Smart Policy
Building an Innovation-Based Economy

by Darrell West, Allan Friedman,
and Walter Valdivia

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Executive Summary

The Internet is creating tremendous social, economic, and cultural value. Through digital connections, people are innovating, communicating with one another, and creating businesses. Yet despite these positive benefits, the United States is experiencing slow economic growth and major barriers to public and private sector innovation. We need smarter policies in order to take full advantage of the digital economy and strengthen our capacity to build society, generate jobs, and improve long-term economic growth. This focus should be front and center for policymakers as they wrestle with social and economic challenges.

This paper looks at ways to reform our economy, improve public sector performance, and train people for 21st century jobs. It draws on a day-long workshop we organized with two dozen innovation leaders in June 2012 and online crowdsourcing responses of several hundred experts around the country in the areas of innovation, technology, and economic development. We asked these individuals to help us develop new solutions to our continuing economic and political woes. This included the identification of promising reform ideas and ways to encourage growth through innovation. We compiled their suggestions and organized them into themes, and present them below in an actionable format for policymakers to consider.

In our recommendations, *we argue that the primary goals policymakers should pursue in creating a strong 21st century economy are the following:*

> *1) Ensuring conditions that promote innovation and entrepreneurship in the private sector, 2) Leveraging the digital economy in a way that boosts government services and makes agencies more efficient and effective, 3) Enhancing digital infrastructure and providing data that allow the proper measurement of the 21st century economy, and 4) Laying the foundation for a strong, educated, and innovative workforce.*

Our overriding theme in each of these areas is how to move from ideas, norms, structures, and regimes developed during an industrial period to institutions and policies for the digital world.

Specifically, we propose the following to encourage an innovation-based economy:

1. We need *better metrics for measuring worker productivity* in the 21st century economy. Past approaches based on worker hours or total employees in relation to Gross Domestic Product (GDP) ignore the transformational nature of digital technology.

Darrell M. West is vice president and director of Governance Studies and founding director of the Center for Technology Innovation at the Brookings Institution.

Allan Friedman is a fellow in Governance Studies and research director of the Center for Technology Innovation at the Brookings Institution.

Walter D. Valdivia is a fellow in the Center for Technology Innovation at the Brookings Institution.

2. We should *encourage entrepreneurship* by expanding Small Business Administration credit for start ups, adding entrepreneurial skills to school curricula, and making changes in immigration policy that encourage entrepreneurs to come to America.

3. We need *governments that learn to innovate and collaborate*, and develop new approaches to service delivery, transparency, and participation. This includes placing more data online and employing data analytical tools, social media, mobile technology, and search results that improve decision-making.

4. We should *strengthen infrastructure* by investing in broadband, data centers, and mobile cell towers, and improving access to spectrum for wireless applications.

5. We should *protect vital digital assets* by updating the Federal Information Security Management Act and developing procedures for monitoring threats to critical infrastructure.

6. We need to *improve knowledge transmission* through faster adoption of digital textbooks, more widespread use of creative commons licenses for instructional materials developed with taxpayer dollars, and policy changes that speed education innovation.

7. We need to *increase technology transfer and the commercialization of knowledge* from universities and federal laboratories so that public and private investments translate into jobs and economic activity as well as better health, security, and well-being.

8. We should *harmonize cross-border laws to promote global innovation and freedom of expression*.

Improving the Foundation for Innovation and Entrepreneurship

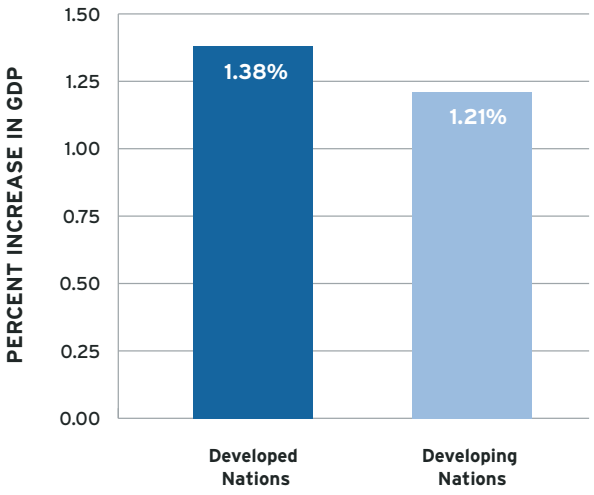
With our economy experiencing weak growth, it is vital that leaders pursue pro-innovation policies that improve productivity and entrepreneurship. The industrial-based economy has given way to a post-industrial order in which the Internet is a crucial platform for commerce and communications. As shown in **Figure 1**, a World Bank study of 120 nations between 1980 and 2006 undertaken by Christine Qiang estimated that each 10 percentage point increase in broadband penetration boosts gross domestic product by 1.38 percent in developed nations and 1.21 percent in developing countries.[1] We need to use digital technology to enhance private sector productivity and boost entrepreneurship. Both of these aspects are important for future prosperity and long-term economic development for society as a whole.

Measuring and Enhancing Private Sector Productivity

Productivity enhancement is key to economic growth. One of the factors that enabled economic development in the 1990s was productivity gains built on digital technology. The new technology associated with the Internet reduced communication and transaction costs, and helped workers become more productive. Businesses were able to operate more efficiently, and the economy as a whole experienced strong economic growth.

To encourage better economic performance in the contemporary period, we *need better metrics for measuring worker productivity that more fully captures the 21st century economy.* Current measures focus on the efficiency of outputs from inputs in the production of goods and services. For instance, labor productivity is measured as the total national output (Gross Domestic Product) per unit of labor (hours worked or employed workers).[2]

FIGURE 1:
Broadband and Economic Development



For each ten percent increase in broadband penetration, there is a corresponding increase in GDP.

These measures miss important aspects of the digital economy. Technology enables organizational reengineering on a large scale. It is crucial to understand how technology adds value, saves money, and reduces production time. *We need more nuanced production measures other than worker hours or total employees in relation to GDP*. Otherwise, it is hard to track operational efficiency in all phases of production.

In addition, there are aspects of our economy that have not fully embraced or been transformed by technology. *Education and health care represent two of the largest sectors that have not fully experienced the impact of transformational digital change*. In many respects, we still deliver education and health care in a similar manner as several decades ago. In each area, there are policy barriers that stand in the way of adopting productivity-enhancing technologies. For example, government licensing requirements sometimes stand in the way of advances in distance education and telemedicine. We need more flexible licensing in order to overcome the limitations of geographically-based systems.

