The Value Added of Innovation Managers: Evidence from the National Institutes of Health

Christina A. Nguyen*
Massachusetts Institute of Technology

September 20, 2025

Abstract

Allocation of authority to innovation managers is a central question that all R&D organizations face. Giving managers the power to choose the people and projects to which they allocate resources means some loss of control for the principal. However, delegating this responsibility can leverage the experience of skilled managers to make optimal choices. Building on models of authority in organizations, this paper investigates how discretion affects the impacts of innovation managers (program officers) at the National Institutes of Health on the performance of researchers who receive public grant funding. Using value-added measures of managerial quality, I find differences in value added depending on whether I examine first-time grantees versus researchers who have already received a grant in the past. My findings suggest that discretion matters most for the short-term outcomes of first-time grantees. Specifically, variation in value added is more salient for publication quantity when the program officer has discretion than when she does not. However, the opposite is true for their long-run citations and for established grantees overall. Having a program officer with a doctorate degree has a positive impact on value added for investigators' publications.

*MIT Sloan School of Management, 100 Main Street, Cambridge, MA 02142 (Email: canguyen@mit.edu).
I am grateful to Scott Stern and Pierre Azoulay for their mentoring and support. I thank participants of the MIT Organizational Economics Lunch and MIT Sloan Economic Sociology Working Group for helpful comments. I also thank the National Institutes of Health program officers, grant management officers, and grantees who shared their knowledge and experiences with me, as well as the U.S. Office of Personnel Management staff members who helped fulfill my Freedom of Information Act requests for data. This material is based upon work supported by the National Science Foundation Graduate Research Fellowship under Grant No. 2141064.

1 Introduction

Understanding the value added of administrators who are involved in the selection and management of scientific projects is central to innovation. Several recent empirical studies have shown that rules or algorithms may make better choices than human discretion (Paravisini and Schoar 2015; Hoffman, Kahn, and Li 2018). However, classical theories suggest that the allocation of authority can incentivize managers to gather and use information more effectively, ultimately leading to better outcomes for the principal or organization (Aghion and Tirole 1997; Campbell, Epstein, and Martinez-Jerez 2011; Grandy and Hiatt 2020).

Consider the program managers at the Defense Advanced Research Projects Agency (DARPA), where the model is to empower managers by giving them discretion. DARPA hires talented individuals from academia, industry, and other parts of government for three to five year stints to create and build programs of scientists and ideas that push scientific progress and innovation (Defense Advanced Research Projects Agency 2023).[1] A notable example is American psychologist and computer scientist J.C.R. Licklider, who spearheaded a vision for global networking as a then-ARPA program manager; his program led to the development of the Internet (Waldrop 2000; Tietz 2019).

Given the freedom to allocate a budget of $10 million in the 1960s, Licklider funded researchers across the country who worked on time-sharing technology, computer networks, and cloud computing. Specifically, he "took a chance on a soft-spoken visionary he barely knew...who had been thoroughly ignored by his colleagues": Douglas Engelbart, who eventually developed the first computer mouse, hypertext, networked computers, and graphical user interfaces (Waldrop 2000). Licklider both identified and managed a portfolio of people and projects that formed the basis for the Internet and interactive computing.

Another agency in which managers fund and oversee a scientific portfolio to advance science is the National Institutes of Health (NIH). As the largest single funder of biomedical research in the world, the NIH administers $33.3 billion in grants to extramural researchers in universities, medical schools, teaching hospitals, and other research institutions across the U.S. and worldwide (Lauer 2023). Although they similarly manage innovation portfolios, unlike DARPA, not all NIH program officers make decisions about which people and projects receive funding. The discretion of the program officer depends on the Institute.

Each year, the NIH spends $2.2 billion on research management and support (National Institutes of Health 2023b). To my knowledge, there is no empirical evidence of the value added of these program officers. They are administrators who not only keep the NIH running,

[1] Although DARPA focuses on technologies for the military, many of the researchers and projects it supports extend to civilian use.

but also play a central role in management and, in some cases, the selection of grants.

The NIH and its program officers provide a unique setting to study the role of discretion in innovation management. Each of the NIH's 27 Institutes and Centers is a separate organization, with its own Director, research agenda, and funding policy (National Academies of Sciences, Engineering, and Medicine 2015). Of the 24 Institutes that administer grants, 10 use peer review percentile cutoffs while 14 rely on the holistic review of the program officers to decide which PIs and projects get funded.

It is possible there are several benefits to giving program officers discretion. First, the program officer is in the same field as the applicant (or the closest possible), whereas there are individuals in the peer review committee who may not be familiar with the applicant's field nor science. Because of the diversity within the committee, a promising PI and/or application may receive mixed reviews (Pier et al. 2018; Fang, Bowen, and Casadevall 2016) and not meet the percentile cutoff for funding. Having scientific backgrounds themselves, and having read the scientific review officer's summary and possibly heard the discussion first-hand (program officers have the option to attend peer review sessions but not participate), the program officer is able to disentangle conflicting opinions and make a more informed decision.

Second, the program officer considers the direction of the field and the applicant's career development in addition to the scientific and technical merit that the peer reviewers evaluate. The program officer chooses PIs and projects while taking into account both the broader vision of the scientific workforce, the Institute's priorities, and the more granular investment in the individual. In these ways, program officers may be able to better select and manage PIs and projects for a particular outcome (e.g., more publications).

The symbol of giving program officers discretion—showing trust in their judgment—can affect their decision-making behaviors. For example, they may put more effort into obtaining additional information about the choice set (Aghion and Tirole 1997) or learning from historical data (Campbell, Epstein, and Martinez-Jerez 2011). Discretion may also increase their confidence to go against peer reviewers' recommendations and lead to decisions with higher payoffs. A higher- or lower-quality manager can make a large difference in the productivity of the people on her team (Lazear, Shaw, and Stanton 2015).

On the other hand, Institutes may rely on scores for practicality: Institutes receive a large number of applications and may believe that scores do an equally or better job of selecting good projects, so program officers do not add enough value to justify the additional time and effort. Regardless of the Institute's funding policy, program officers are in charge of managing their scientific portfolios from beginning to end.

How does the quality of innovation managers vary when they are given discretion over the

people and projects they supervise versus not? Every R&D organization has its own version of an innovation manager and has to decide whether to give these innovation managers discretion over hiring and utilization of resources. In this paper, I investigate the variation in NIH program officer impact on the short-term (publications) and long-term (long-run citations) outcomes of first-time and established grantees or principal investigators (PIs) when the program officers are given discretion versus not. Specifically, I measure managerial impact and quality in the spirit of value added models. I focus on the PIs of R01 grants, the NIH's main independent research project grant.

Using administrative data from the NIH, I find that program officer discretion matters most for first-time R01 PIs and their publications. Specifically, a 1 standard deviation (SD) improvement in program officer quality raises the normalized publication quantity of first-time R01 PIs by 0.13 SD when the program officer has discretion compared with 0.10 SD without discretion. The reverse is true for their long-run citations. In addition, discretion does not seem to matter for established R01 PIs, where the variation in value added is lower when program officers are given discretion than when they are not, for both innovation outcomes. However, program officer quality is still important for established R01 PIs, with increases in innovation output ranging from 0.03 to 0.21 SD with a higher-quality program officer. Having a program officer with a doctorate degree has a positive impact on value added for PIs' publications.

These results suggest that program officers may be able to help select and manage less experienced or first-time R01 PIs to publish more but not necessarily higher-impact papers. Peer review and scores may be sufficient for selecting the best proposals of established R01 PIs, and program officers can devote more time and energy to managing. Advanced research training in a doctoral program (and possible exposure to applying for grants themselves) explains some of the higher value added of program officers.

Prior research on grant funding has focused on the process and quality of peer review. While peer reviewers may provide external expertise, they may also make biased decisions and miss promising or novel ideas (Boudreau et al. 2016; Li 2017; Azoulay et al. 2019). Program officers are able to use discretion in places that matter, such as for supporting first-time R01 PIs. Many papers have conflated the role of peer review scores and program officers in selection and otherwise overlooked their management impact on outcomes. At the NIH in particular, program officers have often been viewed as being mostly administrative and/or having little intellectual or discretionary input for grants (Piore, Colatat, and Beck Reynolds 2015).

This paper challenges that belief and leverages the heterogeneity of funding policies within the NIH to study program officer discretion and quality. In addition, I link the NIH

administrative data on funded PIs and projects to employee data from the Office of Personnel Management (OPM) obtained through a Freedom of Information Act (FOIA) request. These data allow me to describe program officer characteristics such as education, length of service, and salary, as well as examine which of these characteristics may influence their value added.

This paper is organized as follows. In the next section, I describe the institutional context, discussing the organization of the NIH and its grants process. Section 3 adapts theories in the allocation of authority to account for agent quality and describes the main empirical propositions. Section 4 describes the data, sample construction, and summary statistics. I construct program officer value-added estimates and present the main empirical results in Section 5. Section 6 concludes.

2 Institutional Background

This section describes the institutional framework, with information drawn from both NIH materials and interviews with NIH staff and extramural PIs. The NIH aims to fund innovative and productive research that will lead to new discoveries and scientific progress, traditionally measured by publications and citations. It also provides targeted support for scientists in different stages of their careers to not only encourage scientific progress but also build and maintain the next generation of researchers.

