The Color of Money: Federal vs. Industry Funding of University Research

Tania Babina Alex Xi He Sabrina T. Howell

Elisabeth Ruth Perlman Joseph Staudt*

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Abstract

U.S. universities have experienced a shift in research funding away from federal and towards private industry sources. This paper evaluates whether the source of funding – federal or private industry – is relevant for commercialization of research outputs. We link person-level grant data from 22 universities to patent and career outcomes (including IRS W-2 records). To identify a causal effect, we exploit individual-level variation in exposure to narrow federal R&D programs stemming from pre-existing field specialization. We instrument for the researcher's funding sources with aggregate supply shocks to federal funding within these narrow fields. The results show that a higher share of federal funding reduces patenting and the chances of joining an incumbent firm, while increasing the chances of high-tech entrepreneurship and of remaining employed in academia. A decline in the federal share of funding is offset by an increase in the private share of funding, which has opposite effects. We conclude that the incentives of private funders to appropriate research outputs have important implications for the trajectory of university researcher careers and intellectual property.

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*Babina: Columbia University tania.babina@gsb.columbia.edu. He: University of Maryland, axhe@umd.edu. Howell: NYU & NBER, sabrina.howell@nyu.edu. Perlman: US Census Bureau, elisabeth.perlman@census.gov. Staudt: US Census Bureau, joseph.staudt@census.gov. We thank Pierre Azoulay, Lauren Cohen, Daniel Gross, Scott Kominers, Natsuko Nicholls, Jason Owen-Smith, and Beth Uberseder, as well as participants at the NSF Future of IP conference. For helpful research assistance, we thank Belinda Chen and Jun Wong. Howell's research on this project was funded by the NBER Science of Science Program, sponsored by the Sloan Foundation, and by the Kauffman Foundation. This paper uses data from the U.S. Census Bureau. Any views expressed are those of the authors and not those of the U.S. Census Bureau. The Census Bureau's Disclosure Review Board and Disclosure Avoidance Officers have reviewed this data product for unauthorized disclosure of confidential information and have approved the disclosure avoidance practices applied to this release. (DRB Approval Numbers CBDRB-FY20-152, CBDRB-FY20-CES009-004, and CBDRB-FY20-CES009-006).

1 Introduction

When the U.S. government reduced the Defense Advanced Research Projects Agency's budget for funding university computer science research from $214 million to $123 million in 2004, it cited higher corporate funding for university research as one rationale (Markoff 2005). This decision is one small contribution to a decades-long decline in the share of U.S. research and development (R&D) investment that comes from federal government sources, compensated for by an increasing share from private industry (Figure 1). Motivated by these secular changes, we examine whether the source of research funding – federal vs. private – affects how research outputs are commercialized in the form of patents and career trajectories. We focus on universities, a research arena where federal and private funding both play important roles and where new data allow us to characterize funding composition at the level of the individual researcher. Universities are also pivotal to human capital production and in particular to training the next generation of researchers. Finally, universities are engines of innovation, crucial for economic growth (Jaffe 1989, Audretsch and Feldman 1996).

We know little about whether the returns to research investment are sensitive to the source of funding – that is, the "color of money," a term borrowed from federal agency jargon for the type of funding. Our null hypothesis is that the source of funding is irrelevant, and instead only the level of funding matters. In this case, government subsidy of science is warranted mainly because private firms cannot fully appropriate research outcomes and therefore underinvest (Nelson 1959, Arrow 1962).[1] Alternatively, shifting from federal to private sources of funding could alter research trajectories, potentially affecting both intellectual property and human capital outputs. The most salient distinction between private and federal funders is the incentive faced by private funders to appropriate research outputs. However, different sources of funding could also push researchers to be more or less productive, or to do more applied relative to basic research.

We use data from the University of Michigan's Institute for Research on Innovation and Science (IRIS) on all grants at 22 U.S. research universities. The data are transaction-level and include all

[1] There is some empirical research that is at least tangentially consistent with this hypothesis (Jacob and Lefgren 2011, Myers 2019). On the practitioner side, the editor of the *New England Journal of Medicine* has argued that it is the quality of research, not its source of funding, that matters (Drazen 2016).

employees paid by all grants. For every researcher in each year, we calculate the fraction of the researcher's expenditures that comes from the federal government, from private firms, and from other sources. We then link each researcher to career histories (using confidential data at the U.S Census Bureau, including the universe of IRS W2 tax records) and to patent inventors. The time frame for analysis is from 2001 to 2016.

In a methodological contribution, we instrument for an individual researcher's share of federal and private funding using changes in the aggregate supply of federal funding within narrow federal R&D programs. This addresses endogeneity in the relationship between funding source and research outcomes. A change in a government program's funding serves as a shock to researchers who have previously relied on that program. Program funding is governed by Congressional politics and is quite volatile from year to year. An advantage of our instrument is that it stems from actual policies — Congressional budget decisions — and thus the estimates from compliers are informative about the relevant policy counterfactual with somewhat more or less federal funding in a particular field. Moreover, as our data are available for academic use, the instrument can be readily deployed in future research. We include university-department-year fixed effects, which address the concern that university- or department-level responses to federal funding shocks might correlated with individual research outputs. Identifying variation thus comes from comparing colleagues working in the same department and in the same year, but on different topics that have different federal funding availability.

The best measure of monopolizing intellectual property is patents. We show that a 10% increase in the mean share of federal funding reduces the probability that an academic researcher patents the following year by 56%, and also reduces the number of patents produced. The federal share of funding has no effect on producing highly-cited patents, but does increase the probability of a general patent. Finally, we show that a higher share of federal funding reduces the probability that patents have a private sector assignee. It is also the case that 40% of privately assigned patents in our data are assigned to the private sponsor of research. When we instrument for the share of private funding (other sources are universities and state governments, for example), the effects are reversed, which suggests that most of the changes in federal share are compensated by changes in private share.

Turning to career outcomes, we find that a 10% increase in the mean share of federal funding increases the probability of high-tech entrepreneurship within three years by 46%. This result is inconsistent with federal funding leading researchers to be less productive or only pushing them in the direction of conducting more basic research with no immediate commercial application (it is noteworthy that the share of basic research within private and federal sources is quite similar). In contrast, we would expect this result if federal funding is more open for researchers to appropriate for themselves and to use as they see fit, including for the benefit of their startup.

Firms may sponsor research in part to train future employees in an attempt to appropriate human capital as well as intellectual property.[2] Shedding light on this possibility, we show that a higher share of federal funding increases the probability that a researcher remains in academia and decreases the probability that a researcher subsequently works for an incumbent firm. Moreover, we show that, among individuals with private funding who subsequently work at any funder firm (~500 firms), 20% go to the firm that funded their own research. As with patents, instrumenting for private funding reverses the career results. Our findings are all consistent with the human and intellectual capital of privately funded research being more often appropriated, in particular by the funder.

Splitting the sample by occupation, we find that faculty and, to a lesser extent, graduate students drive the patenting results, consistent with them being the primary impetus of patent application decisions rather than other types of grant employees such as undergraduates and staff. We also find that graduate and undergraduate students explain the high-tech entrepreneurship and academic career results, consistent with these individuals being at a crucial juncture in their careers. The large effects of the source of funding on career trajectories is relevant not only for agencies who define their mission in part in terms of supporting training, but also for understanding the role of universities in training future researchers through their graduate programs.

We conduct a range of robustness tests. We address concerns that omitted variables such as technological opportunities or downstream subsidies could explain both changes in aggregate federal

[2]For example, the Stanford University Industrial Contracts Office opens its guide to university researchers by noting that a main reason companies seek to fund research is "contact with students (who may become their employees)." See https://ico.sites.stanford.edu/sites/g/files/sbiybj6716/f/researchersguidetoworkingwithindustry.pdf.

R&D and changes in research outputs. For example, in a placebo test we restrict the sample to researchers who get all of their funding from the federal government and do not switch between sources, as time-varying covariates such as technological opportunities should also affect them. We find no effects among these non-switchers, consistent with a causal relationship between funding changes and different research outputs. Second, we might worry that funding changes are predictable, and researchers adjust their career plans accordingly. In this case, the funding changes should exhibit long term incremental trends. However, we find that controlling for long-term trends in funding does not affect the results, and a visual event study shows that there are no observable pre-trends. Finally, we use several tests to ensure that our results stem from the source of funding and not the level.

