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R STREET POLICY STUDY NO. 44
November 2015

USING PRIZES TO SPUR INNOVATION AND GOVERNMENT SAVINGS

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CONTENTS

EXECUTIVE SUMMARY

In myriad sectors of the U.S. economy, from military technology to medical care, the federal government serves as the single-largest spender. As such, many of the innovations, inventions and discoveries that could propel economic growth in the future also would have a direct and measurable impact on federal spending.

To offer an incentive to research and development that yields significant taxpayer savings, we propose an "innovation savings program" that would serve as an alternative to the traditional patent system. The program would reward teams or individuals who develop discoveries or technologies that produce federal budget savings. In effect, a portion of those savings would be set aside for the discoverers. To be eligible for these rewards, the researchers and inventors would not receive patents on their discoveries or processes.

This perpetual, self-funded federal prize system would be based, in part, on the successful False Claims Act and Medicare Recovery Audit programs. Payouts would be administered by an independent or executive agency, verified by the Government Accountability Office and overseen by Congress to ensure fair and effective implementation.

New technologies developed through this process would be available immediately for generic commercialization, free of royalty fees. This could encourage innovation in sectors where patents and traditional research spending have lagged, while also bringing those innovations to market more quickly and affordably. Prize systems of this type have been in operation in the United States for more than 150 years, in the form of the False Claims Act, and date back to "qui tam" actions from the 13th century, thus predating the patent system by several hundred years.

SECTION I: PATENTS

When Christopher Columbus proposed to travel west to India, his voyage was funded by the rulers of Spain.[1] The agreement stipulated that Columbus was entitled to 10 percent[2] of all revenues from the new lands in perpetuity. (Imagine how rich his estate would be if this actually was applied to all of North America from 1492 to today.)

In 1776, Adam Smith published arguably the defining text of classical economics, *The Wealth of Nations*.[3] Smith argued for a market-based system that generally was *laissez-faire*, but with limited government intervention. He offered examples where monopolies granted by the state for a "certain number of years" could be beneficial, such as when a merchant looked to "establish a new trade with some remote and barbarous nation."[4] Smith explained that a "temporary monopoly of this kind" is "vindicated" on the "same principles upon which a like monopoly" exists for copyrights and patents. Notably, Smith referred to copyrights and patents as abridgement of the free market, rather than as "property," although he saw those abridgements as effective policy.

There has been a shared consensus through history that society has an interest in fostering innovation and risk-taking. Bounties, direct government spending and patents and copyrights are, within this framework, simply different methods of "promoting the progress of the sciences and useful arts."

To encourage innovation, the Founding Fathers endorsed patents as a system of regulation for novel inventions. Patents provide a legal monopoly to the recipient to exclude others from using a particular invention or idea without permission, which usually includes the payment of royalties. But patents are not self-executing; they require a government authority to assess whether the application meets the statutory requirements, which have changed over the years. In the 19th century, Alexander Graham Bell was required to submit a working telephone to earn his patent,[5] while today's patents merely require an application. Authority to grant patents originally was vested in the U.S. Secretary of State, but is handled today by the U.S. Patent and Trademark Office. Patents originally were granted for 14 years; today, most patents last for 20 years.

1. Robin Santos Doak, *Christopher Columbus: Explorer of the New World*, Compass Point Books, Minneapolis, 2005.

2. Malcolm Archibald, *Across the Pond: Chapters from the Atlantic*, p. 20, Whittles Publishing, Caithness, Scotland, 2001.

3. Adam Smith, *The Wealth of Nations*, 1776. Smith saw monopolies as exclusive privileges and explained that: "Some of the [exclusive privileges] are founded on natural reason…These two privileges [patent and copyright], as they can do no harm and may do some good, are not to be altogether condemned, but there are few so harmless. All monopolies in particular are extremely detrimental."

4. Smith explains that this is the "easiest and most natural right" for the state to "recompense them for hazarding a dangerous and expensive experiment" of which the public will ultimately "reap the benefit."

5. *The Nation*, "The Telephone and Its Inventor," Oct. 23, 1879.

During the Founding Era, patents were extremely rare. Just 268 patents were granted in first 10 years after the enabling statute was passed. By contrast, 324,000 patents were granted in 2014 alone. This is not a result merely of the United States becoming more innovative, but instead reflects radical changes within the patent system. Where patents once were granted only to truly novel and innovative ideas, those concepts have been so expanded that recent patents have been issued, for example, for a method of cleaning a building and for the idea of exercising a cat by using a laser pointer.

As Thomas Jefferson noted, once an idea is created, it's impossible to limit its diffusion to others.[6] This spillover effect is good for society, as innovation lifts all boats. But the diffusion of what economists would call "positive externalities" also can engender free-rider problems, in which inventors' inability to exclude others from using the fruits of their imagination may leave them with insufficient incentive to create. This is why the argument has persisted for centuries that the free market alone cannot fully support research-and-development-intensive industries. In exchange for the limited monopoly offered by patents, inventors must file disclosures to teach the world about their inventions. This quid-pro-quo was designed to encourage more risk-taking, but also to disseminate new ideas to society at-large.

When patents limit competition

Even when they work properly, patents limit competition by granting a 20-year legal monopoly.[7] *De jure* legal monopolies are able to use the power of the law to extract excess rents from consumers and other firms. In practice, it is not unusual that multiple teams work simultaneously on similar concepts and make similar or iterative discoveries, but only the team that receives the patent enjoys the windfall. The others typically will be barred from bringing their independent invention to market, rendering the research and development invested in such projects sunk costs.