Of the NIH's 27 Institutes and Centers (hereafter Institutes), 24 administer grants to extramural investigators.[2] I focus on PIs who have successfully received at least one R01 grant, the most commonly-used grant program. R01 grants support discrete, circumscribed projects that meet the goals and initiatives of a particular Institute. For example, the National Institute of Allergy and Infectious Diseases strives to understand, treat, and ultimately prevent the myriad infectious, immunologic, and allergic diseases that threaten millions of human lives" (National Institutes of Health 2023c). Although program officers may be more hands-on with contracts or cooperative agreements, I study R01 grants because they account for 57% of NIH grant funding alone (Lauer 2023).

After researchers submit their applications to the NIH, the Center for Scientific Review assigns them to a scientific review officer (and corresponding peer review committee called a "study section") and to a program officer based on topic and focus. Unlike the scientific review officer, the program officer is associated with a specific Institute in which the PI-project will be managed if awarded funding. Both the scientific review officer and program

[2]The National Center for Research Resources (NCRR) was dissolved and National Center for Advancing Translational Sciences (NCATS) was created in 2011. I include NCATS in my analyses but not NCRR because I do not have information on its funding policies.

officer are typically scientists who are subject matter experts (e.g., molecular neurogenetics, organization and delivery of health services).

Applications then go through a multi-stage review process where they are scored on scientific and technical merit and considered against other applications for funding.

2.1 Review and Selection

During the first stage of review, a study section recruited and led by a scientific review officer evaluates the applications on the quality and originality of the proposed project, quality of the research team and lab, scientific rigor, and proposed recruitment plans for women and minorities, if relevant (National Institute on Aging 2022). The scientific review officer is responsible for choosing the peer reviewers, who are mostly academic scientists, based on their expertise in the study section topic. Because each group evaluates multiple applications, the members are usually not all experts in the particular field or method of a given application. The committee of peer reviewers can be either a standing study section with permanent reviewers who serve four- to six-year terms or a Special Emphasis Panel with temporary reviewers who are brought together specifically for a special topic, for a new area of research, or due to regular member conflicts.

After the study section finishes its reviews and scoring, final decisions are made in Council meetings with the Institute Director and program officers; at this point, the scientific review officer and study section are no longer involved. Of the 24 Institutes that award R01 grants, 10 rely primarily on the overall impact scores from the peer review.[3] Each of these Institutes ranks the applications by score and sets percentile cutoffs called paylines based on the projected number of applications and total funding available for that year.

The remaining 14 Institutes rely on the program officer's discretion. The program officer provides a holistic evaluation and makes recommendations for which PIs and projects to fund. Although the Institute Director technically gives the final approval, in most cases this is just a formality (National Academies of Sciences, Engineering, and Medicine 2015).

The program officer has access to the application's scores and qualitative summary (prepared by the scientific review officer) from the peer review stage, as well as any notes she may have taken from the meeting. Program officers may attend the study section, but do not speak or participate in the peer review. If there are concurrent meetings, they may choose to attend the one for the PI or project that is of particular interest to them. One program officer says that she tends to attend the study section for the application that is competing against the highest number of other applications. In addition to the scientific and technical merit

[3] I use funding policies from 2022. A more granular version would be based on how they may have changed from year to year, but the NIH denied a Freedom of Information Act request for this information.

that the study section evaluates, the program officer considers the research priorities of the Institute and special support for different groups like early-stage investigators, minorities, or women. The program officer may also learn information about the work ethic or individual needs of the PI through their communications. For example, one program officer noted that she made a special effort to support the PIs who would otherwise "have to shut their lab down" so that they could "continue growing in their career and making a contribution."

2.2 Management of Awarded PIs and Projects

Funding policies vary by Institute. In some Institutes, the program officer plays a key role in helping PIs get funded; in others, they are more administrative. Regardless of the regime they work under, the program officer oversees the application from the point of receipt all the way to the end of the project if it is funded.

Program officers want to "make sure [they] get what [they] want from that particular application" and are using taxpayers' money effectively. They can also "have a lot of clout" in Institutes where they are given more authority or discretion. However, similar to selection, managing style and effectiveness can vary across program officers. Some program officers communicate with the PIs primarily around their annual progress reports, while others are closer to the PIs they manage and "get calls all the time."

Program officers are able to influence PIs and projects in several ways that ultimately manifest in career development, more publications, and/or higher impact in the scientific community. First, they can provide guidance on the scientific focus and direction (and methods where relevant) of PIs and projects. This is because they stay up to date on new research and are themselves involved in setting research priorities for the Institute. By attending conferences and engaging with both intramural and extramural scientists, they recognize hot topics, areas of innovation, and gaps in the literature. They may also help PIs take a step back from their narrow focus and redirect them to other experimental models or approaches that could be more appropriate or likely to have a positive outcome. For all of these reasons, they can strategically help PIs frame and focus their projects so that they are productive for both the individual scientist and broader aims of the Institute.

Second, program officers hold workshops on certain topics and may invite their PIs to attend. During these workshops, they can bring general awareness to new areas of research or highlight "cool findings that may apply to [their] science but are not yet mainstream." They may also bring in concepts and methods from other fields that could spark new ideas within their own field.

Lastly, program officers may interact and become familiar with not only the main PI but

the larger team of investigators in the project, including the trainees. They can support early-career, established, and even future PIs' entire bodies of work and overall career development. In doing so, they may be able to provide their expertise on potential improvements or changes that could lead to a higher likelihood of publication and/or impact. The NIH wants to fund researchers and projects that could result in new treatments or breakthroughs, but it also emphasizes helping early-stage researchers establish their careers. For early-career PIs, producing publications can be a large factor (as opposed to established researchers who are less concerned about publication quantity). Program officers may select and manage different PIs and projects with these goals in mind.

3 Theoretical Framework

Because each NIH Institute operates as its own entity, it independently decides whether to allocate discretion to program officers or to rely on peer reviewers' scores to select PIs and projects to fund.

There are some potential tradeoffs to allocating authority. Principals may not want to lose their sense of authority even if discretion could result in better outcomes (Fehr, Herz, and Wilkening 2013). From a political standpoint, there may be concerns that giving government officials too much decision-making power allows for subjectivity and creates susceptibility to unfair or biased decisions (Lerner 2000). However, in the case of federal funding, it is possible that the information asymmetries between program officers and study section members could lead to outcomes that are more consistent with the NIH's goals. In addition, delegation may empower or incentivize managers and facilitate learning for better decision-making (Aghion and Tirole 1997; Campbell, Epstein, and Martinez-Jerez 2011).

This paper adapts Aghion and Tirole's (1997) basic model of the allocation of authority and cost of information acquisition to assess the role of managerial discretion; it also considers the quality of the program officers and variation in quality within the NIH. In this setting, there are two regimes: 1) no discretion, where the Institute chooses applications based on scores or ranking compared to other potential applications and 2) discretion, where the program officer chooses which applications to fund. For the purpose of defining the players, let the no discretion regime be represented by the Institute.

3.1 A Model of Authority Allocation and Confidence

The timing is as follows. Ex-ante, the Institute sets a funding policy that is either score-based or discretionary. There is a competitive supply of program officers, but the Institute

does not know if a given program officer is good or bad. Neither party knows the payoffs from choosing a particular application, and whether it is better to allocate authority depends on which regime maximizes the Institute's ex-ante expected utility. After PIs submit their applications, the study section gives the proposals scores and the scientific review officer writes a summary statement of the meeting.

Next, the Institute and program officer privately collect information about the payoffs for each potential application. The investigation often begins with reading and evaluating the summary statements. For the Institute, this involves determining whether the scientific and technical review conducted by the study section was expert, fair, objective, and in compliance with policy. The Institute, program officer, or PI may find issues with the peer review process or study section recommendation. In these cases, the program officer investigates further with the scientific review officer, who may seek clarity by speaking with the initial study section members. Outside of the summary statements, the Institute and program officer may spend time and effort investigating PIs who work in high-impact or high-priority research areas or methods. In addition, the program officer may have one-on-one conversations with individual PIs or learn other information about potential PIs through interactions with the greater scientific community. The program officer may or may not have attended the study section to listen to the reviewers' discussion.

After the investigations, the party that does not have authority communicates the information learned to the controlling party. Finally, the controlling party chooses an application.

Both the Institute and program officer expend some cost to learn the payoffs of the applications. In addition to time and effort, the Institute spends resources on the staff involved in the grants process. If I follow Aghion and Tirole (1997), the Institute and program officer perfectly learn the payoffs of the applications at a cost of $c_I(E)$ and $c_P(e)$ and with a probability of E and e. In their setup, E and e represent the effort invested in learning the payoffs. Instead, I define E and e as the Institute and program officer's self-perceived level of being informed or their self-perceived confidence. In other words, E and e represent the degree to which each player believes his knowledge to reflect the payoffs perfectly. The cost is associated with the time, effort, and resources spent to gain this level of confidence (i.e., through acquiring information). With probability $1 - E$ and $1 - e$, the Institute and program officer are not confident. Both cost functions are increasing and strictly convex in e and E, respectively. In addition, they satisfy $c_j(0) = 0$, $\lim_{e,E\to 0} c_j'(.) \to 0$, and $\lim_{e,E\to 1} c_j'(.) \to \infty$, where $j = \{P, I\}$.

