SECTION 2 • CHAPTER 3

Promote science and technology research and development

In this Sept. 19, 2011 photo, Rebecca Allred, a second-year chemistry doctoral student at Yale, works at Kline Chemistry Laboratory at Yale University in New Haven.
AP PHOTO/JESSICA HILL

Technological innovation promotes higher wages[1] and long-term economic growth.[2] It underlies the competitiveness of every industry in America—from ongoing innovation in agricultural methods to computer engineering, biomedical engineering, advanced manufacturing, aerospace, and energy. About half of every dollar added to the nation's GDP since the 1940s has come from advances in science and technology.[3]

And as we move into the 21st century, economists expect advances in science and technology to become more and more influential as determinants of national success in the global marketplace.[4]

Despite the critical role of public investments in research and innovation in seeding new industries that can lead the way to long-term economic growth, our public- and private-sector investments as a share of GDP remain below 3 percent, while nations such as Japan and South Korea are nearing 3.5 percent and continue to rise.[5] Even China, though its combined public and private investment level is low at 1.5 percent, is on a steep path that could meet or surpass that of the United States in short order.[6]

At the same time, governments and investors from other countries are harvesting U.S. intellectual property for ideas they can bring to their shores and build there. U.S. investors appear often to be discouraged from investing in potentially transformative new technologies by instead looking for the next big complex derivative or the next Silicon Valley web-service company.

> Public research spending brings a substantial return on investment, estimated by various economists to be between 30 percent and 100 percent or more.

Ensuring that our economy continues to grow and provide opportunities requires that we increase our national investments in science, technology, and engineering—the building blocks of innovation. Specifically, we propose policies that:

- Increase government investments in science and engineering research
- Build partnerships linking academia, industry, government, and nonprofit players to promote innovation
- Institute an improved research tax credit for business
- Invest in grand challenges through a Frontier Prize purse
- Reform the national laboratory system to ensure these unique assets are aligned with public and economic needs
- Encourage the transfer of research from lab to market through better data about the impacts of publicly funded research

Policies that increase government investments in science and engineering research

Public investments in research—in new ideas—are among the best investments we can make. Public research spending brings a substantial return on investment, estimated by various economists to be between 30 percent and 100 percent or more.[7]

The president's 2014 budget requested significant increases for the National Science Foundation, the National Institute of Standards and Technology, and the Department of Energy's Office of Science—ranging from 6 percent to 10 percent.[8] We believe these are exactly the right investments to be making in our national-innovation systems, and we propose that future budgets commit to an explicit doubling of funding by 2020 for these three key agencies from their 2012 levels, to a total of $25.6 billion.

Policies to encourage public-private partnerships linking academia, industry, government, and nonprofits

History has shown that increasing the pool of scientific knowledge through traditional

AT A GLANCE

Science and technology research

Problem: Living and working in a country that leads the world in innovation is key to the prosperity of America's 300 million engines of growth. But the United States is falling behind its peers in many of the key drivers of innovation that will determine technological leadership in the 21st century.

Solution: Focus on key investments in research and harness the economic potential of top research facilities to spur innovation and economic growth.

Key policy ideas:

- Double our public investments in three key science and engineering research agencies: the Department of Energy's Office of Science, the National Institute of Standards and Technology, and the National Science Foundation.
- Build public-private partnerships linking academia, industry, government, and nonprofit players to promote innovation and bottom-up regional economic growth.
- Institute a new and improved research tax credit for business that is insulated from the annual reauthorization process and that is refundable to small businesses and startup companies.
- Invest in grand challenges with flexible, ambitious, and accessible Frontier Prizes.
- Better align federal laboratories and research programs with economic development by reforming the stewardship model of the labs and lowering barriers to transparent collaboration with industry.

Other policies include gathering and releasing better data about the economic output of federally funded university research to encourage best practices in developing academic entrepreneurship.

Outcomes: The United States will be first in the world in public and private investment in research and development as a percentage of GDP. ■

forms of basic and applied research is a smart bet. But in the 21st century, when innovation is so intertwined with advances in science and technology, we need to not only continue to increase the size of that pool of knowledge but also to make it easier for U.S. businesses to make use of what's already in it.

