

these countries through financial, technological, and capacity-building assistance, and through broadening the United Nations' Clean Development Mechanism, which allows polluting companies to purchase offsetting emission-reduction credits from qualified participants in the program.

As part of these efforts, the United States should explore the possibility of a joint R&D project with China to develop new carbon capture-and-storage technologies for coal-fired power plants. Breakthroughs in these areas would be a win-win outcome for both countries, which have the largest coal reserves in the world.

The next president should also champion new global rules based on the principles of nondiscrimination and national treatment to head off trade disputes emanating from differences in national policies on carbon emissions. If developed countries adopt binding caps before developing and emerging countries do, there is a danger that carbon-intensive production and jobs will migrate from countries with caps to those without. National efforts to encourage domestic production of clean energy alternatives through trade-distorting policies such as the local-content conditions recently enacted in China are also potential sources of trade conflicts. New multilateral trading rules are required to support rather than undermine the implementation of an effective, efficient, and equitable global agreement on climate change. Ultimately, a new Global Environmental Organization may be required to realize this objective.

Overview

Science, Technology, and Innovation Challenges

THOMAS KALIL

The outgoing Bush administration's hostility toward science has cost our nation dearly. Federal investment in research and development underpins our economy, our national defense, our safety and health, and our future workforce. To ensure that the United States remains an "innovation superpower" in the 21st century, the 44th president must increase funding for research and development, improve the math and science skills of America's workforce, reform our nation's immigration laws to attract the "best and brightest," strengthen incentives for private sector investment in research and development, and expand the role that science, technology, and innovation can play in meeting

some of our most important national and global challenges. These goals can be achieved, but only if the new president makes them a top administration priority. The new administration must restore America's preeminence in science, technology, and innovation.

Science, technology, and innovation have long provided the foundation for America's prosperity. Naturally inquisitive and inventive, the American people have developed new products and technologies that have fueled our economy and improved our quality of life. Consider how different our lives would be without electricity, air travel, antibiotics, computers, and the Internet. That's why science, technology, and innovation policy must be a central component of U.S. national economic strategy

Innovation—the development of new products, services, and processes—drives economic growth, job creation, and productivity. Innovation is important not only for high-tech sectors such as advanced manufacturing, aerospace, clean energy, the life sciences, semiconductors, and the Internet. It is also essential for companies that are using technology to develop products more rapidly, harness the “collective IQ” of their customers and employees, and orchestrate sophisticated global supply chains.

Even small differences in productivity have a huge impact on America's long-term standard of living. Our average standard of living will double every 23 years if our productivity growth rate is 3 percent, and every 70 years if it is 1 percent. High productivity growth rates will make it much easier to honor our commitments to older Americans, expand access to health care for the uninsured, and increase our investments in infrastructure, education, and worker training.

Innovation is currently a source of competitive advantage for the United States in the global economy. We have world-class research universities, an entrepreneurial culture, flexible labor markets, and deep capital markets. Americans are twice as likely as adults in Europe and Japan to be “high expectation” entrepreneurs—that is, to start a business with the intention of growing it rapidly.

Innovation also plays an important role in meeting many of the most important goals we have as a nation. Innovation can help provide all Americans with longer and healthier lives, fight global warming, maintain a strong defense at home and abroad, expand access to high-quality education and training, and make government more open and efficient. And innovation is important in the civic sector as well as the private sector. A new generation of “social entrepreneurs” is changing the way we educate our children, lift people out of poverty, prevent crime, and build vibrant communities.

Finally, increasing our understanding of ourselves and the world around us are worthy goals themselves. We want to understand the ultimate fate of the

universe, the nature of matter, the origin of life, and how human consciousness emerges from 100 billion neurons and 100 trillion synapses. We want to know why civilizations rise and fall, and how to foster thriving, multicultural societies. So it's vital to support unfettered inquiry to address these and many other questions.

