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The value of insiders: Evidence from the effects of NSF rotators on early career scientists

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Abstract

We show that academics with experience in government jobs generate spillovers for their early career colleagues. Our template is the National Science Foundation (NSF) rotation program in which the agency employs academics, called rotators, on loan from their university. Shortly after the rotator's return from the NSF, fresh assistant professors in her department raise almost $200,000 more NSF funding compared to scientists in carefully constructed control groups. This gain doubles their research resources. Consistent with evidence that the mechanism is knowledge transfer from the rotator, the results suggest that access to individuals with insights

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JEL codes: D02, D62, D80, D83, H50, J62, I23

I. Introduction

Access to superior human capital generates improvements in productivity via knowledge spillovers (Schultz 1961, Zucker, Darby, and Brewer 1998). Indeed, within knowledge intensive sectors such as academia, performance, measured using impactful publications, is largely driven by gaining access to scientists with insights acquired through success and experience within academia (Waldinger 2010, Azoulay, Graff Zivin, and Wang 2010, Brogaard, Engelberg, and Parsons 2014, Borjas and Doran 2015). We report novel evidence that highlights an alternative route—positive spillovers also result from access to academics with insights gained because of their temporary experience in government jobs. Few examples of such academics are Steven Chu, Professor of Physics at the University of California, Berkeley, who served as the Secretary of Energy from 2009 until mid-2013 before returning to his academic home or Alexis Abramson, Professor of Mechanical and Aerospace Engineering at the Case Western University, who also spent two years as a chief scientist at the US Department of Energy before her return to Case Western. These employment spells infuse academics with insider knowledge on the allocation of resources by the government, the main funder of research endeavors, and this knowledge can prove valuable when transmitted to colleagues seeking ways to boost their research capabilities and advance science.

To study the impact of temporary employment in government, we explore the link between research fund acquisition of early career scientists and exposure of these scientists to rotators—academics who are seconded to the National Science Foundation (NSF) for typically two years before they return to their respective academic institutions. During their tenure at the NSF, rotators, formally designated as Program Directors, organize and run the peer review process from the beginning until the end while often exercising decision-making power. They become insiders at the NSF as they gain insights on the process of funding decisions, possess tacit knowledge on the potential funding directions and priorities of the agency, and ultimately gain the ability to discern a promising proposal. [1]

Departing from the extant literature on research fund acquisition, we focus on early career scientists (Feinberg and Price 2004, Arora and Gambardella 2005, Li 2017, Grimpe 2012) because scientific advancements are built on the progress of early career academics (Oyer 2006, Petersen et al. 2011) and because without (federal) funds, science stalls (Alberts et al. 2014, Rosenbloom et al. 2015, Lanahan, Graddy-Reed, and Feldman 2016, Ganguli 2017).We find that rotators leverage their insider knowledge to communicate to their early career colleagues what to write in and how to write a proposal and where to send a proposal. As a result, rotators have a causal impact on the funding acquisition records of new hires landing their first faculty position in their department. Newly hired assistant professors in departments with a returning rotator raise almost twice the NSF amount when compared to the amount raised by similar academics in similar departments without a rotator (approximately *$200,000* more, which is nearly *half* of the average first time grant acquired from the NSF). This increase in funding is due to rotator's colleagues being more likely to secure medium size grants and is realized one and two years after exposure to the rotator.

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[1] The literature on knowledge spillovers within academia has highlighted the significance of context. For instance, while Borjas and Doran (2012) and Waldinger (2012) find negative and no spillover effects, respectively, for same department peers of star scientists, Waldinger (2010) and Azoulay, Graff Zivin, and Wang (2010) report positive spillovers for doctoral students and collaborators of star scientists. The emphasis on context suggests that it is difficult to extrapolate the results of Kolympiris, Hoenen, and Klein (2017), which is the only work, other than the current study that analyzes spillovers from NSF rotators. Using a different research design, methods, and samples, the latter work does not focus on researchers who arguably have the highest need for funds—early career scientists—and, unlike the current study, does not shed light on the dynamics of the potential effect of rotators on their colleagues.

For our identification strategy, we compare the funding records of new hires landing their first faculty post in departments with and without a rotator—the former belonging to our treatment group and the rest belonging to our control group(s). The major empirical challenge in this exercise is that superior human capital is not distributed randomly. Instead, endogenous sorting places individuals with high human capital next to each other (Kim, Morse, and Zingales 2009, Waldinger 2016). Within our framework, this would imply that the colleagues of rotators are more equipped than others in raising research funds. To circumvent this sorting issue, we exploit two features of the rotation program and carefully construct three control groups. The first feature is that the (timing of) entry into rotation is independent of the needs of the colleagues to raise funds. Academics become rotators because they want to learn more about the NSF, not because they recognize emerging colleagues who need advice. The second feature is that the return to the home institution is also exogenous to the needs of colleagues to raise funds. The rotation duties have a fixed end date. As a result, rotators do not return to their institutions because (or when) their colleagues need help. These two features of the program suggest that the allocation of early stage academics to the treatment and control group is largely exogenous to their choice of employer. However, three different sources of endogeneity may still allocate individuals to treatment and control groups non-randomly, which would constitute a threat to identification. We discuss these sources and focus on how we address in the subsequent section.

First, initial job placement can be endogenous to job candidates' choice to accept an offer from a department with a rotator because of the rotator's presence in that department and the associated *ex-ante* expectation of learning how to raise research funds. Along the same lines, labor market conditions differ across years and can have a strong impact on which job candidate lands where. We tackle these issues by exploiting time variation: we construct our first dataset including new hires joining the same department at different points in time when labor market conditions vary, the focal colleague had or not left for the NSF and had or not the rotation experience.

Second, if the academic labor market works efficiently, then the best candidates will land in the best positions and the lesser candidates will land in lesser positions (Cole and Cole 1973). If this holds true, then the success in raising funds may be explained by this matching process with rotators belonging to the better departments. Similarly, difficult to capture heterogeneity among PhD holders may also explain initial job placements. We tackle these issues by crafting a second dataset comprising PhD holders (some landing a job in a department with a rotator and others acquiring a job in a department without a rotator), who had the same PhD advisor, worked in the same science field, and graduated about in the same year (Kahn and MacGarvie 2016). Given that advisor standing and graduating institution are the prime determinants of initial job placements (Miller, Click, and Cardinal 2005, Terviö 2011), it is expected that, as shown in Tables 2 and 3 below, new hires from the same advisor land their first faculty post in departments whose main difference is the presence of a rotator as they are generally of comparable status, academic productivity and research fund acquisition records. Importantly, because the selection into advisors is not random (Waldinger 2010) and PhD training is largely standardized within doctoral programs (hence both the selection and treatment are nearly identical), these new hires are also similar to each other at the time of their first academic appointment in terms of age, gender, measured innate ability, and other similar qualities.

Third, university-wide policies, tenure-track incentives, grant-writing support, and other university-specific factors may boost incentives to become a rotator, shape the types of emerging scientists who decide to join a given university, and ultimately explain the increase in grant acquisition rates. This may lead to erroneous conclusions about the impact of rotators if they are disproportionally employed at institutions that for the aforementioned reasons are more successful in research funding acquisitions than in others. We tackle this issue by constructing our third dataset. This dataset holds university-wide factors constant and allows the comparison of funding records of new hires who joined the same university at approximately the same time but in different, yet comparable, departments having one main difference: some have a rotator as a faculty member and some do not.

Our work is novel on two main fronts. First, we present causal evidence on knowledge transfer through insiders—academics who gain insights through their experience outside academia. Second, we present detailed longitudinal information on early career scientists who are exposed to the tacit knowledge on funding acquisition possessed by NSF rotators—actors in the knowledge economy who play a crucial role (Li and Marrongelle 2013), but who have received considerably less attention in the literature when compared to inventors, entrepreneurs, patent examiners, and others (e.g. Lampe 2012, Lemley and Sampat 2012, Toivanen and Väänänen 2012, Moser, Voena, and Waldinger 2014, Jensen and Thursby 2001).

Despite the careful construction of the datasets to match new hires in the treatment and control departments in ways that can isolate the potential impact of rotators on funding acquisition records, remaining differences in training, ambitions, and career goals, among others, may still exist. As such, we include several control variables in the analysis that are meant to account for such factors. The variables include publication and citation records, research funding from sources other than the NSF, and characteristics of the department of the focal academic joins. Further, we perform a battery of robustness checks to test the sensitivity of our estimates to several potential modeling concerns, including endogeneity and the way we specify our control groups to reduce heterogeneity among treatment and control groups. For instance, a) we use Coarsened Exact Matching to find academics who are similar to those that join departments with a rotator, b) we relax, sequentially, the "same graduation-year" and the "same advisor" criteria from the factors we consider when specifying our control academics, and c) we conduct a difference-in-difference analysis. These tests reinforce the stability of our estimates.