In designing programs to achieve these goals, we believe there are essential characteristics to their success. These include building on existing assets and relationships, which often means focusing at the local and regional level. It also includes taking a network-lifecycle approach to innovation—not only encouraging individual firms to innovate on their own but also encouraging the formation of networks of firms, research institutions, supply-chain companies, and other stakeholders that are in the same field. Finally, it's important that support not be prematurely linked to single technologies before the dust has settled on what approaches are best.

FIGURE 8

21st century innovation policy

Instead of picking winners, encourages vigorous contest by many high-caliber competitors by investing in cross-cutting platforms and shared resources to support many approaches to accomplish the same goal
Network-lifecycle approach to innovation, encourages collaboration among interdependent stakeholders
Regional focus, leverages and builds on existing technological, industrial, human capital assets of regional economies and business ecosystems
Targeted, strategic investments from agencies

Adopting such an approach means that:

- Researchers in universities and federal labs, through more informed interactions, make better decisions about what avenues of research might be most valuable to major industries
- Small innovative businesses at the regional level, through their connections with academia, gain access to state-of-the-art digital modeling and testing facilities to innovate
- Educational institutions train students with the skills needed by local industry, large and small
- Breakthrough discoveries and inventions developed in university labs have a clear ladder to market readiness, investment, and implementation

In terms of concrete steps, in addition to simply increasing the funding for research and development for key agencies, we propose expanding and making permanent a number of Obama administration initiatives aimed at achieving these goals.

Using executive authority in its first term, the Obama administration repurposed existing competitive federal grants and other programs to encourage large and small manufacturers to come together with universities, community colleges, federal labs, and nonprofit economic-development organizations to share resources and promote

This photo released by Michigan State University in East Lansing shows doctoral student Xu Lu, who is part of a team that has developed a new thermoelectric material designed to more cheaply capture waste heat energy produced by car engines and industrial processes .
AP PHOTO/G.L. KOHUTH, MICHIGAN STATE UNIVERSITY

innovation in strategic industries.[9] Critical innovation-centric expansions have included programs such as the Jobs and Innovation Accelerator program, the Department of Energy Regional Innovation Clusters, the Economic Development Administration i6 program, the National Additive Manufacturing Innovation Institute, and the Investing in Manufacturing Communities Partnership. All of these programs delivered grant funding to public-private research, education, and industry consortia in regions around the country to invest in coordinated workforce, research, and infrastructure projects in targeted sectors.[10]

We support expanding these efforts as part of the broader increase in innovation and research support. Fully funding the National Network for Manufacturing Innovation, as called for in the preceding manufacturing section of this report, to link academia and industry to accelerate innovation, would be a great first step. The Center for American Progress, in its briefs "The Geography of Innovation"[11] and "Accelerating Regional Job Creation and Innovation,"[12] has called for expanding the Economic Development Administration's efforts in building the kind of economic-development partnerships that should be widely replicated. Additionally, Congress should immediately appropriate the

A legacy of key investments in American competitiveness[14]

One of the lessons of the 20th century is that when the United States made smart investments in its competitiveness, the dividends were huge. Investments in research and development proved critical in laying the groundwork for America to be the global leader in innovation, advanced by the world's most productive workers. Examples of these efforts include:

Department of Energy Labs: 1943 to present

The department was founded in 1943 in response to the need to mobilize the nation's scientific assets to support the war effort. Projects included the Manhattan Project and development of radar technology.

What we invested: A few million dollars in the early 1940s, growing to about $10 billion, or 0.06 percent of GDP, in 2012.

What we got: The optical digital recording technology behind music, video, and data storage; fluorescent lights; communications and observation satellites; advanced batteries now used in electric cars; modern water-purification techniques that make drinking water safe for millions; supercomputers used by government and industry; more resilient passenger jets; better cancer therapies; and the confirmation that it was an asteroid that killed the dinosaurs 65 million years ago.

National Science Foundation: 1950 to present

The National Science Foundation, or NSF, was championed by Sen. Harley Kilgore (D-WV), a New Deal politician and small businessman with a deep distrust of the laissez-faire attitude toward science and large monopolies that, at the time, controlled much of America's scientific enterprise. In response to these issues, the NSF was founded "to promote the progress of science; to advance the national health, prosperity, and welfare; [and] to secure the national defense."

What we invested: Just $3.5 million for its first full year of operation in 1952 (roughly $29 million in 2012 dollars), growing to $7 billion, or 0.05 percent of GDP, in 2012.