The optimal choice for the Institute yields a private benefit of $B_k > 0$ to the Institute and a private benefit of $\beta b_k > 0$ to the program officer, where $\beta \in (0, 1]$ is the level of congruence between the two parties' preferences from the program officer's perspective. These values

are always positive because whichever application the Institute prefers or chooses yields a positive payoff to the program officer. Similarly, the optimal choice for the program officer yields a private benefit of $b_k > 0$ to the program officer and αB_k to the Institute, where $\alpha \in [-1, 1]$ is the level of congruence from the Institute's perspective. Unlike β, α can be negative because the program officer can make bad choices that yield a negative payoff to the Institute. For example, a program officer can make bad decisions such as choosing a PI who does not produce any papers or long-run citations, but the Institute still spends the same amount of resources on its staff. This is different from Aghion and Tirole, where they define both $\alpha > 0$ and $\beta > 0$. Because the optimal strategy (no discretion or discretion) is the one that maximizes the Institute's utility, I focus on the changes in B_k and α.

Under the no discretion regime, the *ex-ante* utilities of the Institute (u_I^r) and program officer (u_P^r) are

$$\begin{aligned} u_I^r &= [EB - c_I(E)] + (1 - E)e\alpha B \\ u_P^r &= [E\beta b - c_P(e)] + (1 - E)eb \end{aligned} \tag{1}$$

With probability E, the Institute is confident about the payoffs for each individual application and chooses its preferred application. With probability e, the program officer is confident and proposes his preferred application to the Institute. With probability $1 - E$, the Institute is not confident and rubber-stamps the program officer's proposal, but the degree to which this lack of confidence affects the Institute's utility depends on the program officer's own confidence and quality.

Suppose the cost of gaining confidence for the program officer $c_p(e)$ is fixed and that the actual function is different for each program officer depending on his quality, such that the function for a high-quality program officer has $\lim_{e \to 1} c_j(e) \to \infty$ (and $\lim_{e \to 1} c_j'(e) \to \infty$) and the function for a low-quality program officer has $\lim_{e \to 1/2} c_j(e) \to \infty$ (and $\lim_{e \to 1/2} c_j'(e) \to \infty$).

Under the discretion regime, the utilities of the Institute and program officer are

$$\begin{aligned} u_I^d &= [e\alpha B - c_I(E)] + (1 - e)EB \\ u_P^d &= [eb - c_P(e)] + (1 - e)E\beta b \end{aligned} \tag{2}$$

3.2 Variation in Program Officer Value Added

Each program officer makes a set of choices in applications to form his scientific portfolio. Let N be the total number of choices in applications. The quality of the program officer is given by the set of applications or distribution of the corresponding values of α_{PI}.

The total utility for the Institute under the no discretion regime (based on equation 1) can be defined as

$$U_I^r = \sum_{PI=1}^{N} u_I^r = N[EB - c_I(E)] + \sum_{PI=1}^{N} (1-E)e\alpha_{PI}B$$

Suppose that the confidence of all program officers in a given Institute is the same. The total utility for the Institute becomes

$$U_I^r = N[EB - c_I(E)] + (1-E)eB \sum_{PI=1}^{N} \alpha_{PI} \tag{3}$$

and thus depends on the distribution of α_{PI}. A low-quality program officer has high confidence e but makes uninformed (random) decisions and the values of α_{PI} form a uniform distribution. A high-quality program officer has high confidence e and makes informed decisions where $\lim_{\alpha_{PI} \to \infty} F(\alpha_{PI}) \to 1$.

Similarly, the total utility for the Institute under the discretion regime (based on equation 2) is

$$\begin{aligned} U_I^d &= \sum_{PI=1}^{N} u_I^d = \sum_{PI=1}^{N} e\alpha_{PI}B + N[(1-e)EB - c_I(E)] \\ &= eB \sum_{PI=1}^{N} \alpha_{PI} + N[(1-e)EB - c_I(E)] \end{aligned} \tag{4}$$

The primary comparative static of interest is the variation in program officer value added when the Institute gives the program officer discretion versus not. This can be summarized in propositions 1 and 2:

Proposition 1 *There is more variance in value added for a low-quality program officer who has high confidence and makes bad or uninformed decisions (α_{PI} can be positive or negative) compared to a high-quality program officer whose distribution of α_{PI} has an expected value of 1.*

Proposition 2 *Variation in outcomes under discretion is higher than with no discretion because $\sum_{PI=1}^{N} \alpha_{PI}$ in equation 3 is multiplied by a value less than 1. All other terms are constant in equations 3 and 4, so they do not affect the variance of the distribution.*

I am interested in the differences in variation in program officer value added under discretion versus no discretion for 1) first-time versus established R01 PIs and 2) their publication

quantity versus long-run impact (number of papers in the 5th percentile of citations). I hypothesize that the variation in value added is higher when program officers are given discretion than not for the publications of first-time R01 PIs and for the long-run citations of established R01 PIs. It is beneficial for first-time R01 PIs to publish more, while established R01 PIs are less concerned about publication quantity and chase big discoveries; when program officers have discretion, they can help optimize for these different goals.

4 Data

I combine administrative data on funded PIs and projects from the NIH, publication data from PubMed, citation data from Web of Science, and government employee data from OPM. In this section, I first describe the various data sources, variables, and structure of the analytical dataset. I then present relevant summary statistics.

4.1 PIs, Projects, and Program Officers

I use NIH's ExPORTER as my primary source for administrative data on funded PIs and projects and their respective program officers (National Institutes of Health 2023a). To better attribute innovation outcomes and program officer value added to a particular time period, I collapse the fiscal years into grant cycles. A new grant cycle begins with a new, renewal, or competing revision application. A new application is the initial request for funding, and a renewal or competing revision application is a request for additional funding after or during the originally approved grant period, respectively. Each of these application types compete with all other submitted applications for funding in that fiscal year. Other application types, such as noncompeting continuations or previously-approved requests, fall under the existing grant cycle. Table A1 shows the grant cycle construction for a sample PI-project.

For project characteristics, I aggregate the project funding to the grant cycle level and compute length as the number of years in a given grant cycle. I define cohort year as the fiscal year in which the application was awarded funding.

4.2 Institute-Specific Funding Policies

I categorize program officers with and without discretion based on their Institutes' funding policies as of 2022. While every Institute follows the peer review process outlined in Section 2.1, the second stage of review can range from funding all applications that meet the payline without additional review to not setting a payline at all and using the program officer's discretion.

I designate Institutes that fund all or most applications by percentile as those that do not give program officers discretion.[4] I include Institutes that do not set a payline but fund applications based on percentile order and/or expect to fund most applications that meet a certain percentile. For example, the National Institute of Mental Health does not set a payline, but funds in percentile order up to the 10th percentile and "pending a final budget...three-fourths of applications under the 20th percentile and many applications up to the 25th percentile for new and early stage investigators" (National Institute of Mental Health 2023).

I designate the remaining Institutes that do not set a payline as those that do allocate discretion to the program officers. These Institutes rely on the program officers' holistic evaluations, which consider "innovation, impact score, timeliness of the project, mentor(s) supported by the [Institute], availability of resources, and responsiveness to the program priorities," to make funding decisions (National Human Genome Research Institute 2022).

Many of the smaller Institutes choose to use discretion; it is likely more feasible for smaller Institutes that receive fewer applications to have this additional stage of review (Figure 1). Institutes that give program officers discretion have overall less funding, fewer awarded applications, and funding per project (Figure A1). Although the number of awarded applications has stayed relatively constant over time for both Institutes with and without discretion, only those with discretion have seen growth in overall funding and funding per project.

The raw data on which applications get funded by percentile show that there is more variation in the percentiles of the applications that get funded in the Institutes with no discretion versus discretion (National Institute of Health 2023). This variation suggests that program officers use discretion in selection when they are given the option and do not solely rely on scores or ranking.

4.3 Program Officer Characteristics

Using government employee data I obtained from OPM through a FOIA request, I match each NIH program officer to his or her location, occupation, age, education level, adjusted basic pay, pay plan and pay grade, type of appointment, work schedule, and supervisory status.

I use age (<35, 35-44, 45-54, and 55+ years), length of service (<5, 5-14, 15+ years), and whether the program officer has a doctorate (including medical) degree, works in the life sciences, and has internal managerial responsibilities in my analyses. Because a small

[4]Institutes may have a few exceptions (selective pay) that are awarded funding depending on leftover funds and holistic review (some Institutes may also have a specific percentage set aside for selective pay).

percentage of program officers with multiple degrees (MD/PhD) are listed with either a professional or doctorate degree (but not both), I combine professional and doctorate degrees into one category.[5] Next, I use a combination of OPM and Bruce and de Figueiredo's (2020) definitions of scientists to categorize them into scientific fields. Finally, although all program officers are managers of scientific portfolios, some also have internal supervisory responsibilities as part of their roles. Specifically, I identify managers as those who fall under "agency management,"[6] meeting the minimum requirements for Supervisor or Management Official as defined in the General Schedule Supervisory Guide and 5 U.S.C. 7104 (U.S. Office of Personnel Management 1998).