To pinpoint with precision the mechanism via which the effects of rotators on new hires materializes, as presented in section VI, we conduct numerous exercises that test alternative competing explanations including favoritism and peer effects. As part of one of the exercises, we created a helpfulness index based on the intensity of the thank you notes in PhD dissertations to put knowledge transfer as the mechanism under scrutiny. We find that early career scientists in departments with the most helpful rotators raise three times more NSF funding than early career scientists in departments with remaining rotators (Oettl 2012, Laband and Tollison 2003). Along the same lines, when we artificially place rotators to departments that in reality did not have a rotator, we do not find any association between the purported presence of a rotator in that department and the NSF grant acquisition of the rotator's colleagues.

Our results have direct implications for the advancement of science, for the value of mentoring as a form of having access to superior human capital (Blau et al. 2010), for early career academics landing their first faculty post and aspiring to succeed in science, and for policymakers devising measures to allow such scientists to develop independent research programs (Kaiser 2017). They are also relevant for university administrators who confront increasing financial pressures, for job market candidates contemplating which job offer to accept, and for the organization of institutions and how they advance or hinder scientific progress (Furman and Stern 2011).

II. The rotation program at the NSF and how rotators can induce changes in grant acquisition

The NSF has an annual budget that exceeds $7.5 billion and funds approximately 12,000 proposals annually in all non-medical scientific fields. These proposals support more than 360,000 scientists, teachers, and students employed at close to 2,000 institutions (NSF 2017). The agency is structured hierarchically; its seven directorates, corresponding to different scientific fields, are split into divisions that are further subdivided into programs. The program directors (PDs) are subject matter experts who run each program. They put together the review panels, communicate, *ex-ante* and *ex-post*, with submitters of funded and rejected proposals, review proposals even from programs and directorates outside their own, make grant allocation decisions, participate in panels outside their programs, and provide inputs to central strategic planning not only within their program but also across programs and directorates (Li and Marrongelle 2013). Overall, PDs are an integral part of the NSF and are key to shaping the direction of science.

Most PDs are permanent NSF employees. However, since the passage of the Intergovernmental Personnel Act in 1970, roughly 1 out of 3 PDs are academics who are posted at the NSF temporarily (Mervis 2016). These academics, called rotators, infuse the agency with new viewpoints as they move to the NSF headquarters. These rotators, on loan from their university, work full time for the NSF for up to 4 years (most commonly 2) and effectively stall their academic duties during their tenure at the NSF (Mervis 2013). From 2004 to 2014 alone, 800 rotators from around 400 academic institutions served at the NSF. Rotators are subject to strict restrictions during and even after their tenure at the NSF to avoid any conflicts of interest or favoritism (e.g., they cannot submit proposals or evaluate proposals of previous collaborators).

As revealed during a handful of discussions with former rotators, the main reason academics enter the program is attributed to a desire to acquire an in-depth understanding about the NSF and to generally contribute to the field of science.[2] These drivers explain why we do not identify specific trends among rotators; besides the fact that all had won grants from the agency in the past, they are employed at universities of varying size, status, and location. Additionally, they vary in terms of scholarly productivity, leadership activities, and methodological approaches in their research, among others. As mentioned above, the fact that the decision of rotators to join the rotation program is exogenous to the need of colleagues for help in raising funds alleviates the concerns of endogeneity; these endogeneity concerns arise from the former's potential entry into the NSF as a deliberate response to the latter's need for advice to raise funds.

During their tenure at the NSF, rotators become insiders at the agency; they evaluate numerous proposals, observe others performing similar tasks, and gain hands-on knowledge of the largely unobserved factors that shape panel decision making (Bagues, Sylos-Labini, and Zinovyeva 2017); additionally, they become aware of the following: a) what the NSF prioritizes and b) the areas where the demand for promising proposals exceeds the supply. We expect these unique insights to enable rotators to recognize a competitive proposal. In turn, because knowledge sharing is stronger among individuals of the same group (department, in our application) (Hargreaves Heap and Zizzo 2009), this insider knowledge can spillover to rotators' colleagues and create an advantage for them in that they gain knowledge that their counterparts lack. In fact, evidence on the effects of rotators on later stage academics without NSF grants *ex-ante* supports this expectation (Kolympiris, Hoenen, and Klein 2017).

[2] The blog entry of Dan Cosley, Associate Professor at the Cornell University, about his rotation experience serves as a good example of why academics choose to work at the NSF and the types of insights they gain (http://blogs.cornell.edu/danco/2016/09/09/why-im-rotating-at-nsf/)

Specifically, for early career scientists, having access to an insider can be instrumental on three main fronts in securing grants. First, rotators can direct colleagues to research areas the NSF prioritizes that are otherwise difficult to detect. In other words, they can provide suggestions on what the agency is keen to fund. Second, because grant writing is typically not the focus of doctoral training, rotators can fill the gap and assist their colleagues to present ideas effectively and, generally, craft proposals in ways that communicate the research insights in an appealing manner. The sheer number of proposals that the NSF receives makes communication and framing proposal vital to allowing externals reviews and, subsequently, to enabling panel members to appreciate the merits of a given proposal in a better manner. Third, rotators can address the main obstacle concerned with the initiation of the proposal—idea generation (Custer, Loepp, and Martin 2000). Since rotators possess tacit knowledge on research themes that are more likely to receive funding, they can guide their early career colleagues on research questions they can pursue. This process resembles academic mentoring, which can pay off (Blau et al. 2010) and in which fund raising comes up regularly (Feldman et al. 2010).

III. Data Sources and Empirical Approach

A. The Treatment Group

To construct the datasets that trace, over time, the grant acquisition record of new hires in departments with and without a rotator, we collect and merge new data from multiple sources. We accessed the list of 240 academics who served as rotators at the NSF under the Intergovernmental Personnel Act (IPA) from 2009 to 2011 via a Freedom of Information (FOI) request directed to the NSF.[3] Following existing works relying on online data retrieval for academics (Terviö 2011, Amir and Knauff 2008, Kim, Morse, and Zingales 2009), we visited current and archived university websites from https://archive.org/ and combined this search with the career information retrieved from the Men and Women of Science database to identify faculty members who, as their first faculty position, were hired as assistant professors before, after, and during the year of the rotator's return to the department. We were able to build comprehensive and detailed career histories for 80 rotators. Subsequently, we examined the professional history of more than 3,200 seasoned and early stage academics belonging to these 80 departments with a rotator; of these 3,200 academics, we identified 210 academics with a comprehensive career history, who as their first faculty post joined 64 departments with a rotator between five years before and two years after the rotator returned from the NSF. As shown in Appendix Table 1, the 64 rotators in the focal departments are representative of the population of rotators. The 210 academics in the 64 departments with a rotator comprise the treatment group, and the indicators of a treatment effect by a rotator (discussed below) assume positive values as they all overlap with the rotator for at least one year after the rotator's return from the NSF.

We identify the following three cohorts within the 210 academics in the treatment group: a) 55 academics who joined when (or shortly after) the rotator returned from the NSF, b) 66 academics who joined when the rotator was at the NSF, and c) 89 academics who joined within two to five years before the rotator had left for the NSF. The formulation of three cohorts helps

[3] As detailed in the next section, we track grant acquisition 5 years before the departure of the rotator and 5 years after the rotator's return. As such, we focus on academics who served at the NSF between 2009 and 2011 mainly because the start of the *ex-ante* period (2004) is recent enough to source comprehensive data from online sources and the end of the *ex-post* period (2016) allows us to observe the *ex-post* period in its entirety. Along the same lines, our focus on early career academics allows us to collect and organize online data with increased accuracy as scientists of this cohort are generally prompt in keeping their online profiles updated.

us to surmount endogeneity and sample selection concerns. It helps us with endogeneity because from these cohorts we can eliminate nearly with absolute certainty the possibility that the new hires *chose* to join the department expecting to learn from a returning rotator for cohort (c): the academics who joined the department before the given scientist left for the NSF. With regards to sample selection, the rotation experience may correlate with an increased ability to select job candidates with higher chances of attracting research grants. If this was true, and if rotators participated in selection committees, then the treatment groups would have been populated with new hires who, *ex-ante*, were better equipped to win grants. However, the issue cannot hold for cohort (b)—academics who joined when the returning rotator was at the NSF—and it is less likely to hold for cohort (a)—academics who joined at the time of the rotator's return from the NSF. Essentially, these two cohorts allow us to address the potential for sample selection at hand.[4]

B. The First Control Group

The first control group allows us to hold department effects fixed and is composed of 25 academics belonging to 14 departments in the sample; these academics joined a department with a rotator, but their tenure at the department did not overlap with the tenure of the rotator. The absence of overlap may be either because these academics left the respective departments before the rotator returned from the NSF or, in a few cases, because the rotator moved to a new university at the end of her tenure at the NSF.[5]

[4] A threat to identification would be when rotation improves the selection criteria and allows rotators to give informal advice on the selection of candidates during their tenure at the NSF or during their short visits to their institutions. If this holds true, then the new hires around the time of rotation and rotator's return from the NSF would be different from other candidates. However, this is contrary to our observations.

[5] The small size of the first control group is consistent with the tenure track system in the US where (in) voluntary departures from a given department are uncommon before the end of the tenure clock.