What we got: Google, which was started by two students working on a research project supported by the National Science Foundation, is today worth an estimated $250 billion and employs 54,000 people. This investment alone would make up all or almost all the costs of the NSF reaching back to its inception, but NSF funding has also been instrumental in the development of new technologies and companies in a range of industries, including advanced electronics, computing, digital communications, environmental resource management, lasers, advanced manufacturing, clean energy, nanotechnology, biotechnology, and higher education.

DARPA: 1958 to present

Founded in response to the launch of Sputnik to ensure the United States had cutting-edge military technology, the Defense Advanced Research Projects Agency, or DARPA, now operates as a small R&D team within the Department of Defense. It delivers world-leading technology both on the battlefield (Stealth fighter jets) and off (the internet). Described as "one hundred geniuses connected by a travel agent," DARPA continues to work with universities and teams across the country to push scientific and engineering boundaries, focusing on projects such as a human exoskeleton and mobile robots capable of assisting in medical procedures.

What we invested: $246 million in the first appropriation in 1962 ($1.6 billion in 2011 dollars), growing to reach nearly $3 billion, or 0.02 percent of GDP, in 2012.

What we got: The team that would go on to pioneer technologies that brought us the internet, the global positioning system, or GPS, and Siri for the iPhone.

The Apollo Space Program: 1961–1969

Two months after the Soviet Union put the first man in orbit, President John F. Kennedy announced his intention of putting a man on the moon, saying, "No single space project in this period will be more impressive to mankind, or more important in the long-range exploration of space; and none will be so difficult or expensive to accomplish." In fixing a national ambition and rallying resources behind it, the United States went from never having put a man in orbit to landing a team on the moon in less than a decade. At the height of the Apollo program's efforts, it employed 400,000 Americans and worked with 20,000 partnering institutions.

What we invested: $24 billion.

What we got: Massive technological advancement and the start of huge opportunities for technology transfer, leading to more than 1,500 successful spinoffs related to areas as disparate as heart monitors, solar panels, and cordless innovation. And now, a fledgling private-sector American space industry with real growth potential, which in 2012 completed the world's first private-sector cargo delivery to the international space station.

Human Genome Project: 1988–2003

Started as a joint project between the Department of Energy and the National Institutes of Health, the Human Genome Project ultimately helped coordinate the work of scientists in countries around the world to map the human genome. In a joint telecast in 2000, President Bill Clinton and U.K. Prime Minister Tony Blair announced the first phase was complete with the release of a public working draft of the "genetic blueprint for human beings." The project has ushered in a new era of medical and scientific advancement.

What we invested: Approximately $3 billion.

What we got: Critical tools to help identify, treat, and prevent causes of disease—and huge opportunities for the high-growth American biotechnology industry, which accounted for more than $750 billion in economic output, or 5.4 percent of GDP, in 2010, and which now depends heavily on these advances in genetics.

$100 million in direct spending and $300 million in loan-guarantee authority it has already authorized under the America COMPETES Reauthorization Act of 2010[13] to expand these kinds of partnerships on a competitive basis all across the country.

Policies to institute a new and improved research tax credit for business

Economists have long recognized that private-sector investments in scientific research and development suffer from acute market failures, defined as inefficiencies in the distribution of goods and services.[15] New knowledge, ideas, and innovations can be readily appropriated, adapted, and emulated by others in the economy. These spillovers can create a disincentive for people and businesses to invest in research. After all, if a good portion of the value of that research will end up in the hands of others, the investment may not be worth it even though it might yield substantial social returns. Because of the potential for market failures, economists widely agree on the benefit of public policies that create incentives for private-sector R&D.[16]

Ideally, a policy to leverage private R&D spending and capacity would specifically encourage the incremental investments beyond the research that private-sector investors would be willing to fund of their own volition. Otherwise a tax benefit that gives more than an incremental incentive might provide windfall profits by rewarding a company for something it was going to do anyway. What's more, an ideal policy would restrict the incentive to truly worthy "scientific" endeavors that yield broad social benefits and that are discouraged by market conditions.

