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The Disruption Myth and Gaps in the Innovation Ecosystem

The term "disruption" is used broadly to characterize the pattern of technological innovation that unsettles industries and displaces earlier technologies to create new markets and value networks. The Government-University-Industry Research Roundtable held a meeting on October 20-21, 2015 that explored what drives disruptive innovation and disruptive innovators today, how patterns of disruption and business dynamism are changing in a modern world, and how disruption can inform national science and technology policy in the present and the future.

The keynote presentation was given by Richard N. Foster, who spoke about disruption and economic progress. "We can learn a lot from history," said Foster, who cited historian Ibn Khaldun, a forerunner of original theories in social sciences and philosophy of history, and artist Thomas Cole, whose paintings depict the cyclical nature of civilizations forming, peaking, and decaying. "These theories of the cycles of history are the grandparents of the current notions of disruptive innovation."

Foster noted that B.C. Forbes, who founded Forbes in 1917, published a first-of-its-kind list of the largest, most powerful 100 companies in the United States as a means of attracting attention to his magazine. Seventy years later his grandson Malcolm decided to investigate how many of the original 100 companies on the list still existed and found that 61 of them had dissolved. Most of them had not gone bankrupt, but had been acquired by other companies. "That is an important message," Foster said. "Companies don't disappear because they go bankrupt. They disappear because they get weaker relative to other companies operating at the same time."

One question Malcolm did not ask was how many of the surviving 39 companies were still in the top 100. "The answer was only 18," said Foster. In a period of 70 years, 82 of the top 100 companies dropped off the list. The 18 that remained on the list endured 2 world wars, a major depression, and various bouts of regulation and deregulation, and they still survived. But those 18 companies underperformed the market by about 50 percent, and 8 of the 18 have disappeared since the 2000s.

Foster continued, "The speed of the economy has accelerated. In the 1920s and 1930s, companies that made it into the S&P 500 stayed there for about 65 years. Now a company that makes it on the list can expect to stay on it for about 15 years. I believe that in 15 years 75 percent of the S&P 500 will be companies whose names we don't know today because they do not exist yet."

"This is visible on an international basis as well," he continued, citing an index called the Global 1200 that includes the largest companies in the world. Each company has a country associated with it. The country with the greatest increase in the number of private companies was Australia, said Foster, with 20 companies joining this list between 2001 and 2010. "They were mining companies, and they sent what they mined to China. By about 2011, China figured out how to mine its own resources and stopped buying from Australia. Since then, Australia has had five prime ministers. These become matters not only of economics and technological change, but of national leadership and of foreign policy and military action." The impact of disruptive innovation on the global economy remains highly significant.

THE DISRUPTION MYTH: CONTEXTUALIZING THE DEBATE

The first panel offered remarks to contextualize the debate over disruption and its impact on policy and the economy. The moderator of the session, **Len Polizzotto**, partner at the Practice of Innovation, opened the session by raising the question of whether innovation needs to be disruptive to be successful. "We are in an era of continuous innovation," he said. "Moore's Law—originally, the idea that computing speed will double every 2 years—applies in many areas. Exponential growth is happening in areas ranging from drug development to entertainment."

Polizzotto defined innovation as the creation and delivery of new customer value in the marketplace with a sustainable business model. "Value creation happens in the iterations between the research and development and customer needs. Companies that focus on shareholder value often go out of business. In contrast, companies that focus on customer value generally have the highest shareholder value. Innovation is both a discipline and a practice."

According to Polizzotto, five things are necessary to enable innovation: a focus on important customer market needs, a disciplined process, a leader to champion the idea, a dedicated team, and a supportive organization.

Judy Shapiro, founder and CEO of Engage Simply, explored disruption in the field of marketing and questioned the absolute, positive acceptance of disruptive innovation. "The word 'innovation' didn't always have the positive connotation it does today," she noted. "It was approached with a bit of skepticism, as something that needed thoughtful consideration. In 1962, Thomas Kuhn wrote *The Structure of Scientific Revolutions*, in which he asked, 'How do you evolve the scientific methodology to make sure that it is, in fact, based on the scientific method? How do you ensure that quackery doesn't creep in?' He was concerned with how one takes a paradigm—a known body of knowledge—and transforms it."