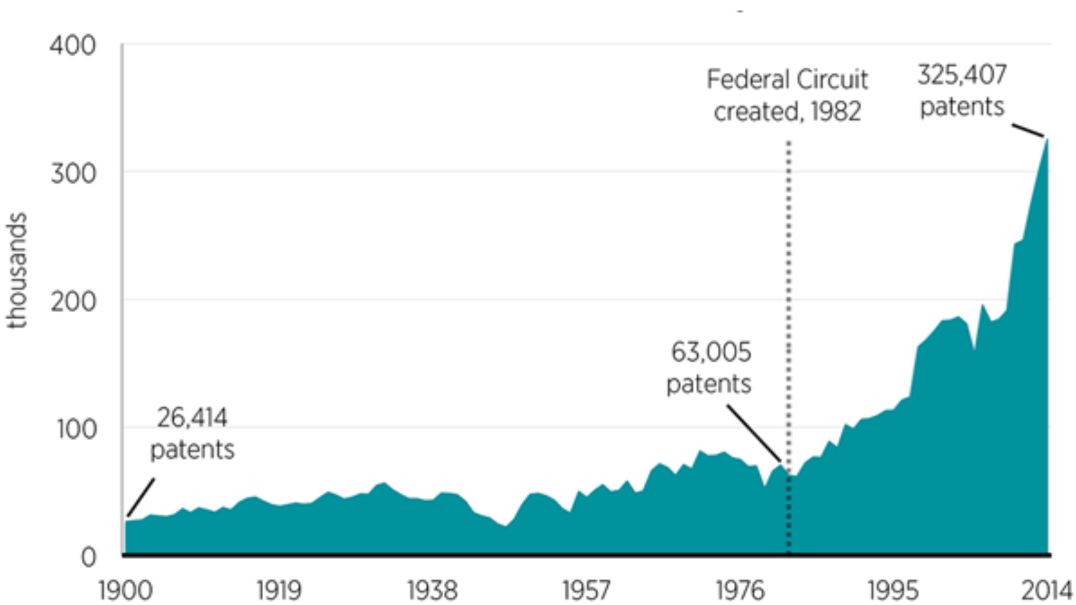
As one notable example: the Wright brothers made a modest improvement to existing flight technology, but their patent allowed them to monopolize the U.S. market and, in essence, to prevent innovation until World War I.[8] Other pioneers in the field effectively were shut out from bringing similar, even superior, technologies to market. As Steven Johnson demonstrates with dozens of anecdotes in his book *Where Good Ideas Come From*, independent invention is the rule,

6. Thomas Jefferson, "Letter to Isaac McPherson," Aug. 13, 1813. http://press-pubs.uchicago.edu/founders/documents/a1_8_8s12.html

7. Heidi L. Williams "Intellectual Property Rights and Innovation: evidence from the Human Genome," *Journal of Political Economy,* 1; 121(1):1-27, July 1, 2010. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3955392/pdf/nihms432485.pdf

8. Seth Shulman, Unlocking the Sky: *Glenn Hammond Curtiss and the Race to Invent the Airplane*, Harper Perennial, September 2003.

FIGURE I: TOTAL U.S. PATENTS ISSUED ANNUALLY, 1900-2014



SOURCE: Mercatus Center

not the exception.[9] Outside of the pharmaceutical industry, more than 95 percent of patent lawsuits do not even claim willful infringement – essentially conceding that the accused infringers likely developed the technology independently.[10]

One of the biggest developments in medical science of the past 20 years has been the gene-editing technology known as CRISPR/Cas9, first discovered as a bacterial-defense mechanism 25 years ago. Over time, researchers have perfected its use to cut DNA strands. Dozens of research teams have worked on CRISPR over the past quarter-century, with the pace of improvement picking up significantly in the past five years. CRISPR has fostered a revolution in genomics, which *Wired* magazine dubbed the "Genesis Engine."[11]

Only recently has there been any attempt to patent the technology platform for a wide array of applications. On June 28, 2012, Jennifer Doudna and Emmanuelle Charpentier's team published their results in *Science* on how to use CRISPR as a tool for genome engineering.[12] In 2013, they applied for a patent to use CRISPR as a platform for genome engineering. Seven months later, Feng Zhang filed for a different patent, specifically on using CRISPR as a platform for genome engineering in humans. Zhang had applied for a fast-track patent, which the USPTO awarded on April 15, 2014. Since the Doudna-Charpentier patent application claims much of the same technology as the Zhang patent, their application may only be granted with significant revisions to limit its scope. Alternatively, if their patent is granted, it could invalidate some of Zhang's claims. Analysts estimate that sorting out this dispute could take another three to five years. Thousands of teams have done CRISPR-related research, but they now may have to pay a fee to continue work begun before any patents were granted.

Perverse market incentives

If businesses are rational economic actors, we should assume they will maximize their opportunities to file for and obtain patents. When patents of dubious quality are granted, this distortion can become more pronounced and more harmful to the goal of innovation. Maximizing patents can mean investing in lawyers, rather than engineers, and filing applications for inventions and processes which the firm has no intent ever to bring to market. In such cases, innovation and competition suffer, for no discernable benefit.