Boosting Entrepreneurship

Boosting entrepreneurship is crucial for long-term economic development. According to our workshop participant Tim O'Reilly, the Chief Executive Officer of O'Reilly Media, "entrepreneurship is making something other people want." Entrepreneurs innovate, create jobs, and build businesses. We need to figure out ways to empower individuals, launch new businesses, and improve crowd-sourcing options for company financing. Breaking logjams in this area can do a lot to improve the overall economy.[3]

There are several ways to do this. First, *we should encourage the Small Business Administration (SBA) and private financial institutions to make loans to entrepreneurs*. Gaining access to capital is one of the hardest parts of launching new businesses. Startups report that this is the most difficult hurdle in many cases. It is a challenge to find funds for new ventures or to locate financial resources for business expansion. Making sure that the SBA has sufficient funding to support small business should be a top priority for economic expansion.

Second, we need to make changes in our immigration policy to encourage those with entrepreneurial skills to stay (or come) to the United States. *Foreign students who earn graduate degrees in STEM fields should get visas that allow them to remain in the United States*.[4] Research by Vivek Wadhwa and colleagues shown in **Figure 2** reveals that 25 percent of the technology and engineering businesses launched in the United States between 1995 to 2005 had a foreign-born founder. And in Silicon Valley, the center of the high-tech industry, 52 percent of the new tech start-ups had a foreign-born owner.[5]

The industrial-based economy has given way to a post-industrial order in which the Internet is a crucial platform for commerce and communications.

CASE STUDY

Information technology has been a major driver of economic growth in recent years. The tech sector has experienced double-digit growth and created considerable wealth and prosperity. In areas such as computer software, digital music, search, online advertising, social media, auctions, and cloud computing, companies have established new models and altered business practices.

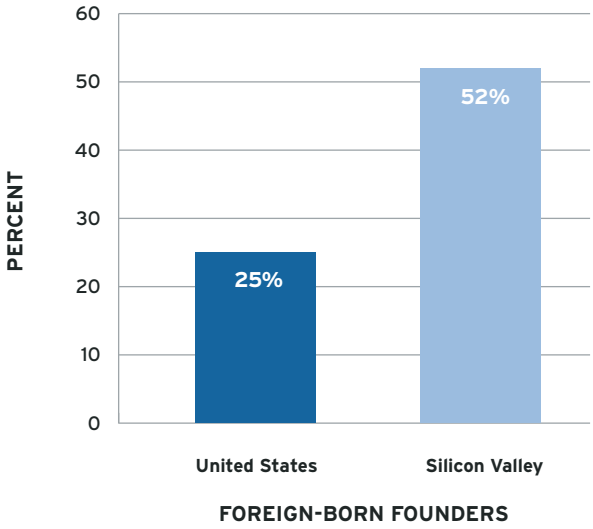
But what a lot of people don't realize is how many of the major companies in this area had a foreign-born founder or co-founder. For example, Google co-founder Sergey Brin was born in Moscow, Russia, and moved to the United States at the age of six. His parents were mathematicians and he quickly developed an aptitude for math and computer science. At Stanford University, he met classmate Larry Page and the two combined their respective interests in data mining and search efficiency to form their company.

Pierre Omidyar displayed a similar ingenuity. Born in Paris, France in 1967 of Iranian parents, he came to America as a young child. With an interest in computers, he earned a degree in computer science from Tufts University and served as a software developer for several computer companies. After working on an Internet shopping site, he designed an online auction service that he called Auction Web in 1995. On this site, people could request bids for collectibles and items were sold to the highest bidder. Two years later, he renamed the company eBay and soon had over one million customers. Within a decade, the business had grown to 95 million registered users, had sales of over $2 billion, and expanded into India and China.

Intel co-founder Andy Grove was born in Budapest, Hungary migrated to the United States, and wrote leading papers on semi-conductors. He helped launch the Intel Corporation in 1968 and made it the preeminent company in the field. As micro-chips got smaller and smaller, computers got cheaper and more powerful. The computing era would not have thrived to the extent it did without his leadership.

Jerry Wang represents another example of an immigrant visionary. Born in Taiwan, he came to America when he was 10 years old. In college, his hobby was compiling links of favorite websites into a central service. This later formed the nucleus of his company, Yahoo!. The firm eventually became a successful portal that offered news, entertainment, search, email, and social networking. It is estimated that nearly 500 million around the world use his company's email service.

FIGURE 2:
Percent of U.S. Tech and Engineering Firms with Foreign-Born Founders



One quarter of tech firms were founded by foreign-born individuals and more than half of these firms are in Silicon Valley.

Third, we should support the American Dream Act so young people can stay in the United States, eliminate per-country visa caps, and expand entrepreneur and venture capital visas for those who invest major financial resources in job creation. According to current law, those who invest $1 million in a new startup and create a minimum of 10 jobs receive a green card through the EB-5 visa program and, therefore, are able to stay in the United States.[6] This initiative is a good start, but the financial threshold is too high for many small businesses. Lowering the initial investment to $250,000 would enable more immigrants to qualify for the visa program and expand opportunities for job creation.

Fourth, *we should encourage students to take internships that develop entrepreneurship skills.* This involves everything from learning how to commercialize knowledge, attract investment capital, market products, and develop business plans. Gaining experience in each of these areas boosts the probability that young people will launch actual companies.

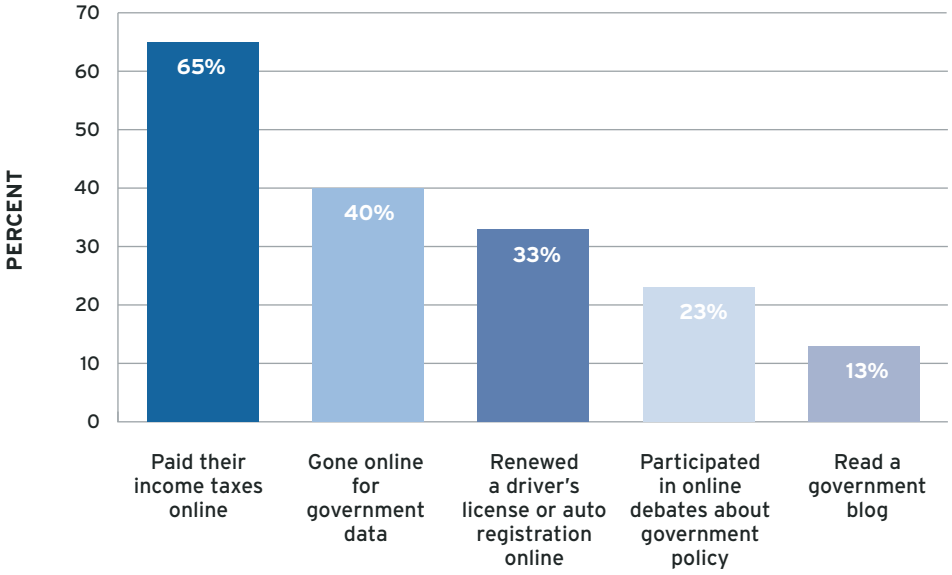
Finally, over the next decade, *we should develop new metrics for measuring entrepreneurship and its impact on the economy*. Benchmarks for assessing entrepreneurship would help public and private sector leaders focus on this important area and create incentives for changes in business, education, and immigration that encourage more entrepreneurial behavior.