Shapiro said that she was startled by the application of Kuhn's paradigm shift idea to the theory proposed in Harvard Business School Professor Clayton Christensen's book, *The Innovator's Dilemma*, which many consider to be the foundational writing on disruptive innovation (by that term). "Christensen took the paradigm shift idea from Kuhn, interpreted it for a vague business application, and then foisted it on the business world," said Shapiro. "The idea was not critically assessed. Unlike Kuhn, nobody questioned how to take the concept and make it truly productive from a methodology point of view."

According to Shapiro, in the late 1990s, the disruption myth began to take on a life-or-death energy, giving people a sense that the fate of entire companies depended on employees' ability to out-innovate. "That's not a great way to create value for customers, to inspire workers, or to truly benefit the planet," said Shapiro. "Disruptive innovation was supposed to bring in new ideas, but 15 years on, it has calcified into a monolithic, non-open system." Shapiro argued that because of the prevalent adoption of disruptive innovation as a business philosophy, technology now largely serves business interests first and people second. She concluded, "Innovation should serve progress; it simply cannot be that it is new for the sake of being new."

The next presentation was offered by **Carl Schramm** of Syracuse University. Schramm explained, "Startups are an extraordinarily important indicator of where our economy is going. Historically, there is a link between the number of new businesses and what GDP will be in 10 years. If one counts the number of new businesses started in a given year and estimates the number that will make it to a billion dollars in sales, one can forecast the size of the GDP in 10 years."

Schramm continued, "Until about 6 years ago we had steadily seen roughly 700,000 startups a year for the last 20 years. Since the dip about 6 years ago, we've been producing fewer than 500,000 start-ups a year. Innovation is falling off in the United States." He identified four factors as potential contributors to the deceleration, including sluggish public sector spending, over-regulation of small businesses, insufficient methods of assessing the productivity of research funding, and a decline in the accessibility of liberal arts education.

CHARACTERIZING DISRUPTIVE INNOVATION: MEETING THE "DISRUPTORS"

The next panel featured remarks by five "disruptors" in various fields. The first presentation was offered by Bruce Willner of Graphene Frontiers. The company's central technology is intended to revolutionize medical diagnostics by transforming lab-scale processes to chip-scale processes with unprecedented speed and sensitivity, he explained.

"Today, if you need to get a blood test, your medical provider will draw several vials of blood and send it off to a lab, and you'll get the results back in a few days to a week," said Willner. "It is a long, slow, inconvenient process, and for a number of time-critical applications—in emergency rooms or operating rooms or in tests for diseases like meningitis—it's completely unacceptable.