C. The Second Control Group

The second control group addresses individual heterogeneity. Using data from the ProQuest dissertations and theses database, we identified the PhD advisor of the new hires in departments with a rotator and the remaining PhD students whom she/he supervised as the main advisor and who graduated in the same year as that of, two years before, and two years after the focal new hire. We focus on same-advisor graduates because of the following reasons: a) initial job placement is largely explained by the advisor's network and standing in the profession and the graduating department (Long 1978, Terviö 2011), b) selection into advisors is not random (Waldinger 2010), and c) doctoral training is largely standardized among PhD candidates of the same cohort. It follows that because graduates of the same advisor are similar both in the selection (into an advisor) phase and in the PhD training/treatment phase, we expect this exercise to allow us to account for individual specific factors that can influence grant acquisition. Specifically, starting with the 210 academics in the treatment group, we construct the professional history of nearly 600 PhD graduates who had the same PhD advisor and graduated within two years of the focal academic's graduation year. By eliminating academics who left academia, never landed an assistant professor position in the US, accepted an academic position outside the US, or did not have a professional history online (CV and LinkedIn, among others), we populate our second control group with 105 same-advisor academics who landed their first faculty position in 100 different US departments without a rotator.

D. The Third Control Group

The third control group accounts for university-specific initiatives that can promote entry into administrative roles outside the university, grant funding sessions and tenure track criteria that can explain differences in raising funds across different institutions. Retrieving data from university websites and the Men and Women of Science database, we populate the third control group with academics who started their first faculty position as assistant professors at the rotator's university, but in a different, yet comparable, department the same year, two years before, and two years after the rotator returned from the NSF. We find similar departments by employing the following criteria. First, the department must belong to the same larger division or school as the department with a rotator. For instance, when the department of the rotator is an Engineering department, we limit the search to other departments in the School of Engineering. Second, the control department must be in an intellectual space that is adjacent to the department with a rotator. Adhering to the previous criterion, when the treatment department is Industrial Engineering, we choose the department of Civil Engineering within the School of Engineering and not, for instance, the department of Chemical Engineering. Typically, the title of the department serves as a sufficient tool to identify similar departments. When not, we choose departments whose faculty members publish in the same journals as the faculty members of the rotator departments. Third, we select a comparable department that hired an assistant professor during the timeframe of our study. These selection criteria yielded 60 academics from 24 departments of the same university that had departments with rotators who were hired into their first position anytime between two years before and two years after the focal academic joined the focal department.

Subsequent to the finalization of the list of names belonging to the treatment and the three control groups, we extracted data from the abovementioned sources, the bibliographic database SCOPUS, and the NSF grant retrieval website to build a full career history for the focal academics. Leveraging on the career history of the academics, we construct variables that describe the NSF acquisition records, tenure at the institution, research productivity, and annual academic position, among others. Appendix Table 2 provides an elaborate description of the sources of data and the associated variables.

E. Baseline Estimation Setup

We employ an ordinary least squares (OLS) estimator wherein the dependent variable is the inflation-adjusted amount of research funds raised from the NSF in a given year by a given new hire who belongs to either a treatment or a control group. These amounts reflect new grant(s), with the focal academic being the principal investigator, and not continuations or extensions of existing grants.

Each observation is a person-year starting from the year the focal academic joined the given department as her first faculty post in an assistant professor position and ending up to five years after the return of the rotator to the department.[6] On average, we track the yearly grant acquisition rate for each academic in the treatment group for 8.7 years (up to five of which are after the return from rotation) and for each academic in the three control groups for 7.7 years. Therefore, in line with the importance of early career academics raising research funds early on, we follow them the years leading to the tenure clock running out. To test whether rotators induce changes in the NSF grant acquisition record of their early career colleagues, we include variables that take the value of 1 when the focal academic is in the department of the rotator in the same year that the rotator returned from the NSF (*Treatment 0*), in the first year since the rotator returned from the NSF (*Treatment 1*), and, in a similar fashion, until the fifth year since the rotator returned from the NSF (*Treatment 5*).[7] The person-year set-up and the associated

[6] Only 8 out of the 210 academics in the treatment group overlapped with the rotator after her return for *less* than 5 years.
[7] We use the 5-year window as it matches the typical application submission time during the common 6-year tenure clock for most junior faculty.

Treatment 0 to 5 variables allow us to test the treatment effect of the rotators on their colleagues with precision, and hence we can uncover the duration of the effect and its magnitude over time.

We conduct the analysis on three different datasets. Each dataset includes the treatment group and the first, second, and third control group, respectively.

F. Control Variables

As demonstrated through Tables 1 to 3 below, by and large, academics in the treatment and control groups are similar to each other and they belong to similar departments. These similarities suggest that any differences in the grant acquisition records between academics in treatment and control groups *ex-post* can be attributed to the rotator. However, additional differences may exist. Accordingly, we include several control variables in the analysis to account for such differences.

Difficult to quantify or observe factors at the department level may induce changes in fund acquisition in the future. These can include visiting faculty transmitting knowledge on fund acquisition or shocks such as increased teaching load at time *t* that can limit the capacity to submit research proposals at time *t*+1,2, 3, among others. We control for such effects by adding the variables *Rotator Department -1* up to *Rotator Department-5* in the analysis. The variables take the value of 1 when the person-year observations refer to academics who joined a department from which a rotator originated from one to five years before the rotator's return from the NSF. To illustrate, if the person-year observations refer to academics who, for instance, joined the focal department two years before the return of the rotator, then the *Rotator Department 1* and *Rotator Department 2* would assume positive values, while *Rotator Departments 3, 4,* and *5* would assume the value of 0. To account for potential learning effects during post-graduate studies, we include the variable *PostDoc* that measures the number of years during which the focal new hire was employed in a post-doctoral position before assuming a faculty post. The variables *Assistant Professor* and *Associate Professor* denote experience and take the value of 1 for person-years during which the focal academic held an assistant professor and associate professor position, respectively, and 0 otherwise (the base category is Professor; this category is composed of 9 scientists who became professors within our time window). We include the dummy variable *Male* for male academics to account for gender differences in grant acquisition. The time-varying variable *H-index* (lagged by one year) measures the H-5 citation index of the academic in question and controls for the influence of an academic's existing track record on grant acquisition. The availability of research funds in previous years or from different sources may condition one's NSF funding record in a given year. As such, we include the variable *External Funding* in the analysis that measures the funding amounts from sources other than the NSF; we also include the variable *Previous NSF* that measures the sum of NSF funding raised by the focal academic during the 5 years preceding the focal person-year observation.

Further, we incorporate explanatory variables that reflect potential influences from the host institution. We include the following: a) the time-varying variable (*Ranking*) that measures the ranking quartile of the focal university to account for potential status effects afforded to academics in higher-ranked universities and b) the time-varying *Faculty NSF* variable that measures the sum of NSF funds raised by existing faculty members in the rotator's department before the rotator's return from the NSF; this variable accounts for the learning on how to raise NSF funds from existing faculty members other than the rotator. Finally, we include the field of science and year-fixed effects to control a) for differences across the scientific fields in the propensity and need to raise funds from the NSF and b) for differences in funding cycles at the agency.

G. Descriptive Statistics

In this section, we provide evidence that our research design allows us to isolate the effect of the rotator; this isolation is possible because the academics who make up the treatment and control groups are similar before the return of the rotator and start their assistant professor positions in similar departments. We also provide a description of the rotators and explain that the rotators employed for the analysis are representative of the population of rotators.

In Table 1, we present selected statistics for the academics in the treatment and the 3 control groups. At the start of their faculty position, between 2003 and 2015 (2012 for those in the treatment group), academics in the four groups were similar in many respects including experience, gender distribution, publication records, and, importantly, previous funding from the NSF. For instance, 75 percent of the scientists in the treatment group had a first author publication before their graduation (as per the measure of innate ability by Kahn and MacGarvie (2016)), had an H-index of 1.92, and had raised, on average, $28,000 from the NSF as a principal investigator when they started their first faculty post. The average corresponding figures for the scientists in the 3 control groups were 70 percent, 2.17 and $27,000. Additionally, when the rotator was at the NSF, the funding records across scientists in the four groups were similar. Where we do observe a significant difference is on the total amount raised from the NSF in the 5 years following the return of the rotator (and the equivalent period for those in control groups). Academics in the treatment groups raise, on average, close to $500,000, while academics in the 3 control groups raise half of that amount, $250,000. As discussed in detail in the subsequent sections, if we attribute this difference to the rotator, then the effect would be substantial. The rotators are not only expected to double the amount that a given early career academic raises from the NSF, but they are also responsible for roughly half of the first major grant that an emerging scientist raises from the agency; based on NSF data, we find that the average inflation-adjusted NSF grant across directorates from 2006 to 2016 for first time principal investigators was $439,000.