Improving Public Sector Performance

It is not just the private sector that needs to make meaningful changes. *Governments must learn to innovate and collaborate*. David Bray, Senior National Intelligence Service Executive with the Information Sharing Environment and the Office of the Director of National Intelligence, pointed out at our workshop that there are "over 18,000 law enforcement jurisdictions in the United States, and each has its own ticketing and licensing requirements. This legacy of a decentralized approach to government services should be improved through shared services available in multiple areas."

In fundamental respects, the U.S. government has failed to deliver the reforms necessary to meet the challenges of the global economy.[7] Our country faces immense challenges in terms of deficit reduction, unemployment, health care, climate change, energy, and immigration reform, among other issues. Trust in government remains near historic lows. Many citizens don't see our elected officials doing much to solve problems or improve public sector performance. Election campaigns do little to inspire public confidence in problem-solving. As explained by our forum participant Carl Shapiro, the Transamerica Professor of Business Strategy at the University of California at Berkeley, "organizations find it hard to change, and government is very bad at change."

FIGURE 3:
Public Accessing Online Services



Many Americans still do not utilize online services that are available at government websites.

Yet we have seen dramatic improvements in productivity and efficiency in private organizations, even in companies with cumbersome bureaucratic operations. Through a combination of new technology and flatter organizational structures, many businesses have altered the way people access information and services. In the banking industry, for example, we have gone from a situation in which people used human tellers to make deposits and withdrawals to automated teller machines. At airports, we have shifted from agents to kiosk check-in procedures. In some stores, self-service scanners combined with debit or credit card readers allow consumers to make purchases without dealing with a sales clerk. At the same time, we recognize that government cannot always borrow directly from the private sector, as public services have their own needs and requirements.

In the public sector, *we need new approaches to service delivery, transparency, participation, and collaboration.* Right now, many Americans still do not utilize online services that are available at government websites. As shown in **Figure 3**, 65 percent of Americans pay income taxes online, 40 percent go online for government data, 33 percent renew their driver's license or auto registration online, 23 percent participate in online debates about government policy, and only 13 percent read a government blog.[8] These low numbers are unfortunate because there are ways to employ digital technology that improve online service delivery, public outreach, social networking, and civic engagement. *The utilization of cloud computing could save over 25 percent of federal technology expenditures in certain areas.*[9] We are early in the digital revolution, but there is an extraordinary opportunity to shift the way in which government performs.[10]

Digital technology also can help get more people involved with government. When federal agencies consider new rules, there is a public comment period when individuals, groups, and businesses can offer reactions and make suggestions regarding proposed regulations. In the past, the rule-making process was heavily dominated by industry

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CASE STUDY

Reverse auctions represent a way to save money and improve the ability of small companies to compete for government contracts. Agencies post their needs for goods and services and online websites allow companies to bid down the prices. A 2011 study by David Wyld of Southeastern Louisiana University entitled "Reverse Auctions: Saving Money and Increasing Transparency" found that reverse auctions could save the federal government $8.9 billion. One of the chief virtues of reverse auctions is their use of technology to increase the number of suppliers. This raises the level of competition and creates tremendous efficiencies in the process. A case study of the U.S. State Department demonstrated that reverse auctions enabled small businesses to win the majority of the government contracts bid through this mechanism.

and did not engage a broad diversity of perspectives. This limited the feedback federal officials received from outside sources. Now, many agencies allow electronic comments, and there is a broader range of participants. Comments are no longer limited to those with a vested interest in a proposed regulation, but arrive from consumer groups, interested experts, and ordinary citizens. *When communication costs are lowered, it is easier for federal officials to get comments from a broader and more diverse range of constituents, including entrepreneurs, small business representatives, and the general public.*

Social media and mobile technology provide early warning systems for government decision-makers. Tracking what ordinary folks complain about helps to identify problematic agencies, restaurants, businesses, or landlords, among other things.[11] This type of information boosts the ability of officials to improve accountability and responsiveness.

Another way to strengthen government decision-making is to involve a broader range of talent in the public sector and reward those who generate innovative ideas. *ExpertNet broadens government expertise by recruiting outside experts for government agencies*. This helps departments become more innovative and improves the human capital available for innovation. Cash prizes further promote incentives for innovation. *Those administrators who generate novel ideas for improved efficiency and operations should get prizes and cash awards to recognize their innovations.*

We need policy shifts that encourage the purchase and adoption of technology innovation in the public sector. *We should ensure that local, state, and federal government procurement processes are fair, open, and transparent in order that public agencies get the best products at the lowest possible prices.* Agencies should be empowered to make the best acquisition choices possible, and build on successes across agencies. We should reform government procurement to include reverse auctions for goods and services. *Reverse auctions and the RFP-EZ program help small businesses secure government contracts and diversify the supply chain*.

Over the next ten years, we need better metrics for measuring public sector innovation. *This should include the number of new data sets placed online, statistics on use and impact of cloud computing, social media, and mobile technology in government, reliance on outside experts, and the budgetary impact of reverse auctions in the public sector.* Each of these metrics would provide valuable benchmarks from which to assess government performance.

Enhancing Digital Infrastructure and Data Resources

We generally think that our infrastructure problems are physical in nature, such as those involving highways, bridges, and dams. There is no question we face challenges in these areas as the country confronts an aging transportation network and structural assets that are in desperate need of repair or replacement.

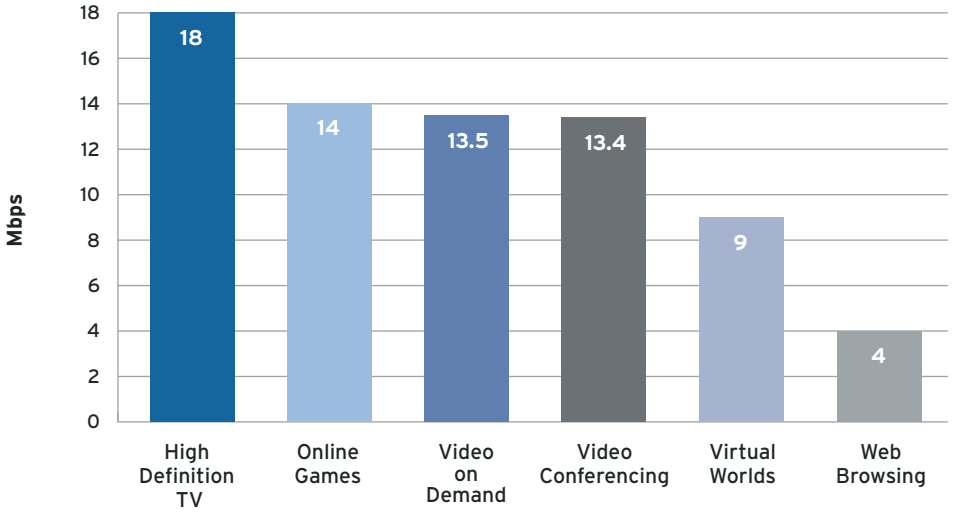
In the 21st century, though, digital infrastructure such as broadband, mobile, and cloud-based data centers provide valuable fuel for economic growth and prosperity. High-speed broadband is crucial for new applications in education, health care, and energy. Fast wireless networks are important because the world is rapidly "going mobile." Data centers represent a major growth area as people and businesses seek cloud-based data storage facilities. We need to enhance our digital infrastructure and use it to improve performance.