Challenges for Innovation Policy

Although the responsibility for developing new products, processes, and services rests with the private sector, the federal government has a catalytic role in promoting and encouraging innovation. Government support for R&D has led to technologies and industries such as computers, the Internet, and biotechnology. As our economy becomes dominated by new ideas, this role becomes more urgent.

Unfortunately, while science, technology, innovation, and a highly skilled workforce are becoming more important to our future prosperity, U.S. federal investment in R&D, particularly in key disciplines such as the physical sciences and engineering, has actually been declining as a fraction of gross domestic product. Agencies such as the Defense Advanced Research Projects Agency, or DARPA, which have traditionally backed breakthrough technologies such as the Internet, have shifted to funding projects with more immediate payoffs.

America continues to do a mediocre job of preparing our children for careers in science, technology, engineering, and mathematics, the so-called STEM disciplines. Ideologically driven policies such as the Bush administration's restrictions on stem cell research have slowed our scientists from developing potential cures for diseases such as spinal cord injuries, multiple sclerosis, or Alzheimer's. And U.S. immigration policies make it difficult for the "best and brightest" from other countries who receive advanced degrees from our colleges and universities to stay here and contribute to our economy.

The challenges we face today are momentous. As the Hart/Rudman Commission on National Security concluded, "Second only to a weapon of mass destruction detonating in a U.S. city, we can think of nothing more dangerous than a failure to manage properly science, technology, and education for the common good over the next quarter of a century."¹

Essential Principles

What are the principles that should underpin a science, technology, and innovation agenda? First of all, the United States will only be an innovation superpower if all Americans are both participants in and beneficiaries of the innovation economy. We must not think of innovation as the province only of

the highly educated. Innovation-driven business models require large numbers of technically proficient, scientifically literate, knowledge workers at every level of the organization who can solve rapidly changing problems.

Similarly, the principle of innovation must be applied to the very challenge of improving economic opportunity for all our citizens. Online learning, for example, can help working adults gain the skills they need to compete for higher wage jobs. Universal design principles can make information and communications technologies accessible for people with disabilities, increasing their independence, employability, and standard of living.

The role of the government is to make investments in areas that the private sector will underinvest in relative to their social return, such as fundamental research and a skilled workforce, and to create a policy environment that will foster competition, innovation, and entrepreneurship. The private sector takes the lead on the commercialization and adoption of new technologies.

There are significant “market failures” associated with the innovation process, such as the positive externalities associated with research and development, and the negative externalities associated with the emission of greenhouse gases. However, government intervention can lead to “government failures,” such as pork-barrel politics, rent-seeking by interest groups, and regulatory capture by the industries that agencies are supposed to police. Decision making, too, can be made on the basis of faulty or incomplete information, policies crafted where costs exceed benefits, and guidelines enacted that lack flexibility to adapt to changed circumstances and new evidence.²

When the government does intervene, careful thought needs to be given to the design of the intervention so that the “cure” is not worse than the “disease.” Whenever possible, governments should seek to take advantage of market forces as opposed to relying on government programs or top-down regulation.

No one can predict the future evolution of technology—not even the participants in the marketplace. In the early 1990s, most of the major players in the media and telecommunications industry were convinced that “video on demand” would drive the development of the “information superhighway.” Few predicted the importance of the Internet. For this reason, the government should set broad goals and invest in a portfolio of approaches to achieve them.

Case in point: the government should support research that has the greatest potential to reduce greenhouse gas emissions, as opposed to the Bush administration’s decision to pick the “hydrogen car” as the solution to the energy and climate crisis. Decisions about which research directions are most promising should be made in close consultation with the scientific and technical community, and a competitive, merit-based process should be used to allocate funding for individual research projects.

