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"Driving Innovation Through Federal Investments"
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Chairwoman Mikulski, Ranking Member Shelby, and distinguished members of the Senate Committee on Appropriations,

Thank you for the opportunity to submit this statement for the record on behalf of the Massachusetts Institute of Technology, and for holding this hearing. Federal investments play a key role in driving innovation and supporting a strong economy. In the face of difficult economic circumstances, U.S. funding for research and development has stagnated. Yet federally funded R&D remains a pivotal factor in our economy's health and future growth. For decades, the U.S. innovation system has been the model for the rest of the world, but I am concerned that we have now begun a process of departing from the very practices that led to our national success. I appreciate the Committee's willingness to look at the necessity of strong and stable federal support for R&D to ensure a vibrant innovation system and a growing economy.

I want to review with you a series of data points that I believe your committee could consider as it undertakes this hearing, to try to illuminate the complex subject of U.S. innovation. Investment in science is a vital end in itself: This knowledge is increasingly central to who we are. But we are also building an increasingly knowledge-based economy. I will focus my testimony on this second issue, on the practical question taxpayers often ask: Is R&D simply spending or is there a return on investment? I will try to build a succinct framework for looking at this question.

First, I briefly review some basic data about the historic ***federal role in R&D***, including the factor of "R&D intensity" – the level of a society's investment in research - which I believe is a crucial indicator. The next logical question is the "why": What does our society gain from these investments to justify their cost? I review studies that tell us about the ***role of science and technology in economic growth.*** But we also need to drill down to the next level. What do we know about the ***economic role of research universities,*** since they are among the primary recipients of these federal R&D investments? How do these institutions – which are part of a complex growth ecosystem - contribute to growth? This section draws primarily on a study of my own university, but the findings are not unique to MIT. Finally, I review data on the ***economic impact of continuing to curtail research investments*** – what does the data suggest about the cost to the economy of foregone economic opportunities? This brief summary highlights the data and studies the Committee will find most useful. I hope this framework approach, summarizing key data points, will inform your debate on the best ways to foster innovation.

<u>The Federal Role in R&D</u>

Research lies at the root of innovation, and the federal role is critical. The federal government funds 60% of all U.S. basic research, and 31% of all U.S. research and development, including basic research, applied research and development.[i] The other 69% of U.S. R&D, primarily development, is funded by the private sector. While we use the merged term "R&D," research and development are like apples and oranges -- very different, and useful in different ways. Research is foundational, uncovering new scientific facts and principles. Development transforms that foundational knowledge into new techniques, technologies and materials. We cannot give up "R" or "D"; both are critical, and they are interconnected. Industry investment in development is a crucial supplement to the federal investment in research – but it is no substitute.

Since World War II, the United States has been a strong supporter of research and development. From the two decades from the mid 50's through the mid-70's, federally-funded R&D

averaged approximately 1.5% of GDP; however by 2011 funding had fallen to 0.8% of GDP.[ii] The combined public and private sector investment in R&D as a percentage of GDP, or "R&D intensity" is 2.9%. These numbers are important because the percentage of GDP invested is the best benchmark for the societal commitment to R&D. The period where federal R&D was in the 1.5% range helped lead to sustained growth, where the U.S. introduced a long series of innovations. Although the U.S. long led in this factor -- as it led the world in creating a comparative economic advantage in innovation – this lead has been eclipsed. Five other nations now boast higher levels of R&D intensity than the U.S., and many other nations, including China, are rapidly increasing their levels of GDP spent on R&D.[iii] While the U.S. remains a world leader in total R&D, the current trajectory of U.S. investment levels is a striking departure from the strong commitment the country has historically made to R&D. If the federal government wants to affect the rate of growth of GDP – to move this needle - then the level of R&D as a fraction of GDP over time is critical. This declining benchmark should be a flashing yellow light for the nation – it should make us pause to consider its ramifications.

The Role of Science and Technology in Economic Growth

Why does this matter? What is the role of R&D investment in our economy?

