ARTICLE IN PRESS

Research Policy xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Research Policy

journal homepage: www.elsevier.com/locate/respol

Show me the Money: Federal R & D Support for Academic Chemistry, 1990–2009

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A R T I C L E I N F O

JEL classification:
O3
O32
I23

Keywords:
Chemistry
Research & Development
University
Research funding
Postdoctoral researchers
Innovation

A B S T R A C T

We examine the distribution of Federal support for chemistry Research and Development (R & D) performed at U.S. universities from 1990 to 2009. Federal R & D funding is an essential source of funds for investigator-driven research at the nation's universities. Previous studies have documented that aggregated federal R & D funding has become more dispersed over time and attributed this to political pressure to spread resources more evenly. There have, however, been few studies of the allocation of funds within narrowly defined scientific disciplines. By narrowing the focus and exploiting the panel nature of our data we are better able to analyze the correlates of funding variation, yielding a number of new insights not apparent in studies using more aggregated data. First, we find that R & D expenditures at the discipline level are considerably more volatile than aggregate funding. Second, we show a strong positive association between several measures of institutional research capacity and future funding. In particular, we find a positive association between the employment of postdoctoral researchers and higher future research funding.

1. Introduction

Despite the central role of federal Research & Development (R & D) funding in supporting basic scientific research conducted at the nation's universities, relatively little attention has been given to how these federal funds are allocated. Attracting research funding is important for university leaders not only because it signals the reputation and prestige of their faculty, but because this support typically includes payments for research overhead costs that cannot be allocated to specific research projects. These payments for "Facilities and Administration" (F & A) costs are commonly in the range of 50% or more of the direct costs of the research being performed. For public institutions grappling with shrinking state appropriations and private institutions seeking to control the growth of tuition, this stream of funding has become increasingly important for stabilizing budgets. Collectively the nation's universities advocate for expansion of the federal research budget, while individually they are all seeking to capture a larger slice of the pie and move up in the rankings. This paper studies the allocation of federal research funding in chemistry to research universities, and finds that research capacity is a key determinant of funding.

While it is true that the ultimate goal of federal support for basic research is to advance the frontiers of knowledge, the allocation of federal R & D funds also has a number of other important implications for higher education institutions. Grant funds provide much of the support for the training of doctoral and post-doctoral scholars, so the way in which funds are allocated plays an important role in determining where the next generation of scholars will be educated. At the same time, the linkage between F & A payments and the direct costs of science means that the allocation of funds has implications for the support of scientific infrastructure. Together these factors influence institutional reputations and resources that affect faculty recruiting, and shape the structure of the higher education enterprise.[1]

Most discussions of the allocation of Federal R & D funding have been purely descriptive and concerned with aggregate funding across all disciplines. There has been little attention to the factors that influence the distribution of funding to individual universities. The premise of the merit-review process used by the National Science Foundation (NSF), the National Institutes of Health (NIH) and other federal agencies is that funding should be allocated to support the best science as judged by other scientists. Yet the primacy of merit review has not fully insulated science funding from the pressure of members of Congress seeking to steer more federal science funds to their own districts. These

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[1] Research universities are themselves sources of local economic development spillovers. As attention to the innovation systems that have emerged in Silicon Valley, Route 128 around Boston, the Research Triangle and in Austin, Texas suggests, fostering robust university research enterprises is seen as one key to innovation-led economic growth strategies.

http://dx.doi.org/10.1016/j.respol.2017.06.008
Received 2 January 2017; Received in revised form 22 June 2017; Accepted 28 June 2017
0048-7333/

pressures are manifested both in earmarks for certain projects and in programs like NSF's Experimental Program to Stimulate Competitive Research (EPSCoR) and NIH's Institutional Development Award (IDeA) Program, both of which target funding to scientists in states receiving disproportionately low levels of funding.

Universities are, of course, concerned about their rankings in the National Science Foundation's annual survey of Higher Education R & D Expenditures, citing high levels of funding as a marker of prestige. There is a small literature that has used these aggregate data to explore what might be called the political economy of federal science funding. Geiger and Feller (1995), Graham and Diamond (1997) and Feller (2001) have used aggregate Federal R & D funding to states or universities to document the growth of national research capacity and the expansion of the group of research universities beyond the small group of elite universities that dominated research and graduate training in the 1950s. In the 1950s and 1960s, as a result of federal investments in science after Sputnik, the group of research universities expanded significantly (Graham and Diamond 1997, ch. 2). Since the mid-1970s, however, as the growth of federal R & D funding slowed, the group of research universities has more or less stabilized, and competition between them to move up the rankings has intensified. This literature is, however, more descriptive than analytical, and offers few empirical insights about the factors that influence the distribution of funding across universities or variations in a university's funding over time.