In sum, federal and private funding are not perfect substitutes. While multiple channels may be at play, a key difference between the two sources lies in contractual arrangements for how intellectual property is commercialized. Private funders – acting in the interest of company shareholders – seek to maximize appropriation of intellectual and human capital outputs. Using examples of actual contracts between industry and academia, we confirm the common understanding among practitioners that industry funders have rights of first refusal to research findings and control over the direction of research (e.g. NAP 1993, McCluskey 2017). These complex industry-university contracts contrast with the absence of any contract for federal grants, which are governed only by existing law and regulation, and which give the researcher the ability to commercialize results.[3] The contractual agreements also indicate, perhaps surprisingly, that there are no meaningful differences between private and federal funding in researchers' ability to publish.

The incentives of private funders to appropriate outputs could reduce knowledge spillovers from university research, with long-term implications for economic growth. There is evidence that more open science has larger spillovers (Williams 2013, Murray et al. 2016) and that new high-tech firms are an important source of economic growth and job creation, with many high-tech startups originating from university research (Feldman et al. 2002, Decker et al. 2014, Avnimelech and Feldman 2015). This paper speaks to the longstanding tension between intellectual property rights and innovation;

[3]Technical march-in rights, which allow a federal funding agency to disregard a patent's exclusivity, are never exercised.

while patents may incentivize private firms to fund university research, these incentives go hand-in-hand with reduced spillovers (Scotchmer 1991, Walsh et al. 2005, Azoulay and Li 2020).

Our paper contributes to the literature on private vs. public funding of research. On one hand, Goolsbee (1998) argues that government efforts to increase inventive activity are problematic because of inelastic R&D labor supply. On the other hand, empirical evidence from the life sciences finds large positive impacts of public funding on private innovation (Azoulay et al. 2019). Other work on the public funding of research includes Hegde (2009) and Budish, Roin and Williams (2015). There is some evidence from surveys, case studies, and university-level data that universities and public funding are associated with startup activity (O'shea et al. 2005, Åstebro et al. 2012, Zucker et al. 1998).[4] To our knowledge, we provide the first causal effect of the funding *source.*

We also contribute to the literature on how universities affect innovation, which beyond work cited above, includes Shane and Stuart (2002), Lach and Schankerman (2008), Belenzon and Schankerman (2009), Foray and Lissoni (2010), Belenzon and Schankerman (2013), Guerzoni et al. (2017), Tartari and Stern (2018), Tabakovic and Wollmann (2019), and Watzinger and Schnitzer (2019). In a seminal paper, Trajtenberg et al. (1997) assume that university research will be less appropriable and closer to science than corporate research. Especially relevant to this paper, Hvide and Jones (2018) show a negative effect on faculty entrepreneurship when invention rights are reallocated from the professor to the university, and Kong et al. (2020) show that university patents are more readable than corporate patents. Building on this work, we document that federal and private research grants to universities yield markedly different commercialization outcomes, apparently because of their divergent incentives to appropriate research outputs.

2 Hypotheses Development

Our null hypothesis is that the source of funding – federal or private – does not affect commercialized research outputs. If funding mainly impacts researchers' budget constraints and does not alter their

[4]Also see Astebro and Bazzazian (2011), Djokovic and Souitaris (2008), Rothaermel et al. (2007), and Siegel et al. (2007) for review.

objectives, then the level and not the source should drive research outcomes. Consistent with this, existing literature points to an important role for the level in determining research outputs and researcher career trajectories (Jacob and Lefgren 2011, Myers 2019).

Alternatively, the source of research funding may also change the objectives of or impose additional constraints on researchers because different types of funders have different goals and structure their research funding programs accordingly (Azoulay and Li 2020). There are three plausible channels for such an effect. First, one type of funding may lead to more commercializable research outputs overall (i.e. more vs. less productive research). This is akin to the effects of having a better teacher on a child's outcome, independent of the child's own quality. Ex-ante, it is not obvious which funding source would be associated with more productive research. On the one hand, the absence of contracts and the more open-ended nature of federal grants might give researchers flexibility to adjust and re-optimize the research process as projects unfold and as more information about the research question becomes available. On the other hand, private funders might be more motivated to monitor, and be able to focus the research process towards more promising ideas. If federal or private funding increases research productivity in the sense of leading to more commercializable outputs, we expect researchers funded by that source to produce (a) more patents and (b) more high-tech entrepreneurship.

Second, the federal government may prefer to fund more basic research, while private funders may prefer to fund more applied work, and each may push researchers in one direction or the other once they receive funding. Basic research, at the earliest stages of scientific inquiry, is thought to yield more spillovers (Funk 2002, Akcigit et al. 2020), which is a key motivation for government funding of research. However, empirically federally funded research is not necessarily more basic: the share of funding supporting basic research is essentially the same across federal and non-federal funding sources (NSF 2018), and private funders tend to also fund research in "Pasteur's quadrant", namely basic research but directed at real-world challenges or problems (Atkinson 2018). If federal funding pushes researchers toward doing more basic research, then we should expect that federal funding should yield (a) fewer patents; and (b) less high-tech entrepreneurship among university researchers, as both of these outcomes are available only to commercially applicable research outputs.

Third, greater appropriation of research outputs by industry funders may affect the trajectory of commercialization. Private firms are obligated to maximize shareholder value and may be penalized for investing in research whose outputs they cannot appropriate. Industry sponsorship of university research involves detailed legal contracts governing intellectual property and disclosure, which may be associated with private funders pushing universities to patent research outputs and provide the funder firm with an exclusive license (examples are in Section 6.3.1). In contrast to private firms, the federal government largely invests in research with the aim of producing public goods, including training future researchers and professors. This may lead to more open outputs. Yet it is not obvious that these different incentives will manifest; importantly, universities have been incentivized to patent since the Bayh-Dole Act of 1980, and this may drive commercialization decisions independently of funding source. If, compared to privately-funded research, federally-funded research produces more open outputs that are more easily appropriated by the researchers – either to benefit their own startups or to be placed in the scientific commons – we expect it to yield (a) fewer patents, which can be appropriated by funder firms; and (b) more high-tech entrepreneurship among university researchers.

3 Methodology

In this section, we first motivate and explain our instrumental variables strategy (Section 3.1). Then we describe our estimation approach (Section 3.2).

3.1 Motivation for Empirical Strategy

A university researcher i can receive funding from multiple sources, including the federal government, private firms, local governments, and universities. The choice of funding source is not random and can depend on many factors, which can be grouped into two broad categories: demand-side and supply-side. Demand-side factors are related to a researcher's preferences for different funding sources, while supply-side factors reflect the availability of different funding sources for a particular researcher and her project. The supply-side factors can be broken into two sub-categories. The first depends on the quality of the researcher and her project. The second, which we isolate as part of our identification strategy, does not depend on the identity of the researcher or the project, and instead reflects the supply of funds available to everyone.

Regressing innovation outcomes on the share of a researcher's funding coming from the federal government will reflect all of these factors and lead to biased estimates. For example, if federal grants are more prestigious or selective, unobserved quality will create a positive correlation between the federal share and innovation outcomes such as patents. Researcher fixed effects do not address endogeneity because quality and preferences may vary over time. Instead, to identify causal effects, we need to isolate the exogenous components of funding sources – those uncorrelated with the unobservable researcher or grant characteristics (i.e. the second sub-category of supply-side factors discussed above). To accomplish this, we exploit changes in the aggregate supply of federal funding within narrow federal programs, treating these changes as supply shocks to the researchers receiving funding from those specific programs. Since these funding shocks affect all researchers working in one area, they are uncorrelated with the characteristics of individual researchers.

The Catalog of Federal Domestic Assistance (CFDA), which is maintained by the government, identifies federal assistance programs.[5] Each CFDA program is related to a specific field of research. Two examples are shown in Figure 2: "Cardiovascular Diseases Research," or CFDA code 93.837 in Panel A, where we observe a positive shock in 2005, and "Agricultural Basic and Applied Research," or CFDA code 10.001 in Panel B, where we observe a negative shock in 2009. The intuition for the instrument is that if a researcher specializes in cardiovascular diseases, then when there is a drop in federal funding in this area, there will be less federal funding available to the researcher. As a result, the researcher will likely get a smaller fraction of her funding from the federal government and a larger fraction from other sources, such as private firms. Moreover, since this funding composition change is driven by an aggregate drop in federal funding for cardiovascular diseases, it is unlikely to be related to the researcher's individual characteristics or to the characteristics of her projects.