The OPM data are recorded at the end of every fiscal quarter, so I keep the most recent data for each program officer. Individuals were disambiguated for 2000 to 2013 and part of 2014, but because of federal data concerns, were de-identified for the remainder of 2014 to 2018. There are some challenges with disambiguating the later years, such as some discrepancies in the data and different data structures, so I am still finalizing this. For now, I am presenting results using program officer characteristics from 2000 to 2014 only.

I match program officers from the NIH data to OPM using first, middle, and last name. Specifically, I link the program officers in ExPORTER to a subset of the OPM data that includes only those who have an appointment at the NIH between 2000 and 2014. In some cases, the names in the NIH administrative and OPM data do not match exactly because of nicknames, misspellings, or different variations (e.g., marriage). For these cases and for names that appear multiple times and are likely different individuals, I find matches by hand based on web searches and OPM characteristics such as age, degree, field, occupation, and location.

If there is no plausible candidate in the OPM data, I leave the program officer unmatched. I am able to match about 90% of the program officers in the NIH administrative data with federal employees in the OPM data. The unmatched individuals are due to first names that include only initials from OPM; nicknames that cannot be verified; and omissions from the OPM data due to privacy, security, and other undisclosed reasons. If I am able to identify the program officer in OPM, but the year does not match up exactly with what is in ExPORTER,

[5] About 7% of program officers have a professional degree. This percentage is based on the program officers that match into the final sample. Because the value-added estimates are at the program officer-grant cycle-discretion level, I use the program officer's characteristics from the latest year in the grant cycle (across all PI-projects). The OPM data do not distinguish between professional degrees (e.g., MD, JD, PharmD), but individual web searches show that they are mostly medical degrees.

[6] "Agency management" includes the "agency head and all management officials, supervisors, and other representatives of management having authority to act for the agency on any matters relating to the implementation of the agency labor-management relations program established under [5 U.S.C.]" (U.S. Code 1995).

I use the closest year of data. This happens in less than a quarter of cases.

4.4 Innovation Metrics

I focus on two main innovation outcomes: publications and long-run citations. I use the ExPORTER data to identify papers that acknowledge a given grant and attribute it to the PI, project, and grant cycle. For publications, I compute the quantity or number of articles as a measure of short-term outcomes. I compute the number of articles that fall into the top 5% of the distribution of citations accrued by 2021, compared to all of the other articles published in the same year, as a measure of long-run impact. All outcomes are aggregated up to the grant cycle level and normalized to have a mean of zero and standard deviation of one by grant cycle and cohort year. This process parallels normalizing students' test results by year and grade in the teacher value added literature.

I also include prior performance as one of my independent variables. To measure prior performance for PI-projects in the first grant cycle, I create proxy measures using the aggregate publications and long-run impact of the individual PI in the two years preceding the award year. I link PIs from the NIH database to publications from PubMed and citations from Web of Science using different variations of their first, middle, and last names and association with at least one paper that acknowledged the grant. For disambiguated authors and their publications in PubMed, I use Torvik and Smalheiser's (2018) Author-ity dataset.

4.5 Sample Construction and Summary Statistics

To analyze managerial impact in the spirit of value added, I construct a dataset that is at the project-PI-grant cycle level, where each project-PI has a first grant cycle that began in 2000 or later and a second grant cycle that ended in 2018 or earlier.

I focus on the first two grant cycles for each PI-project for a couple of reasons. First, I am interested in the program officer value added that comes from the initial selection and management of a PI-project. For example, it is difficult to interpret the meaning of value added moving from grant cycle 2 to 3. Second, many applications do not get renewed (Lauer 2016). To keep my measurement of value added consistent and to maximize the number of PI-projects in my sample, I include only those projects that successfully competed for additional funding at least once.

Further, I include only R01s and assign each project to its corresponding contact PI if it is a multi-PI grant. I drop projects that appear to have incomplete data, such as those that are missing support year one. To minimize potential confounding variables, I drop the PI-project if there was any switch in PI, administering Institute, or program officer. I also

drop the PI-project if the program officer switched from an Institute that allocated authority to an Institute that did not allocate authority or vice versa.

My final sample includes 5,593 PI-projects managed by 549 program officers from 2000 to 2018. Of these program officers, 40% have discretion and 60% do not.

Table 1 presents summary statistics for the sample used to estimate the value-added models. PI-projects have a mean grant cycle budget of $1.06 million (standard deviation [SD] = $850,000), with a mean grant cycle length of 1.85 (SD = 1.07) years. A program officer has an average of 18 PI-projects (SD = 15) in her portfolio.

Table 2 presents descriptive statistics on the program officer characteristics. Over three-quarters of program officers have a doctorate degree, with most being older and having worked in the government for a long time. The majority are in the life sciences.

5 Results

I estimate the impact of program officers in the spirit of value-added models (Kane and Staiger 2008; Jacob and Lefgren 2008; Chetty, Friedman, and Rockoff 2014b; 2014a). Value-added estimation is widely used in education to measure teacher effectiveness and to identify high-quality teachers. Specifically, the models predict the student's test score based on prior performance and demographic characteristics such as age, gender, and free or reduced price lunch status. Traditional teacher value-added models assume that students are randomly assigned to teachers and classrooms. I do not rely on this random assignment assumption and use value added primarily as a way to describe the effect that program officers can have on PIs' innovation outcomes. In my setting, the teacher is the program officer and the student is the PI-project.

To estimate program officer value added, I follow three main steps: 1) residual construction, 2) variance estimation, and 3) value-added prediction.

Step 1: Residual construction

In step 1, I regress the innovation outcome Y_{ijt} on observable characteristics X_i and compute residuals, where i is a PI-project (hereafter project), j is a program officer, and t is a grant cycle, defined as all of the years associated with a new or competing application. The observable characteristics in X_i include a cubic polynomial in prior performance[7] corresponding to the outcome, grant cycle budget, grant cycle length, and cohort year and grant cycle dummies. I also include program officer fixed effects α_j. I run an ordinary least squares

[7]Prior performance for grant cycle two is the PI-project performance in grant cycle one. Prior performance for grant cycle one is the PI's individual performance in the two years prior to the start year; I choose two years because that is the average grant cycle length.

regression separately for first-time versus established R01 PIs and by discretion versus no discretion:

$$Y_{ijt} = \alpha_j + X_i\beta + \epsilon_{ijt} \tag{5}$$

Then, I estimate residual performance measures:

$$\hat{\theta}_{jt} = Y_{ijt} - X_i\hat{\beta}$$

Step 2: Variance estimation

In step 2, I decompose the variance of the residuals:

$$\hat{\epsilon}_{ijt} = \theta_j + \mu_{jt} + \eta_{ijt},$$

where θ_j is a program officer effect, μ_{jt} is a program officer-year (portfolio) effect, and η is a project error term.

I estimate the variance of the program officer component using the covariance between mean residuals, weighted by the portfolio size, across the two grant cycles of data:

$$\hat{\sigma}^2_\theta = cov(\hat{\theta}_{j,t}, \hat{\theta}_{j,t+1})$$

More recent work (Chetty, Friedman, and Rockoff 2014b; 2014a) estimates variance components allowing for "drift" in teacher effectiveness, where the covariance in teacher effects across time depends on the number of elapsed years. This is not possible with two years or two grant cycles of data (Backes et al. 2022).

Step 3: Value-added prediction

In step 3, I construct a value-added estimate for each program officer j in each grant cycle t:

$$\hat{\theta}_{j,-t} = \Omega_{jt}\hat{\mu}_{j,-t}$$

where Ω_{jt} is a vector of inverse precision weights. I standardize the value-added estimates against the distribution of program officer effectiveness using $\hat{\sigma}^2_\theta$ as an estimate of the variability of program officer effects. This prediction is a proxy for a program officer's value added.

5.1 Program Officer Value Added Estimates

I document that higher-quality program officers have a non-zero and positive impact on the innovation outcomes of R01 researchers. The dispersion in value added represents the degree to which improvements in program officer quality are able to increase publications and long-run citations.

I find that discretion matters most for the short-term outcomes of first-time R01 PIs. Specifically, a 1 SD improvement in program officer value added corresponds to a 0.13 SD increase in normalized publications for first-time R01 PIs under discretion, compared with a 0.10 SD increase under no discretion (Figure 2a). In other words, the difference between getting a 25th versus 75th percentile program officer with discretion would mean an increase of 0.13 SD for the average PI-project compared with similar PI-projects in a grant cycle. These magnitudes of program officer value added are consistent with those found in teacher value added studies (e.g., Chetty, Friedman, and Rockoff 2014b).

Although an improvement in the quality of program officers who are given discretion raises publication output more than those who are not given discretion, the opposite is true for number of high-impact papers. A 1 SD improvement in program officer value added is associated with a 0.04 SD increase in normalized long-run citations under discretion, less than half of the increase (0.09 SD) under no discretion (Figure 2b).