But, what could explain the difference in funding records among academics in the treatment and control groups is heterogeneity in the universities and departments the sample scientists belong to. However, Tables 2 and 3 exhibit contrary findings. The departments with a rotator raised $1.1 million annually from the NSF during the period preceding the rotator's return from the NSF (Table 2). The departments without a rotator raised $1.2 million in the equivalent period. The status and research productivity indicators in Table 3 paint a similar picture—55 percent of the universities with a rotator are members of the prestigious Association of American Universities. The corresponding percentage for universities without a rotator is 50 percent. Along the same lines, 23 percent of the departments with a rotator are in the first quartile in the science field specific Shanghai ranking, while 26 percent of the departments without a rotator belong to the same quartile. Overall, we do not observe significant differences in terms of funding records and status/productivity indicators between the departments that are with and without a rotator.

Table 4 describes the rotators in the sample. They are typically mid-career academics who have been successful in raising funds from the NSF and have varied publications and citation records. As shown in Appendix Table 1, the descriptive statistics of the rotators in the sample are similar to the descriptive statistics of the population of rotators who served at the NSF.

---*Tables 1 to 4 about here*---

IV. Main Results

Table 5 presents the baseline estimates. We cluster the standard errors at the department level. This choice is predicated on the finding that, as in our case, when the treatment is at the department level, but the unit of analysis is at the individual level, the estimation needs to employ a White/Huber heteroscedasticity correction for the standard errors (Bertrand, Duflo, and Mullainathan 2004). As we find in the unreported results, the inference remains nearly identical when we cluster the errors at the scientist level to account for the fact that each scientist enters the analysis more than once.

In Model 1, we use the sample that includes the academics in the treatment group and the academics in the first control group. The coefficients of the *Treatment 1* and *Treatment 2* variables (also plotted in Figure 1) suggest that rotators induce positive and economically meaningful changes in the funding acquisition of their early career colleagues. The *Treatment 3* coefficient is also statistically significant. However, we interpret such evidence as suggestive because the significance does not hold across specifications, both for the baseline estimates and for the selected robustness checks. Overlapping with the rotator one and two years after her return from the NSF leads to an increase in funding that exceeds $200,000. To put this in perspective, as shown in Table 1 above, academics in the treatment groups raise $500,000 during the 5 years following the return of the rotator, while in the corresponding period academics in the control groups raise $251,000. At the same time, the average first time grant from the NSF across directorates is $439,000. As such, given the *Treatment 1* and *Treatment 2* estimates, it appears that the rotator treatment effect nearly doubles the fund acquisition record of early career scientists and is responsible for close to half of an academic's first grant from the agency. Interestingly, the gains from the rotator are stronger in the first two years of overlapping (when, roughly, the tenure track clock is about to run out) and do not extend beyond that time period. As we demonstrate in section VII, the main reason we expect this finding to hold is that, within the 5-year window, the increased workload following the award of a grant limits new grant application submissions in the subsequent years. A complementary explanation, which we do not rule out, is that, over a period, there is a decay in the value of the knowledge the rotator transmits to her colleagues as the agency evolves and changes priorities, among others.

In Model 2, we conduct the analysis using the academics on the treatment group and the academics in the second control group. Similar to the results in Model 1, the *Treatment 1* and *Treatment 2* estimates indicate that indeed overlap with a rotator is beneficial to research funding, even after accounting for individual-specific heterogeneity. The reduced magnitude of the *Treatment 1* and *Treatment 2* coefficients in Model 2 when compared to the Model 1 coefficients implies the significance of individual-specific factors for fund acquisition.

In Model 3, we employ the sample composed of the treatment group and the third control group. The results are qualitatively similar to the results in Model 1 and Model 2. The *Treatment 1* and *Treatment 2* estimates suggest that rotators induce an increase in the NSF funding records of their early career colleagues.

---*Table 5 and Figure 1 about here*---

Concerning control variables, we find that academics with previous NSF funding in higher ranked universities, perhaps due to the availability of internal grant writing support or status effects, raise more funds from the NSF. We also document a suggestive positive relationship between non-NSF grants and NSF funding. Importantly, the *Rotator Department* minus 1 to 5 variables are not statistically significant indicating that the estimates are driven by the overlap with the rotator *after* her NSF experience.

V. Robustness of the Results

To measure the potential rotator effect, we include in the analysis, as a subgroup of the 210 academics in the treatment group, 55 new hires who joined a department with a rotator after the rotator returned from the NSF. This modeling choice may plague the estimates if these 55 new hires choose to join the focal department because of the presence of the rotator among the faculty and the expected knowledge transfer from this rotator. To test whether such potential endogeneity biases our estimates in test 1 in Table 6, we omit these new hires from the analysis (showing only the results with the first control group for ease of presentation). The results are qualitatively similar to the baseline estimates suggesting that this source of potential endogeneity does not influence our analysis.

We reduce heterogeneity at the scientist level in the second control group based on the expectation that the same advisor and same graduation-year academics who joined departments without a rotator are similar to academics who joined departments with a rotator. In robustness checks 2 and 3 (Table 6), we reduce heterogeneity by identifying similar academics via alternative means. First, we relax the "same graduation-year" criterion and run the regression on a sample that includes the following: a) academics who joined departments with a rotator and b) academics who joined a department without a rotator, had the same advisor, and graduated 3 to 10 years before the focal academic. Second, we relax the "same advisor" criterion under the idea that several similar academics might not have the same advisor. Specifically, after we create a pool with all the academics who joined departments without a rotator, we identify similar academics from a different advisor, by using Coarsened Exact Matching,[8] and include these

[8] We used the following matching criteria—PhD granting university ranking, H-Index at the time of joining the focal department, and having at least one first authored publication before the PhD graduation.

academics in the sample we analyze together with the treatment group academics. The results are qualitatively similar to the baseline estimates, and hence our conclusions remain intact.

---*Table 6 about here*---

Along the same lines, if unobserved factors in raising funds were not captured by our research design to compare new hires from the same university, advisor, and graduation year—if, for instance, the inherent ability of raising funds was not distributed normally among the population—then it would have been difficult to interpret our estimates as causal. Indeed, in test 4 in Table 7, we employ a difference-in-difference specification under which early career scientists from different universities, advisor, and graduation-year enter the analysis either in the treatment or the control group. Academics who joined a department with a returning rotator *before* her return from the NSF belong to the treatment group and those who joined departments without a rotator belong to the control group. The dependent variable is the average NSF funds raised by the focal individual during the three years before the return of the rotator (*ex-ante* period) or during the three years after the return of the rotator to the department (*ex-post* period). The allocation of scientists to treatment and control groups should be quasi-random as we do not expect most academics to select a department based on the presence of the rotator. Indeed, we include a variable that measures the number of years in the focal department to account for potential selection effects. The statistically significant positive interaction of the *ex-post* and *treatment group* variables is in line with the argument that we are unraveling causal effects. [9]

---*Table 7 about here*---

[9] We have also tested for the influence of outlier observations and found no evidence that they impact the estimates materially.

VI. The Mechanism Driving the Results

In this section, we explore whether the findings we reveal are driven by favoritism, knowledge transfer from the rotator, or by other means. We present only the estimates using the first control group for brevity, whenever applicable, as we expect this control group to approximate the counterfactual as closely as possible. The results, available upon request, continue to be qualitatively similar when employing the remaining two control groups.

In the first two tests, we scrutinize the knowledge transfer mechanism. The first test starts with the premise that if the mechanism underpinning the results is knowledge transfer from the rotator, including tips on how to frame a proposal and to which program to submit, then we would expect more helpful rotators to induce more pronounced changes in the funding acquisitions of their emerging colleagues. Similar to Laband and Tollison (2003) and Oettl (2012) and based on the intensity of the thank you notes in acknowledgements in PhD dissertations supervised by each rotator, we construct a helpfulness index using the sentiment analysis algorithm of Rinker (2013) and the weighted sentiment dictionary of Hu and Liu (2004). Higher values of the index correspond to more helpful rotators (we provide details in Appendix Table 2). Indeed, early career scientists in departments with rotators in the top 10th percentile of the helpfulness score raise, on average, $1,135,346 in the 5 years following the return of the rotator. The corresponding figure for early career scientists in remaining departments is $683,721. The t-test comparing the difference of the two figures is statistically significant at the 5 percent level.

For the second test on whether knowledge transfer is the mechanism, we follow Brogaard, Engelberg, and Parsons (2014), as shown in Table 8, to include "false" rotator appointments. We conduct two exercises. In the first exercise, within departments with a rotator, we randomly pick a year between 2006 and 2011 that we define as the year in which the rotator supposedly returned from the NSF. Accordingly, for this exercise, the *Treatment* variables are by design false (except when the random return year overlaps with the true return year). In the second exercise, we artificially treat the same advisor and graduation-year academics who in reality overlapped with a rotator similar to the academics who landed a job in a department without a rotator. Equivalently, we treat the same advisor and graduation year academics who did not overlap with a rotator in reality as if they did. For both exercises, if knowledge transmission is the causal mechanism, then the *Treatment* variables should be statistically insignificant because there is no overlap with the rotator in reality. Indeed, the *Treatment* variables are statistically insignificant.