There are a large number of public policies that affect America's general ability to innovate, such as those with respect to research funding, education and training, immigration, intellectual property, regulation, antitrust enforcement, taxes, regional economic development, and international trade. The ability of particular research-intensive sectors to compete is affected by spectrum policy (wireless industry), the Food and Drug Administration approval process (biotech, medical devices, pharmaceuticals), and export controls (computers, satellites). So it's imperative that the new administration embrace innovation as a central organizing principle for its economic strategy. Policymakers in many different agencies need to understand the impact that their decisions have on America's long-term competitiveness.

America's innovation policy needs to recognize that even the way we change is changing. The executive director of the University of California-Berkeley's Center for Open Innovation, Professor Henry Chesbrough, observes that many leading companies are pursuing "open innovation" strategies. Increasingly, they are working with external partners to commercialize their internal innovations and to identify external innovations that they can commercialize.³ More than 40 percent of Procter and Gamble's products have a major component that has been sourced externally. And online innovation marketplaces such as InnoCentive allow customers to post complex problems, where more than 125,000 engineers, scientists, inventors, business people, and research organizations from 175 countries can compete to solve them.

Professor Eric Von Hippel, the head of the Innovation and Entrepreneurship Group at the MIT Sloan School of Management, concludes that innovation is becoming democratized as more users of products and services are able to innovate for themselves. Savvy companies are encouraging this development by creating "toolkits" that empower their customers and allow them to quickly and easily customize products and services.⁴

A related concept is what scholars such as Harvard Law School professor Yochai Benkler have called "commons-based peer production," which is the creative energies of large numbers of people who are using the Internet to create information, knowledge, and culture, often without financial incentives or traditional hierarchical organizations. Many observers have called attention to the important role that design, aesthetics, user experience, and opportunities for self-expression are playing in the marketplace as companies seek to differentiate their products and services and avoid "commodity hell."

What's more, the capacity to innovate is becoming increasingly globalized, with entrepreneurs creating teams of Bangalore software engineers, Russian mathematicians, and Taiwanese product designers. U.S. policy needs to take into account these and other changes in the nature of innovation.

Finally, the role of the federal government should be to serve as a catalyst. A good example of the “ripple effect” that federal policy can have on national priorities is the National Nanotechnology Initiative, unveiled by President Bill Clinton in January 2000. After the NNI was announced, major research universities, venture capitalists, entrepreneurs, states, and Fortune 500 companies all launched new efforts in nanotechnology research, education, and commercialization. Such initiatives should be designed to spark additional investments by industry, academia, states, foundations, and other stakeholders.

An Innovation Agenda

The innovation agenda described below would increase funding for research and development, improve the math and science skills of America’s workforce, reform our nation’s immigration laws to attract the “best and brightest,” strengthen incentives for private sector investment in R&D, and expand the role that science, technology, and innovation can play in meeting some of our most important national and global challenges.

There is a compelling case for sustained increases in federal research funding, particularly for university-based research. Federal investment in many key disciplines has actually declined as a fraction of GDP. Currently, agencies can fund only a fraction of the high-quality proposals that they receive. Even if a research grant is awarded, it is often too small or too short for a researcher to make meaningful progress. Young scientists are discouraged from pursuing a career in research because they must wait until they are, on average, 41.7 years of age before they receive their first grant from the National Institutes of Health as an independent investigator.⁵

Over the next 10 years, the federal government should provide 7 percent to 10 percent annual increases in the budgets of the key science agencies, such as the National Science Foundation, the National Institutes of Health, the Department of Defense, the Department of Energy, and the National Institute of Standards and Technology. Although increases in the physical sciences and engineering were proposed in the Bush administration’s American Competitiveness Initiative, and authorized in the America COMPETES legislation, almost none of these proposed increases are likely to be appropriated before the end of the 2008 congressional term.