To the extent that the purpose of patents is to allow inventors to recoup large research and development costs, there is little in the Patent Act to calibrate patents' monopoly rents to be appropriate to the level of upfront expenditure. Patents are granted for inventions large and small, regardless of cost. Some have suggested a "graduated" system of patents could provide more incentive for inventions with more significant

9. Steven Johnson, *Where Good Ideas Come From*, Riverhead Books, October 2011.

10. Christopher Anthony Cotropia and Mark A. Lemley, "Copying in Patent Law," *North Carolina Law Review*, Vol. 87, p. 1421, 2009. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1270160

11. Amy Maxmen, "The Genesis Engine," *Wired*, July 27, 2015. http://www.wired.com/2015/07/crispr-dna-editing-2/

12. Emmanuelle Charpentier, et al., "A programmable dual-RNA-guided DNA endonuclease in adaptive bacterial immunity," *Science*, Vol. 337 no. 6096 pp. 816-821, published online June 28, 2012. http://www.sciencemag.org/content/337/6096/816?ijkey=7a247844cc25b647494a1344762e8e05d04d4a9c&keytype2=tf_ipsecsha

research and development. Alex Tabarrok of George Mason University has called for shorter patent terms for software and business-method patents, which tend to have lower sunk costs than pharmaceuticals and other innovations. Implementing such a system and defining the categories appropriately would be difficult, but there is some precedent. From 1836 to 1861, the patent term was 14 years, with an optional seven-year extension if the inventor could show their profits had not covered the costs of development.

An optimal patent system would limit patent length and strength to provide sufficient incentive for risk-taking, without creating excessive government-provided monopoly rents. Assessing in advance what level of protection is necessary for each invention would be difficult, uncertain and ripe for abuse.

Patents and national security

After the Sept. 11, 2001 terrorist attacks, there was only one company which had developed a drug (Cipro) to combat the Anthrax virus. On Oct. 17, 2001, Health and Human Services Secretary Tommy G. Thompson said the U.S. government was nudging Bayer, the drug's manufacturer, to relax the patent on Cipro and was considering forcing it to do so. The Canadian government actually did override Bayer's patent and allow other companies to produce generic forms of Cipro. Bayer dropped the price in the United States from $1.77 to $0.95 a pill, amid reports that Thompson had threatened similarly to override the company's patent unless it lowered the price of the drug.[13] Some have argued that there was a real threat of compulsive licensing of Bayer's patent.[14]

Since that time, and possibly with the threat of patent expropriation by government authorities in mind, pharmaceutical companies have invested relatively little in drugs to combat the effects of chemical, radiological or biological weapons attacks.[15] Firms may fear that such drugs could be subject to formal or informal compulsory licensing during a national security event, thus limiting the incentive to develop them.

13. Charan Devereaux, Robert Z. Lawrence and Michael D. Watkins, *Case Studies in U.S. Trade Negotiation*, p. 98, Institute for International Economics, Washington, D.C., September 2006.

14. *The Economist*, "Patent Remedies," Oct. 25, 2001. http://www.economist.com/node/836030; See also Kavaljit Singh, "Anthrax, Drug Transnationals, and TRIPs," *Foreign Policy InFocus Newsletter*, pp. 1-3, April 29,2002.; *See also* Press Release, "HHS, Bayer Agree To Cipro Purchase," U.S. Department of Health & Human Services, Oct. 24,2001.http://www. hhs.gov/news/press/200 I pres/200 11024.html

15. Grace K. Avedissian, "Global Implications of a Potential U.S. Policy Shift Toward Compulsory Licensing of Medical Inventions in a New Era of 'Super-Terrorism,'" *American University International Law Review*, Vol. 18, Issue 1, Article 5, 2002. http://digitalcommons.wcl.american.edu/cgi/viewcontent.cgi?article=1188&context=auilr; See also Rep. Sherrod Brown, D-Ohio, "H.R. 3235 - Public Health Emergency Medicines Act," 107th Congress, Nov. 27, 2001. https://www.congress.gov/bill/107th-congress/house-bill/3235?q=%7B%22search%22%3A%5B%22%5C%22hr3235%5C%22%22%5D%7D&resultIndex=1

SECTION II: FEDERAL R&D SPENDING

Government also may encourage research and development by paying for it directly. Examples include grants to the private sector and to academic institutions from agencies like the National Institutes of Health (NIH); basic research conducted internally by various agencies themselves; and contracts between the federal government and, for example, the defense industry to develop new technologies.

Markets have limited incentive to invest in basic research, because the lag between that investment and bringing products and services to market often is simply too long and the returns are too uncertain. For example, Xerox's Palo Alto Research Center (PARC) developed some of the most innovative personal computer technologies from the 1960s through the 1980s, but was unable to capitalize on those breakthroughs. Other companies "borrowed" the technology developed by PARC and spun them off into technologies that surround us today, such as the computer mouse, the touch screen and graphical user interfaces. Similarly, Bell Laboratories – co-owned by AT&T and Western Electric and later spun off into the independent firm Lucent – invented the cellphone, but it would be commercialized by other companies, such as Nokia.

Many important basic discoveries have failed to provide an economic windfall to their creators. The optimal level of basic research is thus likely higher than would be provided by the free market alone. It therefore follows that we would see more basic research if there were appropriate government subsidies. Since basic research is critical to innovation, direct federal spending is one way to close the innovation gap.

Development of the modern computer

Advances at the basic level can create entirely new fields for the private sector. The term "computer" originally referred to an occupation, usually performed by women, who did computations. In the 19th century, the first computational devices merely did arithmetic. Over time, that technology would advance exponentially to create the computer revolution. It was unclear exactly how basic computers would transform the world when they were merely calculating machines, but a pioneering woman named Ada Lovelace could see beyond and imagine how these machines eventually could be programmed to solve complex problems. At first, there was not much private sector use for the technology; the military would be a primary buyer of the equipment.

In World War II, British forces used enormous computational power to crack the Germans' Enigma Code. The U.S. Army commissioned the building of the Electronic Numerical Integrator And Computer (ENIAC) and the Electronic Discrete Variable Automatic Computer (EDVAC). The latter included, for the first time, the idea of a stored program and the use of binary code (0s and 1s). The ENIAC cost approximately $6 million in today's dollars, all of it financed by the U.S. military. It's unlikely that many private-sector companies of the time would have invested anything like that sum.