---*Table 8 about here*---

While the tests above indicate knowledge transfer from the rotator, the estimates could also be driven by knowledge transfer from co-authors or co-investigators who had success in raising funds from the NSF. To test for such potential mechanisms, we conduct three tests that are presented in Table 9. In the first test in Table 9, we omit from the analysis scientists whose more recent and frequent co-authors experienced improvement in their *ex-post* NSF funding record. Specifically, we omit from the analysis academics whose at least 1 of the 3 most frequent co-authors gained more NSF funding in the previous three years than the sample average. In the second test, we omit from the analysis scientists whose co-investigator in the focal grant had recent success with the NSF. In other words, after a focal academic's co-investigator is awarded an NSF grant as a principal investigator, all subsequent person-year observations of this focal academic are omitted. In the third test, we limit the analysis to grants without co-investigators

(69 percent of the grants had no co-investigators). The results from all three tests suggest that neither the co-authors nor the co-investigator account for the findings we reveal.

Another mechanism that is consistent with the results is favoritism. The presence of a former rotator in a given department may induce increased visibility of the department. This visibility may cause favoritism for the applications submitted by the rotator's colleagues (if, for instance, successor rotators are more lenient towards the returned rotator's colleagues). We conducted several tests that lead us to discount such a possibility. First, under favoritism we would expect to observe growth in funding among those colleagues that have an established funding record with the NSF. In unreported results, we find that this does not hold. Second, under favoritism the grants of rotator's colleagues would be of lower quality when compared to other NSF grants. However, Table 10 demonstrates that the number of publications and citations coming out of rotator colleagues' grants are not statistically different than the number of publications and citations coming out of grants awarded during the period 2009–2011 to the sample investigators that do not belong to departments with a rotator. Third, though this was not part of our research design, none of the academics that we analyzed submitted a funded proposal in the *ex-post* period jointly with the rotator. Finally, none of the rotators co-authored a publication with the sample academics *ex-ante* or *ex-post,* which addresses the possibility of "ghost" co-authorship in the funded proposals.

---*Tables 9 and 10 about here*---

Besides favoritism, the results could also be driven by scientists in the treatment departments working on "hot topics" that typically attract more funds. To test for such possibility, we conducted the following exercise. First, we counted the number of articles in the SCOPUS bibliographic database that include, in their list of keywords, the 3 most occurring keywords for articles published in 2010 by all academics in the sample. Subsequently, we counted the number of articles in SCOPUS that 5 years later, in 2014, included the same keywords. The number of articles that include in their list of keywords the 284 unique keywords of the articles published by the 110 scientists in departments without a rotator who published in 2010 increased by 27.7 percent. The corresponding increase for the 470 unique keywords from articles of the 168 scientists in departments with a rotator who published in 2010 was 23.7 percent. The t-test comparing these two numbers was 0.8734 and it was statistically insignificant. We observe similar trends when we use articles published in 2008 and 2009 as our template. Therefore, academics in departments with and without a rotator appear to work on topics that increase in popularity in parallel.

Similarly, the fact that the NSF picks a given scientist to be a rotator may indicate that the scientist's research area is gaining traction and her department is more active in that area when compared to the other departments. The following factors lead us to discount this as a likely driver of the findings: a) as shown above, the control and treatment departments are similar to each other and their research topics grow in a similar fashion in popularity, b) the analysis includes fixed effects for science field, and c) rotators are rarely headhunted by the NSF; they are typically self-nominated and decide to apply for a rotator position mostly because they want to learn more about the NSF and contribute to the field of science.

VII. Supplementary analysis

In this section, we further elucidate the driver of our findings by exploring whether the estimates are driven by an increase in the applications submitted by the rotator's colleagues upon her return, whether the applications submitted are of higher quality, or/and whether they are better targeted and hence are more likely to be successful. Because the NSF does not release rejected applications on an individual basis, we cannot address the question directly. However, two empirical exercises described below suggest that, for the largest part, the estimates are not driven by an increased number of applications but an improvement in the quality of the submitted applications.

First, in unreported results, we econometrically find that rotators do not have an effect on the number of awarded grants. If more applications correlated with an increase in awarded grants, then this finding would imply that the rotator effect stems from direction and feedback, among others, for better and more carefully targeted proposals. Second, as shown in Table 11, the probability of winning a grant is significantly higher for academics in the treatment group when compared to academics in the first control group. This is supportive of our expectation because better and more carefully targeted proposals are more likely to be funded. The magnitude of the effects is also informative. An increase in the probability for academics to win grants in the treatment group is significant for small- to medium-sized grants (84 percent and 73 percent more likely for grants above $50,000 and $250,000, respectively); this probability diminishes for larger grants (23 percent for grants above $500,000) and becomes non-existent for grants above $1 million. This finding is consistent with the $200,000 difference in fund acquisition between academics in the treatment and control groups, as reported in the baseline estimates.

In the last set of supplementary analyses, we inform the mechanism that drives the results by shedding light on why we observe an effect in *Treatment 1* and *Treatment 2* but not in the later treatment years. We consider two main potential explanations. First, in line with the above discussion that an increase in the number of applications to the NSF does not drive the results, it is possible that once the focal academic raises a grant in, for instance, the treatment year 2, then the academic would devote time toward conducting the research of that grant instead of submitting additional grant applications. To test this proposition, we start with the premise that more grants correlate with more number of applications. Subsequently, in Table 12, we limit the analysis to the top 3 directorates in terms of the number of grants awarded from 2006 to 2016 (i.e., engineering, computer science, math, and physics), and hence the need for a continuous flow of grants is larger. If the lack of applications following the award of a grant would drive the results, then among fields of this kind we would expect an effect in the later treatment years. However, this is contrary to our observation. Second, it is possible that the rotator's effect wanes over time in that the insights and knowledge gained by a rotator are not updated as the NSF progresses, likely changes focus, and priorities, among others. The figures in Table 13 do not dismiss such possibility. The longer the rotator stays away from the NSF, the lesser will be the gain of the new hires in their first year of overlap with the rotator. To illustrate, if the rotator returns at year *t*, hires who join the department at *t*-1 and at *t*, raise, on average, $135,467 and $130,252 at *t* and *t*+1, respectively. On the other hand, those who joined the department during *t*+1 raise $70,144 in *t*+2.

---*Tables 11, 12, and 13 about here*---

Overall, the tests devised to understand the reason behind the absence of an effect past *Treatment 2* imply that the following two forces are at play: a) increased workload after the award of a grant that limits the number of new applications and b) diminishing applicability of the insights that the rotator conveys as the NSF changes over time. Empirically, we cannot separate the two forces mainly because the NSF does not provide access to rejected applications and it is prohibitively difficult to measure with accuracy whether the relevance of the rotator's insights indeed diminishes over time. Anecdotally, our discussion with a handful of rotators suggests that a decrease in the number of applications is the stronger of the two forces, but we do expect knowledge decay from the rotator to play a role in the absence of the effect after *Treatment 2*.

VIII. Conclusions

We study spillovers from academics with a temporary experience in government jobs and reveal evidence consistent with a causal link between an increase in the NSF funding record of newly hired assistant professors and their exposure to academics in their department who return after their tenure at the NSF as PDs (rotators). Tracking the grant acquisition of early career academics since their first faculty position, we find that, within a 5-year period, newly hired assistant professors who join departments with a returning rotator raise almost twice the amount of research grants that similar academics in similar departments without a rotator raise (approximately *$200,000* more, which is nearly *half* of the average of the first-time grant from the NSF). This increase is due to rotator's colleagues being more likely to secure medium-sized grants and are realized one and two years after their exposure to the rotator; at this time, early career scientists have the utmost need for raising research funds that can help them build independent long-term research programs and advance science. By employing a variety of empirical tests, we find that these improvements emerge due to knowledge transfer from the rotator to her colleagues on what to write in and how to write a proposal and where to send a proposal.

Overall, our research highlights that insiders, individuals with insights of an organization type that is different from the one in which they are permanently employed, can generate positive spillovers for their colleagues. These findings contribute to the literature analyzing the effects of access to high human capital in academia (Azoulay, Graff Zivin, and Wang 2010, Waldinger

2016, Waldinger 2012, 2010, Borjas and Doran 2012, Borjas and Doran 2015) by adding novel evidence on gains from high human capital with insights from experience outside academia. The work is also relevant for the literatures on success in science (Kelchtermans and Veugelers 2013, Kahn and MacGarvie 2016) and academic mentoring (Blau et al. 2010). Broadly, the results are informative for the academic labor market. Apparently, rotators with recent experience at the NSF are equipped to contribute positively toward the careers of their colleagues by inducing significant changes in early fund acquisition. Essentially, the presence of a rotator in a given department may be a decisive factor when selecting a job offer.

Our research is timely and has policy implications. Because scientific advancements are built on the progress of early career scientists, it is imperative to explore ways in which these early career scientists can gain access to relevant resources that can contribute toward scientific advancements. Indeed, the difficulties this cohort of academics faces in securing resources is a cause for concern (Poirazi 2017), and it may impede the scientific progress and harm the overall social welfare (Alberts et al. 2014, Nature_Editorial 2016). Policymakers have started to take initiatives mostly by altering the institutional environment to ensure that it improves the chances of early career scientists in raising research funds (Kaiser 2017). Here, we demonstrate that tapping into existing knowledge held by colleagues' human capital might also be a complementary and less resource-intensive strategy with immediate results that would address one of the main obstacles early career academics face—lack of experience and insights; this obstacle puts them at a disadvantage as they often compete for the same grants with high-status scientists who have established funding and publication records.