It is possible that program officers with discretion optimize for higher quantity but potentially lower-quality papers for early-stage researchers. Many study section reviewers weigh publication record heavily because it is one of the most accessible pieces of information on an R01 application. However, program officers with discretion are able to consciously weigh publications less heavily during selection, as well as facilitate projects they think are likely to produce papers. Program officer discretion could thus benefit the PI's career development and strengthen the PI's publication history for future applications that would also undergo peer review. The reverse result for long-run citations (lower variation in value added with discretion than without discretion) suggests that program officers may focus on helping first-time R01 PIs publish more but not necessarily high-impact papers.

The NIH emphasizes support for early-stage investigators both for specific projects and for overall career development, and Institutes that give program officers discretion make an extra effort to not go strictly by percentile and to review applications more carefully. For example, although "review panels at [the Center for Scientific Review] are instructed to give special attention to new investigators," program officers at the National Eye Institute "often give a second look to make sure first time [sic] grantees don't fall through the cracks."

Discretion for program officers is not as important for established R01 PIs. The variation in value added when program officers have discretion is lower than when they do not have

discretion, especially for publications (Figure 3). A 1 SD improvement in program officer quality is associated with a 0.03 SD increase in normalized publications under discretion, compared with a 0.21 SD increase under no discretion. This trend holds for long-run citations, but the difference between variation under discretion and no discretion is smaller (0.11 SD under discretion compared with 0.12 SD under no discretion). These magnitudes are substantial, especially the 0.21 SD increase in publications under no discretion, showing that quality is still very important for established R01 PIs.

Figure 4 summarizes these results.

5.2 Are These Differences Statistically Significant?

I use nonparametric bootstrap to compute the standard errors of the standard deviations of the distributions of value added with versus without discretion. I then use a t-test to see whether the difference between the standard deviations are statistically significant. Specifically, I take the following steps, for first-time and established PIs separately:

1. Start with the sample of value-added estimates for each of the two groups: 1) no discretion or 2) discretion.
2. Re-sample from value-added estimates with replacement from each group to obtain another set of value-added estimates for with/without discretion, corresponding to the original number of observations in each group.
3. Take the standard deviation of each group.
4. Repeat this process 1,000 times.
5. Conduct a t-test to compare the standard deviations between the groups from the bootstrapped samples.

I find that all of the differences between the standard deviations of value added under discretion and no discretion are statistically significant for both sets of outcomes and PIs.

5.3 Effect of Program Officer Characteristics on Value Added

To examine the effect of program officer characteristics on value added, I run a basic OLS:

$$Y_{jt} = X_{jt}\beta + \epsilon_{jt} \tag{6}$$

where Y_{jt} is the program officer value-added estimate and X_{jt} is a set of program officer characteristics, including age, length of service, has a doctorate degree, works in the life

sciences, and is a manager. Standard errors are clustered at the portfolio level. Because the value-added estimates are at the program officer-grant cycle-discretion level, I use the program officer's characteristics from the latest year in the grant cycle (across all PI-projects).

The characteristics do not explain the program officers' value added and are mostly not statistically significant, except for having a doctorate degree, which has a positive impact on the value added on PIs' publications (Table 3).

6 Conclusion

In this paper, I draw on theoretical work from organizational economics and leverage the variation in funding policies within the NIH to study the impact of managerial discretion and value added on innovation. My results imply that improvements in program officer quality can raise innovation outcomes, but that impact varies depending on whether we are interested in short- or long-term outcomes and for first-time or established R01 PIs. I find that discretion is important for the program officer's impact on publications for first-time R01 PIs, but is not as important for long-run citations and for established R01 PIs. Nevertheless, this documentation of program officer value added supports the idea that, while they are administrators, program officers are not purely administrative. When given discretion, they can make decisions that influence the publications of less-experienced PIs. Overall, having higher-quality program officers can positively impact innovation outcomes across the board.

These results are different from what we might expect based on theory but consistent with related empirical studies. Although higher-quality program officers with discretion have a positive impact on innovation outcomes overall, these impacts are generally lower than if they did not have discretion. Theory suggests that discretion would matter for both groups of PIs and outcomes. For example, discretion could be important for first-time R01 PIs because they are less experienced or have weaker publication records and could benefit from some lenience during selection and from guidance during project management. For established R01 PIs, program officers that have discretion and existing relationships with the PIs may be able to support any lower-scored applications (or help with other funding barriers) during selection and be more familiar with the PIs' work during management.

In a related study, Ginther and Heggeness (2020) found that trainees recommended by peer reviewers had higher rates of future attempted and successful applications for research awards compared with those that NIH staff selected in disagreement with their recommendations. The authors define discretion as "skipping over" applications that would have been funded based on their scores or "reaching for" applications that would not have been funded. Their setup assumes that NIH staff have discretion across Institutes and applications, and

that they exercise discretion when they go against the recommendations of peer review. In this paper, I highlight the independence of the Institutes and broaden the definition of managerial discretion. Consistent with their findings, I find that discretion may not be as important in some settings (for established R01 PIs and for long-run citations).

Empirical work on program directors at the the US Department of Energy's Advanced Research Projects Agency – Energy (ARPA-E) has shown that having discretion has a positive influence on short-term productivity (Goldstein and Kearney 2020). Like program officers with discretion, ARPA-E program directors are involved in selection and management, but also in developing agency goals and ensuring that their portfolios serve the missions of the agency. Empowering ARPA-E program directors by allowing them to adjust budgets and timelines as they see fit is similar to giving NIH program officers discretion. At the NIH, program officers assess annual reports (interactions between program officers and PIs during the year varies) and decide whether to support the PIs who seek additional funding. I find that higher-quality program officers are more likely to influence short-term than long-term outcomes.

I add to this literature on discretion and federal innovation managers by showing that there is significant value added by NIH program officers overall, and that this value added varies by both discretion and career stage of independent researchers (in contrast to trainees). I also find that program officers having a doctorate degree has a positive effect on their value added for PIs' publications.

This study has several limitations. First, I measure program officer value added using only funded (and renewed) projects and do not have data on unfunded or unsuccessful applications. Some may argue that program officers play a larger role in either selection or management. However, without access to the unsuccessful applications, I am unable to separate these effects. I also exclude a proportion of projects because many do not get renewed (Lauer 2016). Second, I define discretion as a binary variable based on Institute funding policies from 2022, but policies could have changed over time. One option would be to measure discretion as a continuous variable using percentage of exception grants or by year, but these data are not available for all of the Institutes and years in my time frame. From the information that is available, I have found that changes in funding policy from year to year are generally minor. Lastly, program officers may help PIs revise their unsuccessful applications for resubmission; I do not observe these actions.

Because the NIH has Institutes with different funding practices and a long record of administrative data, I am able to compare the impact of program officers with and without discretion on both short- and long-term outcomes. My results have several implications. First, they support the NIH's administrative staff costs and shed light on the potential

for administrators to have an impact on innovation outcomes. Second, I start the process of identifying the characteristics of high-quality program officers that could inform future hiring decisions to maximize their impact. Institutes could benefit from training programs or initiatives that help program officers improve their selection and management of their portfolios. Third, while the quality of program officers is important for management, perhaps discretion or holistic review does not add a lot to the evaluation that peer review already provides for selection, particularly for established R01 PIs.

Innovation managers exist in every R&D organization and are more administrative in some compared with others. By identifying a new source of variation in a well-studied setting—the NIH and federal funding—and combining it with government personnel data, I am able to study the role of program officers and managerial discretion. Program officers have often been considered secondary to peer reviewers or otherwise overlooked outside of their administrative duties. Quantifying the value added of program officers on innovation outcomes and highlighting the patterns in which they may strategically influence outcomes for different groups of PIs underscores the importance of high-quality innovation managers and considering discretion for administrators.

References

Aghion, Philippe, and Jean Tirole. 1997. "Formal and Real Authority in Organizations." *Journal of Political Economy* 105 (1): 1–29.

Azoulay, Pierre, Joshua S Graff Zivin, Danielle Li, and Bhaven N Sampat. 2019. "Public R&D Investments and Private-sector Patenting: Evidence from NIH Funding Rules." *The Review of Economic Studies* 86, no. 1 (January): 117–152.

Backes, Ben, James Cowan, Dan Goldhaber, and Roddy Theobald. 2022. *Teachers and School Climate: Effects on Student Outcomes and Academic Disparities.* CALDER Working Paper 274-1022. American Institutes for Research.

Boudreau, Kevin J., Eva C. Guinan, Karim R. Lakhani, and Christoph Riedl. 2016. "Looking Across and Looking Beyond the Knowledge Frontier: Intellectual Distance, Novelty, and Resource Allocation in Science." *Management Science* 62 (10): 2765–2783.

Bruce, Joshua R, and John M de Figueiredo. 2020. "Innovation in Government." *Working Paper* (May).

Campbell, Dennis, Marc J. Epstein, and F. Asis Martinez-Jerez. 2011. "The Learning Effects of Monitoring." *The Accounting Review* 86 (6): 1909–1934.

Chetty, Raj, John N. Friedman, and Jonah E. Rockoff. 2014a. "Measuring the Impacts of Teachers I: Evaluating Bias in Teacher Value-Added Estimates." *American Economic Review* 104 (9): 2593–2632.

———. 2014b. "Measuring the Impacts of Teachers II: Teacher Value-Added and Student Outcomes in Adulthood." *American Economic Review* 104 (9): 2633–2679.