Most of the proposed increases in research funding should augment the core disciplinary programs of science agencies that support investigator-initiated projects in biology, the physical sciences, engineering, the behavioral sciences, and the social sciences. Some of the increase in funding should be targeted to multidisciplinary initiatives that respond to national priorities and

emerging opportunities. Again, the new president and Congress should set broad goals, and rely on the scientific and technical community (and other stakeholders) to identify the most promising research directions. Existing initiatives that should be supported include the multiagency efforts in information technology and nanotechnology R&D.

New efforts should be launched in areas such as clean energy technologies, which will accelerate the transition to a low-carbon economy, including nanotechnology-based solar cells as cheap as paint, or intelligent grids that support distributed energy resources. Similar efforts should target advances in learning technologies, such as games for middle school math and science that are as compelling as those from the video game industry, and technologies that address major challenges faced by developing countries, such as infectious diseases and a lack of safe drinking water.

New discoveries should also be explored in synthetic biology. Although still in its infancy, synthetic biology can be used to lower the cost of making the most effective antimalaria drug by a factor of 10, discover and destroy tumors, turn sugar into gasoline, and clean up toxic waste sites. Due to the shortcomings of today's science policies, the new administration should expand support for high-risk, high-return research, particularly at agencies such as DARPA, and fill the void left by the demise of research labs such as Bell Labs with new university-industry partnerships, such as the Nanoelectronics Research Initiative. These new research efforts should encourage multidisciplinary research and education.

The 44th president also needs to increase the capacity of the federal government to foster innovation in support of a broader set of national goals. The Environmental Protection Agency, for example, currently has a limited ability to encourage innovations that minimize pollution, instead focusing much of its energy on "end of pipe" regulations. Finally, agencies should make greater use of "inducement prizes" such as the X Prize for stimulating technological innovation.

Workforce with World-Class Skills

America is not on track to create the workforce that we need to remain globally competitive in the 21st century, particularly in science, technology, engineering, and mathematics, the so-called STEM disciplines. Improved math and science literacy is becoming increasingly important in a wide range of jobs—not just for chip designers and computer programmers.

This problem exists along the entire education "pipeline." Sixty-eight percent of U.S. 8th graders receive instruction from a mathematics teacher who does not hold a degree or certification in mathematics. American 15-year-olds rank 24th out of 40 participating countries in an international test that meas-

ures the ability of students to apply mathematical concepts to real-world problems. In the United States, 15 percent of all undergraduates receive a degree in the natural sciences and engineering, compared to 50 percent in China and 67 percent in Singapore.⁶

While there is no one single initiative that will address this challenge, the new administration should improve the quantity and quality of K–12 math and science teachers. The National Academy has recommended providing 10,000 four-year, merit-based scholarships to students who are receiving a K–12 teacher certification and a bachelor’s degree in a STEM field. The new administration should also make it easier for science and technology professionals to gain certification to teach in our classrooms.

Another top priority: increase funding for partnerships between industry and community colleges to develop customized job training and associate’s degrees for technicians. Supporting programs aimed at increasing the diversity of the STEM workforce and getting more young men and women excited about science and engineering is a critical step, as is providing grants to colleges and universities that expand the number of undergraduates who receive a bachelor’s degree in science and engineering.⁷

In higher education, we need to triple the number of the National Science Foundation’s Graduate Research Fellowships from 1,000 to 3,000.⁸ The number of NSF graduate fellowships has remained unchanged since the early 1960s, despite a large increase in the size of the undergraduate population. Funding fellowships also gives graduate students more autonomy in choosing their research projects.

Finally, the new president needs to bring our immigration laws in line with 21st-century economic needs. The number of “green cards” in employment-based categories must be doubled to clear up the backlog of skilled immigrants waiting to become permanent residents, but not at the expense of family-based immigration. A “fast track” system should be adopted that allows foreign students who receive advanced technical degrees from U.S. universities to receive an employment-based visa without having to return to their home country; and the H1-B visa program should be expanded and reformed to address current economic needs while ensuring that U.S. workers are protected. These steps need to be taken as part of a comprehensive immigration reform initiative to require the 12 million undocumented immigrants living and working in the United States to become legal, taxpaying, and contributing members of our society.