Strengthening Infrastructure

Internet infrastructure serves as the backbone for new applications in various areas. For example, patients can get second opinions from physicians geographically distant from themselves by emailing them X-rays or MRIs.[12] Fast broadband also enables distance learning in education and smart energy grids for businesses and residences.

Given the importance of digital infrastructure, there are several actions that would improve the ability of our economy to enable innovation. We should encourage private companies to make investments that *raise U.S. broadband adoption from 70 to 95*

FIGURE 4:
Bandwidth Required for Apps



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percent and increase broadband speed up to 50-100 mbps, especially for schools, hospitals, and libraries.[13] We need faster and more universally available broadband because many applications are coming online that demand considerable bandwidth. **Figure 4** shows that high definition television requires 18 mbps, online games need 14, video on demand requires 13.5, video conference needs 13.4, virtual worlds need 9 and web browsing uses 4.[14]

Faster broadband would speed the transition of the economy from an industrial to post-industrial order. It would unleash mobile-health applications for physicians to read medical tests, communicate with patients, consult medical directories for the latest information, and reduce duplicative testing. It also would boost collaboration and digital content in education, energy, and transportation.

At the same time, *we must improve Internet and mobile access to underserved communities*. Right now, there are significant disparities in access to technology based on income, race, education, and geography.[15] Having a digital infrastructure with holes in it based on socio-economic status widens the gap between information haves and have-nots. Nicol Turner-Lee, the President and Chief Executive Officer of the National Association of Multi-Ethnicity in Communications, explained at our workshop that "some minorities do not have access to technology so in disruptions, we need to be sensitive to those communities."

Attention needs to be paid in order to reduce this divide at schools, libraries, and hospitals so that more people can gain the full benefits of the technology revolution. For those without technology experience, *digital literacy programs can help people and businesses learn how to use the Internet*. Surveys have found that senior citizens and low income individuals in particular require training on Internet usage to understand how it can be helpful to them.

We need to *streamline the approval process for building new cell towers and laying fiber optic lines*. Streamlining is

CASE STUDY

Data.gov allows people to access thousands of new data sets. One example comes in the area of car safety. Users can visit the website and view more than 20 years of data on crash worthiness and rollover safety gathering during car safety tests. People can download the information into a variety of database, shapefile, or mapping software packages. In order to assist other users, website visitors rate each dataset on overall usefulness, ease of access, and data utility. This helps other people determine which data resources are most helpful to users.

vital to improving mobile and broadband access. Right now, virtually every community has different rules and processes for cell tower construction and laying fiber optic lines. This makes it difficult for private businesses to expand digital infrastructure in a timely and affordable manner.

Having a 21st century infrastructure requires greater access to spectrum for wireless applications. *We need more spectrum for exclusive licensed usage, a spectrum rights system that allows for multiple, non-interfering uses, and cognitive radio applications that make more efficient use of existing spectrum.*[16] We should keep unlicensed spectrum to encourage next generation innovation. *Government agencies that have unused or underused spectrum should pay fees for holding unused spectrum*. Our workshop participant Michael Capellas, the Chairman of VCE, noted that "spectrum is licensed in silos, but not used. We have a treasure trove of unused capacity." Having fees for unused spectrum would provide clearer incentives for government agencies to use the spectrum under their control.

We need metrics that measure spectrum availability and allocation, the time involved in building cell towers, and Internet access and usage. This would help track progress over time and identify areas in need of greater attention.

Expanding Data Access, Sharing, and Analytics

Many public and private sector organizations are sitting on a gold mine of information. Through data resources, data mining, and data sharing networks created with other entities, these organizations have detailed material on consumer behavior, administrative data, student performance, hospital re-admission rates, Internet searches, or social media likes and dislikes, among other areas.

At Data.gov, for example, there is information on airport flight delay times, car safety ratings, crime statistics, small business loans, and business permits. People can download raw data, map information, or search for particular items of interest. *We need to expand federal data availability so that citizens and businesses have access to the latest and most relevant information*. This would improve data utilization for the public good and make it easier for people to access information.

Wise decisions are impossible without quality data, and *government can play a key role in creating good data by expanding standardization efforts*. These initiatives are most powerful when they are international in scope and have support from cross-national standards bodies, key regulators, and regulated industries. The same data that enables more effective and efficient decision-making have already been used to great success by industry. One successful example is the project for global Legal Entity Identifiers in the financial industry, promoted by the Financial Stability Board. This joint effort of global regulators, experts, and standards bodies argued strongly that better information management leads to better risk management and corporate governance.[17] This type of effort, and other attempts to apply the power of metadata and semantics to information objects, make government's job easier while actually reducing the burden on private firms.

In addition, data analytics have tremendous potential to transform public and private sector decision-making. By providing analysis of data in real-time, analytics speed up the feedback loop and enable administrators and policymakers to see what data patterns are emerging and what the trends are overtime. So-called "big data" make it possible to study different areas for insights regarding student performance, health care, energy efficiency, and public sector performance. Rather than rely on infrequent assessments, analysts can determine what is happening in real-time and what actions are associated with the most effective results.

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In the education area, for example, the development of computerized learning modules enables new forms of assessment. Data mining and data analytic software can provide immediate feedback to students and teachers about academic performance. Researchers can analyze underlying patterns to predict student dropout rates, at-risk students, or those capable of more demanding assignments. These approaches also can identify pedagogic approaches that are most effective with particular students.

As an indication of the possibilities in the education area, *schools in sixteen states already employ data mining techniques to identify at-risk students*.[18] Using prediction models based on truancy, disciplinary problems, changes in course performance, and overall grades, analysts have discovered that they can identify students who are likely to drop out. A number of school districts have been successful in developing "risk-factor scorecards" that show who is at-risk and in need of special assistance.[19]

Similar efficiencies can be gained in the health care area. Our workshop participant John Wilbanks, a Senior Fellow in Entrepreneurship with the Ewing Marion Kauffman Foundation, explained in the medical field that "information is available only to a small set of people and they can pervert the process. We need data autonomy and portability." Medical providers should build data sharing networks that enable assessment of comparative effectiveness. Right now, many health policy decisions are based on inadequate analysis or incomplete information. *Data analytics enable using information to improve medical decision-making*. There are ways to improve service delivery while simultaneously reducing costs.