Defense Advanced Research Projects Agency. 2023. *DARPA's Commitment to Small Businesses.* https://www.darpa.mil/work-with-us/commitment-to-small-businesses.

Fang, Ferric C, Anthony Bowen, and Arturo Casadevall. 2016. "NIH peer review percentile scores are poorly predictive of grant productivity." *eLife* 5:e13323.

Fehr, Ernst, Holger Herz, and Tom Wilkening. 2013. "The Lure of Authority: Motivation and Incentive Effects of Power." *American Economic Review* 103, no. 4 (June): 1325–1359.

Ginther, Donna K., and Misty L. Heggeness. 2020. "Administrative discretion in scientific funding: Evidence from a prestigious postdoctoral training program." *Research Policy* 49 (4).

Goldstein, Anna P., and Michael Kearney. 2020. "Know when to fold 'em: An empirical description of risk management in public research funding." *Research Policy* 49 (1): 103873.

Grandy, Jake B., and Shon R. Hiatt. 2020. "State Agency Discretion and Entrepreneurship in Regulated Markets." *Administrative Science Quarterly* 65 (4): 1092–1131.

Hoffman, Mitchell, Lisa B Kahn, and Danielle Li. 2018. "Discretion in Hiring*." *The Quarterly Journal of Economics* 133 (2): 765–800.

Jacob, Brian A., and Lars Lefgren. 2008. "Can Principals Identify Effective Teachers? Evidence on Subjective Performance Evaluation in Education." *Journal of Labor Economics* 26 (1): 101–136. ISSN: 0734-306X, 1537-5307.

Kane, Thomas, and Douglas Staiger. 2008. *Estimating Teacher Impacts on Student Achievement: An Experimental Evaluation.* Technical report w14607. Cambridge, MA: National Bureau of Economic Research. https://doi.org/10.3386/w14607.

Lauer, Mike. 2016. *Are Attempts at Renewal Successful?* Accessed May 15, 2023. https://nexus.od.nih.gov/all/2016/02/16/are-attempts-at-renewal-successful/.

———. 2023. *FY 2022 By the Numbers: Extramural Grant Investments in Research.* https://nexus.od.nih.gov/all/2023/03/01/fy-2022-by-the-numbers-extramural-grant-investments-in-research/.

Lazear, Edward P, Kathryn L Shaw, and Christopher T Stanton. 2015. "The Value of Bosses." *Journal of Labor Economics.*

Lerner, Josh. 2000. *150 Years of Patent Office Practice.* Technical report w7477. Cambridge, MA: National Bureau of Economic Research.

Li, Danielle. 2017. "Expertise versus Bias in Evaluation: Evidence from the NIH." *American Economic Journal: Applied Economics* 9, no. 2 (April): 60–92.

National Academies of Sciences, Engineering, and Medicine. 2015. *SBIR/STTR at the National Institutes of Health.* Pages: 21811. Washington, D.C.: National Academies Press, December. https://doi.org/10.17226/21811.

National Human Genome Research Institute. 2022. *FY2022 NHGRI Funding Policy.* https://www.genome.gov/about-nhgri/Policies-Guidance/funding-policy/FY2022.

National Institute of Health. 2023. *Funding Patterns by Institute or Center (IC).* Accessed May 30, 2023. https://report.nih.gov/nihdatabook/category/23.

National Institute of Mental Health. 2023. *FY 2023 Interim Funding Strategy for Research Grants.* Accessed August 28, 2023. https://www.nimh.nih.gov/funding/grant-writing-and-application-process/fy-2022-funding-strategy-for-research-grants.

National Institute on Aging. 2022. *The Process of Getting an NIH Grant,* June. Accessed August 25, 2023. https://www.nia.nih.gov/research/grants-funding/process-getting-nih-grant.

National Institutes of Health. 2023a. *ExPORTER,* June. https://reporter.nih.gov/exporter.

———. 2023b. *FY 2022-2024 Supplementary Tables.* Technical report. https://officeofbudget.od.nih.gov/pdfs/FY24/br/Overview%20of%20FY%202024%20Supplementary%20Tables.pdf.

———. 2023c. *List of Institutes and Centers,* July. https://www.nih.gov/institutes-nih/list-institutes-centers.

Paravisini, Daniel, and Antoinette Schoar. 2015. *The Incentive Effect of Scores: Randomized Evidence from Credit Committees.* Technical report w19303. Cambridge, MA: National Bureau of Economic Research. https://doi.org/10.3386/w19303.

Pier, Elizabeth L., Markus Brauer, Amarette Filut, Anna Kaatz, Joshua Raclaw, Mitchell J. Nathan, Cecilia E. Ford, and Molly Carnes. 2018. "Low agreement among reviewers evaluating the same NIH grant applications." *Proceedings of the National Academy of Sciences* 115, no. 12 (March): 2952–2957.

Piore, Michael J, Phech Colatat, and Elisabeth Beck Reynolds. 2015. "NSF and DARPA as Models for Research Funding: An Institutional Analysis." *MIT Industrial Performance Center,* Working Paper Series.

Tietz, Tabea. 2019. *J.C.R. Licklider and Interactive Computing,* March. Accessed March 18, 2023. http://scihi.org/licklider-interactive-computing-arpanet/.

U.S. Code. 1995. *5 U.S.C. Government Organization and Employees S7103a.* Technical report.

U.S. Office of Personnel Management. 1998. *General Schedule Leader Grade Evaluation Guide.* Technical report.

Waldrop, M. Mitchell. 2000. *Computing's Johnny Appleseed,* January. Accessed March 18, 2023. https://www.technologyreview.com/2000/01/01/236431/computings-johnny-appleseed/.

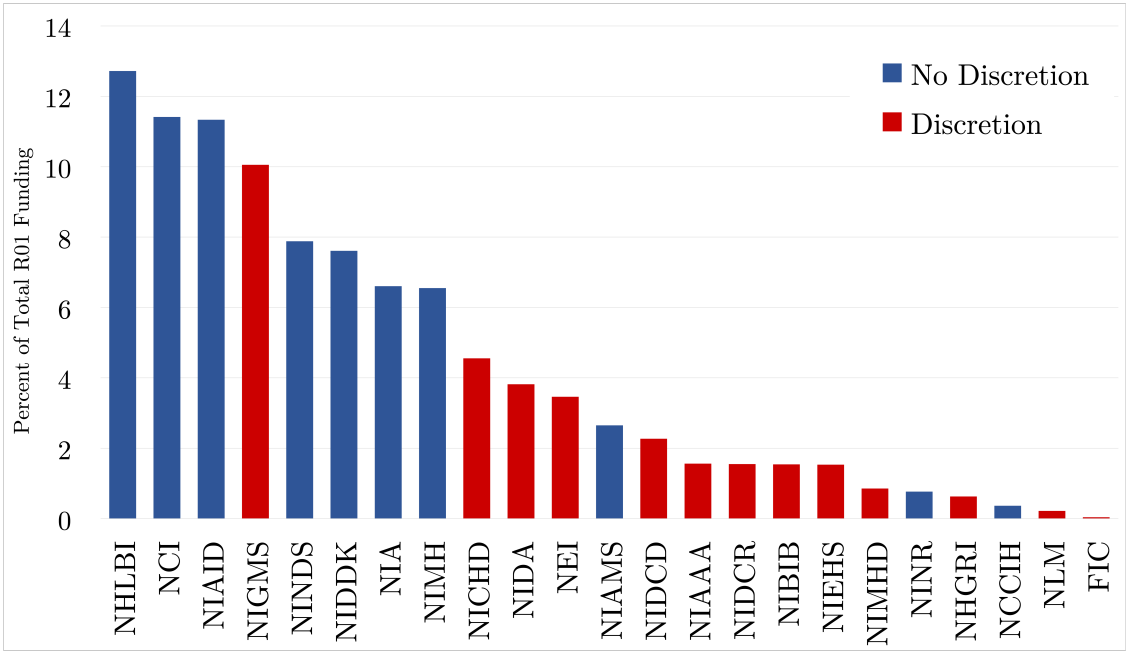


Figure 1: Discretion by Institute

Notes: This graph shows the NIH Institutes that do and do not give program officers discretion, ordered from highest to lowest proportion of total R01 funding in 2018. Discretion is measured at the Institute level and are based on current policies. NCI and NIAID have more overall funding than NHLBI because this graph focuses only on funding for R01 grants. NCATS is omitted because it did not support any R01 grants in 2018. NCRR is also omitted in all analyses because it was dissolved in 2012 and I do not have information on its funding policies.

Table 1: Summary Statistics for Sample Used to Estimate Value-Added Model

Variable	Mean	SD	N
Publications	5.26	7.49	11,157
Publications in 5th percentile	0.94	2.21	11,157
Prior publications	8.11	9.38	11,157
Prior publications in 5th percentile	1.34	2.53	11,157
Cohort year	2007	4.32	11,157
Grant cycle budget (millions)	$1.06	0.85	11,157
Grant cycle length	1.85	1.07	11,157
Portfolio size	18.47	14.84	11,157

Notes: All innovation variables are aggregated to the grant cycle level. This table presents the outcomes (publications and publications in the 5th percentile) as counts but are normalized to have a mean of 0 and standard deviation of 1 in the main analyses. Prior performance for grant cycle 1 is the PI's individual performance in the 2 years prior to the start year. Prior performance for grant cycle 2 is the PI-project performance in grant cycle 1. Portfolio is defined as a program officer-grant cycle.

