies that have complementary capabilities. Our theory is that networks provide an effective way for companies to share information with each other and to defray the costs of organizational learning.

But our experience has taught us two rather sobering lessons. First, like any experiment at institution building, this kind of effort is extremely time-consuming. Therefore, public programs had better be in it for the long haul. Second, it is resource intensive – not only in terms of money but in terms of the unique mix of technological and organizational skills that service providers need to have in order to help companies with the problems they face.

In my opinion, we still know remarkably little about the kind of organizational infrastructure – change strategies, skills, or resources – necessary to support small and midsize U.S. manufacturers in their efforts to achieve global standards. So by all means, let's define strategic new directions for government technology policy, but let's not stop there. In the end, the success of these new directions will depend overwhelmingly on addressing the nuts-and-bolts issues of implementation.

Thomas H. Lee
President
Center for Quality Management
Professor Emeritus
Massachusetts Institute of Technology
Cambridge, Massachusetts

Lewis Branscomb's article on technology policy is timely and thought-

ful, but a few issues deserve more attention.

□ In a recent study that I chaired for the National Academy of Engineering, we raised the question of national interest in an age of global technology. The issue at hand was: Will the corporate interest and national interest diverge in an age of globalization?

Japan supported critical industries after World War II and has an enviable record of economic growth as a result.

The question of "who is us" (see Robert B. Reich's article in the January-February 1990 issue of HBR) deserves much more careful consideration. I don't believe that has been done, and there is no sign that priorities will be given to that debate. The most important conclusion from our study was that we must make the United States an attractive place for all phases of technical work, from basic research to development to design to production to distribution. To do so, we must go far beyond technological factors to include education, capital investment, and, perhaps most important, our sense of value in the business community – such as the value we attach to leveraged buyouts, quarterly reports, and so on. To think that a technology policy will get us out of the competitiveness issue is a reflection of our ignorance of the systemic nature of the problem. The property of the whole – that is, the competitiveness of a nation – cannot be decided by working on only one of the elements. And technology is only one element.

□ Branscomb properly points out that we did have a technology policy: to be the leader in military technology. That policy was successful for a very important reason: the government was the final user and the final customer. We still haven't learned that when the government is not the ultimate user, its sponsored R&D is usually ineffective.

□ Finally, Branscomb emphasizes the strength of the Japanese in adopting technologies for commercialization. I want to point out that the Japanese have developed a technology for that: total quality management. Few of us understand that Japan's TQM system resembles the manufacturing processes of high-tech devices. Few of us would dare to deviate from the manuals in a semiconductor factory. We tend to laugh at the rigid structure of Japanese TQM methodologies. We like to consider management a "science." So we talk about the "what," while the Japanese talk about the "how." Few in this country realize that adopting TQM may be more difficult than the latest advances in biotechnology or communications because it involves a cultural change. We tend to think that having a Baldrige Award will solve our problems. That is far from the truth. In our debate on technology policy, shouldn't we consider *management* technology in the list of critical items?

Julie Fox Gorte
Senior Associate
Office of Technology Assessment
Congress of the United States
Washington, D.C.

Creating a demand for new technologies in the private sector is indeed something federal technology policy to date has addressed poorly, as Lewis Branscomb points out. However, the details of his analysis are incomplete.

The United States can do a much better job of developing and diffusing technology, both of which are needed to improve competitiveness. To do that, we need long-term, low-cost capital. America also needs first-class human resources, which means we must do a better job of educating children and a more thorough job of training workers, managers, and engineers. Small and midsize companies could benefit greatly from a manufacturing or technology extension service, several of which already exist in the states. And government and industry must share the costs of developing particularly risky but potentially rewarding technologies. That means our executive branch needs the institutional capacity to analyze the competitive situations of critical industries and advise executive agencies on how their actions affect competitiveness. For industries in deep trouble, such a new agency could, in close coordination with private-sector representatives, develop action plans for industrial support tailored to specific needs.

