April 29, 2014
U.S. Senate Committee on Appropriations
Hearing on "Driving Innovation through Federal Investments"

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Chairwoman Mikulski, Ranking Member Shelby and Members of the Committee, it is my distinct privilege to provide written testimony on driving innovation through Federal Investments. I am Dr. Julia Lane, senior managing economist at the American Institutes for Research, the former program Director of the Science of Science and Innovation Policy program at the National Science Foundation, and co-chair of the National Science and Technology Council working group on Science of Science Policy.

Research universities play multiple social and economic roles. In addition to their educational activities, research institutions are simultaneously: (1) sources of cutting edge discoveries in science and engineering fields; (2) engines for economic development, economic growth and entrepreneurship across multiple industries; (3) anchors and sources of economic resilience for their regions. These activities are all facilitated by research investments from institutional, state, and national sources (both public and private). The core questions to be answered in managing those research investments, as with any set of federal investments are: What are the returns to both public and private research? Are they short-term or long-term? Are they purely social or is there also an effect on economic growth and job creation? And how can the federal government foster activities that maximize federal returns?

We are making progress in answering these questions. This progress depends on establishing an empirical relationship between funding investments and subsequent outcomes that is grounded in an understanding of the process of research and innovation. My recent work, published in Science magazine, demonstrates that it is possible to do so by building on the already existing federal and university investment in the STAR METRICS[1] program (Weinberg et al. 2014)

I have three key recommendations to continue this important research:

(1) develop a better evidence framework for analysis by building out the STAR METRICS program nationally;

(2) build better measurement of research investment outputs by linking STAR METRICS data to Census Bureau and United States Patent and Trademark Office data and by using 21st century tools and technologies; and,

(3) foster better dissemination and analysis by explicitly supporting an independent research entity dedicated to examining the empirical link between federal research investments and innovation.

Background

Serious academic work has provided some answers to the question of the returns to investment in R&D. Much of the productivity growth in the 1990's to investments in information technology, which were driven at least partly by investments in basic research (Jorgenson 2001). More

[1] Science and Technology for America's Reinvestment—Measuring the Effects of Research on Innovation, Competitiveness, and Science (https://starmetrics.nih.gov)

recent work suggests that a 1 percent increase in university expenditures in a county increases local labor income in other sectors by 0.08 percent; the spillovers are larger when local universities are more intensively focused on research and when research universities are technologically closer to local firms (Hausman 2012). The Association of American Universities[2] draws a dotted line between research grants and the invention of the Internet and the World Wide Web, MRI's, MP3 players, and Global Positioning Systems(Press 2013). Yet, as Ben Bernanke has pointed out, there is still limited knowledge about how federal support for R&D affects economic activity.

We now have the tools to provide much richer insights into how federal investments can be made more wisely: just as "Moneyball" showed how data could be used to help build better baseball teams, new types of data -- if used wisely and well -- can help us manage science more efficiently, better understand how returns are generated and offer new ways to maximize returns.

The Federal government can do three things to deepen understanding of the returns to federal R&D investments – and, hence, position the United States for a strong scientific future: build a better framework, support better measurement and promote better dissemination and analysis.

Build a better framework

A better framework is already being built and used to study science. Universities and agencies – recognizing the need for accountability - are starting to build a people centered data system, largely inspired by the STAR METRICS project. The data show for the first time the building blocks of research at *the project level*: the people who do the work and the firms who supply the scientific equipment. The approach avoids manual, burdensome reporting, and uses existing data drawn from the human resource records and financial reports of universities. It provides detailed immediate insights into the production of science and can be leveraged to describe much more (Weinberg et al. 2014).

Recommendation: My earlier experience with building the Census Bureau's Longitudinal Employer-Household (LEHD) program[3], a national statistical program which measures job creation and destruction from data drawn from state level administrative records in a fashion similar to the design of the STAR METRICS program, suggests that it is critical to keep the program voluntary and collaborative. However, strong Congressional support will help foster and expand the program which will require both federal and non-federal resources to be successful.

Support better measurement

My recent Science piece documents that the key actors in the process of science are scientists (not only faculty but also post-docs, graduate students, staff scientists and undergraduate students); their activities are what need to be – and can - be measured. Capturing these data is critical - the evidence is clear that scientists and their networks are the drivers of innovation: the vibrant growth of Silicon Valley, Boston, San Diego and the Research Triangle was driven by each region's research institutions and the people within them and by intangible flows of knowledge, such as contacts at conferences, business networking, and the flows of students from the bench to the workplace. One way to think about universities is as an umbrella organization simultaneously fostering the operations of collections of numerous small businesses – university scientific labs and networks – and transferring knowledge both within and inside the university environment. The recent Science piece also showed that the purchases of research equipment quite separately generates much economic activity across the country, as scientific labs buy high tech inputs like genome sequencing machines, lenses for telescopes and computer equipment.