It is helpful to illustrate the the sources of variation using examples. There is a CDFA program

[5]For more information, see https://www.rpi.edu/dept/finance/docs/tips/CFDA.pdf and https://www.govinfo.gov/app/details/CFR-2014-title2-vol1/CFR-2014-title2-vol1-sec200-10/summary.

entitled "Healthy Marriage Promotion and Responsible Fatherhood Grants" (93.086). Congress appropriated $150 million for these grants for each year from 2006 to 2010 as part of the "Deficit Reduction Act of 2005," reflecting the Bush Administration's interest in marriage. These funds emerged from a complex political process linked to the reauthorization of the Temporary Assistance for Needy Families (TANF) program.[6] Reflecting a change in priorities, the amount was reduced to $75 million per year under the Obama Administration, starting in 2011. Other examples include the common NIH situation in which Congress earmarks more money for research in one disease than is provided in additional funding, forcing the NIH to cut funding in completely unrelated disease areas; sudden new Congressional priorities such as the massive increase in funding for Parkinson's research after Congressman Mark Udall died of Parkinson's disease; or new White House priorities, such as the Trump Administration's 2018-2020 increase of defense R&D funds by 13.5% while insisting that overall R&D funds decline by 5.1%, which among other things led the Environmental Protection Agency's R&D funding to fall by 42.1%.

These examples highlight how year-to-year changes in CFDA program funding typically reflect particular political or personal priorities expressed through the Congressional budgeting process. Unlike countries such as China, the U.S. has no national innovation strategy, and there are no meaningful coordinated efforts across agencies or across time to invest in particular sectors or problems. The result is that funding in narrow fields of study varies substantially year-to-year, and exhibits mean reversion. Table 1 Panel A shows that the standard deviation of the log change in the CFDA-level funding amount (which we term "Amount R&D") is several times the mean. While our primary approach uses all changes, the results are robust to using only large shocks.

To address the concern that particular universities or departments might respond differently to federal funding shocks in a way that is correlated with research outputs or for time-varying shocks at the university or department level, we include university-department-time fixed effects.[7] Identifying variation thus comes from comparing colleagues working in the same department and in the same year,

[6] See The Congressional Research Services report "Welfare Reauthorization in the 109th Congress: An Overview" (January 23, 2007 (RL33418) https://www.everycrsreport.com/reports/RL33418.html)

[7] The departments are consistent across all universities, and there are 17 departments in total, such as computer science, biology, chemistry, and mathematics.

but on different topics that have different federal funding availability. In order to isolate the effect of funding source, rather than funding level, we also control for the individual researcher's amount of expenditures. In robustness tests, we ensure that the level of funding does not drive our results. Moreover, we show in Section 5.1 that, conditional on total funding, federal funding shocks do tend to shift researchers into private funding.

The identification assumption is that among researchers in the same department, year, and conditional on the individual's total grant funding, funding shocks to the researcher's narrow area affect outcomes only through the composition of funding sources. In Section 7 we show that other unobserved supply-side factors, such as government subsidies for downstream technology deployment, or demand-side factors such as technological opportunities in the sector, are unlikely to explain the results. While our IV strategy is not a true experiment, it takes a useful step toward answering an important, novel question about innovation and offers a new approach to a literature that has found it challenging to find sources of exogenous variation in innovation investment.[8] Also, since the instrument stems from Congressional budget decisions, the marginal effect among compliers is informative about the counterfactual effect of government funding changes.

3.2 Estimation Approach

We now formally describe the instrument construction and empirical strategy. Suppose researcher i gets a fraction s_{it} of her total funding in year t from the federal government, and $(1 - s_{it})$ from other sources. The instrument FS_{it} for the share s_{it} consists of lagged changes to funding in programs from which i previously had grants. We construct FS_{it} using Equation 1:

$$FS_{it} = \sum_{j} \frac{A_{ijt}}{\sum_j A_{ijt}} \log\left(\frac{F_{j,t}}{F_{j,t-1}}\right). \tag{1}$$

[8]For example, Bloom et al. (2013) instrument for innovation investment using state and federal tax credits. Kline et al. (2019) examine the effect of innovation on wages by comparing firms whose first patent application was granted with firms whose first patent application was rejected, extrapolating patent value from publicly-traded firm patents. These strategies, which also lack truly experimental variation, represent the frontier of empirical research on innovation.

In this expression, A_{ijt} is the total amount of funding researcher i receives from CFDA program j before year t, and $A_{ijt}/(\sum_j A_{ijt})$ is the share of researcher i's federal funding up to year t that is from program j. $F_{j,t}$ is the total amount of funding in program j in year t. The instrument is a researcher-level weighted average of log changes in the amount of funding from federal programs. Importantly, the variation in this measure across researchers comes entirely from the variation in the field of specialization, which is pre-determined.

We use the following IV model:

$$y_{iudt} = \beta_1 \hat{s}_{i,t-1} + \beta_2 X_{i,t-1} + \delta_{udt} + \varepsilon_{it}. \quad (2)$$

where y_{iudt} is the outcome for researcher i in department d from university u in year t. $\hat{s}_{i,t-1}$ is the share of funding from the federal government in year $t-1$ instrumented with lagged changes in aggregate federal funding $FS_{i,t-2}$ and $FS_{i,t-3}$.[9] $X_{i,t-1}$ represents the lagged amount of total funding the researcher receives. δ_{udt} represents a vector of university-department-year fixed effects.

This IV strategy is related to Bartik-style shift-share instruments because we use aggregate changes in the supply of federal funding relative to other types of funding to instrument for the share of federal funding at the individual level, with the weights given by individual level exposure to federal CFDA programs (Goldsmith-Pinkham et al. 2019, Autor et al. 2013). The identifying assumption is that the CFDA program shares are uncorrelated with the time-varying errors of innovation outcomes conditional on our controls. To test the plausibility of this assumption, Goldsmith-Pinkham et al. (2019) suggest checking for pre-trends prior to the shocks.

We conduct an event study using large funding shocks to test for pre-trends and to serve two further purposes. First, the event study illustrates the timing dynamics of the effects. Second, it offers evidence against the hypothesis that unobserved technological opportunities bias the results, because such opportunities should manifest in secular changes to both funding and outcomes, leading to null

[9] There are usually lags between changes in funding availability and switching funding sources. We include multiple lags because past shocks can affect federal funding share.

or attenuated effects from one-time shocks. We estimate the following event-study regression:

$$y_{iudt} = \sum_{\tau=-5}^{5} \beta_\tau D_{i\tau} + \beta_2 X_{i,t-1} + \delta_{udt} + \epsilon_{it}. \tag{3}$$

The vector $D_{i\tau}$ is composed of dummies for each year around a negative, large (40% or more), and temporary shock, ranging from five years before to five years after.[10] The controls are as defined above.

4 Data and Sample Overview

This section briefly summarizes the data sources and sample construction. A comprehensive description is in Appendix B. We begin with data from 22 universities that participate in the IRIS UMETRICS program.[11] The data provide information on all research grants, including all employees on each grant, in every covered year. The data also include grant expenditures by employee-year, funder name, and CFDA code for federal agency sponsors, among other variables. We use the CFDA codes and funder names to determine whether the funder is a federal government agency, private firm, state or local government, foreign government, or university. We also observe each researcher's occupation (faculty, graduate student/post-doc, undergraduate student, and staff) and department (e.g. physics or biology). For simplicity of exposition, we refer to graduate students/post-docs as "graduate students." Table 1 Panel A reports summary statistics for key variables. Among the researchers, 19.3% are faculty, 44.5% are graduate students, 13.4% are undergraduates, and 28.8% are staff members.[12]

[10]We define negative, large, and temporary funding shocks as cases that meet the following conditions: (1) the total expenditure of federal funding drops by at least 40% from the previous year; (2) the decline in funding is temporary and the funding level reverts back to the pre-shock level at some later point in time; (3) there is no big positive or negative funding changes (>20% or <-20%) in the two years preceding the shock. The 20th percentile of funding changes is -40%. Results are similar when using slightly higher (-30%) or lower (-50%) cutoffs. The timing variable τ is zero in the year of the funding shock and for researchers who did not experience a negative shock.