Since it is impossible to actually determine how much R&D a company would support in the absence of a tax incentive, a policy can at best only adopt decidedly arbitrary metrics for establishing what portion of a company's R&D spending is "incremental." What's more, in practice it is very difficult for policy to distinguish between what should qualify as research and development expenses deserving of support and what should not—as evidenced by a spate of recent court rulings in cases considering the scope of the existing U.S. research tax credit.[17]

While the current U.S. research tax credit is designed with these issues in mind, real implementation problems create uncertainty and distorting inefficiencies in business investment decisions, and lead both companies and the IRS to devote considerable resources for auditors, tax lawyers, and other expensive consultants—not to mention lobbyists—to navigate the fuzzy definitions governing the current research tax credit. Recognizing the practical problems of implementing a theoretically ideal incentive to boost private R&D spending, we propose a tightening of standards and both a broadening and simplification of the incentive by:

- **Establishing a simplified, level credit at a reduced rate:** Our current mechanism for delivering R&D tax incentives to the private sector offers a 10 percent credit for

Sylvia Earle, center, puts on her helmet as Dale Stokes, left, and Roger Garcia, right, assist before a dive to the undersea research laboratory owned by NOAA, Aquarius Reef Base, Jul. 13, 2012, in the Florida Keys.
AP PHOTO/LYNNE SLADKY

any R&D spending above prior levels of R&D spending by the firm. In practice, this is a poor and complicated way to target the credit. Instead, we propose that businesses receive a level credit on total qualified research and development expenses, not just the ostensibly additional portion. A flat credit stimulates R&D spending by reducing the average cost of research investments for which there are significant social benefits. A flat credit also eliminates much uncertainty over the amount of the credit by simplifying complicated and arbitrary formulas aimed at trying to ascertain what amount of research is "incremental," and this simplification means reduced costs of compliance for both businesses and the IRS.

- **Making the research tax incentive permanent:** In recent years, Congress has extended the research credit on a year-to-year basis, even letting it expire for entire years before renewing it retroactively. The perpetual uncertainty of renewal has made it more difficult for businesses to plan, and it likely diminished the credit's incentive effect. Making the tax credit permanent eliminates uncertainty and recognizes the broad benefits to the overall economy from private R&D investments. Congress should, however, continuously review the credit to ensure that it is serving its purpose cost effectively.

- **Ending the bias against small business R&D:** Large corporations receive a disproportionate 65 percent of the research tax credit but are fewer than 4 percent of companies claiming the credit. Small companies are disadvantaged by the complexities and costs associated with claiming the credit, and start-up companies may not yet have incomes sufficient to benefit. Moreover, research shows that smaller companies tend to produce higher-quality R&D.[18] To further encourage innovation in America's small businesses, this simplified credit will be refundable for small businesses up to a cap; for large companies, the credit will remain nonrefundable.

- **Honing eligibility to focus on innovation:** Legal costs associated with intellectual-property registration or licensing and interest payments pertaining to R&D expenditures would be excluded from eligibility. Compensation through stock options, which require no current expenditure from the employer, will also be excluded. Because the worth of stock options is premised on future realized gains in valuation from innovation successes, there is already ample market incentive to conduct quality research in this regard.

- **Clarifying internal-use software eligibility:** Companies have many motivations to develop software for their own use, and the nature of this business practice is changing with the evolving nature of information technology and the service-sector economy. But not all internal-use software—such as that developed for administrative or management purposes—advances scientific or technical knowledge. In light of existing confused guidance on what software is eligible for the credit, we propose clarification to focus tax incentives on maximizing the social return from internal-use software development.[19] Software developed for internal administrative or management purposes will be ineligible for the credit.

- **Creating incentives for economically strategic research:** Companies conducting R&D in industries and activities deemed important in the government's quadrennial National Economic Strategic Assessment (see chapter on creating the mechanisms for an adaptive national economic strategy) will qualify for a bonus R&D credit.

- **Denying credit claims on amended returns:** The tax credit aims to provide businesses with an incentive to increase their R&D spending above the level they would otherwise choose. A significant share of R&D credit claims are, however, made on amended tax returns. Sometimes these amended returns are filed years after R&D spending decisions have been made, suggesting that the credit was not a factor in the company's decision to perform the research. To target the credit to new research that might not be conducted without the credit, the credit should have to be claimed on tax returns when they are initially filed.