A few months after the ENIAC's unveiling, as part of "an extraordinary effort to jump-start research in the field," the Pentagon invited "the top people in electronics and mathematics from the United States and Great Britain" to a series of lectures on digital computing. This sparked a collaboration that jump-started computer research. While the ENIAC was developed for calculating artillery-firing tables, it also was the first general-purpose automatic computer. It would be used for weather prediction, atomic-energy calculations, cosmic-ray studies, thermal ignition, random-number studies and wind-tunnel design. For the first time, computers were able to do anything that could be programmed. Over a generation, the computer market would transition from the few owned by the military to become an essential tool in modern business.

Human Genome Project

Planning for the Human Genome Project got underway in 1990 and the $3 billion project, expected to take 15 years, was completed by 2003. Funded by the NIH, the HGP was able to announce a working draft of the genome in 2000, several years ahead of schedule. Almost immediately after publication, significant advancements were made in human genomics, as researchers were able to find 20,500 genes and 3.3 billion base-pairs. In March 2000, then-President Bill Clinton announced that the genome sequence could not be patented, and should be made freely available to all researchers. Fifteen years later, the cost of DNA sequencing has dropped from $3 billion to between $100 and $1,000.

In 2013, President Barack Obama announced the BRAIN Initiative, with the goal of understanding brain function. This goal is quite ambitious, arguably more ambitious even than the Human Genome Project was in 1990. The brain contains roughly 100 billion neurons, roughly comparable to the number of stars in the Milky Way. Those neurons have a combined 100 trillion connections.

Apollo missions

In the aftermath of World War II, early computers used vacuum tubes, which were hot, took up a lot of space and were difficult to improve. But the vacuum tube's far superior successor, the transistor, was slow to gain acceptance. What pushed the technology forward was the interest and financing of the National Aeronautics and Space Administration (NASA). When then-President John F. Kennedy in 1961 announced the plan to land a man on the moon by the end of the decade, he launched a project that ultimately would require the development of many technologies that did not yet exist.

Given the per-pound cost of $4,000 to $5,000 to launch objects into outer space, NASA desperately needed an alternative to 60,000-pound vacuum tube computers. Relatively primitive integrated circuits reduced the costs of space exploration enormously and, through 1965, NASA's Apollo Guidance Computer was the largest user of integrated circuits in the world. That designation would shift in 1965 to the U.S. Army, which launched its Minuteman Project, a land-based intercontinental ballistic missile that served a central role in the country's nuclear strategy against the Soviet Union.

Computer technology was not the only beneficiary of the space race. Flat-panel televisions, high-density batteries, trash compactors, sports bras, athletic shoes, LASER surveying, solar cells, telemetry systems, sewage treatment, energy-saving air-conditioning, magnetic resonance imagery (MRI), advanced welding torches, wireless communications, cellphone cameras, computerized axial tomography (CAT) scans, water filtration, Doppler radar, fire detectors and electric cars are some of the technologies credited as stemming from government-backed space exploration. Much of the modern field of robotics also owes its genesis to NASA advances. Between the computer revolution, the Internet (created in part by the Defense Advanced Research Projects Agency, or DARPA) and robotics/automation, these fields constitute a significant portion of the productivity gains of the past three decades.

These approaches to direct federal spending were effective, in large part, because the objectives were clear. The government had a specific need for specific kinds of technology and the market impacts of this basic research were relatively positive. There is no equivalent to the Flat Earth Society wishing we could go back to the days of vacuum tubes.

Moral hazard

A contrast to the benign effects of the Apollo missions can be seen in federal efforts to speed adoption of so-called "green" energy technologies. Through a variety of tax, loan and grant programs, government agencies have chosen to subsidize some technologies over others. Some recipients – most notably, Solyndra – have been disasters. By picking winners and losers, the government has opened the door for certain energy technologies while stalling natural-gas development and miring the development of pipelines in endless red tape. When the process fails to acquit itself as transparent or objective, it creates tremendous uncertainty in the market, and uncertainty stifles risk-taking and investment.

Direct federal spending can be a recipe for cronyism. Companies hire lobbyists to extract government largesse and funds are distributed to those with the most political clout, rather than to the most promising or most cost-effective technologies. In the specific case of energy subsidies, much of the money has been spent to make the consumer price of solar power, wind power and corn-based ethanol artificially cheaper. Ethanol, in particular, appears unlikely ever to compete in the market absent the subsidy.

Some proponents of green technologies, such as Bill Gates, have advocated redirecting government funds toward long-term breakthroughs that would drive down the costs of these technologies permanently. This would be in line with the experience across multiple sectors. Government spending on basic research holds the potential to move entire industries forward, while direct subsidies flow primarily to the bottom lines of incumbent firms.

All of these raise the issue of what economists call "moral hazard." To the extent that private-sector actors can continue to enjoy the gains from research and development, while shifting the risk to taxpayers, resource allocation is misaligned and distorted. Moreover, while there are certainly smarter ways for the federal government to invest directly in research, the public appetite is wearing thin. Politicians fear public outcry when funded projects perform poorly, as they inevitably will some portion of the time. Meanwhile, the benefits of research and development often aren't seen until decades into the future. In recent years, nearly all agencies that dole out domestic research and development funds – including DARPA, NASA and the NIH – have faced budget cuts.[16]

Federal R&D spending can be part of the solution, but particularly given the current political climate, it is unlikely to be sufficient.

SECTION III: THE PRIZE MODEL

A third method to encourage innovation is the use of structured prizes. Under the prize model, government agencies, private organizations or a mix of the two, typically host a competition to achieve some specific breakthrough, with the winner promised a set reward. The prize model is notable for its ability to produce significant multiplier effects, as a relatively small prize can spark major investment by the private sector.