Expand Incentives for R&D

Private sector companies do not capture all of the benefits from their investment in R&D. Economic analysis shows that the benefits to the economy as a whole

from private investment in R&D are significantly larger than the returns that flow to individual companies. Because companies will underinvest in R&D, federal law should again provide a tax credit for companies that invest in research and development. The United States has done so since 1981; unfortunately, this credit has been renewed 11 times and expired twice, most recently in 2007. This inconsistency seriously undermines its effectiveness since companies are not able to rely on the existence of the credit when making investment decisions.

Moreover, the United States in the 1980s once provided the most generous tax incentives for R&D among the industrialized member nations of the Organisation for Economic Cooperation and Development, but by 2004 we had fallen to 17th place. At a minimum, the United States should make its R&D tax credit permanent. The new administration should also consider proposals to expand and increase the effectiveness of the credit, such as increasing the credit's rate from 20 percent to 40 percent, or creating a flat credit for research that is conducted in partnership with industry consortia, universities, or national labs.

Benefits of an Information Society

The new administration should identify appropriate steps that the federal government can take to promote the economic and societal benefits of the information revolution. Among the steps it could take would be to eliminate or reform legal and regulatory barriers to the further expansion of global electronic commerce; ensure that IT is designed to be accessible to people with disabilities, thereby increasing their ability to work and improving their quality of life; and develop multimedia digital libraries that place our shared cultural and historic heritage at the fingertips of every American.

To improve our nation's human capital, the new administration should empower adults who are struggling to meet the competing demands of work and family to acquire new skills through online learning, which will allow them to gain new skills at a time, place, and pace that is convenient for them. Another important step is to promote applications that are specifically designed to address the needs of underserved and low-income communities, such as high-quality, compelling software for English as a Second Language and Adult Basic Education.

To improve government, the 44th president must make government more open, transparent, efficient, and user-friendly by taking a page from former Center for American Progress fellow Carl Malamud, who put the Securities and Exchange Commission's EDGAR database of corporate filings online, and successfully urged C-SPAN to expand citizen access to its online video of congressional hearings, agency briefings, and White House events. The new admin-

istration should require government to make it easy for citizens, community-based organizations, and the private sector to add value to data, especially given the power of “mash ups” and other Web 2.0 tools and techniques.

The United States should also make it a priority to restore our leadership in broadband technology. The United States, the birthplace of the Internet, ranks only 15th out of 30 OECD countries in broadband deployment.⁹ A study commissioned by the Communication Workers of America concluded that average broadband speeds in the United States were less than 2 megabits per second, compared to 61 mbps in Japan and 45 mbps in South Korea.¹⁰

Some of the applications described above will help stimulate demand for broadband. Other actions that the government should take include creating tax incentives for companies that invest in next-generation broadband networks and provide access to underserved urban and rural communities.¹¹ The new administration should also push Congress to permanently extend the moratorium on Internet taxes.

Allocating additional broadband spectrum on a licensed and unlicensed basis, with the goal of making wireless a viable competitor to cable and phone companies in the residential broadband market, should be another key policy goal. The result would be lower prices, faster deployment of advanced networks, and a lower risk of anticompetitive behavior that stifles the openness of the Internet.¹² More federal investment in R&D would also allow us to make better use of the existing spectrum of technologies such as “cognitive radio,” which allows wireless devices to automatically adjust transmission frequencies to maintain efficient and uninterrupted communications. Finally, the new administration should help the states boost broadband deployment.

Overview

Economic Opportunity for All or a New Gilded Age?

PETER EDELMAN AND
ANGELA GLOVER BLACKWELL

Economic mobility must be a vital priority for the new administration. Fulfilling the promise of equal economic opportunity for all depends on our success in growing the economy justly for all—a task neglected over the past eight years. Stimulating economic