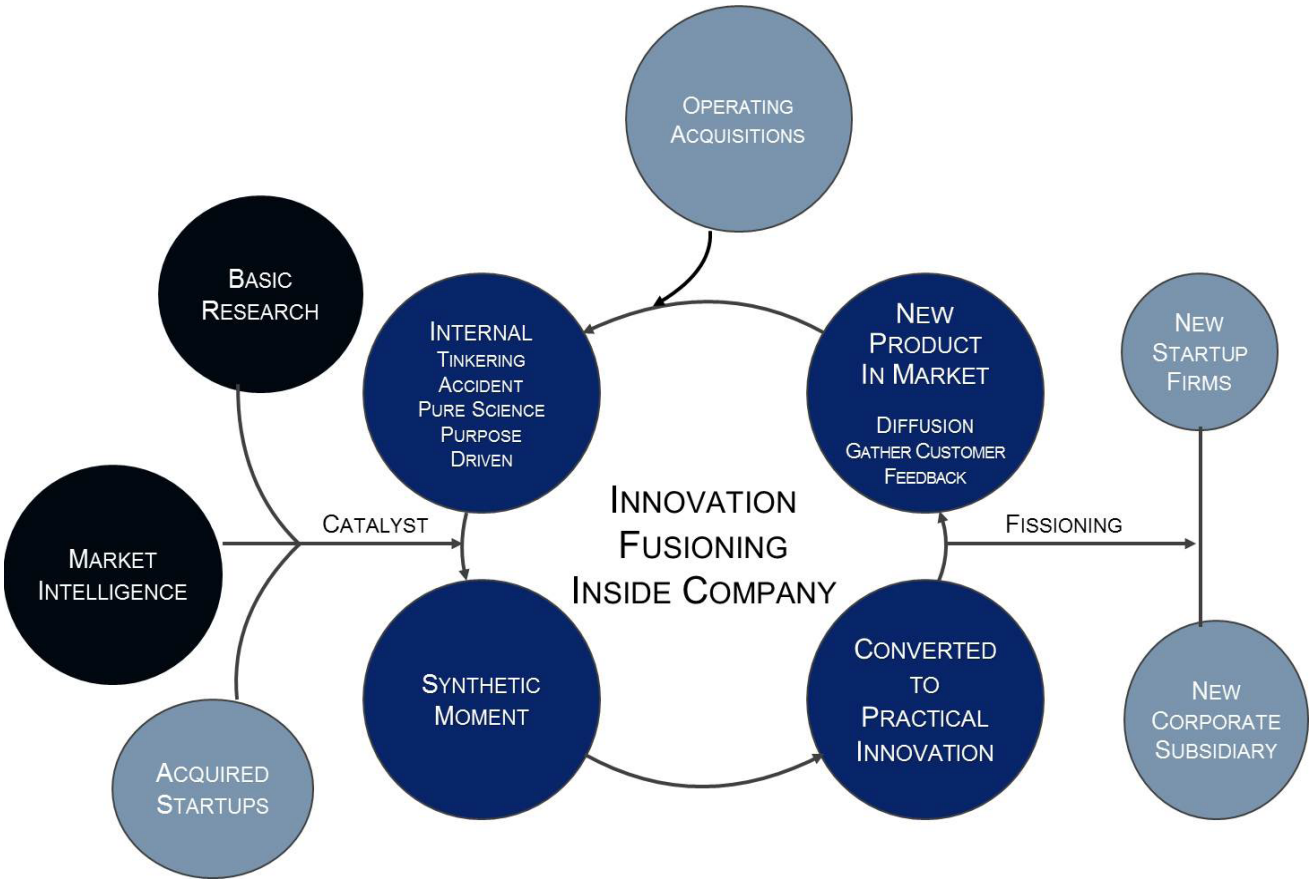

Figure 1 Corporate Innovation Fusion Cycle.
Source: Carl Schramm

Instead, imagine a test that requires only a pinprick and one drop of blood and can deliver the results in 5 or 10 minutes, while you wait—an approach called point-of-care diagnostics."

Tests such as these are being developed by Graphene Frontiers, and Willner suggested the technology will change medical treatment by providing rapid feedback. "Right now, it's challenging for emergency rooms to determine whether someone having chest pains is having a heart attack. If doctors can start treatment within an hour of a heart attack, there are much higher success rates and less long-term damage." Graphene Frontiers' biosensor technology has both life-saving and cost-saving applications.

When the company spun out of the University of Pennsylvania's physics lab, its original goal was to produce graphene films at large scale and size—making lots of the material and assuming people would want it. But the company discovered that it needed to integrate the technology into an end product that people would want to use. "That is a challenge with technology coming out of R&D labs," said Willner. Scientific research is discovering and developing new materials and technologies, but it tends to be a solution looking for a problem to solve. "Our plan is to go to market and disrupt," said Willner. Among the challenges the company faces is that medical diagnostics is a large, well-established industry, and the health care industry does not like to change. In addition, the approval path is slow and expensive, and it needs to be repeated for each individual test the company wishes to introduce to the market. Graphene Frontiers intends to partner with existing diagnostic companies to make it into the market.

The next presentation was offered by **George Siemens** of the LINK Research Lab at the University of Texas at Arlington, who spoke about disruptive innovation in education. "We've had a dismantling of the power structure that underpins much of traditional education," said Siemens. "Students now have control and influence—they can go directly to sources and fact-check what their professors say—though without necessarily having the skills to manage that environment or those content sources well.