16. NIH funding was cut from $33 billion in 2010 to just over $30 billion today. See National Institutes of Health, "Budget," http://www.nih.gov/about-nih/what-we-do/budget

In practice, the prize model offers a uniquely level playing field. Newer teams frequently bring novel solutions that outpace participants with nominally more impressive credentials. While prizes are not as common as other incentives to innovations, the historical basis for the model is at least as old as that as for patents. Prizes sponsored both by the private sector and by the public sector each have proven effective in encouraging research and development. A 2009 McKinsey report found that philanthropic and private-sector investment in prizes has increased significantly in recent years, including $250 million in new prize money brought to bear between 2000 and 2007.[17] *The Wall Street Journal* concluded that "prizes have proliferated because they actually work."[18]

Longitude

During the Age of Discovery, from the 16th through the 18th centuries, a consistent challenge for maritime navigators was determining longitude at-sea. The rulers of Spain, Britain and the Netherlands each offered prizes to see who could crack the code. In 1773, John Harrison was awarded Britain's Longitude Prize of 20,000 pounds (more than US$2 million today). His system revolutionized navigation and maritime trade. Interestingly, Britain had left the method of solving the problem open, which ultimately led to some delay in paying Harrison, but it resulted in a surprising solution. Most expected the winning method to make use of improved star charts; Harrison instead used a chronometer.[19]

Flight

The growth of commercial flight benefited extensively from prizes.[20] In 1909, the *Daily Mail* newspaper of London offered 1,000 pounds (US$111,500 in 2006) to fly across the English Channel, a contest won by Louis Bleriot.[21] In 1910, the Milan Committee Prize paid the equivalent of US$665,500 (in 2006) to fly across the Alps from Switzerland to Italy.[22] In 1919, Raymond Orteig offered the $25,000 Orteig Prize for the first nonstop flight between New York and Paris.[23] Charles Lindbergh would win in 1927 with his "Spirit of St. Louis." Nine competitors had prepared to make the flight

17. McKinsey & Co., "And the winner is ...," 2009. http://www.mckinsey.com/App_Media/Reports/SSO/And_the_winner_is.pdf

18. Eric S. Hintz, "Creative Financing," *Wall Street Journal*, Sept. 27, 2010. http://online.wsj.com/article/SB10001424052748704505804575483423120157674.html

19. Knowledge Ecology International, "Selected Innovation Prizes and Rewards Programs," 2008. http://keionline.org/misc-docs/research_notes/kei_rn_2008_1.pdf

20. William A. Masters and Benoit Delbecq, "Accelerating Innovation with Prize Rewards: History and Typology of Technology Prizes and a New Contest Design for Innovation in African Agriculture," International Food Policy Research Institute, pp. 19-29, December 2008.

21. Ibid.

22. Ibid.

23. Ibid.

and three tried and failed. Nine teams spent $400,000 to try to win the purse, but Orteig paid nothing to the losers. Lindbergh's success led to a boom of American interest in aviation. It was an incentive prize that helped build today's $300 billion global aviation market.

Autonomous cars

In 2003, DARPA announced the first DARPA Grand Challenge, initially promising to award $1 million for the first robotic vehicle to complete a course from California to Nevada in under 10 hours. Multiple teams competed in 2004, but none made it through the course until 2005, when the Stanford Racing Team won the then-$2 million prize. In 2007, the third driverless car competition attracted 53 qualifying teams. The top 11 teams competed on three "missions" of approximately 55 total miles, with Tartan Racing – a collaborative effort of Carnegie Mellon University and General Motors – declared winners of the $2 million top prize. Stanford Racing Team took home another $1 million for taking second place.

After the 2007 DARPA challenge, the last for autonomous driving, self-driving-car research exploded in the United States and around the world. Nearly every major carmaker is working to develop autonomous cars, from Tesla, General Motors, Ford, Chrysler and Audi even to non-automotive companies like Google, whose self-driving cars have logged more than 1 million miles.[24] Starting this fall, Tesla's Model S will allow a firmware update to enable "autopilot" mode, enabling the car to self-dive on the highway.[25] Fully self-driving cars may be on the road within 10 years.[26]

Private prizes

As the game of billiards was growing more popular in the 19th century, the billiards industry had to confront the declining availability of ivory – to that point, the material from which all billiard balls were carved. In 1863, Phelan & Collander, the leading U.S. billiard supply company, offered a $10,000 prize for the inventor of a suitable alternative.[27] John W. Hyatt would develop the solution, a celluloid billiard ball, which likely saved thousands of elephants and may have led to the development of the modern plastics industry.

Netflix offered a $1 million prize to whomever could improve their recommendation algorithm by 10 percent.[28] In two weeks, they received 170 submissions, three of which outperformed Netflix's algorithm. By the time the contest was complete, 40,000 teams had submitted their own algorithms, several of which outperformed Netflix's.

The Ansari X Prize was a competition to grant $10 million for the first non-governmental organization to launch a reusable manned spacecraft into space twice within two weeks. Peter Diamandis, founder and chairman of the X Prize Foundation, was inspired by the prize that encouraged Lindbergh to fly the Spirit of St. Louis across the Atlantic. In 2004, 22 teams from around the world would compete, with the prize going to Tier One's "SpaceShipOne."[29] Soon after, a deal was made with Virgin Atlantic to develop the Virgin Spaceship based on a scaled-up version of Tier One's design. Virgin Galactic's launch has been delayed, but it continues to look likely that humans will enjoy commercial space travel within the near future.[30] The Ansari X Prize has sparked significant investment in commercial space travel.