Both education and health care are in need of new metrics that track the use and impact of data analytics. Once such

measures are developed, it will become easier for policymakers to employ these numbers to measure budget effects, impact on learning, and ramifications for health care quality, access, and affordability.

Protecting Digital Assets

The digital revolution has enabled advances in productivity in many areas. Unfortunately, the benefits to society have also introduced new risks which we are just beginning to understand.[20] How can we protect the systems and the processes of increased agility and innovation on which we have come to depend? The government is one of the most vulnerable segments of society, both in terms of the magnitude of the threat and the poor state of preparedness. Federal policy for securing our digital infrastructure is hamstrung by the fact that most of the digital assets and the resources to secure them are controlled by the private sector. This requires a careful strategy that balances a number of priorities. We need to ensure good security practices in government and the private sector.

The first thing the government can do is get its own house in order. One needed step is *to update and streamline the Federal Information Security Management Act*. FISMA requires federal agencies to secure their information systems, and was a law ahead of its time when it was enacted in 2002. Recognizing that security is a process, it allowed organizations to assess their own risks and develop plans to address these risks with guidance from the National Institute of Standards and Technology and the Department of Homeland Security. Agencies need more leeway to make rapid decisions to improve the security of their networks.

However, the security process has grown stagnant, and failed to keep up with both the technology and how it is used. Compliance with this law is expensive and does not offer real insights into the risks faced by civilian government networks. *Annual static assessments must give way to continuous monitoring, and experts in both the public and private sector should come together to establish baseline security controls, as well as mechanisms for gauging the effectiveness of these controls*.

One of the obstacles in securing government systems is the bureaucratic hurdle in using affordable and widely deployed commercial technology. As information technologies shift to a more virtualized infrastructure, the traditional approach of requirements-based acquisition is too slow and onerous, and therefore fails to address security risks.

To address these concerns, cloud computing and security experts from across the Federal government have collaborated to establish the Federal Risk and Authorization Management Program. The executive branch must *encourage public sector reliance upon FedRAMP*. While this process of vendor security testing and certification does not solve all the problems with shifting government computing to the cloud, it addresses one of the biggest challenges. The public sector has established standards and requirements for assessors, and begun the process of certifying and authorizing cloud providers. The largest benefits of the program require widespread buy-in across the government, as agencies take

advantage of products and architectures that have already been approved, without having to go through their own re-certification process. This has the potential to dramatically streamline and simplify acquisition, making government IT adaptation and evolution cheaper and easier.

Private actors own and control many of the systems and information infrastructure at risk. This makes fostering good information security practices and resilience particularly tricky for the government. Securing cyberspace requires balancing incentives for secure investment and transparency for accountability. One approach to this has been the state-based data breach notification laws. First passed by California in 2004, these laws dramatically increased the number of breaches that the public knew about, as well as presented tangible costs to those responsible for privacy incidents[21]. As a result, an entire industry has grown up around helping firms prevent, detect, and deal with data breaches. Unfortunately, by regulating at the state level, firms with a national customer base must comply with some 47 different state laws. We must *develop a national data breach law to coordinate policies among the 50 states*. It is important that this *law* maintain the goals of the original policy, which is to encourage firms to safeguard personal data, and provide public information about the state of data security.

We need public data about the risks to our competitive information even more than the personal data. Strong and growing anecdotal evidence tells us that the computer systems of American firms are regularly attacked, and strategic intellectual property and trade secrets are stolen by the terabyte. Yet with a few notable exceptions, we know very little about who is being attacked, how they are being victimized, and what has been stolen. This ignorance extends to the investors, who are left in the dark about long term strategic implications of these attacks on the companies they own.

We should *consider networks for sharing information or improve reporting requirements for publicly-traded companies that have been victims of cyber attacks*. New guidelines issued in October 2011 direct public companies to review "adequacy of their disclosure relating to cybersecurity risks and cyber incidents," but these non-binding guidelines are inadequate. Firms can report general declarations of vulnerability or discussions of a threat environment, without revealing and being held accountable for specific losses. While it is important not to interfere with law enforcement and forensic investigations, firms that do not face short-run costs from successful attacks are much less likely to invest adequate resources in preventing them. This is particularly important for the theft of strategic information, which can have a cumulative effect for the American innovation-based economy. If no one reports serious data theft, policy makers will lack the necessary information to understand the threat of cyberespionage and be in a position to respond accordingly, both domestically and internationally.

The challenges of building a set of cybersecurity strategies are manifold, but a key obstacle is the need to share information. Secrecy is important, but too much can be as bad as not enough. The importance of confidentiality spans from the public sector where it is hidden away as classified

to the private sector, where liability and antitrust present risks to sharing information. The government must *approach confidentiality of key cybersecurity data through a risk-based trust model, rather than riding on top of National Security classification systems*. It is important to protect investigations and not reveal too much to the adversaries we are investigating, but the current default has gone too far in the opposite direction. Government monitoring and defenses first discover a large percentage of attacks, breaches and security incidents. Federal agencies must expand their capacity to work with private companies under attack. An overemphasis on secrecy can further inhibit information sharing and disclosure that can drive accountability. Moreover, public analysis of data can guide the future of research, direct policy, and law enforcement efforts.

Many observers have stressed the importance of sharing information between private actors as well as between industry and the government. Sharing information allows collective action that can improve the odds for defenders. Firms argue that current laws punish companies for working together, exposing them to risks on the privacy, antitrust, and liability fronts. Yet proposals to grant blanket immunity for information sharing can go too far in the opposite direction, compromising privacy and removing incentives to prevent security incidents with blanket liability protections. *We must promote information sharing through context-specific organizations rather than blanket laws*. Different types of information sharing require different contexts, be it automated data sharing between computer systems or carefully vetted and redacted incident reports. Information sharing is an organizational and architectural problem.[22] The federal government can expand on efforts such as Infraguard and the Defense Industrial Base Collaborative Information Sharing Environment to foster trust and build flexible systems that enable multi-lateral information sharing.

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Throughout each of these initiatives, it is important to put the efforts to protect digital assets in perspective. Threats can range from file sharing to strategic data theft; addressing one in a unilateral fashion can endanger long term efforts to address the other.[23] Overzealous attempts to enforce security can endanger the entire digital ecosystem if it leads to overly broad systems of control that inhibit innovation. This applies to government policy that can drive up costs of developing new tools, as well as private technical and legal enforcement that can inhibit business model innovation and the creation of new works.

To examine the impact of these ideas, *we require metrics that measure information-sharing about cyber-security incidents*. Improved data would show the extent of the problem and shed light on possible remedies to improve security. We also should measure utilization of various FedRamp applications in order to see how the national government is implementing different efforts at security and certification.