[11]The universities in the 2018 q4 UMETRICS release are: University of Arizona, Boston University, University of Cincinnati, Emory University, University of Hawaii, Indiana University, University of Iowa, University of Michigan, Michigan State University, University of Missouri, New York University, Northwestern University, University of Pennsylvania, Penn State University, University of Pittsburgh, Princeton University, Purdue, Stony Brook University, University of Texas at Austin, University of Virginia, Washington University in St Louis, and University of Wisconsin.

[12]Occupations defining our "graduate students/post-docs" category include: Graduate Student, Post Graduate Research, and Research (Staff Scientist, Research Analyst, Technician). Occupations defining our "staff" category

These data allow us to document patterns of funding at the individual researcher level. Table 1 Panel A shows that, across all researcher-years 11% of grant funds are from private sources. In untabulated results, we find that 23% of researcher-years have some private funding. This varies by occupation: at least 23% of graduate students, 32% of faculty, and 7% of undergrads receive some private funding. Figure 4 displays histograms of the private share of funding (Panel A) and the federal share of funding (Panel B) among researcher-years that receive at least some private funding. In both panels, we see substantial variation, which is crucial for assessing the effects of the private and federal funding shares.

To construct the instrument, we use aggregate federal funding at the CFDA program level from the Federal Audit Clearinghouse. On average, researchers receive funding from two CFDA programs. Table 1 Panel A shows that total expenditures within CFDA programs fluctuate dramatically; the first (second) lag has a mean of .06 (.09) and a standard deviation of 1.14 (1.11).

Patent-based variables are described in Panel B of Table 1. We use four measures: the number of granted patents on which an individual is an inventor; the number of forward citations (normalized by patent class and year), which are informative about knowledge spillovers; generality, which is higher when the patent influenced subsequent innovations in a broader range of fields; and originality, which is higher when the patent cites previous patents in a wide range of fields. We define a patent as *highly cited* if its normalized citation count is in the top 10% of the distribution (we use 10% because around half of patents have no citations). We define a patent as *original* or *general* if the originality or generality score is above the median in a given year. About 1% of researchers have been granted a patent, but this is much higher – at 2.6% – among faculty. Around 4% of all granted patents are assigned to private companies.

We obtain career outcomes, shown in Panel C of Table 1, from confidential administrative data at the U.S. Census Bureau, including the Business Register (BR), the Longitudinal Business Database (LBD), IRS W-2 tax records, and the Longitudinal Employer Household Dynamics (LEHD) program. The W-2 records are crucial for our setting because, unlike the LEHD, they include graduate student stipends. By linking UMETRICS individuals to these data sources, we track each person's full

include:: Clinical, Research Facilitation (Research Support, Research Administration, Research Coordinator), Technical Support, Instructional, and Other Staff.

domestic job history. We construct the following outcome variables, which indicate whether the individual: Works at an age-zero high-tech firm (*high-tech entrepreneurship*); works at an age-five or older firm (*incumbent employment*); or works at a university (*university employment*). These indicators have a value of 1 if the employment event takes place this year or in the next two years, a lag structure similar to that in Babina and Howell (2019) and Babina (2020). In supplementary analysis, we consider other outcomes such as working at different firm types and log wages.

5 Results

This section reports the IV results. We begin with the first stage estimates (Section 5.1). Then we describe the main effects of the instrumented federal share of funding on patents (Section 5.2) and career outcomes (Section 5.3). Last, we describe effects of the share of private funding (Section 5.4).

5.1 First Stage

We begin by reporting the first stage results in Table 2. We show three lags of the log change in government-wide R&D expenditure in individual i's CFDA code (federal program area, typically corresponding to a narrow field of study). All lags predict our main outcome of interest – the share of an individual's funding that is from federal government sources – positively and robustly (column 1). The instruments also negatively affect the private funding share (column 2). Finally, they reduce the share of funding from other sources (such as the university or state governments), albeit by a much smaller amount relative to the mean (column 3).[13] The larger effect of federal funding shocks for the private share than for the other share means that shifts into private industry funding are the primary compensation for supply-driven changes in the share of federal funding, consistent with Figure 1. The F-statistics are above 50 using either two or three lags, which is well above the rule-of-thumb cutoff of 10 for weak instruments. In our main model, we use the two lags with the strongest effects based on

[13]As an example of interpretation, the coefficient on *Log-change Amount* $R\&D_{i,t-2}$ implies that a one-standard-deviation increase in this variable increases the share federal (private) (other) by 0.46% (0.31%) (0.14%). Statistics for this and subsequent calculations are in Table 1.

the F-statistic, following the convention in the literature. The results in both the first and second stages are qualitatively similar when using all three lags. Expenditure is positively correlated with the federal and private shares, but negatively related to the Other share. This reflects the fact that federal and private grants are on average larger than grants from universities and other local sources of funds.

Figure 3 presents a dynamic visual first stage using Equation 3. It shows that large negative shocks to the researchers' funding predict compositional change, conditional on the individual's total expenditure. The share federal declines while the share private increases, consistent with the regression results in Table 2. Importantly for the instrument's validation, neither the private nor federal share exhibits trends before the shock.

5.2 IV Effect of Federal Share on Patent Activity

Granted patents serve as a proxy for innovation with commercial application. That is, if researchers intend to have a practical private sector use for their outputs, then more productive research will likely be associated with more patents. However, patents also reflect a decision to engage in the requisite disclosure and costs associated with applying for a patent, implying intent to create contractible intellectual property; alternatives are to publish the invention as openly available science, or maintain it as a trade secret.

In Table 3, estimates of Equation 2 show that a higher share of funding from federal sources reduces patenting activity (columns 1-2). Specifically, the interpretation of the coefficient in column 1 is that a 10% increase in the mean share of federal funding reduces the probability of any patenting by 0.4 percentage points, about half the mean. On the intensive margin, a 10% increase in the mean federal funding share leads to 0.006 fewer patents, which is 56% of the mean. While there is also a negative effect on the number of patents conditional on patenting, this result is largely a byproduct of the extensive margin effect. The event study estimates around large negative federal funding shocks using Equation 3 are shown in Figure 5. Both the propensity to patent (Panel A) and the number of patents (Panel B) increase significantly after the shocks, and neither measure shows differential trends before the shock.

Patents vary widely in their quality and importance to future research. We consider three measures that shed light on knowledge spillovers. First, we consider citations, which proxy for how intensively a patent is related to or is the basis of future inventions (column 3). There is no relationship between the federal share and the probability of having a highly cited patent. Second, we consider patent originality, which measures the breadth of inputs into a given patent (column 4). A 10% increase in the mean of the share of federal funding reduces the probability of having an original patent by 35% of the mean. Third, we consider patent generality, which measures the breadth of patent citations (across) classes (column 5). A 10% increase in the mean of the federal share increases the probability of having a general patent by 55% of the mean, which is quite striking given that it must "overcome" the negative effect on any patenting.

The last result in the table, in column 6, shows that the share of federal funding reduces the probability that patents have a private sector assignee. When matching assignee names to funder names, we find that over 40% of patents with private sector assignees are assigned to a company funding the research. This may reflect the funder licensing the patent, in which case there is often a reassignment. This result indicates that federally-funded patents are less immediately appropriated by the private sector. We report OLS results for all outcomes in Appendix C.

Effects by Occupation

We expect the effect on patenting to be most salient among faculty inventors, who are likely the primary impetus of patent application decisions, and also to a lesser extent among graduate students. Therefore, we estimate our main model separately for each occupation class in Table 4. Columns 1 and 2 show that the negative effects on patenting and the number of patents are driven by faculty. Among graduate students, the effects are large relative to the mean, but imprecise (columns 3 and 4). The coefficients are small and insignificant for undergraduates and staff, which is intuitive. The result (not reported) is similar for general patents, with faculty and graduate students driving the effect.