Mr. Branscomb agrees with some of these points. He mentions the need for long-term, low-cost capital and advocates industrial extension in a review of Philip Shapira's excellent report, *Modernizing Manufacturing: New Policies to Build Industrial Extension Services*. He also endorses government support of strategic technologies, using Sematech as an example of a program that, while good, is too narrow. And Branscomb cites the Department of Commerce's Advanced Technology Program, which, because it is frankly based on economic security, is a better example than Sematech of how government and industry can collaborate to fund R&D in potentially remunerative but currently risky areas. The ATP has done a good job of attracting serious bids, developing a thorough and rigorous evaluation system, and funding sound development programs on a shoestring budget ($10 million in 1990, $36 million in 1991, and $47 million in 1992).

Branscomb's criticism of efforts to develop critical technologies lists is not clear, however. The similarity of the four existing lists is not necessarily a bad thing. The U.S. government (the Department of Defense and the Office of Science and Technology Policy), a group of U.S. companies (the Council on Competitiveness), and the governments of Japan, the European Community, Taiwan, Korea, and probably other nations have all developed similar lists. In fact, identifying industries or technologies that make disproportionately large contributions to the ability of nations to generate economic growth is relatively straightforward. And, in many industries, the costs of advancing and implementing new technology have gone through the ceiling. Even big, robust companies with handsome research budgets, such as IBM, NEC, and Siemens, cannot support complete research agendas without having government as a partner.

Finally, the United States did not invent government support of critical technologies. Japan supported critical industries throughout the post-World War II period and, while sustaining some disappointments, has had an enviable record of economic growth as a result. Government support of critical technologies is not a bad idea the United States is trying to export; it's a good idea we could learn from–and import.

James S. Langer
Director
Institute for Theoretical Physics
University of California
Santa Barbara, California

I heartily agree with Lewis Branscomb's thesis. The United States urgently needs a technology policy aimed primarily at stimulating the demand for rather than the supply of new technologies. The main point that I would add is that this policy had better not neglect the supply side altogether. In the United States especially, the supply of new technologies is intimately linked to the supply of new technologists, and the latter are going to be essential to the success of any demand-side strategy.

During the last few years, I have spent a great deal of time–probably more than is sensible for a theoretical physicist these days–helping to write the National Academy of Sciences's recent report on materials science and engineering and participating in follow-up activities that now have led to a proposed presidential initiative in that area. This experience has convinced me that progress in solving many of the scientific and technological problems facing this country will depend strongly on the skills of a broader range of scientists and engineers than we ordinarily have been able to enlist in such efforts. For example, my engineering and industrial colleagues talk frequently about "materials by design" and "integrated approaches to design and manufacturing." What they have in mind is taking advantage of national strengths in computing, systems analysis, and both basic and applied materials research to develop new generations of science-based technologies.

As Branscomb points out, however, no amount of new research is going to do much good for the nation, or ultimately for the research scientists and their institutions, if the manufacturing and defense industries are in declining health. The problem is especially severe in the United States, where the most advanced research has traditionally–and so far very successfully–been tightly coupled to advanced education. If U.S. industries are not looking ahead toward manufacturing new products, then they are not investing in R&D, and they are not providing professional opportunities in engineering and science. In turn, if the national need for engineers and scientists is declining substantially, the rationale for maintaining strong faculties at U.S. research universities is weakened, and our whole system for carrying out technologically relevant basic research is in jeopardy.

Thus I do agree with Branscomb that the most important objectives of a national technology policy must be to identify the causes of the decline in manufacturing industries and to address these problems directly. As we do this, however, we must try to protect our substantial research capabilities during what will be a very difficult next few years or more.

What is actually to be done? Although it may not be in my immediate best interest to say so, I think that the most effective use of available resources would be to develop new efforts in civilian research at the federal laboratories. New activities of this kind would provide the long-term professional opportunities that are so urgently needed, pending revitalization of industrial research.

Also, the government labs should be ideal places for building consortia involving industry and universities, a scheme that fits well into a demand-side strategy. With proper leadership, which I believe is presently available, the labs may be able to institute truly innovative programs; it ought to be possible for them to avoid both the natural shortsightedness of industrial research and the disciplinary constraints that are hard for universities to cope with during times of stress. In short, new centers of activity have to be established to draw both industry and academia away from old ways of doing business. And, because maintaining the strength of the nation's scientific work force is clearly a federal responsibility, the federal government must take the lead in these efforts.