Building an Educated and Innovative Workforce, and Reducing Bottlenecks in the Dissemination and Commercialization of Knowledge

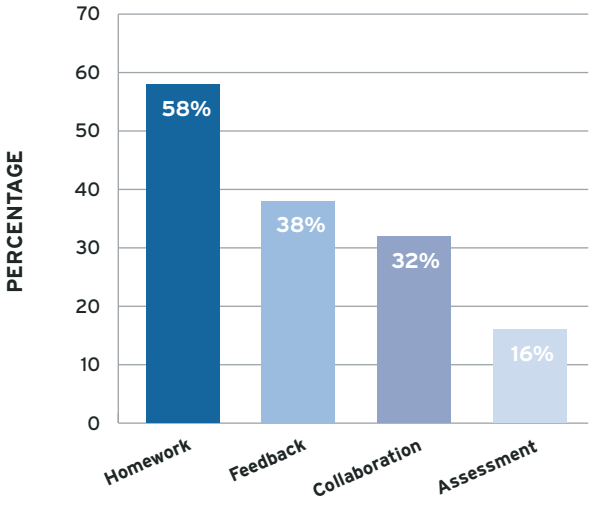
There are a number of challenges in our current system that constrain innovation and make it difficult to take full advantage of the digital revolution. We need to improve training for 21st century skills, increase the commercialization of knowledge, harmonize cross-border laws, and protect freedom of expression.

Improving Knowledge Transmission and Training Students for 21st Century Skills

Digital technology enables new forms of educational instruction through improvements in engagement, interest, personalization, collaboration, and interactivity. Online learning can engage young people, personalize learning, improve learning for non-traditional students, facilitate social networking and collaboration, and provide new platforms for learning through interactive processes.[24] Our participant Gordon Freedman, the President of the National Laboratory for Education Transformation, said that "we still are reliant on an institution to pass out a credential to hire someone."

Yet despite the obvious opportunity for revitalizing education, there remain numerous barriers to the fulfillment of these objectives. Many schools remain structured around a schedule based on a 19th century agrarian society and a 20th century industrial model,

FIGURE 5:
Teacher Use of Digital Technology in Classes



Currently, there is little use of digital resources in American schools. Only five percent of American school textbooks today are digital. This means most textbooks are out-of-date as soon as they are published.

and do not address the needs of a 21st century information-based economy. Educational institutions are overly bureaucratic and too hierarchical, and poorly equipped to train students for newly emerging jobs. Often times, they do not engage students' interests or make the education process very relevant.

One issue facing contemporary schools is that they are labor intensive operations. For most elementary and secondary school districts as well as institutions of higher education, employee salaries and benefits comprise more than half of the annual school budget. Some districts report that salaries and benefits total more than 70 percent of their overall budgets.

High personnel costs limit technology innovation because as long as schools continue with the current business model, it will be difficult to find funds to support digital initiatives. With a large proportion of school budgets going to personnel, there are few funds to support digital learning resources, digital textbooks, distance education, personalized learning, social media applications, mobile learning, or real-time assessment of students or teachers. We must balance the financial needs of schools with the desire to invest more in new digital technologies.

One of the most pressing priorities is for *school districts to speed the movement from paper to digital textbooks in order to increase efficiency and keep teaching materials up-to-date*. The United States currently spends $7 billion a year on paper-based textbooks. These books are obsolete by the time they are published and lack interactive electronic and multi-media links that allow students to search for additional information.[25]

Currently, there is little use of digital resources in American schools. *Only five percent of American school textbooks today are digital*.[26] This means most textbooks are out-of-date and do not link to the Web or online resources. In addition, **Figure 5** shows that teachers make limited use of existing technology. For example, only 58 percent of teachers say they use digital technology for homework, 38 percent say they use it for student feedback, 32 percent rely on it for collaboration, and only 16 percent use it for student assessment.[27] These low numbers reduce the benefits of the technology revolution in the education area.

In an era of limited resources, educators must figure out how to do more with fewer financial resources. One action that would improve school efficiency and financing is to *have educational resources developed with taxpayer dollars be licensed under a creative commons license that would improve accessibility to instructional materials*. Budget circumstances require schools to get more efficient, boost productivity, and make do with fewer financial resources. While this poses obvious problems for school districts, it also creates the possibility of making changes in business operations that are innovative and transformational.

Several policy changes are required in order to encourage the adoption of personalized learning approaches. *Many secondary schools use the "Carnegie Unit" and colleges use the "Student Hour" to monitor student progress*. Early

CASE STUDY

The Open Learning Initiative (OLI) represents a successful example of open course content for distance education. Developed at Carnegie Mellon University in 2002, the initiative features web-based courses with open source educational resources available to a consortium of colleges. Subjects offered include statistics, French, economics, biology, physics and visual communications design, among other topics.

Students can take courses for free from instructors at Carnegie Mellon. Professors use OLI web resources to supplement their own instructional materials. Each course is team-developed and based on ongoing data analysis regarding what works and how students and faculty respond. A salon-style social network allows users to pose questions, compare notes, and learn from one another.

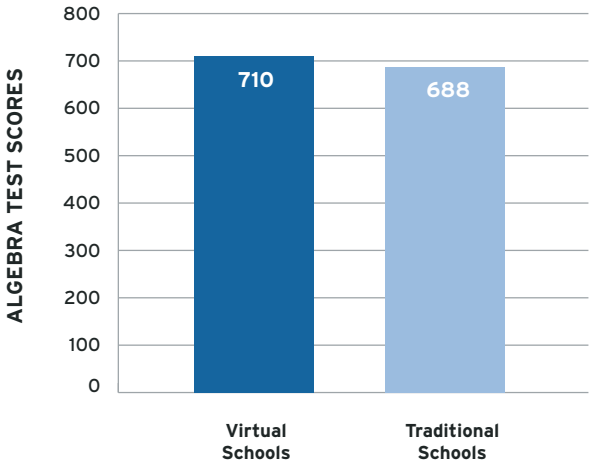
Research on the OLI statistics course has found positive impacts in regard to student learning. Integrating web-based materials into traditional classes speeds up concept mastery. A 2008 analysis of OLI undertaken by Marsha Lovett, Oded Meyer, and Candace Thille for the *Journal of Interactive Media in Education* compared students in traditional, stand-alone courses with those completed exclusively on the web, but found no significant differences. However, in a hybrid model integrating traditional and web content, "students learned a full semester's worth of material in half as much time and performed as well or better than students learning from traditional instruction over a full semester."

in the 20th century, educators adopted these "time-based" approaches that mandated students must have at least 120 hours of classroom time over the course of a year to master particular subjects. In addition, four years was specified as the appropriate length of high school and bachelor's degrees in college. Most American schools continue to employ this framework to structure the curriculum and daily classroom schedule.

The problem with time-based approaches is that they equate time spent with subject area knowledge. They assume that if students have enough face-time with instructors on a particular topic, most of them will meet minimum performance standards at the end of the course. However, this logic is flawed at both ends of the education spectrum. There are some students who need more time to master specific subjects and there are others who can learn the material in a shorter period of time.