More recently, Google created the $30 million Lunar XPRIZE, also known as "Moon 2.0," to be awarded to the first privately funded team to land a robot on the moon and see it travel on the surface for more than 500 meters. The competition will be open until the end of 2017.[31] The first team to complete the task will claim $20 million, while the second team will receive $5 million. There are currently 16 officially registered Google Lunar X Prize teams involved in the competition, four of which have a launch under contract.

A large number of technology companies also pay rewards to hackers who find and report key vulnerabilities. United Airlines recently paid 1 million airline miles for finding bugs in their software. Microsoft, Google and Facebook all pay large rewards as "bug" bounty programs. These are alternative types of prize programs.

24. Phil LeBeau, "Crash data for self-driving cars may not tell whole story, CNBC.com, Oct. 29, 2015. http://www.cnbc.com/2015/10/29/crash-data-for-self-driving-cars-may-not-tell-whole-story.html

25. Tesla Motors Team, "Your Autopilot has arrived," Tesla Blog, Oct. 14, 2015. http://www.teslamotors.com/blog/your-autopilot-has-arrived

26. Matt Burgess, "Autonomous commercial vehicles will shape our jobs and lives," *Factor*, July 28, 2015. http://factor-tech.com/feature/autonomous-commercial-vehicles-will-shape-our-jobs-and-lives/

27. Nesta, "The Billiard Ball Prize," accessed Nov. 6, 2015. http://www.nesta.org.uk/news/guide-historical-challenge-prizes/billiard-ball-prize

28. Jennifer Van Grove, "$1 Million Netflix Prize To Be Won Imminently," *Mashable*, June 26, 2009. http://mashable.com/2009/06/26/netflix-prize/#WuXPQ8Fktaqf

29. Catherine E. Parsons, "Space Tourism: Regulating Passage to the Happiest Place Off Earth," *Chapman Law Review*, Spring 2006. http://www.chapmanlawreview.com/archives/1224

30. Kari Lundgren and Cory Johnson, "Branson Sees Year Delay to Virgin Galactic Spaceship After Crash," *Bloomberg Business*, April 9, 2015. http://www.bloomberg.com/news/articles/2015-04-09/branson-sees-year-delay-to-virgin-galactic-spaceship-after-crash

31. XPRIZE, "Deadline for $30 Million Google Lunar XPRIZE Extended to End of 2017," Google Lunar XPRIZE, May 22, 2015. http://lunar.xprize.org/news/deadline-30-million-google-lunar-xprize-extended-end-of-2017

SECTION IV: AN INNOVATION SAVINGS PROGRAM

Due to the inherent limitations of both the patent system and federal R&D spending, our current policy structure is not ideally suited to encourage groundbreaking and money-saving innovation. Expanding the prize model could open an additional path to innovation, encouraging the private sector to engage more heavily in identifying inventions and processes that could revolutionize the modern world.

The federal government already is the largest market buyer in a number of fields, from military technology to medical care. Many of the inventions and discoveries expected to propel the economy in the future – a space elevator; cures for AIDS, cancer and diabetes; new battery technology; developments in solar and wind power – would have a direct and measurable impact on federal spending.

The combined annual federal budgets of Medicare, Medicaid, the Children's Health Insurance Program and subsidies through the Affordable Care Act's exchanges are nearly $1 trillion;[32] any significant medical breakthrough holds the potential to save the federal government millions or billions of dollars. It has been estimated that increases in life expectancy due to reductions in cardiovascular disease mortality from 1970 to 1990 were worth more than $30 trillion.[33] If medical research could reduce cancer mortality by 10 percent, it would be worth $5 trillion to U.S. citizens.[34]

We propose an "innovation savings program" (ISP), rooted in similar prize structures found elsewhere in the public and private sectors. Imagine a research team developed a cancer drug that could save the federal government $1 billion a year. Under the innovation savings program, a portion of those savings would flow back to the researchers themselves, in exchange for their not patenting the technology. In order to be eligible for a prize payout, the innovation would need to meet a minimum cost-savings threshold established by Congress (e.g., $100 million). Since the researchers would be paid out of funds already authorized by Congress, there would be no additional cost to taxpayers, who instead would expect to see still additional savings.

Because the prizes would be limited to research teams that eschew patenting the technology, the innovations these prizes encourage would be available immediately to all Americans, free of royalty fees. If successful, the program would encourage more innovation in sectors where patents are currently lacking, while simultaneously allowing those innovations to reach the public more quickly and more affordably. Moreover, other innovators would be free to build upon the technology immediately.

This idea is directly inspired by the centuries-old concept of "qui tam" claims. Qui tam statutes allowed a private citizen to bring action on behalf of a government to recover a penalty. It comes from the Latin phrase *qui tam pro domino rege quam pro se ipso in hac parte sequitur*, which translates to "he who brings an action from the king as well as for himself." Under a qui tam statute, a person who pursues the action receives a portion of any amount recovered on the government's behalf.

One example from U.S. history was the False Claims Act of 1863, also known as the "Lincoln Law," enacted during the Civil War for the purpose of combating fraud. The original False Claims Act entitled those who pursued funds for which the federal government had been defrauded to half of any money recovered. A modern example is the Centers for Medicare & Medicaid Services' Recovery Audit Program, whose mission is to "identify and correct Medicare improper payments." CMS has entered into contracts with private auditors across the country, who are tasked with identifying improper payments. In 2013, recovery auditors identified $3.75 billion from more than 1.5 million improper payments. After accounting for payouts to contractors and other program costs, the net savings to the Medicare Trust Funds amounted to more than $3 billion.

This relatively small-scale demonstration shows the power of aligning public and private sector incentives to save taxpayers money on the "back end." But programs that seek only to stamp out waste, fraud and abuse do little to encourage the kinds of innovations that would reduce costs on the "front end." That's the goal of the innovation savings program: to provide a profit mechanism, separate and apart from patents and direct subsidies, to encourage innovations that could revolutionize such fields as medical technology, energy efficiency and payment processing.