Along the same lines, this study speaks directly to the design of the rotation program. Under the premise that home universities gain from the rotation program, a recent policy mandates that they cover part of the rotation program bill (Mervis 2016). Here, while we do not fully measure the benefits and the costs of the program, we do find that home institutions realize gains from returning rotators.

Our analysis, albeit careful, has caveats that render it incomplete; hence our study is subject to improvements. First, we follow previous contributions (e.g Kahn and MacGarvie 2016) to construct one of our control groups by matching on observable characteristics such as having the same PhD advisor. Success in raising funds may be driven by unobservable factors, which we cannot account for in this study. Our expectation, however, is that the unobserved factors correlate, at least to a certain extent, with the observable factors. The difference-in-difference analysis that we conducted as a robustness check supports this expectation. Second, we focus on early career scientists who land their first faculty position in the US. However, all the PhD holders do not follow such a career trajectory (Sauermann and Roach 2016). Accordingly, our analysis is conditional on early career scientists having secured a faculty position in a US university. We do not see this as a major concern, *per se*, because our focus is not on who lands a US faculty post in the first place as we compare only similar emerging scientists who follow an academic career in similar institutional environments. Third, the analysis focuses on the US, and hence the results may not generalize directly to other countries as the rotation setting is unique to the NSF. This uniqueness of the rotation program at the NSF together with our estimates gives rise to the question whether other funding agencies in the US and elsewhere would benefit from a similar setting. This is because the diffusion of knowledge that we document is likely predicated on the design of the NSF that requires the inclusion of external academics in its grant review process not only as reviewers but also, and perhaps more importantly, in more central roles as decision makers.

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Table 1. Selected statistics for the academics in the treatment and control groups.

	Treatment group				1st control group			
	210 academics who, as their first faculty post, joined a department **with a rotator** between the 5 years before and 2 years after the rotator returned.				25 academics who, as their first faculty post, joined a department **with a rotator** but did not overlap with the rotator			
	Average	Standard Deviation	Min	Max	Average	Standard Deviation	Min	Max
Previous NSF funding at the start of the faculty post ($M)	0.028	0.115	0.000	0.761	0.045	0.201	0.000	1.001
Yearly NSF funding from the start of the faculty post until the rotator's return from the NSF ($M)	0.015	0.049	0.000	0.349	0.014	0.108	0.000	0.240
Total NSF funding in the 5 years *ex-post* rotator return ($M)	0.494	0.730	0.000	3.420	0.253	0.540	0.000	2.253
Male	0.714	0.453	0.000	1.000	0.683	0.720	0.000	1.000
Years as a Post-Doc	2.181	2.006	0.000	10.000	2.320	1.600	0.000	5.000
H-index at the time of the first faculty post	1.921	2.147	0.000	10.000	2.339	2.556	0.000	9.000
Yearly non-NSF funding until first faculty post ($M)	0.006	0.054	0.000	0.750	0.002	0.010	0.000	0.050
Years between PhD graduation and first faculty post	2.683	1.962	0.000	10.000	2.817	2.400	0.000	7.000
First author publication before PhD graduation	0.751	0.433	0.000	1.000	0.654	0.478	0.000	1.000

For the Treatment group the Rotator Department and Treatment variables take the value of 1 as follows: RotatorDepartment-5: 40 RotatorDepartment-4: 56, RotatorDepartment-3: 65, RotatorDepartment-2: 86, RotatorDepartment-1: 199, Treatment 0: 214 Treatment 1: 206, Treatment 2: 204, Treatment 3: 204, Treatment 4: 202, Treatment 5: 200

Table 1 continued. Selected statistics for the academics in the treatment and control groups.

	2nd control group				**3rd control group**			
	105 academics who, as their first faculty post, joined departments **without a rotator** and had the same advisor and similar graduation year as academics who joined departments with a rotator				60 academics who, as their first faculty post, joined a department **without a rotator** in the rotator's university in a similar department			
	Average	Standard Deviation	Min	Max	Average	Standard Deviation	Min	Max
Previous NSF funding at the start of the faculty post ($M)	0.003	0.019	0.000	0.150	0.034	0.181	0.000	1.270
Yearly NSF funding from the start of the faculty post until the rotator's return from the NSF ($M)	0.014	0.058	0.000	0.401	0.007	0.038	0.000	0.260
Total NSF funding in the 5 years *ex-post* rotator return ($M)	0.261	0.717	0.000	5.689	0.238	0.395	0.000	1.675
Male	0.683	0.468	0.000	1.000	0.733	0.446	0.000	1.000
Years as a Post-Doc	2.308	2.252	0.000	9.000	2.650	1.830	0.000	8.000
H-index at the time of the first faculty post	1.587	2.032	0.000	8.000	2.600	2.294	0.000	7.000
Yearly non-NSF funding until first faculty post ($M)	0.001	0.006	0.000	0.065	0.001	0.003	0.000	0.015
Years between PhD graduation and first faculty post	2.817	2.550	0.000	11.000	3.017	2.221	0.000	8.000
First author publication before PhD graduation	0.654	0.478	0.000	1.000	0.783	0.415	0.000	1.000

Table 2. Departments with and without a rotator raise similar amounts from the NSF.

	Average yearly department NSF funding the five year preceding the rotator's return from the NSF.			
		Total		Per faculty member
Department with a returning rotator	$	1,111,788	$	34,903
Department without a returning rotator	$	1,220,669	$	33,467

Table 3. Departments with and without a rotator are of similar status and research productivity.

		Departments with a rotator	Departments without a rotator
Member of the Association of American University		55%	50%
Department Shanghai ranking the year the rotator' return	*First quartile*	23%	26%
	Second quartile	17%	15%

Table 4. Descriptive statistics of the 64 sample rotators who ended their rotation between 2009 and 2011

	Mean	**Std. Dev.**	**Min**	**Max**
Years in rotation	1.625	0.951	1.000	5.000
Male	0.730	0.447	0.000	1.000
Career age at start of rotation	21.500	8.214	8.000	31.000
Publications (5 years *ex-ante*)	11.627	11.697	0.000	42.000
Citations per paper (5 years *ex-ante*)	15.667	27.482	0.000	108.080
NSF funding (5 years *ex-ante*)	$643,205	$1,747,756	$0.000	$ 13,086,007

Table 5. OLS Baseline Estimates. Dependent Variable is NSF funding in million.

	MODEL 1 Treatment Group & 1st Control Group	**MODEL 2** Treatment Group & 2nd Control Group	**MODEL 3** Treatment Group & 3rd Control Group
RotatorDepartment t-5	-0.014	-0.010	-0.003
	(0.015)	(0.010)	(0.012)
RotatorDepartment t-4	0.059	0.079	0.099
	(0.040)	(0.045)	(0.055)
RotatorDepartment t-3	-0.010	0.002	0.019
	(0.018)	(0.018)	(0.017)
RotatorDepartment t-2	0.007	0.005	0.029
	(0.027)	(0.028)	(0.027)
RotatorDepartment t-1	0.007	-0.003	0.010
	(0.023)	(0.020)	(0.021)
Treatment 0	0.034	0.037	0.040
	(0.021)	(0.019)	(0.022)
Treatment 1	**0.092*** **	**0.058** **	**0.070** **
	(0.032)	**(0.026)**	**(0.027)**
Treatment 2	**0.113*** **	**0.061** **	**0.088*** **
	(0.036)	**(0.026)**	**(0.024)**
Treatment 3	0.072**	0.034	0.042**
	(0.035)	(0.018)	(0.019)
Treatment 4	0.030	0.007	0.005
	(0.037)	(0.020)	(0.024)
Treatment 5	-0.000	-0.001	-0.004
	(0.033)	(0.025)	(0.026)
PostDoc	-0.003	-0.003	-0.003
	(0.002)	(0.002)	(0.002)
Assistant Professor	0.017	0.025**	0.011
	(0.016)	(0.012)	(0.013)
Associate Professor	0.009	0.008	-0.007
	(0.015)	(0.012)	(0.013)
Male	-0.001	0.013	0.010
	(0.011)	(0.009)	(0.009)
H-index	-0.000	0.001	0.000
	(0.001)	(0.001)	(0.001)
External Funding ($M)	0.355	0.381**	0.341
	(0.186)	(0.181)	(0.187)
Previous NSF ($M)	0.113***	0.098***	0.122***
	(0.017)	(0.015)	(0.017)
Ranking	-0.007**	-0.007**	-0.007**
	(0.003)	(0.003)	(0.003)
Faculty NSF ($M)	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
Constant	0.039	0.035	-0.004
	(0.022)	(0.023)	(0.019)
Science field FE	YES	YES	YES
Year FE	YES	YES	YES
Observations	2,152	2,642	2,319
R^2	0.170	0.156	0.179
Adjusted R^2	0.155	0.144	0.166
Number of Departments	65	158	80