- **Standardizing record-keeping requirements and integrating credit with national statistical systems:** The IRS should issue guidelines to clarify a com-

The power of innovation prizes

When the Spirit of St. Louis finally touched down in Paris after its record-breaking 33.5-hour nonstop flight from New York, Charles Lindbergh didn't just earn a place in the history books. He also earned a $25,000 award from New York hotel owner Raymond Orteig, who had offered the prize to any aviator who could make the transatlantic journey.[25] With Lindbergh's achievement came a sudden explosion in the public's interest in air travel: by 1930, just three years later, the number of airports in the United States had doubled.[26]

Innovation prizes have sometimes been the proverbial carrot, creating intense competition and spurring new heights of ingenuity. The Orteig Prize is just one example of a phenomenon that has long propelled technology forward, from the Ansari X Prize that sent Burt Rutan and his SpaceShipOne into orbit, to Carnegie Mellon's Fredkin Computer Chess Prize, which prompted IBM to build the powerful Deep Blue supercomputer that beat chess grandmaster Garry Kasparov.[27]

We are living in a second golden age of innovation prizes, and while U.S. government agencies have supported relatively small innovation prizes in recent years, we also see scope for a basket of larger prizes that can capture the imaginations of scientists and engineers and answer some of our most pressing national challenges. For example, innovation prizes could be awarded for:

Printing the first kidney (synthetic biology and 3-D printing): New biomaterial science, new ways of growing cells outside the body, and new technologies to supply blood to organs are already converging to enable the creation of tissues and organs in the laboratory. Printers using cells rather than ink are manufacturing small pieces of implantable bone and even the model of a fully functioning human liver.[28] The first research entity to print a working human kidney that can be implanted into a patient in need would win the prize.

Decoding the blood proteome (personalized medicine): The proteins encoded by the human genome are the machines of human biology. While each cell contains the same genetic information, it is largely the levels and actions of proteins that determine biology. But to understand the proteins, we need new technologies that will allow us to measure hundreds or thousands of proteins in a sample. The invention of a "protein identifier" would be the single most powerful step we can take toward advancing personalized medicine for both preventative and proactive medical care, and would provide a window into the health and disease states of an individual and make its inventor a prizewinner.

Developing high energy-density solid-state batteries for electric vehicles (energy): Current electric vehicles use Li-ion battery systems that are heavy and cumbersome because of required cooling devices and support materials in the battery cells. With advancements in materials science, development of solid-state batteries that do not require cooling and the extra bulk of conventional Li-ion battery systems could result in dramatically cheaper and higher energy-density batteries for electric vehicles, thereby lowering costs and increasing the range of these vehicles. The inventor of a cheap, high energy-density solid-state battery would win the prize.

> The federal laboratory system has now grown to more than 300 facilities, spends $35 billion annually, is the source of thousands of new inventions and medical treatments each year, and represents one of the most significant federal investments in innovation.

pany's necessary record keeping documenting research expenses qualifying for the tax credit. Credit recipients will be required to report specific quantitative data that will integrate with a retooled national statistical system (detailed in the chapter on creating the mechanisms for an adaptive national economic strategy) and can integrate with existing efforts to measure the economic impact of public R&D support such as those of the government's STAR METRICS consortium.[20]

Policies to increase investments in grand challenges

As demonstrated by President Obama's April 2013 announcement of the Brain Research through Advancing Innovation Neurotechnologies, grand challenges can fuel innovation. The 2010 America COMPETES Reauthorization Act allows agencies to conduct innovation prize competitions.[21] Since the act's enactment, there have been more than 200 competitions supervised by more than 25 agencies.[22] These prizes are cost effective and promote greater investment in R&D and areas of research that may otherwise be neglected.

For this reason, we propose a Frontier Prize allocation of $100 million a year to allow agencies to offer innovation prizes that would fund both discrete, smaller challenges such as the Department of Agriculture's Apps for Healthy Kids challenge, which for $60,000 generated more than $5 million in investment,[23] as well as a small number of large challenges that can capture the imagination of scientists and engineers in the private and university sectors. An example of the latter is the $15 million Scottish Saltire Prize, which has encouraged international investment in renewable energy in the North Sea.[24]

The government can also play a part in encouraging the current revival of innovation prizes by creating a platform for prize philanthropy. Right now, government agencies make up the vast majority of organizations with challenges posted on the website, challenge.gov, an online platform for agencies to post challenges and for the public to propose solutions. The administration should encourage more citizens, corporations, and foundations to submit prizes to this platform. Some amount of the Frontier Prize purse could also go to offering matching funds for prizes developed by citizens, corporations, and foundations.