The program would be authorized by Congress, administered through an executive or independent agency and verified for accuracy by the Government Accountability Office (GAO). This structure draws heavily from the model presented by the Recovery Audit Program. It is intended to balance the need for congressional oversight, appropriate agency latitude to execute details and reliable verification to protect taxpayers and prevent costly errors.

The program would need to be administered by an independent or executive agency, like the Office of Management and Budget or the General Services Administration, to ensure timely payouts. Congress would direct the agency

32. Center on Budget & Policy Priorities, "Where Do Our Federal Tax Dollars Go?," Policy Basics, March 11, 2015. http://www.cbpp.org/sites/default/files/atoms/files/4-14-08tax.pdf

33. Philip Aspden, ed., "Medical Innovation in the Changing Healthcare Marketplace: Conference Summary," National Research Council, 2002. http://www.ncbi.nlm.nih.gov/books/NBK220598/

34. Alex Tabbarok, "Launching the Innovation Renaissance: A New Path to Bring Smart Ideas to Market Fast," p. 89, TED Conferences LLC, 2011.

to establish procedures that meet statutory guidelines for applications, determining eligibility and structuring payouts. The administering agency would write detailed rules to clarify the process, both for innovators and for the agencies with whom they would work. It also would be in charge of managing disputed claims, as the USPTO already does for patent applications.

In addition to allocating some set portion of savings (e.g., 25 percent) to the innovator who applies, some portion likely should flow back to the administering agency, to cover its costs and avoid creating an unfunded mandate. In order to provide incentives to federal agencies to seek out and implement proposed innovations, another portion also could be returned to the agency in question as "deprogrammed" funds, which could be spent as agency officials deem most appropriate.

The remaining savings should accrue to taxpayers, through deficit or debt reduction. The Medicare Recovery Audit Program accomplishes this goal by depositing savings in the Medicare Trust Funds. The wider scope of the innovation savings program might instead recommend devoting savings to a government-wide deficit-reduction fund.

For a program like this to work, reliable assessment of savings will be vital. This role is a natural fit for the GAO, an independent agency that already serves as the "congressional watchdog," auditing federal finances and identifying needed improvements in program administration. The ISP's authorizing legislation should mandate an annual GAO audit to verify cost and savings estimates provided by the administering agency. By providing Congress with an accurate picture of the program's operations, these mandatory annual audits would offer legislators a chance to modify the underlying statute and bring the program in line with congressional intent.

Congress also could require GAO to release in its annual report a list of top cost-saving areas for further research, in much the same way the agency releases its annual "high risk" list of agencies and program areas vulnerable to fraud, waste, abuse and mismanagement. This annual exercise would help to focus private-sector innovators on those areas most likely to yield large-scale taxpayer savings. These might include solar-panel technology, space exploration or curing or managing major conditions. Researchers are more likely to justify significant investments in some of these fields if they had greater clarity as to the potential for cost savings.

Case study: 3-D-printed organs

Each day, 18 Americans die because they lacked access to needed organ transplants. The longest waitlist is for kidneys, for which more than 400,000 Americans are on dialysis awaiting a transplant. Dialysis costs more than $70,000 per-patient, per-year. It isn't an equivalent replacement for a new kidney. And it's fully covered by Medicare for people of all ages.

Improvements in dialysis-like instruments or replacement kidneys fabricated with 3-D printers could revolutionize the field. One promising area of research is 3-D printed organs made from one's own stem cells, ensuring that the body won't reject the new organs. A perfected 3-D printing process could ensure organ abundance and make transplants extremely cheap. If donor-compatible organs were as abundant as blood stocks, it would be one of the most significant developments in modern medicine.

The impacts could go well beyond transplantation. Surgeons tasked with removing cancerous tumors currently must strike a careful balance, so as not to remove too much of the organ. Often, they don't remove enough and the cancer metastasizes. Nearly 600,000 Americans die of cancer each year, one-quarter of all deaths. Current transplants also require immuno-suppressant drugs, which can be dangerous for those battling cancer.

In a world of organ abundance, doctors could instead choose to remove a cancerous organ immediately, in favor of a 3-D printed replacement. Abundant organs could address the number one killer, heart disease, by making it possible to swap out heart valves as necessary. Americans living with type-1 diabetes could receive pancreas transplants, allowing them to regulate blood-sugar levels properly. Eventually, organ transplants could become a form of preventative care, allowing patients to swap out those most likely to fail with 3-D printed replacements.

Just using estimates of the cost of renal disease, readily available transplantable kidneys could save the government more than $500 billion in 10 years.[35] But while current NIH spending per year on kidney disease research is $549 million, NIH spending on all 3-D printing research is only an anemic $4 million. If a Human Genome Project-scale approach introduced printed kidneys to the market two years earlier than they would otherwise arrive, it will have saved the government more than $100 billion. We will eventually develop 3-D printed organs, but with proper funding and incentives, we could speed that development from almost a generation away to less than a decade.

35. Congressional Kidney Caucus, "Kidney Disease by the Numbers," accessed Nov. 6, 2015, http://mcdermott.house.gov/index.php?option=com_content&view=article&id=381&Itemid=62; "$57.5 billion Annual Medicare costs to treat people with Chronic Kidney Disease – 28% of Medicare spending. $106,373 Medicare spending for kidney transplant per patient in the first year. $72,064 Medicare spending on a dialysis patient, per-year."