Effects by Field

To assess whether the effect on patenting is larger in particular fields, we divide the sample into four fields (based on the researcher's department in the UMETRICS data): Science, Biology/Medicine/Pharmaceutical, Engineering, and Liberal Arts/Other. The categories are mutually exclusive; science includes all hard sciences besides biology such as physics and chemistry, while Liberal Arts/Other includes a range of non-science disciplines such as law and economics. In Table 5 we find robust, negative effects on patenting in Science (columns 1-2) and Bio/Med/Pharma (columns 3-4), with the effect being especially large relative to the mean in Science. The effects in Engineering are also large and negative, but less precise (columns 5-6). Finally, as we would expect there is no effect in the Liberal Arts/Other category, where the patenting intensity is very low (columns 7-8). These results are consistent with the intuition that in fields where research is less often ex-ante commercially applicable and where there is a strong tradition of leaving results in the scientific commons – the Science fields – more researchers will be on the margin in terms of deciding whether or not to patent.

5.3 IV Effect of Federal Share on Career Outcomes

We next consider commercialization of human capital through the individual researcher's career trajectory. We are especially interested in high-tech entrepreneurship given its spillover benefits and perceived ties to university research. Table 6 column 1 shows that the share of federal funding has a very large positive effect on high-tech entrepreneurship. This, like the subsequent outcomes, is one if it occurs in any of the three years following year $t-1$ when share federal is observed. The coefficient of 0.0421 means that a 10% increase in the mean of the federal share increases the probability of high-tech entrepreneurship by 46% of the mean.[14] Consistent with this result, in Figure 6, we show the event study estimates for this outcome, and observe a significant decline following large negative shocks to federal funding.[15] Like the earlier event studies, this figure shows no evidence of pre-trends.

[14]The mean is 0.74%. The calculation is 46% = 0.0421*(10%*0.816)/0.0074, where 0.816 is the mean federal share. For career outcomes we use *Log-change Amount* $R\&D_{i,t}$ and *Log-change Amount* $R\&D_{i,t-1}$ as instruments, as this increases the number of observations that are matched to the Census data given the limited time window and thereby increases statistical power.

[15]In order to satisfy Census Bureau disclosure rules, we construct, for Figure 6, a continuous measure of high-tech entrepreneurship. Recall that our binary measure of high-tech firm indicates whether an individual works at a firm with a NAICS code that is classified as high-tech in this year (reference year) or the two subsequent years. For the individuals with an indicator value of 1, the continuous version of the entrepreneurship outcome is computed as 1/(1

This result reflects high-tech startups specifically and not entrepreneurship more broadly. We study four related variables in Appendix Table A.1. Column 1 shows no effects on entrepreneurship when defined as joining any new firm (age zero; i.e., the first year it appears in the LBD). Column 2 similarly shows no effect on joining a young firm (older than zero but less than five years old). In contrast, when we turn to young high-tech firms in column 3, and young patenting firms in column 4, we find large, positive effects with similar magnitudes as the main result from Table 6.

The source of funding also affects more common trajectories. Table 6 shows that a higher fraction of federal funding significantly decreases the probability that a researcher leaves academia to work for an incumbent firm, defined as a firm that is more than five years old, and significantly increases the probability that they work for a university (columns 2-3). Relative to the means, these effects are smaller in magnitude than the effect on high-tech entrepreneurship. A 10% increase in the mean of the federal share decreases (increases) the probability of working for an incumbent firm (university) by 8% (1.5%) of the mean. Note that the career outcome variables are not mutually exclusive, as people can have multiple jobs in a three-year window, and there are other outcomes such as leaving the U.S. labor force or working for government. We do not report event studies for these secondary career outcomes due to implicit sample disclosure restrictions.

The positive effect on working at a university suggests that federal research funding pushes individuals to pursue an academic track. This may reflect a decision to pursue a research vocation, lack of private sector opportunities, or interest in teaching. The difference is relevant to policy, as an important goal of some federal grant programs is to train the next generation of researchers.[16] To assess whether our results are driven by individuals likely to take on research, we divide universities into two groups using Carnegie Classifications: R1 and all other. R1 institutions are doctoral universities with "very high research activity."[17] In Appendix Table A.1 column 5, we redefine the

+ firm age), where firm age is the minimum age of the high-tech firms at which the individual works during this three year period. For example, if the individual works at the same firm in all three years, firm age will be the firm age in the reference year. In contrast, if an individual works for an older high-tech firm in one year and then switches to a younger high-tech firm the next year, the firm age will be the age of the younger firm. For all individuals that do not engage in high-tech entrepreneurship, this variable is zero.

[16]For example: https://www.nsf.gov/awardsearch/showAward?AWD_ID=2025170

[17]About 130 institutions are designated as R1. See https://carnegieclassifications.iu.edu/classification_descriptions/basic.php

university outcome to exclude all non-R1 universities, and find an effect that is 70% higher than the main effect for all universities. We confirm that the difference between these is significant in column 6 by restricting the sample to individuals who subsequently work at any university and then using the same outcome as in column 5. The estimate shows that a higher federal share increases the chances of working at an R1 university relative to other types of universities. In sum, our results are consistent with federal sources of funding keeping researchers on an academic track and in institutions where they are likely to continue to be involved with research.

Effects by Occupation

We consider in Table 7 which occupations explain the career effects. We expect the source of funding to have the most profound impacts for student researchers, who are at a crucial juncture in their career paths; deciding whether to stay in academia, help found a high-tech startup, or work at an incumbent firm. Indeed, the large positive effect on high-tech entrepreneurship is driven by graduate students (column 1 of Panel A). The effect among undergraduate students is positive, but insignificant (column 4 of Panel A). There are no effects among faculty and staff (columns 1 and 4 of Panel B).

The negative effect on working at an incumbent firm is driven by undergraduates and faculty (column 5 of Panel A and column 2 of Panel B). Exposure to the private sector via industry funding (induced by the federal funding shocks) appears not only to attract undergraduates to incumbent firms but also to induce faculty to leave academia for the private sector. Last, the positive effect on working at a university appears driven by undergraduate students (the smallest subsample), though the effects on this outcome are noisy for all the subsamples. The F-statistics for all of these results are well above the rule-of-thumb cutoff of 10.

Effects by Field

We also assess career effects by field. The results, reported in Table 8, paint a nuanced picture. The positive overall effect on high-tech entrepreneurship is driven by Engineering and Bio/Med/Pharma, with no effects for Science and Liberal Arts/Other. The negative effect on working at an incumbent firm is present in all fields. Finally, the positive effect on working at a university is driven in large part by Engineering and Liberal Arts/Other.

In sum, we show that through its effect on students and post-docs, a higher share of federal funding stimulates founding and joining high-tech startups, but not low-tech entrepreneurship. This result is particularly salient in the applied sciences of Bio/Med/Pharma and Engineering. Among faculty, the only significant effect is on joining an incumbent firm. Losing high-quality faculty to the private sector, which is typically more lucrative, has been identified as an important concern facing the hard sciences (Gofman and Jin, 2020).[18] The null effect on faculty departures to high-tech entrepreneurship contrasts with other channels, such as consulting, which have been found to result in faculty departures to entrepreneurship (Thursby et al. 2009). Finally, the absence of effects among staff (e.g., lab technicians) is expected, as these individuals are typically more set in their career paths and are less involved in the creative aspect of research.

5.4 Share of Private Funding

The results thus far have focused on the share of federal funding, which is most relevant to policy. We are also interested in the independent role of private funding because private firms have particular incentives to appropriate outputs and employ complex legal contracts with researchers. Recall that the shares of federal and private funding do not add to one, because there are a variety of other funding sources, such as universities and state governments. In Tables 9 and 10, we repeat the analysis from Tables 3 and 6 but with the instrumented share of private funding as the independent variable of interest.

Table 9 shows a strong positive effect of the private share on any patents (column 1) and the number of patents (column 2). Despite leading to more patents, an increase the share of private funding does not increase the probability of having a highly cited patent (column 3). The subsequent columns contain results that are the inverse of the federal share findings, but somewhat larger in magnitude. Column 5 shows that a higher share of private funding reduces the probability of having any general patents despite the positive effect on any patenting. Last, column 6 shows that the private share dramatically

[18] For example, one popular press article asked, "If industry keeps hiring the cutting-edge scholars, who will train the next generation of innovators in artificial intelligence?" See https://www.bloomberg.com/opinion/articles/2019-01-07/tech-giants-gorging-on-ai-professors-is-bad-for-you and https://www.nytimes.com/2019/09/06/technology/when-the-ai-professor-leaves-students-suffer-study-says.html.

increases the probability that a patent has a private assignee. The coefficient implies that a 10% increase in the mean of the private share increases the chances of having a private assignee by 35% of the mean.