Robust standard errors in parentheses clustered at the department level
*** p<0.01, ** p<0.05

Table 6. Omit from the treatment group new hires who join the rotator department after the rotator has returned + Relax same advisor and graduation year criteria

	Test 1 Omit hires who joined the department after the rotator returned	*Test 2* Add academics with the same advisor who graduated 3 to 10 years before the focal academic who joined a department with a rotator	*Test 3* Use Coarsened Exact Matching to populate the control group
RotatorDepartment t-5	-0.010	0.008	-0.009
	(0.015)	(0.012)	(0.069)
RotatorDepartment t-4	0.067	0.081**	0.046
	(0.041)	(0.038)	(0.054)
RotatorDepartment t-3	-0.000	-0.005	0.023
	(0.020)	(0.019)	(0.047)
RotatorDepartment t-2	0.007	0.003	0.036
	(0.029)	(0.023)	(0.036)
RotatorDepartment t-1	0.007	-0.022	0.003
	(0.025)	(0.022)	(0.027)
Treatment 0	0.032	0.025	0.054**
	(0.024)	(0.018)	(0.023)
Treatment 1	**0.098*** **	**0.055** **	**0.064*** **
	(0.037)	**(0.026)**	**(0.021)**
Treatment 2	**0.119** **	**0.072*** **	**0.060*** **
	(0.045)	**(0.024)**	**(0.020)**
Treatment 3	0.084**	0.039**	0.026
	(0.042)	(0.017)	(0.020)
Treatment 4	0.033	0.006	0.003
	(0.042)	(0.020)	(0.019)
Treatment 5	-0.010	0.004	0.001
	(0.046)	(0.024)	(0.019)
PostDoc	-0.003	-0.003	-0.004
	(0.003)	(0.002)	(0.003)
Assistant Professor	0.010	0.030***	0.013
	(0.017)	(0.010)	(0.019)
Associate Professor	0.006	0.016	-0.008
	(0.015)	(0.011)	(0.021)
Male	0.002	0.012	0.004
	(0.014)	(0.008)	(0.010)
H-index	-0.000	0.001	0.001
	(0.001)	(0.001)	(0.001)
External Funding ($M)	0.395**	0.338	-0.038
	(0.176)	(0.186)	(0.055)
Previous NSF ($M)	0.111***	0.096***	0.104***
	(0.018)	(0.013)	(0.009)
Ranking	-0.006	-0.006**	-0.005
	(0.003)	(0.002)	(0.003)
Faculty NSF ($M)	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
Constant	0.034	-0.019	-0.022
	(0.022)	(0.015)	(0.045)
Science field FE	YES	YES	YES
Year FE	YES	YES	YES
Observations	1,800	3,181	2,654
R^2	0.197	0.138	0.094
Adjusted R^2	0.179	0.127	0.0813
Number of Departments	180	193	66

Robust standard errors in parentheses clustered at the department level
*** p<0.01, ** p<0.05

Table 7. Robustness Check 4. Difference-in-difference estimation.

After	0.032
	(0.022)
Treatment	-0.010
	(0.020)
After * Treatment	**0.070****
	(0.030)
PostDoc	-0.010**
	(0.005)
Assistant Professor	0.018
	(0.024)
Associate Professor	-0.015
	(0.036)
Male	-0.004
	(0.022)
H-index	0.002
	(0.001)
External Funding ($M)	0.012
	(0.048)
Previous NSF ($M)	0.296***
	(0.108)
Ranking	-0.009
	(0.006)
Faculty NSF ($M)	0.000
	(0.001)
Constant	0.121**
	(0.061)
Science field FE	YES
Year FE	YES
Observations	426
R^2	0.185
Adjusted R^2	0.132
Number of Departments	141

Robust standard errors in parentheses clustered at the department level
*** $p<0.01$, ** $p<0.05$

Table 8. False rotator appointments.

	Random timing of rotator's return to the department	Random appointment of rotator department
RotatorDepartment t-5	-0.022	-0.002
	(0.018)	(0.025)
RotatorDepartment t-4	0.016	0.292
	(0.031)	(0.265)
RotatorDepartment t-3	0.020	-0.071**
	(0.035)	(0.032)
RotatorDepartment t-2	-0.013	0.062
	(0.020)	(0.064)
RotatorDepartment t-1	-0.001	0.024
	(0.022)	(0.033)
Treatment 0	0.027	-0.023
	(0.027)	(0.029)
Treatment 1	**0.007**	**-0.031**
	(0.026)	**(0.039)**
Treatment 2	**-0.006**	**-0.013**
	(0.023)	**(0.026)**
Treatment 3	0.039	-0.013
	(0.031)	(0.020)
Treatment 4	0.032	-0.007
	(0.030)	(0.014)
Treatment 5	-0.042**	0.001
	(0.020)	(0.021)
PostDoc	-0.003	-0.002
	(0.002)	(0.002)
Assistant Professor	0.021	0.033***
	(0.017)	(0.011)
Associate Professor	0.012	0.016
	(0.013)	(0.013)
Male	-0.001	0.012
	(0.011)	(0.008)
H-index	-0.000	0.001
	(0.001)	(0.001)
External Funding ($M)	0.360	0.388**
	(0.184)	(0.183)
Previous NSF ($M)	0.113***	0.099***
	(0.016)	(0.015)
Ranking	-0.007**	-0.007**
	(0.003)	(0.003)
Faculty NSF ($M)	0.000	0.000
	(0.000)	(0.000)
Constant	0.039	0.035
	(0.021)	(0.022)
Science field FE	YES	YES
Year FE	YES	YES
Observations	2,152	2,642
R^2	0.170	0.176
Adjusted R^2	0.155	0.141
Number of Departments	65	158

Robust standard errors in parentheses clustered at the department level
*** p<0.01, ** p<0.05, * p<0.1

Table 9. Neither co-authors nor co-investigators drive the baseline estimates

	Omit co-authors with recent success in raising NSF grants	Omit all person-year observations after a recent Co-I is awarded an NSF grant	Omit NSF grants with a Co-I
RotatorDepartment t-5	-0.031	-0.025	-0.012
	(0.016)	(0.014)	(0.012)
RotatorDepartment t-4	0.021	0.024	0.022
	(0.028)	(0.026)	(0.022)
RotatorDepartment t-3	-0.019	-0.005	-0.010
	(0.020)	(0.017)	(0.011)
RotatorDepartment t-2	-0.015	-0.009	0.027
	(0.032)	(0.030)	(0.016)
RotatorDepartment t-1	-0.013	-0.016	0.003
	(0.020)	(0.019)	(0.018)
Treatment 0	0.028	0.028	0.025
	(0.020)	(0.018)	(0.019)
Treatment 1	**0.090****	**0.067*****	**0.083****
	(0.044)	**(0.025)**	**(0.036)**
Treatment 2	**0.135*****	**0.081****	**0.077****
	(0.034)	**(0.033)**	**(0.030)**
Treatment 3	0.039	0.046	0.033
	(0.031)	(0.032)	(0.030)
Treatment 4	0.007	0.016	0.015
	(0.032)	(0.026)	(0.028)
Treatment 5	-0.015	0.021	0.004
	(0.035)	(0.016)	(0.015)
PostDoc	-0.003	-0.002	-0.004**
	(0.003)	(0.002)	(0.002)
Assistant Professor	0.018	0.017	0.015
	(0.017)	(0.015)	(0.009)
Associate Professor	0.005	0.009	0.009
	(0.017)	(0.015)	(0.011)
Male	-0.001	-0.011	0.001
	(0.012)	(0.012)	(0.007)
H-index	-0.000	-0.000	-0.000
	(0.001)	(0.001)	(0.001)
External Funding ($M)	-0.070**	-0.031	0.061
	(0.034)	(0.029)	(0.076)
Previous NSF ($M)	0.113***	0.131***	0.060***
	(0.015)	(0.024)	(0.018)
Ranking	-0.002	-0.005	-0.007***
	(0.003)	(0.003)	(0.003)
Faculty NSF ($M)	0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)
Constant	0.025	0.001	0.046***
	(0.026)	(0.017)	(0.015)
Science field FE	YES	YES	YES
Year FE	YES	YES	YES
Observations	1,784	1,843	2,031
R^2	0.112	0.100	0.083
Adjusted R^2	0.0930	0.0808	0.0656
Number of Departments	65	65	65

Robust standard errors in parentheses clustered at department level
*** p<0.01, ** p<0.05

Table 10. Grants of scientists in treatment and control groups yield similar outcomes

	2009 to 2011 grants of scientists in departments *with* a rotator		2009 to 2011 grants of scientists in departments *without* a rotator		
Variable	**Mean**	**Standard Deviation**	**Mean**	**Standard Deviation**	**Two-sides t-test**
Publications	6.385	0.854	6.667	1.375	0.859
Citations	322.517	83.296	281.462	112.260	0.781

Table 11. Change in probability of securing an NSF grant after the rotator returns.