Even without central control, we still want the ability to nudge learners in that environment, in order to help them navigate and to direct them to particular outcomes."

Siemens ran the first MOOC—massive open online course—at the University of Manitoba in 2008, with 25 students in the class and 2,300 people joining the course online. "MOOCs have provided a supply-side answer to a decades-long demand-side increase in learning needs," said Siemens. In 2011 a group at Stanford ran their own MOOC with many more people, and this spawned a series of startups. Millions of students have been or are currently enrolled in a MOOC, and the new openness of learning offered by these alternative courses is affecting how universities function and make decisions.

Another area of interest for Siemens is learning analytics. The intent of learning analytics is using data that learners generate through the process of engagement with one another and with content in order to optimize and improve the learning experience.

Most universities are aware of the data they possess; however, none has effectively used the data to achieve organizational transformation, where they function differently as a university and begin to engage differently in the competitive market. "A university president should be able to readily see the names of students at risk of dropping out in the next 24 hours," said Siemens. "The data exists, but we haven't had the proper kind of integrating or visioning."

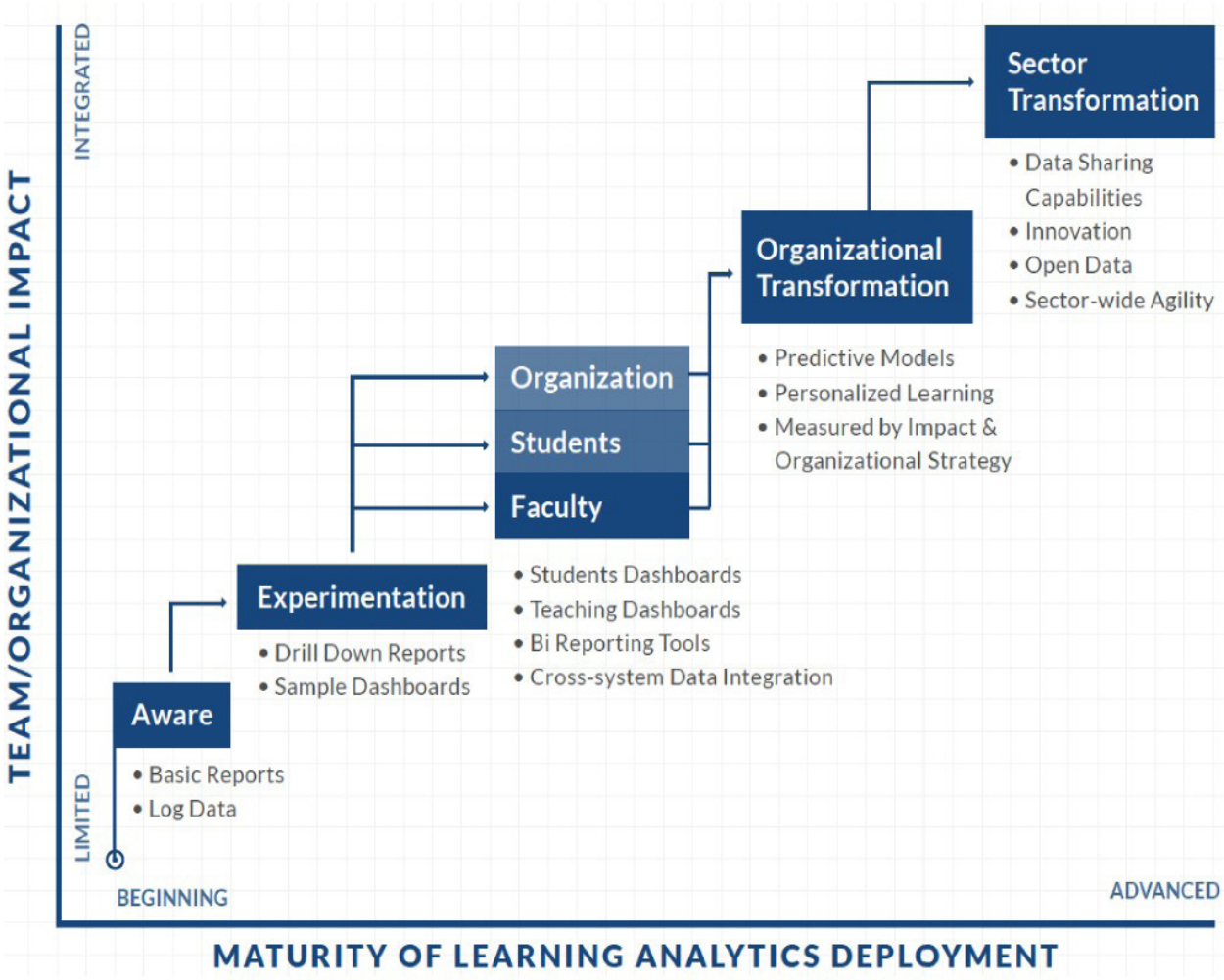

Figure 2 Maturity of Learning Analytics Deployment
Source: George Siemens

The next presentation was given by **Emil King** of the District of Columbia Department of Energy and the Environment, who spoke about disruptive innovation in alternative energy at the local government level.