The U.S. experienced tremendous economic growth following the Second World War, with U.S. per capita income growing at an exponential rate. Research by the Nobel-Prize-winning economist Robert Solow demonstrated that the leading enabler of this growth was technological innovation, the source of 60% or more of historical U.S. economic growth.[iv] (Capital supply and labor supply are important factors, but the dominant factor is technological and related innovation.) Work by other leading economists [v,vi,vii] has confirmed the importance of technological innovation for economic growth. As William H. Press summarizes the findings, "As a factor of production, technology produces wealth and produces more technological progress, enabling a virtuous cycle of exponential growth."[viii] The underlying argument is that following World War II, by multiplying its innovation inputs, the U.S. created a competitive advantage over other nations in innovation. Since technological innovation is the dominant factor driving economic growth, this strategy made the U.S. the wealthiest nation in the world. How does this play out?

Numerous economic studies have verified that R&D investments create "knowledge spillovers" into the economy that multiply the returns on the initial R&D cost. In short, technology advances stemming from R&D create productivity gains that increase GDP and real standards of living.[ix]

Studies of particular economic sectors indicate that innovations stemming from federally-funded research have the potential to transform those sectors -- and that many have done so. A study by BIO, for example, found that, from 1996 to 2010, the economic benefits derived from technology transfer of health research from universities and non-profit research institutes to industry resulted in an increase of up to $836 billion in gross industry output, $388 billion in GDP, and 3 million jobs.[x] According to a 2011 study by Battelle Memorial, the $3.8 billion Human Genome Project, led by NIH, created an estimated $797 billion economic sector that did not exist before, generating 310,000 jobs.[xi] Over and over, research opens the door to new knowledge, which then opens the door to economic growth: In information technology (IT), federally-funded research in digital communications played a major role in today's broadband and mobile communications; research in computer architecture played a major role in microprocessor advances; research in software played a major role in personal computing; research in parallel and distributed systems played a major role in cloud computing; and research in databases played a major role in enterprise systems.[xii] Each of these IT sectors is now valued at over $10 billion, according to an NSF study, and most are worth many times that.[xiii]

The list of technologies that relied on federally-supported research is extensive. It includes the core technologies behind the smartphone, including key microchip advances, the Internet, the

touch screen, speech recognition and GPS.[xiv] Even the Google search engine derived from NSF-funded research.[xv] This is not just a recent phenomenon. In the 1820s and 1830s, the War Department funded R&D for interchangeable machine parts, a key breakthrough that eventually made mass production possible and enabled the U.S. to emerge as a leader of the industrial revolution.[xvi] In the first part of the 20th century, the Department of Agriculture supported the research and development of hybrid corn; commercially released in 1921, it dramatically multiplied corn yields and food supplies, and helped to feed a growing population.[xvii] The list of innovations that received federal support is rich with technologies that are essential to our everyday lives and fuel our economy.

The Role of Universities and MIT in National and Regional Economies

Since research universities are major recipients of Federal R&D funding, we should also examine the role they play in our knowledge-oriented economy. The story is evolving and complex. Universities play two roles, of course, education and research, and part of the genius of the American research university is that the two roles are profoundly joined and mutually supporting in a "learning by doing" model. Economists tell us that the quality of technical talent that feeds into an innovation system is a critical determinant of innovation strength.[xviii] Universities are the spigot that supplies the science and technology talent pool for both research institutions and industry. At the same time, research universities also produce (through "knowledge spillovers") most of the foundational research that industry relies on for translation into technological advance. In the United States today, universities conduct the majority of basic research, 56%, up from 38 % in 1960. [xix] Most research universities now feature technology transfer offices to help transition research to the market. In 2011, university-based research produced 671 business spin offs. According to a report by the Science Coalition these businesses were more likely to survive the first five years than new U.S. business overall.[xx] In short, the university role in technology transition was always important, but it used to be indirect; as it becomes more direct, it grows even more central to the system's success.

MIT is just one of many institutions that help transition new technology into the market, positively benefiting the U.S. economy. However, the example of MIT's impact demonstrates that the most important role universities play in the innovation system is educating and training the next generation of talent. A 2009 Kauffman Foundation report on MIT's economic impact showed that if the annual revenues of active companies founded by living MIT alumni were compared to the GDP of nations, these companies would have a combined value between the 11th and 17th largest national economies in the world.[xxi] At the time of the report, there were approximately 25,800 active companies founded by living MIT alumni. The companies collectively employed about 3.3 million people and generated annual world revenues of some $2 trillion.[xxii] The benefits to a university's regional economy are large as well. An estimated 6,900 MIT alumni-founded companies are headquartered in Massachusetts, with annual sales of $126 billion or about 26% of all sales by Massachusetts companies. Worldwide, these companies employed approximately 1 million people.[xxiii]