If Congress enacted the prize model explained in this report, the GAO could produce a report identifying the potential cost-savings of advances in kidney disease and the amount that could be claimed under the prize statute. Such a large bounty may spur innovation in itself. But the NIH also could work with scientists to identify the major problems to be solved to develop 3-D printed organs in the form of a public checklist. They then could divide the potential award among groups that solve individual components. A problem of this magnitude would benefit from many researchers tackling individual aspects, rather than simply awaiting the final "invention." Innovation generally occurs with small discoveries, not grand overarching solutions.

While the approach outlined here would certainly speed up research, it would fail to provide upfront capital to researchers. Researchers may be able to leverage the potential prize and get investment, or if the problem is sufficiently important, Congress could choose to provide additional upfront resources or smaller rewards along the way.

Supplements

Getting a drug approved by the Food & Drug Administration can cost several hundred million dollars. The vast majority of drugs fail in clinical trials, but the legal monopolies offered by the patent system are sufficiently lucrative that pharmaceutical companies regularly enjoy among the highest rates of return of any industry.[36]

But there are some compounds – such as those found in nature – that are ineligible for patents. In practice, drug companies sometimes alter natural compounds to create a novel formula, which would then be patentable, but natural remedies themselves remain generally unpatentable. As one might expect, extremely few drugs in such categories ever are submitted for FDA approval.

While many are perhaps justifiably skeptical of most natural remedies, we know that many natural compounds do hold medicinal qualities. Penicillin, for example, comes from penicillium fungi, and was one of the first effective antibiotics. Since natural drugs can't receive patents, researchers have few avenues to recoup the costs of exploring and testing the performance and medicinal value of natural remedies. As a result, there are likely dozens, perhaps hundreds or thousands, of drugs which could pass FDA testing, but for which there is no economic incentive to test that proposition.

If an FDA-approved supplement with medicinal properties had an impact on a major condition or disease, there would be a potential cost savings to the government. Under this proposal, the team that invested in the clinical research would be able to recoup those expenses. This also would signal to future researchers that clinical testing on supplements, and obtaining FDA approval, holds sufficient promise of compensation to be worth their time.

CONCLUSION

It's important to address potential shortcomings and challenges associated with the innovation savings program approach. First and foremost, to function effectively, such a program would rely on a rather intricate piece of legislative design. It would need to provide sufficient incentive to innovators and agencies to participate, while protecting taxpayers from unwarranted payouts. The authorizing legislation also would need to balance carefully the roles of the private sector, Congress, the executive branch and independent agencies in a manner consistent with the principles of limited government and separation of powers. It also would have to guard appropriately against the natural tendency of bureaucracies to resist change and disruption. While this challenge is not insignificant, it should be surmountable with appropriate research and consultation.

An innovation savings program also runs the risk of both "overshooting" and "undershooting" the targets it is intended to hit. If the program's structure is too difficult or expensive to navigate, it could erode the potential incentive effects dramatically, providing little or no benefit to taxpayers or the economy as a whole. On the other hand, if the structure is too permissive, it could lead to large payouts for relatively little benefit to government or broader society. While these payouts would not constitute net costs to taxpayers, as they are only paid out of identified savings, they could prove inefficient at targeting benefits. In this way, the program could become subject to some of the same political and special interest influences that already bedevil direct federal R&D spending. It is thus inevitable that the ISP will require some "calibration" to create a structure that addresses these concerns appropriately.

We also recognize the shortfalls of multiple discovery, where more than one researcher or research team claims credit for inventing the same thing. A similar complication involves "subsequent" discovery, where another researcher makes a marginal improvement to a technological breakthrough. How to handle multiple discovery and subsequent discovery is a persistent problem in policy-supported innovation, both for patents and prizes. For most of the patent system's history, it has sought to resolve these disputes by determining who was "first to invent," although recent legislative changes have shifted to a "first to file" system.

36. Uwe E. Reinhardt, "Perspectives on the Pharmaceutical Industry," *Health Affairs*, vol. 20, no. 5 p. 136-149, September 2001; "On the more meaningful ROA criterion, the drug industry also ranked at the top of Fortune's list in 1999—16.5 percent, compared with the 15.4 percent earned by the closest runner-up, the computer peripherals industry."

A prize system might suffer similar drawbacks, but it does offer some benefits that patents do not. For instance, patents must, by design, grant a monopoly to only one team. The team that obtains a patent can get an injunction to shut down competitors' research entirely. By contrast, with prizes, if two teams discover the same thing or make a subsequent discovery, the "losing" team can still sell the product and build upon their invention without fear of legal retribution. A prize model also could allow flexibility to offer smaller rewards to "runners-up," which is not contemplated in the patent system.

It's also important to recognize that it's not entirely clear what sorts of parties would be motivated to invest and research new technologies and apply for a prize, instead of a patent. We've offered some examples where patents may not apply. In some cases, the potential windfall of a prize may exceed expected returns from a patent. It's also possible that, if this alternative model to foster innovation proved successful, Congress could act to rein in patents to be closer to their original, more limited constitutional purpose. In that case, prizes could effect even more discoveries.

But even if it did not prove transformative, or even remotely popular, the downside risk of this proposal appears minimal. If the prize system is not considered useful, then companies and individuals would continue to apply for patents, as they currently do. If the ISP wasn't used, Congress could revise it or discard it. Its failure wouldn't cost have costs to taxpayers, because prizes would be paid only where there is a cost savings. Indeed, that's precisely what happened to the False Claims Act, which for decades was forgotten and rarely used. In 1986, Congress revised the law and it has since been used regularly.

In short, there is nothing to lose by trying a system which holds potential to spur innovation and risk-taking. Moreover, there are many possible ways to structure such a program. This paper intends to raise just one possible structure for discussion, in full knowledge that it holds potential sources of weakness that could be strengthened through future research and discussion. We can and should encourage the best and brightest to solve some of the biggest problems facing our country, our economy and our world.

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