Seeking to improve D.C.'s competitiveness, city leaders have developed the Sustainable D.C. plan to make D.C. the healthiest, greenest, and most livable city in the nation within one generation—about 20 years. "That is obviously a big challenge, but we think it's achievable," said King. The Sustainable D.C. goals include cutting citywide energy use by 50 percent by 2032, supplying 50 percent of the city's power demands with renewable energy in the same time frame, and reducing the city's greenhouse gas emissions by 50 percent.

"In terms of green policies, much of the innovation in D.C. has been driven by legislation," said King. The Green Building Act, which instituted codes, fines, and regulations, was the beginning of the green building industry in D.C. at a large scale.

Another initiative is the Living Building Challenge—a program that seeks to localize buildings to the extent that they can adapt to the climate at the site and operate pollution free, harvesting all of their own energy and water onsite.

"Currently, the use of solar energy in the city is mainly concentrated in the Capitol Hill area and the northwestern part of the city around Rock Creek Park," said King. One of the most challenging aspects of the development of renewable energy in the city is maintaining equitable development in wealthy and economically depressed neighborhoods, so that all citizens can appreciate the benefits of this kind of disruptive innovation.

Thomas Reed, founder and chief science officer at Intrexon Corporation, offered the next presentation. Reed started Intrexon in 1998 as a graduate student at the University of Cincinnati, during the time the human genome was being sequenced.