[2] http://www.aau.edu/policy/article.aspx?id=4692 ; www.aau.edu/WorkArea/DownloadAsset.aspx?id=11556

[3] http://lehd.ces.census.gov/

Unfortunately, much current measurement of science, dominated by counts of publications and patents, does not capture the hive of entrepreneurial activity that is actually occurring at our universities. The current approach is flawed for a variety of reasons, including mis-measurement of the process of science, cost and burden. This is a challenge, because although bibliometrics have come to dominate science metrics, they do not measure scientific knowledge and were not designed to describe the scientific enterprise. And continuing to require research institutions and principal investigators to report research outcomes manually is neither practicable nor desirable[4].

Better measurement is now possible, and could be fostered through the establishment of a credible, independent, entity. The entity could build on the core of the STAR METRICS approach, which is to use new digital technologies, that is respectful of the existing data systems of universities, and can be used to capture the data needed to understand and demonstrate the broad scientific, social, economic, and workforce results of Federal S&T investments. Research institutions are already developing structured information architectures to capture current and more accurate information about the interests, activities, and accomplishments of their scholars.[5] An increasing volume and variety of research outputs, such as publications, patents, and datasets, are accessible in digital form, and are harvested via services such as Citeseer, Google Scholar, and Microsoft Academic Search.

STAR METRICS data could then be linked (with appropriate confidentiality protections) to rich data at the Census Bureau. The Census Bureau has a long history of collecting administrative information for its programs; the Census Bureau could use STAR METRICS data to augment and improve Census Bureau programs on innovation measurement and develop new statistical products that demonstrates the impact of funded university research on economic innovation. In particular, the Census Bureau could produce aggregated statistical analysis of the results by integrating STAR METRICS data with the Integrated Longitudinal Business Database, Longitudinal Business Database and LEHD data and measure the results of funded university research in a number of informative ways, to include, for example

1. Regional economic measures of science based innovation (firm startups, firm productivity growth and firm payroll growth) by industry and geography;

2. Regional workforce measures of science based innovation (the employment and wages of scientific staff, including graduate and undergraduate students and postdoctoral fellows); and

3. Measures of innovation through patents and links to U.S. Patent and Trademark Office data.

But measurement is only partly about data. It is also about getting better people to analyze data and develop better measurements. Data and theory develop together. The experience of other fields, for example, the field of labor economics, has been that policy fields can be analytically transformed by the infusion of new scientists to study hard problems. The independent entity should be charged with ensuring just such an infusion – both to foster credible and reproducible results and promote new discovery. In an example of how this might be done, the Business Higher Education Forum is in conversation with the National Academy of Engineering on a potential joint effort to examine the use of exactly these types of administrative records from

[4] A recent study found that poorly integrated federal reporting and other regulations impose a heavy and growing administrative burden on federally funded research. The report argues that this "regulatory overhead" is both large (and getting larger) and inefficient, with many federal reporting requirements overlapping and even conflicting. It estimates that 42% of faculty time relating to federally funded research is spent on administrative duties, rather than on the research itself (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2887040/).

[5] Including, for example, the VIVO Project http://vivoweb.org, the Harvard Profiles System, and others

universities to describe the effects of private and public investments in cybersecurity education on student and business outcomes.

Recommendation: The technology now exists to draw from existing data and tools to measure science better. The approach is eminently feasible and could be used to create new measures of the links between federally funded science and innovation. An independent entity could be formed, with support from both federal and non-federal sources, so that data from a wide variety of sources could be collected, synthesized and, in partnership with the Census Bureau, be used to trace the activities of federally funded researchers in order to create new measures of innovation. That entity should engage with the scientific community to develop those new measures.

Foster better dissemination and analysis Building better measurement and understanding will also involve a building a more scientific approach to the communication of statistically valid information so that decision-makers can better understand the answers to the key questions: What are the returns? And how can the federal government foster activities that increase those returns?

The new world of Big Data provides new and different approaches to conveying information in an intuitive and statistically valid manner. In our early experience with the LEHD program, the On the Map tool (http://onthemap.ces.census.gov/) was useful for policy makers and decision makers because it conveyed detailed information about regional economic activity in an accessible fashion. Early work suggests that the same will be true for this approach. For example, the prototype R&D Dashboard (http://rd-dashboard.nitrd.gov/) was enthusiastically received in the United States; the HELIOS dashboard (http://helios.e-cancer.fr/ password and userid inca) has been well received in France.

Recommendation: New measures linking scientific investment with innovation outcomes should be delivered in visually appealing, easily interpretable and actionable ways.

Summary

Answers to the important questions of what are the returns to federal investment in science, and how can the federal government foster activities that increase those returns have been hamstrung by a limited framework, measurement and dissemination. Although we have learned much from prior analysis, there is a need for large scale, believable, modern evidence so that we can foster the important link between science investments and innovation. The potential exists to develop that evidence, thanks to the substantial federal and university investment in STAR METRICS and the potential to link to important existing datasets at the Census Bureau. I urge the appropriations committee to support providing the additional federal and non-federal resources needed to advance these efforts. I would welcome the opportunity to engage further with the committee on how this might be accomplished. Thank you.

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