In addition to this work there have also been some studies that explored the interactions between federal and non-federal sources of funding. Mostly this research has been motivated by the question of whether federal funding is a substitute or complement for non-federal funding. Using somewhat different approaches Blume-Kohout et al. (2014), Payne (2001), and Lanahan et al. (2016) have all concluded that increased federal funding tends to increase research expenditures from other sources rather than crowding them out.[2] Ehrenberg et al. (2003) have pointed out that in aggregate, since the 1980s the share of university research expenses supported by federal funds has declined, dropping from over 60% to under 55%. Analyzing panel data for 228 universities, they conclude that universities have responded to the falling levels of federal support by reducing faculty-student ratios, and increasing tuition, in effect subsidizing research expenditures by increasing the costs and reducing the quality of instruction.

Aggregate descriptions of the sort noted above are helpful in sketching the broad outlines of federal research support, but because they combine data on funding across a broad range of scientific disciplines they cannot yield much insight about the factors influencing the patterns that they describe. Wachtel (2000) has analyzed the distribution of the National Science Foundation's funding of economics research. Given that economics funding has been concentrated among a few institutions, he argued that funding decisions are not being made objectively. In contrast, Feinberg and Price (2004) controlled for proposal quality and found that researchers affiliated with the National Bureau of Economic Research (NBER) were more likely to receive funding than otherwise comparable applicants.

Focusing at the level of individual investigators, Ginther et al. (2011, 2012, 2016) examined race/ethnicity and gender differences in the probability of receiving NIH funding. After controlling for several individual and institutional covariates, these studies found that the NIH funding rank of the institution was associated with a higher probability of funding. In other words, the wealthier the institution in terms of NIH funding, the more likely a proposal from an investigator affiliated with that institution was to receive funding. However, these studies do not control for the fact that the best researchers are more likely to be employed by the best-funded institutions.

With the exception of these few studies, we are not aware of other work that has sought to analyze the distribution of federal R & D funding within a single scientific discipline. If we are going to gain greater insight about the factors that influence the allocation of funding, however, it is necessary to study funding at this more disaggregated disciplinary level. In this article we provide what we believe is one of the first empirical examinations of the determinants of the distribution of research funding, examining the factors that influence federally funded R & D expenditures in chemistry at a panel of 147 U.S. universities between 1990 and 2009.

Because of disciplinary differences in publication and citation practices, as well as variation in laboratory structure and organization we believe it is essential that any effort to identify the determinants of funding must be conducted at a disaggregated level, rather than attempting to encompass aggregate R & D Funding. Chemistry provides an excellent area for our exploration. It is a foundational discipline that receives a relatively large level of federal R & D funding, amounting to over $1 billion annually, or close to 4% of federally funded university-performed R & D in the period we are considering. In addition, chemistry research includes a broad range of topics, from fundamental scientific exploration to highly applied areas in biochemistry and chemical engineering. Also, the organization of the Chemistry discipline allowed us to compile the necessary data to analyze inputs in the knowledge production process. The American Chemical Society keeps a roster of members that allows us to identify Chemistry and Chemical engineering faculty at research universities over several decades. These data are not readily available in other disciplines.

Our empirical results offer a number of intriguing and policy-relevant insights about the allocation of funding in this field. First, we document that scientific capacity plays a large role in the distribution of funding. Faculty numbers, graduate program size, and numbers of postdoctoral scholars are all positively associated with Federal R & D funding. Of these relationships, however, only the number of postdoctoral scholars is consistently statistically significant. The effect of an additional postdoc is also economically large, implying an increase in funding of nearly $14,000 in Federal R & D funding. Second, consistent with the focus of most federal agencies on scientific merit, we find holding personnel numbers constant, higher rates of publication are associated with more funding. Third, we find that higher levels of non-federal R & D funding are associated with more federal funding, a result consistent with the complementarity between these funding sources found by Blume-Kohout et al. (2014) and Payne (2001).

We begin in the next section by describing in more detail the data that we use, and present a number of summary and descriptive statistics. We show that federal support for chemistry research is quite unevenly distributed across universities and that the overall size distribution of funding has remained stable over time. Looking at the performance of individual institutions, however, belies the initial impression of stability. The fortunes of particular universities have changed quite a bit since the early 1990s. In Section 3, we introduce a dynamic panel regression framework to systematically analyze the determinants of funding at the university level. This analysis points to several important conclusions. Section 4 places these results in context and considers their significance for our understanding of federal support for university-based R & D.

2. An overview of the research funding landscape for academic chemistry

Our analysis sample consists of the 147 institutions with the highest aggregate value of real federally financed academic chemistry R & D expenditures over the 20-year period from 1990 to 2009. We initially focused on the top 150 institutions, but were subsequently obliged to drop three of them because the available data were incomplete or appeared inconsistent.[3] In aggregate, our sample accounted for over 90% of federally supported and total chemistry R & D expenditures in each year, produced more than 90% of research doctorates earned in

[2] David et al. (2000) survey the literature on the relationship between federal and industrial R & D spending.