Marina N. Whitman
Vice President and Group Executive
Public Affairs and Marketing Group
General Motors Corporation
Detroit, Michigan

Lewis Branscomb's arguments for a demand-oriented U.S. technology policy are not only compelling in general but also apply with particular cogency to U.S. automobile manufacturing. This industry dramatically illustrates how many basic product innovations that originated with U.S. companies were commercialized more effectively, more quickly, and more cheaply by the Japanese because of their lead in developing new technologies. The resulting ability to convert technical innovations rapidly into new sources of profitability poses a harsh challenge to U.S. manufacturers.

This situation underlies the policy dilemma that confronts the United States as it faces intensified global competition. On the one hand, we remain committed to a strong reliance on the marketplace, to a "consumer capitalism" whose flexibility and dynamism many business leaders want to preserve, even while they increasingly decry its short-term outlook. On the other hand, we feel a growing sense of threat and insecurity in the face of Japanese "producer capitalism," with its long view, strategic mixture of cooperation and competition among companies, and strong tradition of cooperation between business and government.

The supply of new technologies is intimately linked to the supply of new technologists.

I share Mr. Branscomb's belief that, in the U.S. political context, any attempt by the government to direct

technological outcomes by "picking winners and losers" would be counterproductive because it would undermine the right to fail. That is, by placing the burden of failure for noncompetitive decisions on the political process, it would encourage government bureaucracies to keep high-profile R&D commercialization projects that would otherwise have collapsed, like the synfuels and breeder reactor projects, alive on expensive life-support systems. But, even more important, Branscomb's emphasis on policies that facilitate "rapid absorption and application of innovative ideas" reflects a basic truth of today's global competitive environment: the "pipeline" model of technological innovation, followed by the commercialization of a new technology by its original developer, no longer applies, if it ever did.

Branscomb offers a "capability enhancing" technology policy as a viable alternative. A number of projects that would fit under this general rubric already exist. General Motors, for example, has recently accelerated its efforts to establish and participate in consortia for the generic or precompetitive research Branscomb favors. Most recently, General Motors has proposed to the 11 national laboratories that we explore possibilities for joint research efforts in several broad areas critical to U.S. manufacturing competitiveness. These initiatives were all motivated by the recognition that even the world's largest industrial company can no longer afford to go it alone in the development of basic technologies.

Business and public officials should use public contracts to stimulate new product development.

The need for cooperative approaches applies to the development of existing technologies as well. In particular, any manufacturing company that depends wholly or partly on outside suppliers for parts or components must, in its own self-interest, ensure that these outside companies have access to the necessary technology. In response to this need, manufacturers in the automobile industry and many other industries are moving toward fewer, closer, and more long-term relationships with suppliers, which would involve joint efforts at the early stages of product development. These changing relationships will require suppliers to be proficient in new technologies and thus create increasing demand for the sort of industrial extension services offered by the six manufacturing technology centers recently designated by the Department of Commerce.

While I agree with many of Branscomb's points, I also believe they represent one segment of a larger framework of policies that affect, often adversely, the global competitiveness of U.S. manufacturing companies. Most fundamental of all, therefore, is the requirement to "do the patient no harm." At the risk of repeating the obvious, that means moving toward macroeconomic policies that encourage savings and investment while also decreasing the U.S. budget deficit. It also means developing coherent, cost-effective regulatory policies in a nonadversarial framework that do not unduly burden U.S. industry. Costs should be distributed to avoid handicapping the sectors most exposed to global competition.

Catherine O'Neill
Cofounder
Citizens for Public Transportation in the Public Interest
Pacific Palisades, California

An effective technology policy for America must go hand in hand with an industrial policy and a public works policy. Yes, we should have a demand-based technology policy, and, yes, it should be cost-sensitive. Yes, we should strip away impediments so that American industry can work cooperatively to develop and commercialize products that can be sold internationally. And yes, we must become more flexible in quickly adapting technologies for commercial use. Several of Lewis Branscomb's theses should be translated into public policy – but, if anything, he does not go far enough.