The effects of the instrumented private share on career outcomes are in Table 10. A higher private share reduces the chances of high-tech entrepreneurship. It also increases the chances of joining an incumbent firm. Indeed, after manually matching private funders to firms in the Census data, we find that among people who have private funding and later go work for one of the funding firms, 20% work at the firm that funded their research. Last, there is no significant effect on working for a university. The inverted results relative to the effect of federal funding indicate that, consistent with Figure 3, shocks to federal funding are compensated for mainly by changes to private funding.

6 Discussion

This section assesses the hypotheses from Section 2. There is evidence against a primary role for the productivity and the basic vs. applied channels (Sections 6.1 and 6.2), though this does not imply that these or other channels have no role whatsoever. We present evidence consistent with a primary role for appropriation incentives of private funders in Section 6.3.

6.1 Null Effect and Productivity Channel

We clearly find that the source of funding matters, so federal and private funding are not simply substitutes. We also do not find support for a story in which one type of funding leads to higher productivity or more commercializable research. While federal funding yields fewer patents, it yields more startups. Though a welfare analysis is beyond the scope of this paper, the results point to a more nuanced perspective than one type of funding simply pushing toward more productive research.

6.2 Basic vs. Applied

Some of our results suggest that federal funding pushes researchers toward more basic research (note that our IV strategy obviates the possibility that researchers more interested in basic science select into federal funding). The effects on having any patents and number of patents are consistent with this hypothesis. The patent quality measures are not inconsistent with it; while there is a positive effect on having general patents, which are associated with more basic research (Jaffe and Trajtenberg 2002), we would also have expected a strong effect on having more highly cited and original patents, and we find neither.

The evidence that is in direct conflict with this hypothesis is the large positive effect of the federal share on high-tech entrepreneurship, because this outcome requires an applied idea. Consider the example of the $11 million in grant funds from the U.S. Department of Energy that MIT Professor Donald Sadoway and his PhD student David Bradwell used to develop a molten metal battery for large-scale grid energy storage. The team chose to bring the battery to market via a startup named Ambri. David Bradwell served as co-founder, while Sadoway remained a full-time professor at MIT.[19] With a clear applied intention, the federal grant described the researchers as "creating a community-scale electricity storage device using new materials and a battery design inspired by the aluminum production process known as smelting."[20]

A further factor that may explain the large effect of federal funding on high-tech entrepreneurship is the increased focus of universities on commercialization. Following the Bayh-Dole Act of 1980, it became much easier to commercialize inventions that have government financial support (Henderson, Jaffe and Trajtenberg 1998, Mowery, Sampat and Ziedonis 2002, Hausman 2017). This could have shifted all research in a more applied direction, regardless of funding source. In sum, we do not exclude the possibility that federal funding pushes researchers to do more basic science, but also do not find especially compelling evidence in favor of this channel.

6.3 Open vs. Appropriated Outputs

In this sub-section, we consider the hypothesis that private funding has important implications for who appropriates research outputs.

[19] See https://ambri.com/company/, http://news.mit.edu/2016/battery-molten-metals-0112, and
[20] https://arpa-e.energy.gov/?q=slick-sheet-project/electroville-grid-scale-batteries

6.3.1 Motivation from Practice

In practice, private funders negotiate with universities over ownership of research results. In contrast, federal grants come without these negotiations or contracts and offer the university and its researchers free use of any outputs. The Stanford University Industrial Contracts Office emphasizes in its guide to university researchers that industry funders approach research in a "closed" manner, while the standard at the university is to be "open" and public."[21] The guide explains that:

> "Contract terms such as IP ownership, pre-negotiated licensing terms, confidentiality of results, publication review and approval, and indemnification provisions may be difficult to negotiate. Companies may have unrealistic expectations concerning IP and other results, if the researchers have not communicated sufficiently with the business people. Companies may also terminate research projects early when results don't meet their expectations or when their business plans change."

This quote highlights the overall control and rights that industry sponsors tend to seek.

The focus on rights to own outputs appears in the industry-university contracts that we have reviewed. One example of an actual contract between NYU Langone Health (the Grossman School of Medicine) and a redacted industry funder is provided in full in Appendix D, with key components highlighted. The contract claims broad intellectual property rights for the funder in paragraph 7.2, which notes:

> "Institution understands and agrees that the underlying intellectual property rights to any Company Technology that is the subject of the Research are owned solely by Company…Institution agrees not to seek or obtain patent protection directed to or covering Company Technology, including without limitation the Materials, without the prior written consent of Company, which Company may withhold in its sole discretion."

The contract also restricts researchers from disclosing confidential information without the company's explicit approval. The scope for defining "confidential information" proprietary to the company is very broad; the exclusions, as highlighted in paragraph 6.2, mostly require the researchers to have already

[21] https://ico.sites.stanford.edu/sites/g/files/sbiybj6716/f/researchersguidetoworkingwithindustry.pdf

known about the technology or invention from some public source or have arrived at it completely independently and without using any company materials, which may be hard if, for example, a company has funded or provided key laboratory tools such as computers.

We reviewed further contracts from a range of other universities, many of which provide template agreements publicly available on their industry contracts office websites. In our conversations with contract officers, they emphasized that these tend to be a starting point for negotiations, with the firm typically imposing more stringent requirements.[22] Harvard's standard contracts with industry, even before negotiations and for patents that Harvard has claimed for itself, states that: "With respect to each Invention, Harvard hereby grants to Company an option to negotiate in good faith with Harvard (an "Option") for a non-exclusive or an exclusive (at Company's discretion), royalty-bearing, worldwide license..." Similarly, the University of Maryland's standard contract notes that the sponsor will be notified of any research results within 60 days and may choose "to negotiate an exclusive or nonexclusive commercial use license in the UMD Research Results." Notably, research results are potentially very broad, including "all data, inventions, discoveries, copyrightable works, software, tangible materials, and information that are conceived of, first reduced to practice, collected, or created in the performance of the Research Project and funded under this Agreement." The contract template further states that "UMD and Sponsor will jointly own all rights, title to and interests in Joint Research Results," which include anything making use of the sponsor's material.

This paper does not use research publication data. These are not available, but more importantly, they are not material to this hypothesis because contractual agreements reveal no meaningful difference between private and federal funding in researchers' ability to publish. The only restriction that exists in these contracts and thus for private but not federal funding, is that the company may redact confidential information deemed proprietary and may take 30 or 60 days to file a patent before the manuscript is made public. As one example, the contract in Appendix D includes the following: "Institution is free to publish the Results of the Research conducted hereunder and agrees that any proposed publication will be provided to Company at least thirty (30) calendar days in advance of submission."

[22]These negotiations can be complicated, one scientist consulted by the authors recalled that a contact between U Mass Boston and their company took a full year to negotiate.

In sum, it is abundantly clear from the contracts themselves – especially when compared with the absence of any contract for federal grants – that appropriation of output is a key rationale for private grants to university researchers. While there are no doubt exceptions to this rule, the contracts motivate us to interpret our evidence through an appropriation lens.

6.3.2 Interpretation of Results

The contract evidence above coincides with the expectation that when a firm is making the case to shareholders that funding university research is a NPV positive investment, the argument is more straightforward if the firm will have some rights to the output. Our results are consistent with the hypothesis that, relative to federal funding, a higher share of private funding pushes researchers towards work that the firm can appropriate. First, the standard way to protect inventions is to patent them, and we observe that private funding causes significantly more patenting. Consistent with this, in manually matching private funders to patent assignee firms, we find that 40% of the privately assigned patents are assigned to the firm that funded the researcher's grant.

Second, private funding leads to less high-tech entrepreneurship, consistent with the funder preventing research outputs from being used by the grant employees in startups. As federal funding has fewer strings attached, the funded intellectual property is freer to be used in a startup. For example, Sergey Brin and Larry Page created the PageRank algorithm while PhD students at Stanford as part of their work for a grant from three federal agencies to develop a "Digital Library." They were able to make this algorithm the basis for their startup, in part because the government did not assert rights to the output. Had a private company funded the research, where and how this innovation would have been commercialized might have been quite different. Third, we find evidence that human capital created by a private grant is also often appropriated by the sponsor. This is consistent with a common perception that firms sponsor research in part to train future employees. We find that among individuals with private funding who subsequently work at any funder firm (~500 firms), 20% go to the firm that funded their own research.

