What Is the Payoff from Public R&D Investments?

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Pierre Azoulay, Joshua S. Graff Zivin, Danielle Li & Bhaven N. Sampat, *Public R&D Investments and Private-Sector Patenting: Evidence from NIH Funding Rules* (revised 2017), available at NBER.

Intellectual property scholars have increasingly recognized that IP is only one of many legal tools for incentivizing innovation. In addition to facilitating transfers from consumers to innovators through a "shadow tax" on IP-protected goods, the U.S. government also directly rewards innovators with public funds through R&D tax incentives, innovation prizes, and—most significantly—well over $100 billion per year in direct federal and state R&D support. This direct public science funding, which primarily goes to grants and national laboratories, has long been viewed as important to U.S. economic growth. But federal R&D spending has been declining and is the subject of an increasingly partisan divide, making this a key moment to ask: What is the public's return on this investment?

In an outstanding empirical analysis, corresponding author Danielle Li at MIT Sloan and her three coauthors—Pierre Azoulay at Sloan, Joshua Graff Zivin at UC San Diego Economics and Public Policy, and Bhaven Sampat at Columbia Public Health (collectively, "AGL&S")—have tackled this question for grant funding by the U.S. National Institutes of Health (NIH). With a budget of over $30 billion per year for biomedical research, the NIH is the single largest research funder in the world. But assessing the causal impact of this investment is difficult, even when focusing only on its effect on private-sector patents. How can one measure information flows in fields full of serendipity and spillovers? Are grants merely correlated with private-sector advances? Does public funding "crowd out" private investment? AGL&S's empirical design makes progress on each of these issues, and they conclude that each $10 million in NIH funding in fact generates 2.7 additional private-sector patents.

Prior work has studied outcomes in specific areas of NIH grant funding (which misses advances in different fields) or citations to university patents (which misses grant-funded academic results that are not patented). Instead, AGL&S look to *publications* resulting from these grants, and then to patents that cite these publications, which have been shown in a validation against survey results to be a better measure of the influence of public sector research than patent-to-patent citations. Out of the 153,076 NIH grants funded between 1980 and 2005, about 40% led to a publication cited by a patent; and out of the 232,276 private-sector life-science patents issued by the USPTO between 1980 and 2012, about 40% directly cited an NIH-funded publication.

A second empirical challenge is that public funding may target the most promising research areas, so increased grant funding might simply be correlated with increased patenting in that area rather than causing it. AGL&S take on this problem in two ways. First, they classify grants by disease (e.g., cancer), scientific approach (e.g., cell signaling), and time (e.g., 1990), allowing them to include fixed effects to account for these potential sources of endogeneity in funding. Second, they find effectively random variation in funding at the disease/science/time level based on grant applications whose review scores were just above or just below the NIH's funding cutoffs, and they use the "windfall" funding received by a disease/science/time above the cutoffs as an instrument for total funding. Under both approaches, they find that additional funding increases the number of patents that cite NIH-funded publications.

The third challenge noted above is that grant-funded research might crowd out private-sector funding, such that the increase in private-sector follow-on patenting is accompanied by a decrease in patents that do not rely on NIH-funded results. To be clear, substitution of patents with grants is not necessarily problematic from an economic perspective: both are costly, and neither is optimal in all circumstances. But AGL&S show that grant funding spurs rather than substitutes for private-sector R&D. To study this effect, they use a separate dataset of patents that cite publications

related to NIH-funded publications (using a keyword-based similarity measure). If NIH funding merely crowded out private research, the authors argue that one would not expect the award of an NIH grant to increase the number of patents in a research area, but instead, they find an increase here as well.

These results come with a number of caveats, the most important of which is that AGL&S focus on the outcome of only private-sector patenting, which ignores the many other benefits of public biomedical research. In the life sciences, more innovations are probably captured by the patent system than in other fields, but there are certainly medical innovations such as ICU hygiene checklists that have enormous social benefit that is not easily excludable with patents. This problem would be exacerbated in other areas of research, which is one reason that it would be difficult to replicate AGL&S's analysis for grants from other funding agencies.

Of course, even within the life sciences, turning this result into a rate of return is difficult. AGL&S's back-of-the-envelope calculations lead to tentative estimates on the order of a $20–$30 million increase in firm market value for each $10 million NIH grant. The true social rate of return might be significantly higher (e.g., if social value is significantly higher than firm market value, or if firms often build on uncited knowledge) or lower (e.g., if patents frequently cite to papers that are not real intellectual influences). But even if one focuses only on the results that can be determined with more precision—the positive effect on private-sector patenting and the lack of measurable crowding out—the results in this paper are important data points for the increasingly polarized discussion of direct government R&D funding.

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