First, Mr. Branscomb does not sufficiently emphasize the critical role that government at all levels in the United States can play as a guaranteed purchaser of new technology and products. If, at a policy level, a national or regional decision were made to support development of an electric car, a light-rail industry, clean energy sources, or more advanced forms of waste disposal systems – to name just a few products – then those who invest in moving ahead with commercialization should be assured that there's a guaranteed market. It is government's job to stimulate demand for products that are in the national interest to develop and that might find a market abroad. Demand can be stimulated through purchasing as well as through tax credits to businesses that use the products.

Second, government has an obligation to ensure the manufacture of competitive products that have a legitimate market outside government-guaranteed purchasing. This responsibility has been virtually ignored by the U.S. government and, sadly, by boards of directors that too often have not pushed management into making the long-term, critical decisions clearly connected to consumer demands.

One area Branscomb does address is the need for cost-sensitive design, but, unfortunately, that is an area in which government technology policy has almost no foundation. Many of us are concerned that politicians won't be able to discipline themselves to call for the creation of products that are cost-sensitive. The defense industry has ignored any requirement for cost sensitivity, and that is the primary model U.S. policymakers still use for a technology policy.

A case in point is the recent debate in Los Angeles over the specifications for the kind of railcar the city should buy. Instead of selecting a standard design that could be used in all further railcars purchased in L.A. County, public officials selected a design that was costly and had no assured market beyond the limited L.A. system. Cost implications were not given enough weight, in other words,

so the possibility of using the chosen car as a prototype for establishing some elements of a light-rail industry in the region was lost.

Happily, Los Angeles transit officials are now discussing with transportation companies the "market niches" they might target where demand exists. They want to use the contract as leverage to make sure a portion of the railcars built in the region can also fill a demand that might exist after the present order is completed. Such practices should be repeated around the country, as public officials proactively work with business to establish where an opportunity for a new product might exist – and then use public contracts to stimulate new product development.

Bruce R. Guile
Director, Programs
National Academy of Engineering
Washington, D.C.

Lewis Branscomb is wonderfully correct in his diagnosis of the problem and depressingly weak in suggesting cures. As Mr. Branscomb suggests, extension services and private-sector collaborative arrangements can be useful. I would not, however, expect them to make a big difference in the performance of the U.S. economy in developing new technologies that make a profit. Public-sector extension services compete with existing private-sector consulting or equipment-marketing activities and are likely to affect only a few industry segments. Industry collaborative arrangements depend too much on agreement among companies that are (and should be) competitors. To engage in collaborative arrangements, companies must recognize a mutual interest and manifest a political and technological agenda through what are, for the most part, poorly developed channels.

Credible or not, I have a personal favorite that is quite different: use federal tax policy to create temporary, artificial demand for products or processes that use new technologies. Being able to deduct mortgage interest encourages many Americans to buy houses, and excluding employer-provided health insurance premiums from personal income encourages companies to provide and individuals to consume more health care. Why not use similar practices to stimulate demand for new technologies?

Imagine what would happen if the government declared that in 1995 every household appliance manufactured in the United States that incorporated, for example, significant structural ceramics would allow the purchaser to take a tax credit equal to the value of the product? Capital would flood toward companies that were either planning such products or already making them. A raft of new products – good and bad – would be developed, launched, and sold. *Consumer Reports* could offer a special issue to evaluate them if manufacturers provided them by mid-1994.

Why not use federal tax policy to create demand for products that use new technologies?

By the end of 1995, the government would have improved the nation's household capital stock and, perhaps, it would have helped develop some permanent competence in U.S. industry in the design and commercial manufacture of structural ceramics. If 50 million households (about half of the total) took advantage of the offer, the government would have "spent" $5 billion in lost tax revenue. That may look like a lot of money, but it's not. In 1991 alone, mortgage interest deductions for owner-occupied homes "cost" $41 billion in foregone tax revenue, and the exclusion of employer-provided medical insurance premium payments "cost" $36 billion.

If the government's agenda is to modernize the U.S. industrial base, it could focus on production equipment. For example, it's possible to design a total-cost tax credit for companies that replace, over the next five years, existing production equipment with equipment that uses significant amounts of optical fiber for information transfer and processing – or equipment that uses bioengineered organisms to prevent or clean up environmental damage. Such an approach does, of course, involve the government in "picking winners and losers" but much less so, I would argue, than current supply-side approaches that invest in technology development *entirely* without the discipline of selling a product to a customer.