	Grant larger than $50,000	Grant larger than $250,000	Grant larger than $500,000	Grant larger than $1,000,000
Year of rotator return	0.167 **	0.157 **	0.05	-0.007
1 year after rotator return	0.214 ***	0.198 ***	0.116 ***	0.018
2 years after rotator return	0.235 **	0.226 ***	0.109 ***	0.010
3 years after rotator return	0.224 **	0.145 **	0.007	-0.005
4 years after rotator return	0.096	0.035	0.012	-0.003
5 years after rotator return	0.062	0.038	0.003	-0.004

The change in probability is calculated after holding all other variables at their means

Table 12. Limit the analysis to the top 3 directorates in terms of the number of grants awarded from 2005 to 2016.

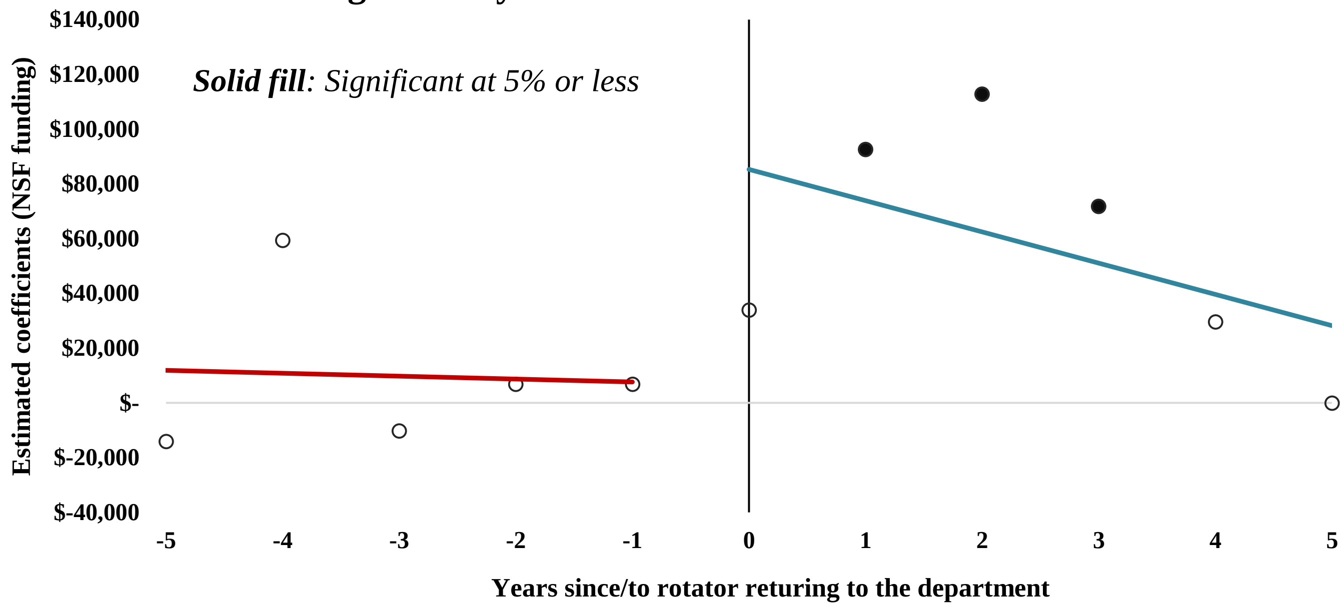
	Treatment Group & 1st Control Group
RotatorDepartment t-5	-0.028
	(0.026)
RotatorDepartment t-4	0.019
	(0.044)
RotatorDepartment t-3	0.013
	(0.025)
RotatorDepartment t-2	0.049
	(0.036)
RotatorDepartment t-1	-0.015
	(0.036)
Treatment 0	0.029
	(0.041)
Treatment 1	**0.139****
	(0.059)
Treatment 2	**0.175****
	(0.075)
Treatment 3	0.118
	(0.106)
Treatment 4	0.089
	(0.091)
Treatment 5	-0.023
	(0.049)
PostDoc	-0.009***
	(0.002)
Assistant Professor	0.029
	(0.030)
Associate Professor	0.001
	(0.029)
Male	-0.006
	(0.025)
H-index	-0.000
	(0.001)
External Funding ($M)	-0.073
	(0.074)
Previous NSF ($M)	0.113***
	(0.021)
Ranking	-0.012**
	(0.006)
Faculty NSF ($M)	-0.000
	(0.000)
Constant	0.097**
	(0.043)
Science field FE	YES
Year FE	YES
Observations	893
R^2	0.132
Adjusted R^2	0.096
Number of Departments	27

Robust standard errors in parentheses clustered at the department level
*** p<0.01, ** p<0.05

Table 13. The longer the rotator has been away from the NSF, the less new hires in their first year of overlap with the rotator gain.

	Average NSF funding acquired during first three years of overlap with rotator after return from NSF				
Variable	**Tr0**	**Tr1**	**Tr2**	**Tr3**	**Tr4**
Joined 1 year before the rotator returned	$135,467	$262,451	$217,168		
Joined the same year the rotator returned	$11,349	$130,252	$130,834		
Joined 1 year after the rotator returned		$28,518	$70,144	$61,849	
Joined 2 years after the rotator returned			$36,058	$24,383	$78,931

Figure 1: Dynamics of the rotator effect



Appendix Table 1. Sample rotators are representative of the population of rotators.

	64 Rotators who ended their rotation in 2009-2011 and are in the sample.	176 Rotators who ended their rotation in 2009-2011 and are not in the sample.	All 816 Rotators between 2004 and 2014.
Years in rotation	1.625	1.862	1.971
Male	0.730	0.678	0.714
Career age at start of rotation	21.500	22.111	23.372
Publications (5 years ex-ante)	11.627	13.894	11.661
Citations per paper (5 years ex-ante)	15.667	14.930	13.100
NSF funding (5 years ex-ante)	$643,205	$697,347	$699,332

Appendix Table 2. Details on the construction of selected variables

Variable Code	Description	Construction
Dependent Variable	Sum of NSF funding received in the person-year. The sum does not include grant extensions of continuations.	We first look up last names of faculty members at the NSF grant database (https://www.nsf.gov/awardsearch/download.jsp). Then, using first name(s) and institution records, the correct person ID is identified manually. Finally, the sum of NSF funds in the specific person-years is calculated.
Rotator Department / Treatment	A range of 11 variables that take the value of 1 when the focal academic was in the department of the rotator for the specific year. Example: A rotator returns to his department in 2010 and an academic starts his position at this department in 2006. For the person-year 2007, *RotatorDepartment-3* takes the value of 1. For the person-year 2012, *Treatment2* takes the value of 1.	For every academic who joins a rotator department we retrieve the year the rotator returns to the department and calculate for each person-year observation how many years this specific observation is removed from the year of rotator return. Then, we distribute the result of this calculation over the range of *Rotator Department* and *Treatment* variables.
PostDoc	Measures the number of years the focal new hire was employed in a post-doctoral position before assuming a faculty post.	Professional history was collected manually from CVs originating from university, laboratory, personal websites and Linkedin.
Assistant Professor and Associate Professor	Takes the value of 1 for person-years the focal academic has an Assistant Professor or Associate Professor position respectively, and 0 otherwise.	Professional history was collected manually from CVs originating from university, laboratory, personal websites and Linkedin.
Male	Takes the value of 1 for academics who are male.	Determined manually from faculty websites and personal websites.
H-index	Time-varying H-5 citation index of the academic in question. For example: An H-5 index of 3 is read as "In the last 5 years, there have been at least 3 publications that have each been cited 3 times or more."	All the SCOPUS indexed publications of the rotator are extracted and then the h-index for the specific person-year is generated.
External Funding	Sum of funding received in the person-year period that does not originate from the NSF.	Funding history was collected manually from CVs originating from university, laboratory, personal websites and Linkedin. Additionally, National Institutes of Health records were cross-examined with our observations.
Previous NSF	Sum of NSF funding received before the specific person-year	For each identified academic, the sum of NSF funding in the 5 years before the focal person-year is calculated.
Ranking	Takes the value of 1 if the university is ranked in the first Shanghai ranking quartile for the specific field and year of rotation, 2 if the university is ranked in the second quartile, 3 if the university is ranked in the third quartile and 4 if the university is ranked in the	For each specific science field and year of rotation, the Shanghai ranking of the universities is configured into quartiles.

	lowest quartile for the specific field and year of rotation.	
Faculty NSF	Measures the sum of NSF funds raised by existing faculty members in the rotator's department before the rotator's return from the NSF	The websites of the academic units are visited for the year the rotator returns using https://web.archive.org/. For each faculty member not in adjunct or emeritus positions the sum of NSF funding before the year of the rotator's return is calculated.
Science Field FE	Dummy variables that reflects the science field of each focal scientist's academic unit	For each academic unit we measure the number of NSF awards from each Directorate over time. The 7 Directorates are Biological Sciences, Computer & Information Science, Education & Human Resources, Engineering, Geosciences, Mathematical & Physical Sciences, Social, Behavioral & Economic Sciences. We determine the science field (and include associated dummy variables) by identifying the Directorate that has awarded the most grants to the focal academic unit.