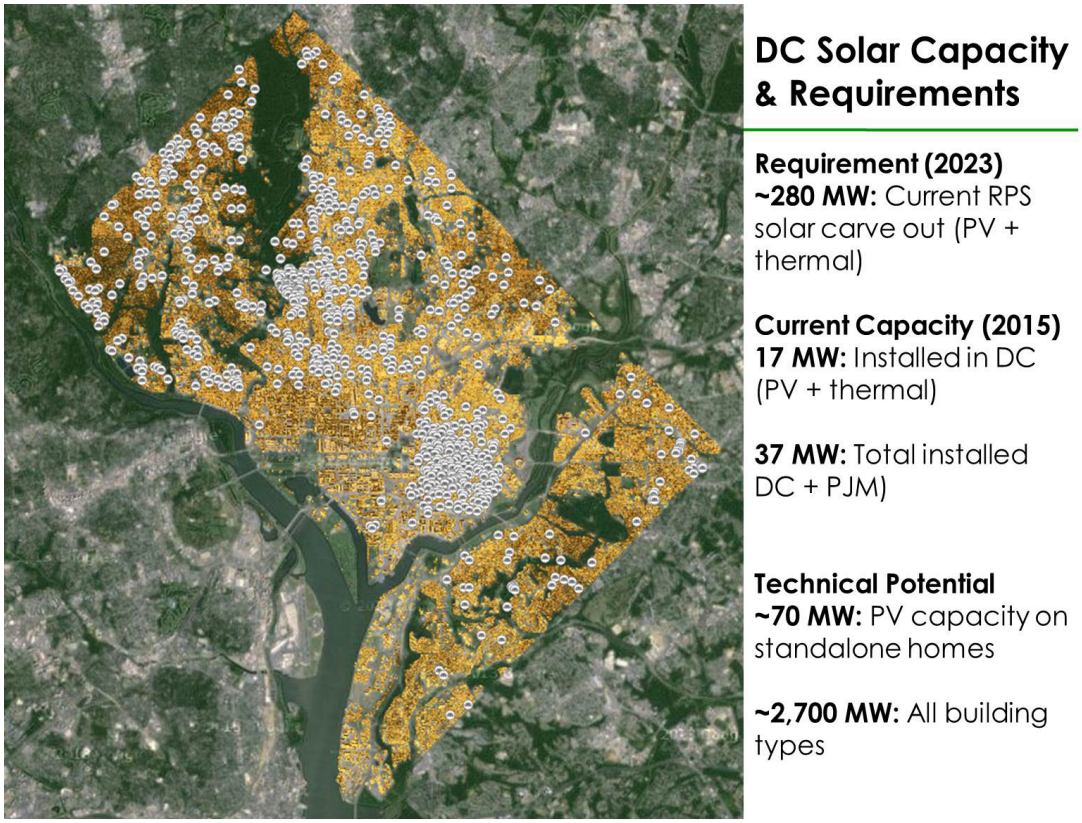

Figure 3 DC Solar Capacity and Requirements Under Current Renewable Portfolio Standard (RPS). Source: Emil King

When he saw how many DNA molecules he had to make to test function in cells and then in animals, only to discover frequently that his hypotheses were incorrect, Reed figured there might be value in making DNA to sell to the world. His goal when he began the company was to equip and empower the scientists funded by the National Institutes of Health to understand the human body and how it operates to develop therapies.

Reed sought venture capital funds, but the crash of the tech sector in 2001 left all of the VC firms bunkered down. However, economic development groups still had money. For a $1 million investment, Reed moved his company to Blacksburg, Virginia, where he was discovered by a serial biotech entrepreneur nearby. The UltraVector® platform, a foundation of the company, is a modular, object-oriented DNA design and fabrication system that is built on a robust relational database.

"Intrexon was built upon the concept of locus-specific, multi-genic control systems," said Reed. "We wanted to have multiple gene programs linked together, and we wanted to be able to control their function and move them to a very precise position in the genome." One aspect of the company's business model is the acquisition of technology platforms that allow Intrexon to broaden the capabilities offered to its collaborators and expand its reach across multiple markets.

In his presentation, **Col. Daniel Wattendorf** of the Defense Advanced Research Projects Agency (DARPA) emphasized that the government-university-industry interface has been critical to DARPA's success in achieving important capabilities for defense and society, especially in its disruptive biotech research. He described some of DARPA's work to develop more effective vaccines and new immunoprophylaxis strategies. As an example, billions of dollars are spent on flu vaccinations every year. But the time it takes to develop, produce, and distribute seasonal flu vaccines, and the time it takes the body to develop protective immunity, limits the effectiveness of this strategy. Additionally, current flu vaccines only work 40 to 60 percent of the time. DARPA has been working with universities and biotechnology companies to look at new ways to improve protection by speeding up the development and production timeline, as well as novel delivery methods to enhance immunity.

The platform approach, described by Wattendorf, involves rapidly identifying protective antibodies from an emerging strain of flu or any infectious disease. Once potent antibodies are found, their genetic sequences are deciphered to enable delivery of the blueprint to create these antibodies. "We could then give people a single injection with the genetic code for their bodies to make the protective antibodies—we could intervene many months earlier than we can now and deliver almost immediate immunity," said Wattendorf. "We're experimenting with this in mice, but it's not ready for use in people yet."