Yet if picking technological winners and losers is too politically problematic, what about a $1,000 tax credit for U.S.-manufactured cars that get 50 miles to the gallon in city driving in 1997? That would require significant technological advances. What about allowing companies a tax credit for new production equipment *if* they scrap all matching equipment that is more than five years old?

I know that changing tax policies to stimulate demand for new commercial technologies is problematic. Tax credits for U.S.-manufactured, designed, or developed products may create trade barriers; many critics would consider them too protectionist. But we should not delude ourselves; as a nation, the United States has created plenty of artificial demand for goods or services that it wanted to favor for one reason or another. We aren't accustomed to letting that experience guide us in driving the development of new technologies. It just might be worth trying.

Mark G. Allen
Principal Research Scientist
Physical Sciences Inc.
Andover, Massachusetts

The policy Lewis Branscomb outlines is more an *industrial* policy than a *technology* policy and rightly deserves skeptical scrutiny. The chief purpose of a government technology policy should be the creation of new technologies in a free environment that encourages the open exchange of ideas and results. But how a government policy can support a creative business environment, where new technologies are rapidly and efficiently translated into competitive products, is not at all clear.

Branscomb rightly applauds the achievements of government-sponsored precompetitive research by

agencies such as DARPA. Increasingly, the DOD and NASA are also sponsoring such research. In cases such as NASA's High Speed Civil Transport development program, for example, the government effectively plays the role of a venture capitalist (providing seed money, often with matching funds from industrial contractors) to support critical technology development. Unlike venture capital investments, however, the government does not retain ownership of the technology and often funds a competitive consortium of industrial companies. These types of programs, along with the Small Business Innovative Research Program, suggest how a national technology policy could be implemented by current government research institutions.

What a national technology policy should not do is create an environment where companies abdicate their responsibility for and involvement in research on new commercial products and services. A national technology policy should indeed foster the creation of new technologies and processes but with a broader perspective than what the U.S. government currently maintains. In turn, the private sector must develop the corporate environment wherein technological advances are translated efficiently into competitive products.

S. Allen Heininger
Immediate Past President
American Chemical Society
Clayton, Missouri

A nation's industrial policy consists of the sum of its tax policies, trade policies, federal R&D investment policies, intellectual property-protection policies, antitrust and regulatory policies, and any others that influence the ability of private-sector companies to compete effectively in world markets. Still, companies do not enter and exit product lines and entire businesses on national competitiveness considerations but on the potential for profit.

Europe takes no pleasure in seeing the decline of the U.S. high-tech industries that have led the world for a generation.

Most U.S. industrial sectors, for example, operate with higher net after-tax margins and higher returns on assets and equity than do their Japanese counterparts. But coupled with this comes a lower average annual rate of growth. While this superior profitability, driven by shareholder demands, may be a matter of pride to U.S. businesses, it could, over time, lead to our downfall. Producers consistently able to operate with lower margins and returns and still have capital for expansion will inevitably gain market share over the more profitable competitor. Thus pressures on U.S. managers not only for quarter-to-quarter profit improvements but also for significantly higher margins and returns play a critical role in our current so-called "industrial policy."

While in Europe recently, I asked my counterpart strategic planners for large multinational chemical companies to describe their stockholders' expectations. German planners responded by noting that investors expected their companies to sustain a dividend stream offering returns equivalent to ten-year treasury notes. A Swiss executive said that shareholders wanted his company to "be ethical and in business 50 years from now." Few U.S. CEOs could respond in a similar vein, although their lives might be more comfortable if they could.

Of course, Mr. Branscomb's observations refer chiefly to the electronic, semiconductor, and durable manufacturing sectors. We should not lose sight of the fact that other sectors in the U.S. economy, the chemical and pharmaceutical industries, for example, look quite different. In 1991, the $260 billion chemical industry produced a positive trade balance that approached $20 billion, including a positive balance of $2.4 billion with Japan alone. And the U.S. chemical industry does not depend on federal dollars for research support. The industry invests between 4.5% to 5% of sales to finance its own innovations.

The pharmaceutical industry also does not depend on federal expenditures but reinvests 15% of sales, on the average, in R&D. While significant federal expenditures for basic research by the National Science Foundation and the National Institutes of Health clearly benefit both the chemical and pharmaceutical industries, the technological breakthroughs made in this field are available worldwide to all competitors, Japan included.