The Kauffman study notes that, like other research universities, MIT also plays the more direct role in the innovation system noted above. MIT actively works to support its students and alumni by fostering an on-campus innovation ecosystem that provides entrepreneurship education, start-up support, links to financing, prizes for student business plans, support for technology patenting and licensing, and mentoring for young companies. Each year, the people of MIT use the results of R&D performed on campus to found around 20 to 25 companies. [xxiv] Companies founded and technologies developed recently by MIT researchers include the algorithms behind Akamai, the cybersecurity firm; E Ink Corporation, which invented the screen technologies for Amazon's Kindle; iWalk, a company that makes advanced prosthetic feet; early devices that led to the now-ubiquitous PET scan; and improved high-powered lithium-ion batteries. [xxv]

The Effect of Declining Federal R&D on Economic Growth

Federal support of research and development is in decline, a direct result of the Budget Control Act passed by Congress in 2012 that called for cuts to defense and nondefense discretionary funding; we should brace ourselves for an inevitable blow to economic growth. There is a straightforward economic rule operating here: if you cut back on a major input to growth, it will reduce the output. Cuts to the Federal R&D budget will result in lower long-term GDP growth and potentially curtail the historic trend of exponential growth. Sequestration, as proposed, would result in cuts of up to 9.4% for defense spending and 8.2% for non-defense spending, across a decade beginning in 2013. The American Association for the Advancement of Science (AAAS) estimated this could result in a cut of at least $50 billion to federal R&D from FY2013 to FY2017.[xxvi] AAAS found that, in constant 2013 dollars, federal R&D has already declined under Sequestration from $158.5 billion in 2010 to $133.2 billion in 2013.[xxvii] ITIF estimates that, between 2013 and 2021, Sequestration cuts to R&D will result in a loss of U.S. GDP in the range of $203 billion to $860 billion, as well as a loss of or lost opportunity for 450,000 jobs.[xxviii]

Sequestration amounts to an unprecedented departure from the historic levels of U.S. growth in R&D investment that will, if left uncorrected, hobble U.S. innovative capabilities. The impacts beyond 2021 are difficult to project but will most likely consist of lost opportunities: to invent new technologies, launch new companies, create and dominate new industries –and reap the economic rewards. Budget legislation at the end of 2013 (H.J. Res. 59) moderated the effects of Sequestration for FY2014 and FY2015, but Sequestration is set to resume in full force following FY2015, and continuing through 2023. I should emphasize that resolving Sequestration for R&D is not the only effort required. While it is the most visible problem, overall R&D investment was already stagnating in many critical areas well before Sequestration. So the problem of the investment level in federal R&D is a deep one requiring a longer term focus by policymakers in addition to resolving Sequestration.

Conclusion

I have attempted to provide the committee with a framework and key data for understanding four deeply connected issues: the federal role in R&D, the role of science and technology in economic growth, the pivotal role of research universities in the health of this system, and the potential economic effects if we continue to curtail federal research investments.

I am concerned that reductions in federal research will over time place the country on a dangerous downward path. Through its leadership in innovating at the frontier of science and technology, the U.S. built the strongest economy the world has ever seen. We led nearly all the innovation waves of the 20th century, which delivered step-wise economic growth and tremendous advances in quality of life. We should think hard before abandoning this brilliantly effective model, a model of our own invention and a central source of our national success. In a self-reinforcing negative cycle, the economic stresses driving the budget pressures that are pushing down R&D investments will only be exacerbated by declining R&D and falling growth. With an aging population and rising health care costs – the underlying elements driving our federal deficits -- the country urgently needs a growing economy; faced with this national predicament, it is urgent that the nation grasp that curtailing R&D will only increase U.S. deficit problems over time. By the same token, restoring strong federal support for research and innovation offers a useful path to solving our deficit problems. Research and development make up a small portion of all federal expenditures but produce disproportionately large national economic returns.

Thank you for the opportunity to present this testimony. I hope the committee can and will uphold our nation's longstanding bipartisan support for research and development and for the U.S. innovation system as a whole.

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