He also described another project that highlights the interface between government, universities, and industry. DARPA is working on genetically engineering blood—creating high-value blood by putting proteins of interest in it—and testing this in mice, in conjunction with MIT and biotech and pharmaceutical companies. The engineered blood cells function the same as the mice's own blood cells; they live as long, and they do not cause an immune reaction. With drops of blood, the researchers protected the mice against varying doses of a neurotoxin. "There may be a future when you can be injected with a small amount of engineered red blood cells that will circulate among your own blood cells, protecting you from infectious diseases or toxins," said Wattendorf. "The only way DARPA has been able to do these projects is to create interfaces with academia and industry," he emphasized.

INNOVATING IN DISRUPTION-RESISTANT "LEGACY" SECTORS

Bill Bonvillian of Massachusetts Institute of Technology's Washington, D.C. office spoke about innovating in disruption-resistant legacy sectors—sectors of the economy that are defended by traditional, long-standing technological, economic, social, cultural or legal paradigms. "The United States is pretty good at doing the next big thing, and it has tended to lead the bulk of innovation waves in the last 75 years. We like standing up technologies in new frontier areas; but we 'go west' and leave our legacy neighborhoods behind. So we'll lead a revolution in biotechnology; we won't bother to go back and fix the health care delivery system. Yet there would be huge gains in terms of public goods if we could figure out how better to innovate in these legacy sectors," Bonvillian said. "We need to have researchers in innovation and science and technology policy pay more attention to these legacy sectors that resist disruptive innovation."

Bonvillian explained, "Legacy sectors tend to be defended by a paradigm that is technological, economic, political, social, cultural, and legal. This system protects those legacy sectors from the entry of innovation. There are technological and economic models that legacy sectors lock into, and they build political support and social systems around themselves. In addition to those barriers, there are market imperfections that tend to affect legacy sectors.

Innovations can enter, if they fit the established paradigm of the legacy sector. For example, fracking's entry into the fossil fuels sector took only about 12 or 15 years because it fit the paradigm."

Disruptive innovations will face high obstacles because they largely will not fit prevailing business models. "Legacy sectors—which include sectors such as energy, manufacturing, transportation, the electric grid, higher education, health delivery, and defense—are well-defended by strong vested interests. These sectors constitute over half the economy, and resistance to innovation in these sectors drags down our growth rate," Bonvillian noted. "It also affects our ability to get to those big public goods."

"To overcome these barriers, we need to understand better the models by which innovation comes about, such as the push model, in which the federal government invests in R&D, which is then taken up by the private sector; and the induced or "pull" model, where industry spots a market opportunity and makes technology advances to fill that niche. We will likely need to use these and other models together to encourage innovation in the legacy sectors."

Bonvillian suggested the first step to instigating disruption in legacy sectors is the strengthening of the front end of the innovation system: "We won't be able to innovate unless we have innovations. There are critical innovation institutions—public and private—that can put those on the table." The second step is to identify launch pathways for technologies, which will be different for different innovations. As a third step, it is necessary to conduct a gap analysis of the innovation system, which can reveal weaknesses in investment (both public and private) and policy.

ROLE OF GOVERNMENT IN THE INNOVATION ECOSYSTEM

The final presentation was given by Paul Zielinski of the National Institute of Standards and Technology, who spoke about the federal government's work in innovation, exploring the question of how we increase the impact of the public investment in R&D for the betterment of the country. "Everything we do in government needs to have a private partner to find its way into use," he said. "We spend between $130 billion and $140 billion a year in research and development—a lot of taxpayer dollars—but we do not really make things. For everything to find a home, we need an industry partner, and in order to innovate, we need university partners."

"There is currently a cross-agency effort called Lab-to-Market that is seeking to build enthusiasm at a high policy level for facilitating technology transfer and increasing the economic impact of federal R&D efforts," Zielinski explained. The initiative is organized around several sub-goals: developing human capital, empowering effective collaborations, opening R&D assets, fusing small business innovation, and evaluating impact. "The last of these creates an interesting issue," said Zielinski. "How we evaluate and what we pick to evaluate makes a big difference to what we do." The Lab-to-Market effort is meant to maximize the American people's return on investment dedicated to research and development, not only accelerating technology development but also improving the innovation pipeline within government agencies. ■

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