I agree that demand-side policies that favor the success of U.S. businesses are a far better alternative than government-funded development programs that attempt to do the job for industry. But America must invest in civilian technologies at a level comparable with Japan and Germany if we are to prosper in the future.

Brian Oakley
Director
Logica Cambridge Limited
London, England

From the other side of the pond, the debate over U.S. technology policy has a strange ring about it. Here in the United Kingdom, we have lived for far too long with a government that has a clear technology policy. Unfortunately, this policy is to have no policy and to leave everything to market forces. Whether that has been a success must be left to the historians; but it doesn't seem likely from where we sit now, watching impotently as our high-technology industries slip away.

Fortunately, the European Community also has a policy, even if it is not very clearly articulated in its R&D framework programs. It bears some resemblance to what Lewis Branscomb proposes in that it aims to improve the innovative capacity of EC companies and nations largely through cooperative precompetitive research. Programs such as ESPRIT, RACE, and BRITE have been remarkably successful in stimulating research, training research workers, encouraging new technology development, and bringing together the European research community. In the past, most European researchers knew only their own national communities and looked to the United States for stimulation and cooperation, but now they look for partners somewhere in Europe.

So far, the European technology strategy has been largely directed at innovation, meaning concentration on the supply side of the equation. But a good technology policy must embrace the customer as well as the supplier. It is rare for a high-tech industry to thrive without an active and informed home market. The Japanese have based their invasion of world markets on a firm foundation of market experience at home first.

One practical outcome of embracing customers in a technology policy is to ensure that user companies always participate in cooperative research efforts. Getting users involved early helps speed up initial exploitation. It also serves to bind users to the suppliers they know and so reduce their propensity to believe that all good technical innovation comes from abroad. Of course, suppliers like technology policies in which the government itself acts as a sponsor and purchaser of advanced technology. The U.S. Department of Defense's ability to pull through advanced technology products has been admired and envied the world over. A successful U.S. technology policy must ensure that other departments of state emulate the DOD in its enlightened purchasing policies.

There is another aspect of an enlightened technology policy – marketing. While at IBM in the late 1950s, I visited Yorktown Heights and asked to see the scientist who had invented and given his name to a cryogenic storage device, the Crow Cell. "Oh!" I was told, "he's been promoted. He's now in marketing." Many of the best research laboratories have let themselves down by failing to market their innovations, even to other parts of their own companies. For example, critics blame Xerox management for not appreciating the work of a group of geniuses at PARC in the 1970s. But surely the research workers themselves should share part of the blame. The best European laboratories take such responsibilities seriously, making sure that their market-oriented colleagues and, if necessary, the rest of the world know all about their work.

The world has become such a small place that what is good for the United States is also good for Europe. We look for open competition with the United States but get no pleasure in seeing the decline of U.S. high-technology industries that have led the world for a generation. We look to the EC and the governments of Europe to embrace a technology policy that will enable our companies to play their part in the global economy. And we welcome the strengthening of a technology policy in the United States, for, as has happened so often in the past, that policy may well rub off on Europe.

D. H. Roberts
Provost
University College London
London, England

After spending 35 years in the electronics industry, including "majoring" in microelectronics from 1959 to 1989, I strongly support the points Lewis Branscomb makes about stimulating demand as the government's key role. In the mid-1960s, I tried unsuccessfully to persuade my government that the way to exploit the U.K.'s lead in silicon integrated-circuit technology was to place an order for a large quantity of devices, thus stimulating the development of an appropriate manufacturing technology. At that time in the United States, defense programs such as the Minuteman missile pulled SIC technology out of the laboratory and into volume production. It did not happen in the United Kingdom.

And, sadly, the United States's initial commercial leadership has now been eroded by Japan. Japanese leadership is not based on government-funded research but on industry-led marketing, which identified new product opportunities. In turn, bringing such products to market was greatly assisted by government-led (and subsidized) precompetitive research in collaboration with business.

The lesson to be learned is that we must start with the market. Government should use its purchasing power to stimulate that market in an intelligent way and encourage industry to adopt TQM programs. And government must provide the financial stability on which economic development depends.