Policies that better align federal laboratories with economic needs

Since 1846, when the first federal laboratory was established—the Smithsonian Institution—the federal government has invested directly in research to address national needs and promote scientific and technological advancement.[29] The federal laboratory system has now grown to more than 300 facilities, spends $35 billion annually, is the source of thousands of new inventions and medical treatments each year, and represents one of the most significant federal investments in innovation. Though a quarter to a third of this spending occurs in labs originally built for defense purposes, many of the Cold War-era nuclear research labs today are vibrant, multidisciplinary environments with programs ranging from biology to computer science, in addition to nuclear physics research.[30]

Labs of all stripes and diverse origins often play an important role at the interface of federal investments in R&D and private-sector commercialization of new products and services. In fact, many significant private-sector technological successes have been born from national lab research and partnerships between labs and industry—from fluorescent lights to digital memory to the discovery of "good" cholesterol and satellite communications.[31]

Counting just the largest labs operated by the nine federal agencies with research budgets of more than $500 million, in FY 2010 (the most recent year for which complete data is available) more than 4,783 new inventions were reported, almost 1,200 new patents were issued, and 8,525 cooperative R&D agreements, called CRADAs, with industry were carried out.[32] Technologies licensed from just the National Institutes of Health, the largest nondefense national lab system, yielded nearly $6 billion in revenue for companies doing business in the United States in FY 2011.[33] And this figure does not include the products made possible by non-patented breakthroughs in basic science.

The lab system, however, was built in a piecemeal fashion over many decades, without a coherent mission or standardized management procedures. Science, technology, and the state of the economy have all changed in the decades since many parts of the lab system were formed, but the vision for the mission of the labs and how they interact with industry has not kept pace.

Reforming the stewardship model, management practices, and relationships of the labs with industry would help to maximize the

The aircraft Solar Impulse is prepared for the second leg of the 2013 Across America mission, early May 22, 2013, at Sky Harbor International Airport in Phoenix. The plane's creators, Bertrand Piccard and Borschberg, said the trip is the first attempt by a solar airplane capable of flying day and night without fuel to fly across America.
AP PHOTO/MATT YORK

economic and societal opportunities of the labs and meet the challenges of 21st century innovation-based competition.

Reform the federal lab-stewardship model

Most federal labs nominally serve the mission of a particular mother agency in the federal government but, as a practical matter, funding is often fragmented. Pacific Northwest National Lab, for example, originally a nuclear-testing facility, now receives only 17 percent of its funding from its sponsor agency, the Office of Science, and the rest comes from places such as the Department of Defense, the Department of Homeland Security, the National Nuclear Security Administration, and other government and private-sector clients.[34]

Further, these funding streams from separate agencies can be overly prescriptive with regard to technological pathways. Money is appropriated by technology to be researched, rather than problems to solve, which forces lab managers to pursue courses of research even if they are not technically or economically promising. Acquiring funding via many small pots of money, with many strings attached, limits the flexibility and therefore the effectiveness of lab management.

The White House Office of Science and Technology Policy should set up a National Research and Development Management Council with representation from all of the key stakeholders in national labs: directors of the federal laboratories; the relevant sponsoring agencies such as the Department of Energy, the Department of Defense, the National Institutes of Health, and others; the contractors in charge of managing labs; the scientific establishment that makes use of laboratory facilities; and the industry leaders who partner with labs. This council would be tasked with assessing how the sponsoring agencies can maintain necessary oversight of lab operations while reducing red tape, speeding up bureaucratic processes, and leaving the scientific decisions to the scientists.

As a first step, this group should issue recommendations to create more flexibility and coherence in the streams that fund lab work and reduce technical micromanagement in grant opportunities. Rather than fulfill thousands of pre-prescribed and unrelated grant requirements from potentially dozens of agency sources, while simultaneously trying to fulfill top-down requirements from sponsor agencies, the scientists who manage labs should have the flexibility to scale up or scale down research programs, invest dollars flexibly, and pursue outside partnerships as needed to meet the mission requirements of any funding program. Such reforms would also allow the labs to provide excellent service to client companies paying in full for access to the capabilities and services that labs maintain in excess of what is needed by agency stewards. With respect to the latter, it is important that the national labs not simply become private contractors to the detriment of important research serving national priorities. Nevertheless, private-market actors' willingness to invest is one relevant indicator of what avenues of research are likely most able to successfully meet national technical and economic objectives.