Table 2: Program Officer Characteristics

Variable	Percent	N
Age		1,856
<35 years	1.45	
35-44 years	12.23	
45-54 years	34.21	
55+ years	52.10	
Length of service		1,846
<5 years	13.43	
5-14 years	48.43	
15+ years	38.14	
Doctorate[a]	77.89	2,090
Scientific Field[b]		1,462
Life Sciences	93.71	
Math and Statistics	1.64	
Engineering and Computer Science	0.27	
Physical Sciences	1.09	
Social Sciences	3.28	
Adjusted Basic Pay (Mean, SD)	$135,879 ($24,288)	1,852
Manager[c]	16.03	1,846

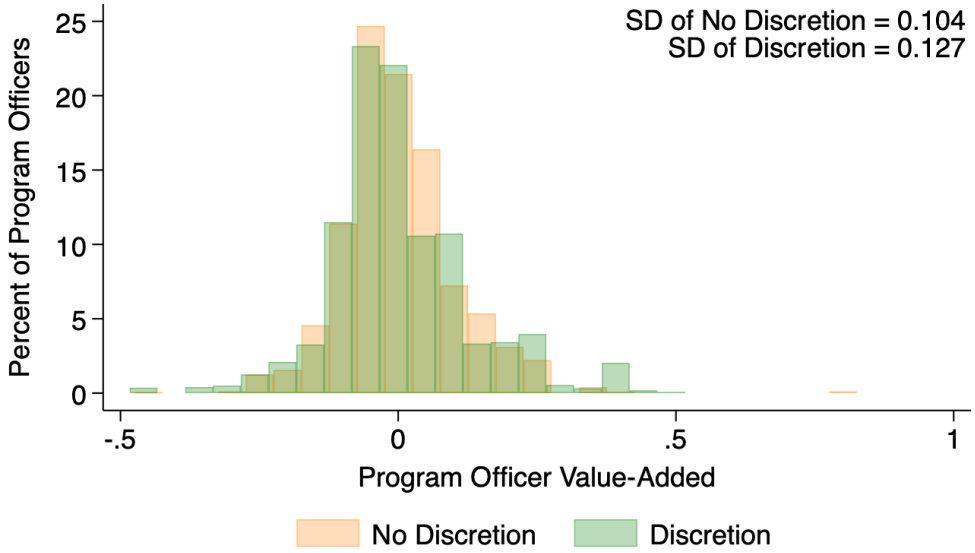
Notes: This table is at the program officer-grant cycle-discretion level because it is based on the value added estimates from earlier analyses.

[a]Doctorate includes individuals with medical degrees.

[b]I use a combination of the Office of Personnel Management and Bruce and de Figueiredo's (2020) definitions of scientists to categorize the program officers into scientific fields.

[c]All program officers are managers of scientific portfolios, but some also have supervisory responsibilities as part of their role. This could include program officers who have become branch chiefs and manage other program officers.

(a) Publications



(b) Publications in Top 5% of Citation Distribution

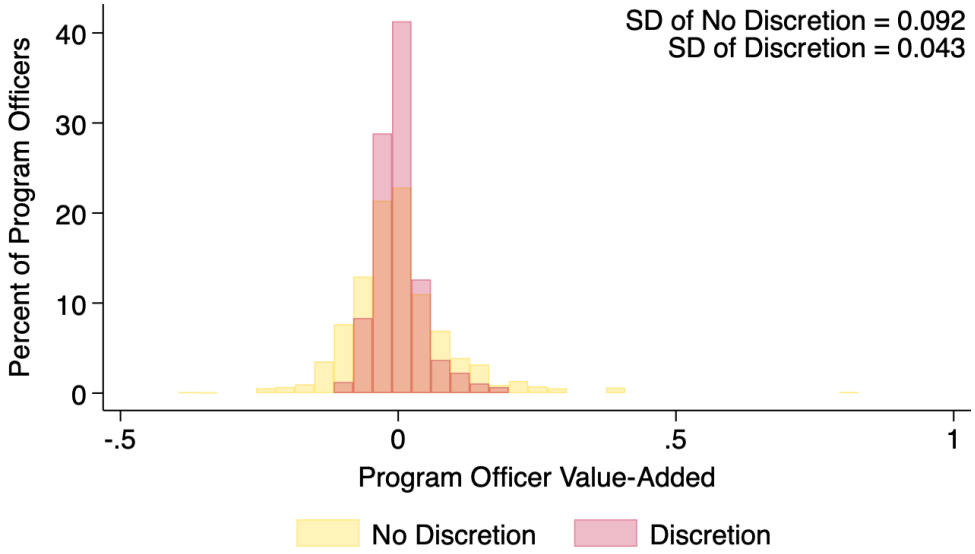
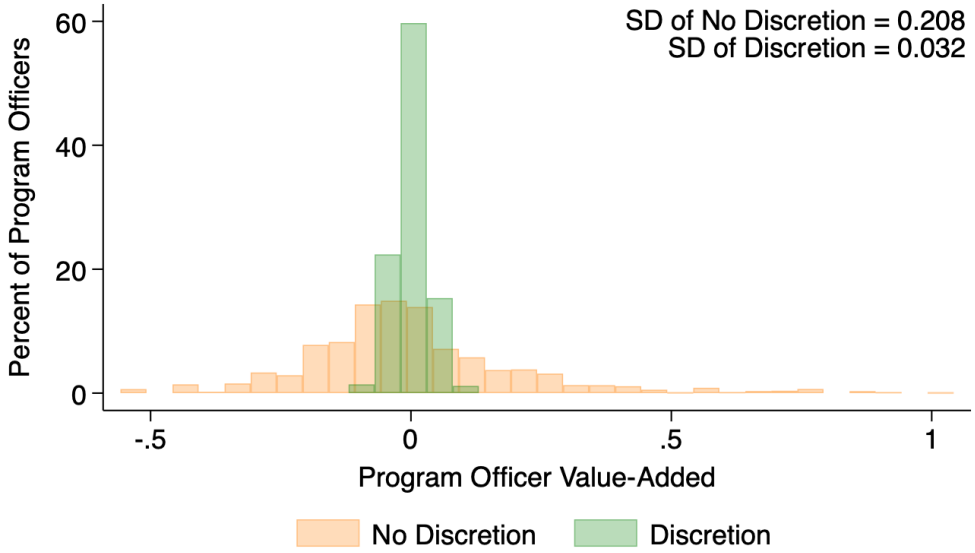


Figure 2: Distribution of Program Officer Value Added on Innovation Outcomes for First-Time R01 PIs

(a) Publications



(b) Publications in Top 5% of Citation Distribution

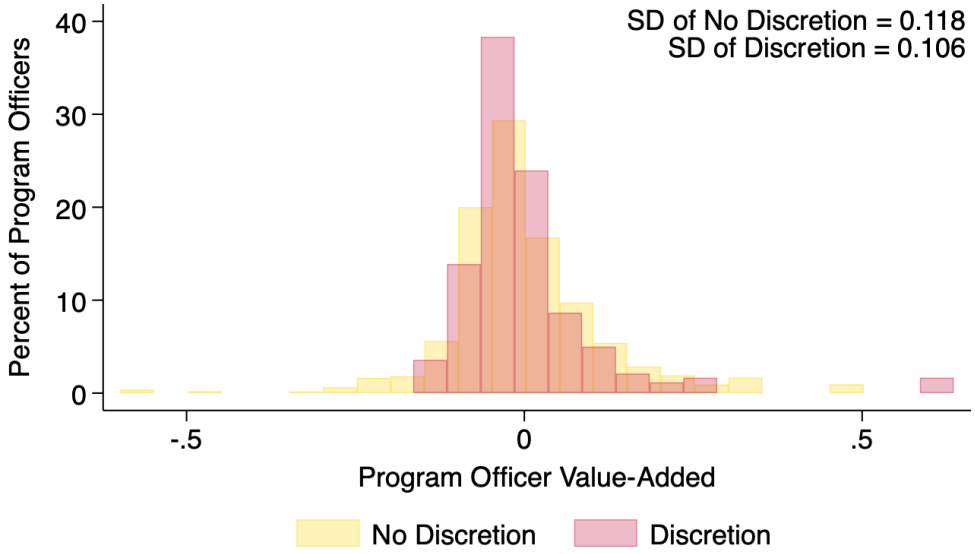
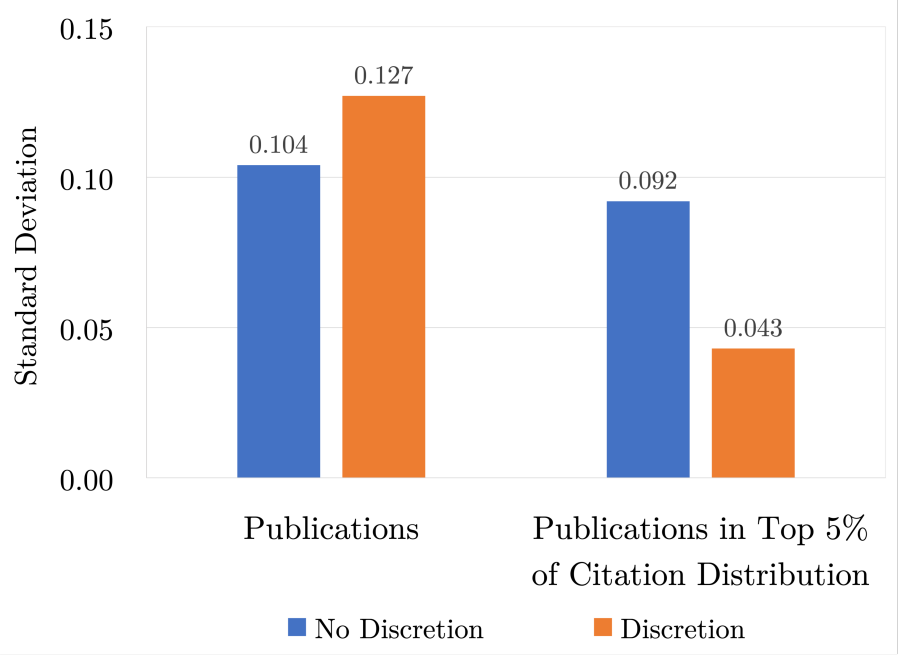