The separate estimates by field help to flesh out this hypothesis. We find that Engineering and

Bio/Med/Pharma drive the effect on high-tech entrepreneurship; these are areas where research is often immediately applicable to the private sector and also has outputs that are more readily contractible and protected with patents. There may, therefore, be a sharper contrast between private and federal funding in the ability of a researcher to take their invention to a startup. When it comes to future work at an incumbent firm or university, we observe strong effects in the Science field (which excludes Engineering and Bio/Med/Pharma). This is consistent with differences in human capital appropriation. When private firms invest in more basic research, they train scientists whose skills they may be more easily able to appropriate by hiring them subsequently. Thus, for more basic science, there are strong positive (negative) effects of federal share on working at a university (incumbent firm).

In sum, a shift away from federal funds and towards private funds appears to lead to intellectual property and human capital that are more often appropriated by the sponsor and less often deployed in startups. As mentioned above, however, the presence of an important role for appropriation does not mean that this is the only difference between federal and private funding.

7 Robustness Tests

This section assesses potential concerns with the analysis. The first and most important concern is that an omitted time-varying covariate is correlated with both changes to government funding and research outputs, violating the exclusion restriction of the IV strategy. Two plausible violations are: technological opportunities in the sector that drive both federal funding changes and researcher decisions; and downstream federal policies that drive researcher decisions and are determined alongside upstream federal research priorities.

Both of these confounders predict that researchers in the same CFDA code who do not comply with the instrument should also respond to the funding changes. In Appendix Table A.2 columns 1–2 we restrict the sample to individuals whose federal-private funding source composition does not change during the sample period ("non-switchers"). We examine whether changes in federal R&D in their CFDA code have any predictive power over their patenting activity. The placebo test finds a near zero, insignificant result. We find a similar null placebo result for the career outcomes.[23] This test rules out either channel in a single test, unless there is something different about researchers who ever switch funding sources that leads them to be uniquely responsive to the omitted variable. This is not impossible but seems unlikely because in such a case we would expect at least attenuated results in the placebo group.

The technological opportunities story should also be related to long-term funding changes. The event studies in Figures 5 and 6 indicate that long-term funding changes do not explain the results, making this explanation less plausible. We test this further by controlling for long-term funding trends in the researcher's CFDA code. Appendix Table A.2 columns 3–4 shows that controlling for changes in federal funding between the sixth and first year before year t actually increases the estimates slightly. By the same token, if technological opportunities are the main driver, one-time shocks to federal funding should yield a smaller or noisier effect than our main result. To test whether this is the case, we restrict variation in the first stage to instances where year-to-year funding in the CFDA code changed by more than 30%. The results, in Appendix Table A.2 columns 5-6, are again slightly larger than the main findings and equally precise.

Another concern may be that past patenting (the lagged dependent variable) somehow causes current patenting and affects the results. It might be the case that the disclosure of inventions attracts more private funding, as in Thursby and Thursby (2011), and also predicts higher future patenting rates. Therefore, we control for the researcher's past patenting in Appendix Table A.2 columns 7-8. The results are robust to controlling for the 3-year lags of the dependent variables.[24]

We next assess whether federal funding operates via researcher wages. If an increase in federal funding leads to higher wages, which in turn affect the researcher's decision about how to commercialize research outcomes, then the higher income might be responsible for decisions to, for example, do less patenting and more high-tech entrepreneurship. Note that if a higher federal share is

[23]We have not reported them because the test creates a sub-sample that makes disclosure very challenging and restricts potential future disclosures. In a final version of the paper, this and other results can be reported.

[24]Because our instrument are 1-year and 2-year lags of federal funding shocks, we control for 3-year lags of the dependent variables because 1-year and 2-year lags of dependent variables are after the shocks take place. The number of observations are smaller because the first two observations of each individual are dropped.

a positive shock in other ways, such as prestige, which in turn changes the nature of work that an individual performs, this is not an identification problem but rather a potential mechanism for the causal effects. Appendix Table A.1 column 7 shows that there is a negative effect of the federal share on wages. This is consistent with federal funds keeping researchers in academia and thus depressing wages. To illustrate, a biology professor would likely earn more at Pfizer, an engineering professor at Boeing, and graduate students who choose to leave mid-program are likely to receive a salary increase. This points to a possible tradeoff between more money in the private sector and more prestige or research satisfaction from federal funding and a career in academia.

An important aspect of our analysis is the focus on the source of funding rather than the level of funding. We therefore instrument for the source while controlling for the level. However, this raises the concern that level is a "bad" control and might introduce bias as an endogenous variable. We conduct two types of tests for whether this is the case. First, in Appendix Tables A.3 and A.4, we show that the results are robust to alternative approaches. For each outcome, we show three models. The first includes the log change in expenditure between year $t-2$ and $t-1$. The second includes two lags of expenditure rather than one. The third omits the expenditure control entirely. The results are generally insensitive to these additions. All the career results, and our key patenting results for number of patents, patent generality, and private assignees remain robust in all cases.

In a second test, we examine whether changes in the level of funding could drive the IV estimates. We expect that if aggregate funding shocks affect researcher outcomes because they change the researcher's level of funding, then changes in the individual funding amount should more powerfully predict outcomes than the federal funding shocks themselves. Therefore, in Table A.5, we regress the outcomes on the raw instrument as well as year-to-year changes in individual level of funding over the last three years in addition to the lagged level of funding. Consistent with existing literature, columns 1 and 2 show that the individual's amount of funding and its changes are positively related to the following year's patenting. In contrast, consistent with our IV results, positive changes in aggregate federal R&D in the individual's narrow area of study negatively predict patenting. Since the coefficients are highly significant, go in opposite directions, and because the terms related to funding levels do not soak up the effect of aggregate federal R&D shocks, we conclude that levels of funding do not explain the negative effect of the instrumented share of federal funding on patenting, and if anything, lead to an upward bias in our estimates.

There is a similar pattern for high-tech entrepreneurship in Column 3, where the coefficients on the individual's level of funding and those on the federal funding shocks go in opposite directions. The effect of changes in aggregate federal R&D on high-tech entrepreneurship occurs at a lag of two to three years. This is intuitive, since people likely take time to finish their degrees or push the technology to a place where it is ready to be spun off into a startup, while patenting occurs more immediately. In columns 4-5, we see that the level of funding has a negative (positive) effect on working at an incumbent firm (university), which are in the same direction as the aggregate funding shocks. This implies that we should be slightly more cautious in interpreting the effects on these two outcomes. That said, since the relationship of aggregate funding changes and moving to an incumbent firm or university is large and highly robust even when controlling for levels, we believe that there is an independent effect of share as estimated in the IV with a control for level. Overall, this exercise leaves us convinced that changes in aggregate federal funding are related to outcomes independently of the individual's level of funding and do not explain the effects of the instrumented source of funding, but that we can be most confident in the causal effects of funding sources on patents and high-tech entrepreneurship.

Our final test concerns standard error assumptions. We are concerned that researchers in the same university and department might experience correlated shocks to federal funding, making it inappropriate to cluster standard errors at the individual level. In Appendix Table A.6, we report the main results with clustered standard errors at the university-by-department level. The results for patenting and the key career outcomes remain robust, though the effect on generality becomes slightly more imprecise and (barely) loses statistical significance. The results are also robust to a variety of other cluster assumptions. For example, we report results with errors clustered by researcher's main CFDA code in Table A.7.

8 Conclusion and Policy Implications

The decline in the federal share of university research funding has raised concerns among practitioners. For example, Rush Holt, CEO of the American Association for the Advancement of Science, wrote: "Corporate research, as beneficial as it may be, is no substitute for federal investment in research" (Holt 2016). In 2017, an *Atlantic* magazine article argued that academics are "under increased pressure from corporate funders to agree to conduct studies that would remain the property of the funder" (McCluskey 2017). Observers often point to anecdotal evidence that applied but transformational inventions often originate in federally-funded university research, such as the internet and artificial intelligence, as well as companies such as Google and Genentech.[25]

Using individual data on grant employees from 22 universities linked to patent and U.S. Census Bureau data, this paper offers the first causal analysis of the relative effects, separate from that of funding levels, of federal and private university research funding on commercial innovation outputs. We instrument for an individual's source of funding with government-wide R&D expenditure shocks within a narrow field of study. This novel instrument provides a set of compliers who are pushed towards or away from federal funding as opposed to private funding. We show that neither technological opportunities, downstream subsidies, nor predictable trends confound causal interpretation.