Reward innovation in the marketplace

Another related issue with the federal lab system is that the transfer of technology to the market—where it can solve real-world problems and create economic growth—is not a major part of the mission of federal labs. In 1980 Congress legislated that "technology transfer, consistent with mission responsibilities, is a responsibility of each laboratory science and engineering professional."[35] Congress, however, provided neither guidance nor funding to enable labs to carry out this directive. And technology transfer remains "an underfunded mandate," according to the Institute for Defense Analysis.[36]

But relationships with industry, managed properly and with transparency, can be very beneficial to both the scientific and economic outcomes of research. There are two major reasons for this. First, ensuring that valuable inventions currently sitting idle in laboratory intellectual-property portfolios can find commercial homes helps establish U.S. technological leadership, benefits U.S. industry, and creates jobs. Second, the missions of the agencies, government, and public can be better served by better leveraging the capabilities and capital of the private sector to do collaborative research that is mutually beneficial to the public mission and private objectives.

To strengthen these relationships, two actions should be taken. First, lab-sponsoring agencies should be required to adjust their annual performance-evaluation procedures for lab managers to reward lab managers for proactively engaging with and forming productive partnerships with industry. Implementing these changes could likely be done through executive authority alone, in the context of better implementation of the Stevenson-Wydler Technology Innovation Act of 1980, which already calls for labs to maximize commercial outcomes of publicly funded research to the greatest degree possible without compromising the government mission of the labs.[37] In the longer run, Congress should build upon or amend the Stevenson-Wydler to set benchmarks and more clearly emphasize industry engagement as a priority in lab management and evaluation.[38]

Second, the administration should review the conflict of interest policies at all of the federally funded research and development centers to remove unnecessary roadblocks to collaboration with industry, while ensuring that science continues to be guided by unbiased scientific opinion. In some labs, for example, it is considered illegal for scientists to do work for the government in any field related to a patent they own. This restriction prevents many accomplished scientists and inventors from using their talents in the national lab system or forces them to choose between furthering the frontier of knowledge and applying their discoveries in the real world. One national laboratory, the National Institute for Standards and Technology, took steps in 2010 to change this policy.[39] These reforms could serve as a model for broader reform to encourage other labs to contribute to the economy, while serving their publicly guided science missions, and to ensure that highly skilled researchers aren't barred from contributing to lab and agency missions and vise-versa.

Policies that encourage market adoption of university discoveries and inventions by collecting better data

Universities are engines of innovation and economic growth. Yet few statistics are gathered in a systematic way about their contribution to commercialized innovation, the launch of new firms, and job creation. The lack of high-quality data about the overall performance of these invaluable assets is distressing and leaves us behind many other industrialized nations.[40] Getting better data on how universities move research and discoveries into the marketplace would allow for better benchmarking of universities against one another and more rapid propagation of best practices in technology innovation.

Several efforts are now underway to develop new metrics to measure university contributions to the economy, and Congress called broadly for more and better reporting of university innovation data in the America COMPETES Reauthorization Act of 2010.

The administration should use the authority granted by Congress in that act to convene stakeholders to implement new across-the-board metrics to be reported by universities annually. These efforts should build upon the existing partnerships established under the STAR METRICS consortium,[41] which seeks to establish the economic and social returns to government-funded R&D, the National Center for Science and Engineering Statistics, the Association of Public and Land Grant Universities, and the Association of University Technology Managers, and engage other stakeholders, including the federal science agencies, associations, and industry. Building upon the existing voluntary reporting of some metrics by research universities, the administration should gather input from these stakeholders and set a timeline for implementation of new measures of university economic engagement.

Although we have focused on the direct value to the economy of commercial ideas that develop out of university research, there will always be ways that universities promote innovation and benefit society that simply cannot be measured. Academic publishing is effectively a global economic intellectual commons, where ideas are exchanged and built upon. So while numbers can help us better understand how universities are most effective in moving research to technology, any attempts to better understand the functioning of, and thereby improve upon, our nation's engines of innovation must not detract from a core American value: that the pursuit of new knowledge and education are ends unto themselves. ■

Endnotes

1 According to a Department of Commerce report, wages grew in innovation-intensive industries at 2.5 times the national average in recent years. *Patent and Trademark Office, Patent Reform: Unleashing Innovation, Promoting Economic Growth, and Producing High-Paying Jobs* (Department of Commerce, 2010), available at http://www.commerce.gov/news/fact-sheets/2010/04/20/white-paper-patent-reform-unleashing-innovation-promoting-economic-growt.

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4 Organisation for Economic Cooperation and Development, "Economics: Innovation Central to Boosting Growth and Jobs."

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