Figure 3: Distribution of Program Officer Value Added on Innovation Outcomes for Established R01 PIs

(a) First-Time R01 PIs



(b) Established R01 PIs

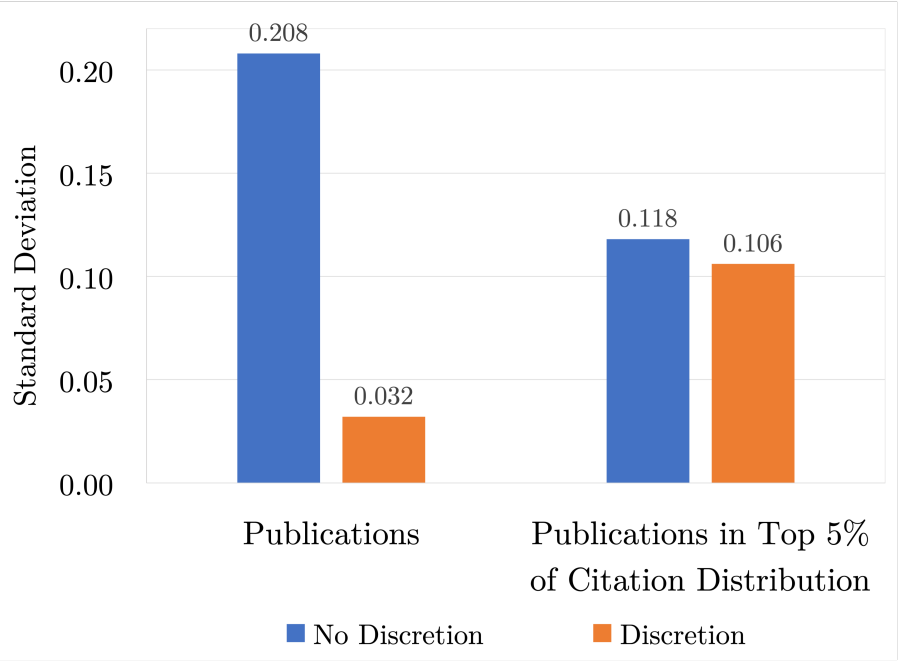


Figure 4: Standard Deviation of Program Officer Value Added by PI Type

Table 3: Effects of Program Officer Characteristics on Value Added

	(1) Value Added on Publications	(2) Value Added on Publications in Top 5% of Citation Distribution
Age		
<35 years	—	—
35-44 years	-0.014	-0.014
	(0.019)	(0.010)
45-54 years	0.002	0.000
	(0.018)	(0.009)
55+ years	-0.001	-0.007
	(0.018)	(0.009)
Length of Service		
<5 years	—	—
5-14 years	0.009	0.003
	(0.010)	(0.006)
15+ years	0.006	0.005
	(0.010)	(0.006)
Doctorate	0.024**	0.009
	(0.011)	(0.007)
Life Sciences	-0.007	0.003
	(0.008)	(0.005)
Manager	-0.006	-0.004
	(0.008)	(0.005)
Constant	-0.028	-0.016*
	(0.018)	(0.009)
R-squared	0.006	0.007
Observations	1,838	1,838

Notes: This table is at the program officer-grant cycle-discretion level because the dependent variables are based on the value added estimates from earlier analyses. $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

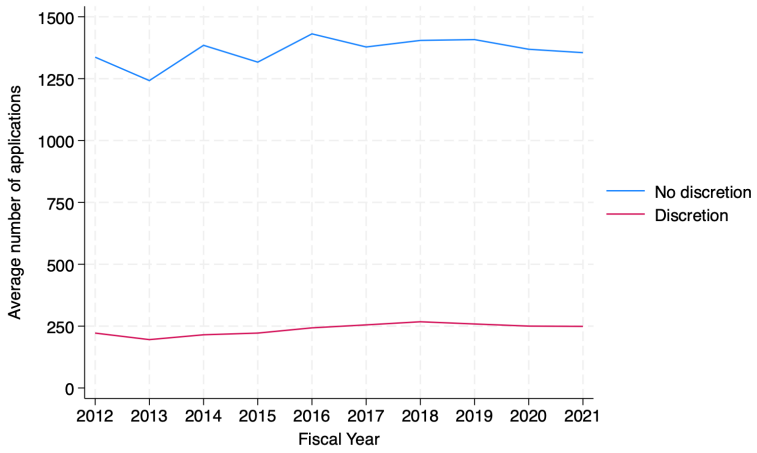
Appendix Tables and Figures

Table A1: Defining Grant Cycles

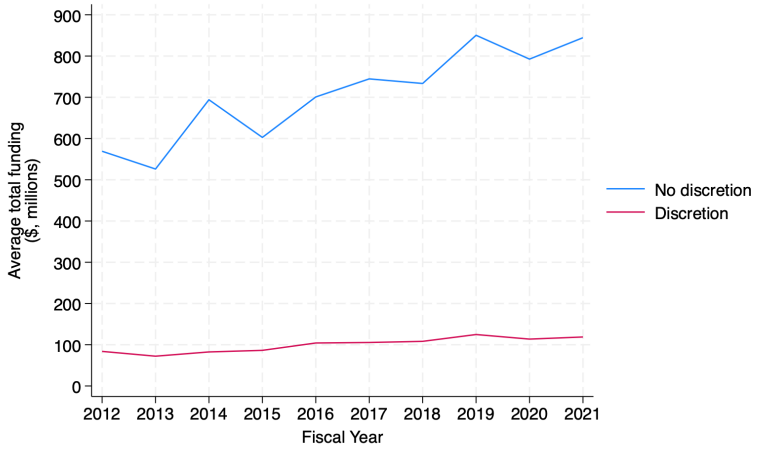
Grant	PI	Application Type	Year	Cohort Year	Grant Cycle
R01AG032319	Yashin, Anatoliy	New	2008	2008	1
R01AG032319	Yashin, Anatoliy	Noncompeting continuation	2009	2008	1
R01AG032319	Yashin, Anatoliy	Noncompeting continuation	2010	2008	1
R01AG032319	Yashin, Anatoliy	Competing revision	2011	2008	2
R01AG032319	Yashin, Anatoliy	Noncompeting continuation	2012	2008	2
R01AG056163	Prescott, Carol	New	2016	2016	1
R01AG056163	Prescott, Carol	Competing revision	2017	2016	2

Notes: This table shows an example of how new grant cycles are defined for a particular PI-project. The red boxes or new applications indicate the start of grant cycle 1. The blue boxes or competing revisions indicate the start of grant cycle 2.

(a) Applications Awarded per Institute or Center



(b) Funding per Institute or Center



(c) Funding per Project per Institute or Center

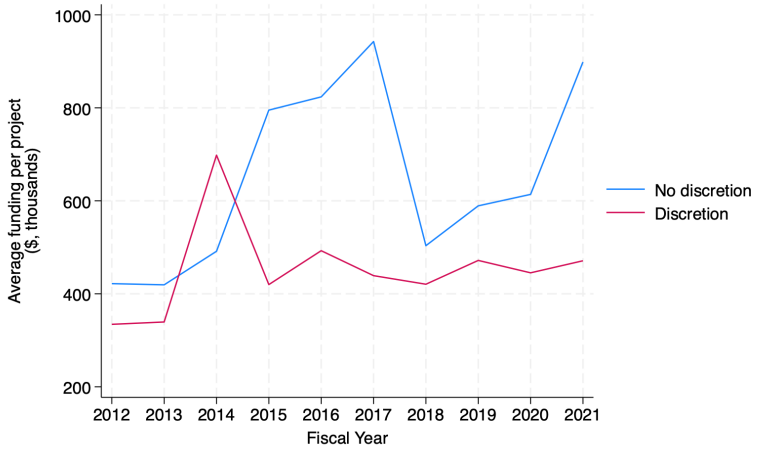


Figure A1: NIH Institute Funding and Applications Over Time