We need a "mastery-based" approach that works better than one based on time. Right now, education funding is determined by the "average daily attendance." This means that schools that incorporate online learning or have students who can master material in less time than required by seat-time measures, are penalized financially for these innovations. They

FIGURE 6:
Online Course Achievement



Students who demonstrate mastery of educational materials are allowed to advance in virtual instruction based on their interest and ability. For some subjects, student performance has been higher than through conventional classes.

end up with fewer budgetary resources even though their systems may make more efficient use of education dollars. In general, according to our forum participant David Friedman, a law professor at Santa Clara University, "we need to move to a model based on ability, not credentials."

States such as Louisiana have ended the seat-time requirement in favor of distance learning. Students who demonstrate mastery of educational materials are allowed to advance in virtual instruction based on their interest and ability. For some subjects, student performance has been higher than through conventional classes. **Figure 6** reveals that in algebra courses, students in Louisiana virtual schools earned test scores of 710, compared to 688 for those attending traditional schools, controlling for relevant factors.[28] This led state officials to argue that *every student should have access to an online course and be able to make decisions on taking those courses with a certified instructor based on their own needs.*

In addition, *accreditation agencies should provide schools and universities with more flexibility in use of classroom time*. Students can be promoted when they learn a subject as opposed to when they have sat a minimum number of hours in a seat. Such a system would need more flexible teacher roles, better financing of classroom technology, and regular evaluation and assessment so school officials know what works. Personalization makes sense only if there is documented evidence that students are learning the subject matter and making progress in various areas.

We need to train students for 21st century job skills. In some cases, this means instruction for the jobs of tomorrow which may not even exist today. We should encourage instruction in data analytics, data visualization, mapping, video game design, computer science, programming, math, engineering, artificial intelligence, and machine-to-machine communications since these are in short supply currently and likely to be vital for the future. Robotics and additive manufacturing technologies are now affordable enough to be available in many districts. They represent an engaging, hands-on learning experience for students in a variety of age ranges. *Many states forbid the meeting of science and math requirements through computer science classes* even though programming skills are desperately needed in many different industries.

We also need to increase the number of students graduating with advanced degrees in science, technology, engineering, and math. *We should provide merit pay and bonuses for secondary school STEM teachers* in order to reward excellence and attract more people, including women and minorities, into STEM fields. Of course, it is important to recognize that schools also need to attract quality teachers in music, the arts, social sciences, and foreign languages.

We should encourage instruction in data analytics, data visualization, mapping, video game design, computer science, programming, math, engineering, artificial intelligence, and machine-to-machine communications since these are in short supply currently and likely to be vital for the future.

CASE STUDY

Professor Henry Jenkins of the Massachusetts Institute of Technology and his colleagues argue that students require new learning skills in the 21st century. They include:

- **PLAY:** "the capacity to experiment with one's surroundings as a form of problem-solving,"
- **PERFORMANCE:** "the ability to adopt alternative identities for the purpose of improvisation and discovery,"
- **SIMULATION:** "the ability to interpret and construct dynamic models of real-world processes,"
- **APPROPRIATION:** "the ability to meaningfully sample and remix media content,"
- **MULTITASKING:** "the ability to scan one's environment and shift focus as needed to salient details,"
- **DISTRIBUTED COGNITION:** "the ability to interact meaningfully with tools that expand mental capacities,"
- **COLLECTIVE INTELLIGENCE:** "the ability to pool knowledge and compare notes with others toward a common goal,"
- **JUDGMENT:** "the ability to evaluate the reliability and credibility of different information sources,"
- **TRANSMEDIA NAVIGATION:** "the ability to follow the flow of stories and information across multiple modalities,"
- **NETWORKING:** "the ability to search for, synthesize, and disseminate information," and
- **NEGOTIATION:** "the ability to travel across diverse communities, discerning and respecting multiple perspectives, and grasping and following alternative norms."[29]

Throughout each of these initiatives, *we should have metrics assessing education innovation implementation and impact*. We should determine how fast we are transitioning from paper to digital textbooks, usage of creative commons licenses, and changes in education policy and accreditation that encourage more innovative approaches to learning and achievement.

Increasing Commercialization and Technology Transfer

One of the most important policy questions about innovation is how the nation can extract the maximum social benefit from its investments in research and development. The absolute level of R&D investments in the U.S. is by far the largest among all industrialized nations,[30] exceeding $402 billion. Private industry remains the major funder of research and development, contributing to 62 percent of the national total. The public sector is the second major investor in R&D contributing about 31 percent of the total. The commitment of government is even higher when looking only at research; in fact, 53 percent of the $40 billion invested in basic science is funded with tax-dollars.[31]

This picture reveals a double objective for government. First, *the government must create the environment where private and public investments in innovation are translated into productivity gains, jobs, and economic activity.* Second, public R&D investments must be made in the public interest so that they improve public health, strengthen national security, and raise standards of living across all socioeconomic strata. In most circumstances, these two goals are one and the same. Still, they could sometimes be at odds and, when this happens, the challenge for government is to align them.[32]

Commercialization and dissemination of publicly funded research are two domains where fostering innovation in the interest of the two government objectives—promoting economic activity and advancing the public interest—may come into conflict. The protection of intellectual property (patents and copyrights) introduces the profit incentive to inventive activity; but this is a rather ineffective incentive if the innovator does not or cannot pursue profit. That is precisely the case of public R&D because the general expectation is that new knowledge created with taxpayers' money be made available to taxpayers at minimum cost. If new knowledge is inexpensively disseminated, profit-seeking enterprises will not seek its commercialization.

The expectation of a wide dissemination of public research has inspired a bill that is currently being considered in Congress. *We should support the Federal Research Public Access Act (HR4004, S2096) that mandates public dissemination of federally funded research within six months of publication* (for agencies with extramural funding exceeding $100 million). The bill proposes an exclusion of classified research, books from which authors receive a royalty, and patentable discoveries. If some accommodation can be made to compensate for revenue lost by for-profit publishers of academic journals, we believe that this bill is consistent with the goal of pursuing widespread dissemination of the knowledge funded with public monies.

With respect to commercialization, the regime is governed by the Bayh-Dole Act of 1980 whereby the government allowed research contractors to take title to discoveries made with federal grants. This policy effectively converts a public good into a private one by assigning ownership.[33] Bayh-Dole has made it simple for universities to patent (a few have even profited handsomely from licensing their patents) and, in this way, has contributed to streamlining the translation of research into new products. It is less clear, however, whether this act has always been effective in directing public research towards public interest.

An example of this ambiguity can be appreciated in the evolution of innovation and costs of healthcare. The revolutionary advances in biomedicine, largely derived from publicly funded science, have given new hope to patients suffering from medical conditions that not long ago eluded early-diagnosis and effective treatment. But hope does not

mean that more patients can access or afford the latest technologies of medical care or even afford older ones. In fact, the costs of healthcare and health insurance are rising much faster than the prices of general consumption, excluding an ever-large size of the population from healthcare.[34] Coordination among insurance companies and healthcare providers and asymmetries of information inherent to the provision of care are largely responsible for inflation in this sector. But innovation could play a significant balancing role. As a new generation of treatments enters the market, the older cohort should become less expensive. But there is no evidence that new discoveries are playing that role. Rather, it is quite possible that *one unforeseen consequence of Bayh-Dole allows for modes of commercialization that have an inflationary effect on the whole healthcare system, not just new products.*

The reason why this is plausible is that established pharmaceutical companies can outbid smaller firms seeking to license a promising university patent. New companies will not rise to replace old established ones, and any new technological platform in biomedicine will not produce the creative destruction that injects markets with dynamism. The result is that the global pharmaceutical industry can set prices for final products, above what otherwise would be competitive prices. Innovation ends up strengthening the power of established companies, and in this way, innovation becomes complicit in keeping healthcare prices on the rise. It should be added that in a free market economy, firms are allowed to use their own resources to gain market power—in this case, it would be research paid by the pharmaceutical companies themselves—but much of biomedical innovation is coming out of research done with public funds. If tax dollars fund an important part of biomedical innovation, it is not altogether unreasonable for the government to exercise some degree of control over pricing excesses. Yet, no such measures are currently in effect.

Looking into policy changes for the immediate future, it is important to build upon the successes of Bayh-Dole in fostering the translation of publicly funded research into economic activity. Nevertheless, to achieve the second objective of directing public research investments into the public interest, *Congress should amend Bayh-Dole to promote the formation of competitive as opposed to monopolistic markets*. A step in that direction is for the letter of the law to explicitly encourage the use of non-exclusive licenses. Without banning the use of exclusive licenses, *an explicit government preference for non-exclusive licenses would increase the power of federal agencies to promote wider use of patents*, regulate monopolistic practices with the products that result from them, and shift the weight-of-proof from the bureaucracy to the licensees to justify an exclusive patent.[35]

Some changes could be made by Executive Order. Federal laboratories make a significant contribution to research-based innovation and could be directed to initiate "responsible licensing programs" modeled after similar programs tested at universities.[36] These programs structure licensing contracts in creative manners, for instance, assigning exclusive licenses within specified jurisdictions, out of which non-exclusive licenses are allowed (e.g. an exclusive license could apply for OECD countries, while companies in developing countries can have it on a non-exclusive basis). *A licensing contract may also have a conditional exclusivity clause, where exclusivity expires if the licensee company does not commercialize the product in a manner consistent with wide dissemination of the patented product and certain agreed upon uses.*

Agencies can also play a role fostering competitive modes of innovation. *Federal agencies may in various forms introduce incentives for the formation of patent pools, by increasing the scoring of a grant proposal that lays out a plan for patented discoveries to be part of an existing patent pool, or*

require from all grantees of specified grant-purses to agree to patent discoveries and assign them to a patent pool. The joint ownership of a patent portfolio should address several concerns with the current regime. First, legal analysts have feared that patenting research tools may reduce the collective ability to innovate as scientists make regular use of tools developed by their peers. Second, licensing contracts must be negotiated in the best interest of all the pool's partners, increasing the likelihood that patents will be used to create competitive markets of innovation rather than strengthening monopolies.

Schools need better metrics for measuring commercialization and technology transfer. Right now, *there is too much focus on numbers of patents and startups without determining which products make it to the marketplace and what type of social and economic impact they have*. We would be in a stronger position to address innovation roadblocks if we had more complete data on commercialization.

Harmonizing Cross-Border Laws and Freedom of Expression

The lack of legal uniformity across national borders creates problems for innovation policy. Many countries have different laws on cloud computing, privacy, data retention, security processes, and personnel training. It is hard to get the full benefits of an innovation economy when rules are inconsistent or contradictory. Sometimes, countries require data disclosure even if the cloud data center is not located within their national boundaries.[37]

Rules on cross-border transactions should be harmonized in order to facilitate innovation and get the greatest economies of scale from new technology. We need international agreements harmonizing national rules so that the current "Tower of Babel" doesn't undermine fiscal efficiencies or utilization of digital platforms. A World Economic Forum study ranked collaboration with other governments to reduce the complexity of compliance requirements as the most important priority.[38] Leaders in a number of different countries see cross-border differences as problematic and in need of resolution.

We should discourage U.S. government units from requiring that cloud data be stored within their own geographic boundaries or other nations from imposing those requirements. This undermines the benefits of cloud computing and imposes unnecessary constraints on cross-border information flows and trade agreements. Having to maintain data storage facilities in particular countries encourages digital protectionism and harms international trade.

Right now, there is too much focus on numbers of patents and startups without determining which products make it to the marketplace and what type of social and economic impact they have.

Countries and private companies should encourage freedom of expression in the digital world. Censorship or blocking sites discourages the free flow of data, goods, and services across counties. If public or private sector organizations make requests to remove Internet content or censor usage, Internet service providers should publicize this situation by listing such requests on their websites. This will let consumers know about these types of requests and hopefully deter authorities from engaging in this kind of behavior.

We should compile information on data storage rules across national boundaries, how trade agreements further or restrict innovation, and the manner in which various countries deal with digital freedom of expression issues. By having more complete metrics and data analytics, we would be in a stronger position to address roadblocks and encourage innovation around the world.

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NOTE

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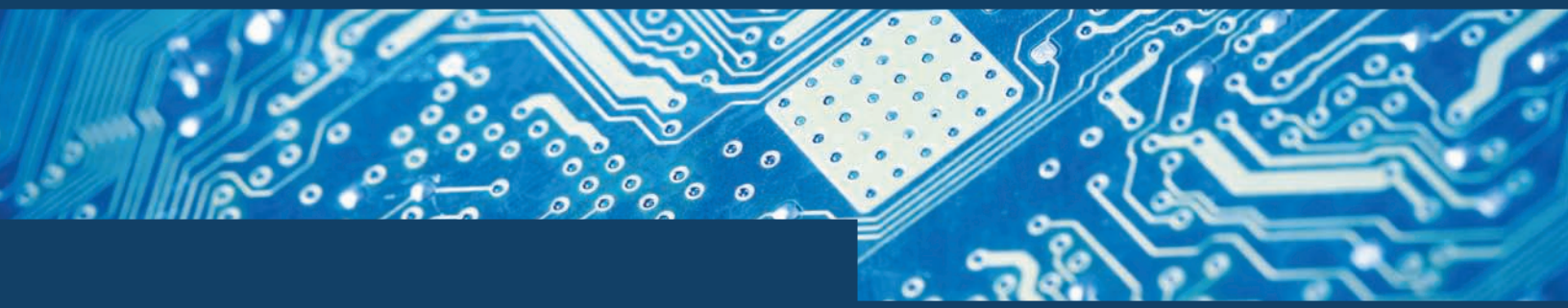

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