We find that federal and private funding are not substitutes. A higher share of federal funding causes fewer but more general patents, more high-tech entrepreneurship, a higher likelihood of remaining employed in academia, and a lower likelihood of joining an incumbent firm. These results are inverted when we instrument for the share of private industry funding. Together with evidence from industry contracts, the effects support the hypothesis that private funding leads to greater appropriation of intellectual property by incumbent firms. Privately funded research outputs are more often patented, while federally funded research outputs are more likely to end up in high-tech startups founded by graduate students.

[25] Google: NSF; see https://patentimages.storage.googleapis.com/37/a9/18/d7c46ea42c4b05/US6285999.pdf. Genentech: NIH; see https://www.ncbi.nlm.nih.gov/pmc/articles/PMC427208/pdf/pnas00138-0206.pdf.

The policy implications of these findings are complex and beyond the scope of our work. However, universities are increasingly dependent on industry funding, and many actively recruit corporate research sponsors.[26] Universities have sought out more corporate funding in part because they have faced a secular decline in government funding for public universities. One open question is the degree to which federal funding of university research crowds out private funding, along the lines of Goolsbee (1998). Our results cannot speak to whether or not this is the case, though existing work on R&D subsidies to private firms has generally not found evidence of crowding out (Hall and Van Reenen 2000, Bloom et al. 2002, Dechezleprêtre et al. 2016, Howell 2017, Balsmeier et al. 2018).

Finally, our results are relevant to interpreting the implications of the Bayh-Dole Act of 1980, which enabled private firms to benefit more from funding university research. Aghion et al. (2008) show how this creates a tension. To the degree that academia is a second-best solution to the underinvestment problem identified by Nelson and Arrow, then greater appropriability and private sector funding of research in general should improve efficiency. However, if research that would otherwise be left in the public domain is now privately appropriated, it will yield fewer knowledge spillovers. Our results indicate that private and federal funding push university researchers towards different means for commercializing successful innovations. They are consistent with one mechanism that Aghion et al. (2008) propose, which is that private sector funding may lead to greater emphasis on pursuing projects with more immediate economic value and fewer knowledge spillovers, with negative implications for cumulative innovation.

[26]For example, a research program at Virginia Tech notes on its website that becoming an industry affiliate of the program "is an excellent way to get broad access to MICS's research and intellectual property (IP) and to direct the focus of the MICS research." See https://www.mics.ece.vt.edu/.

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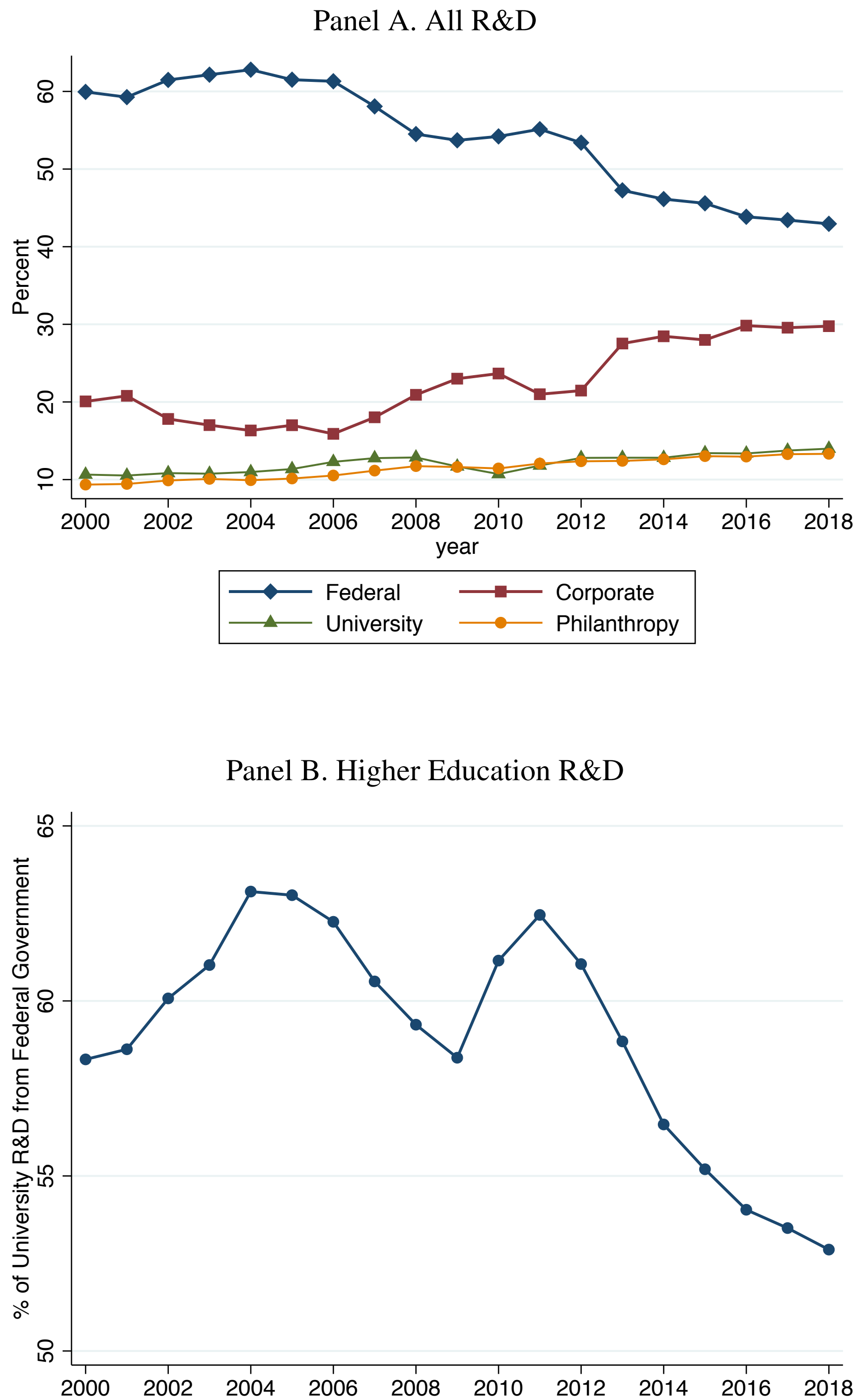
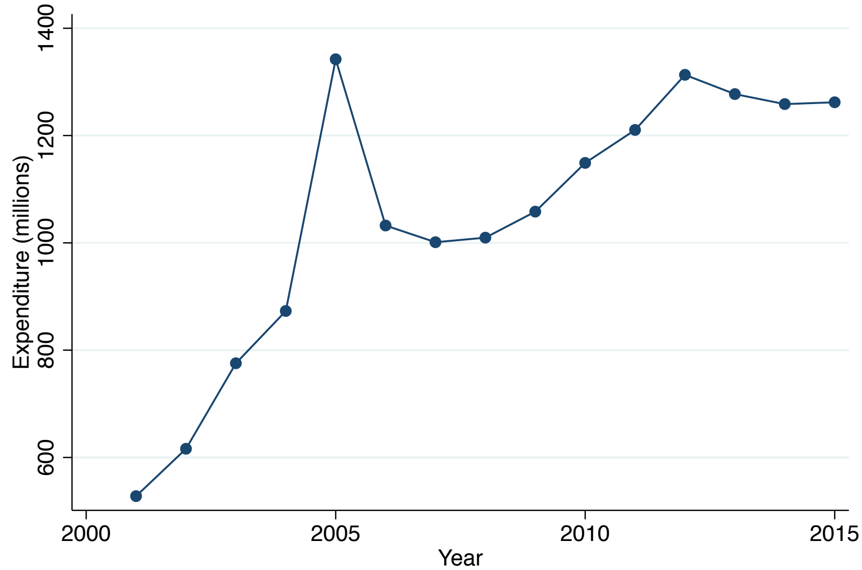
Figure 1. Sources of U.S. Research Funding, 2000-2018



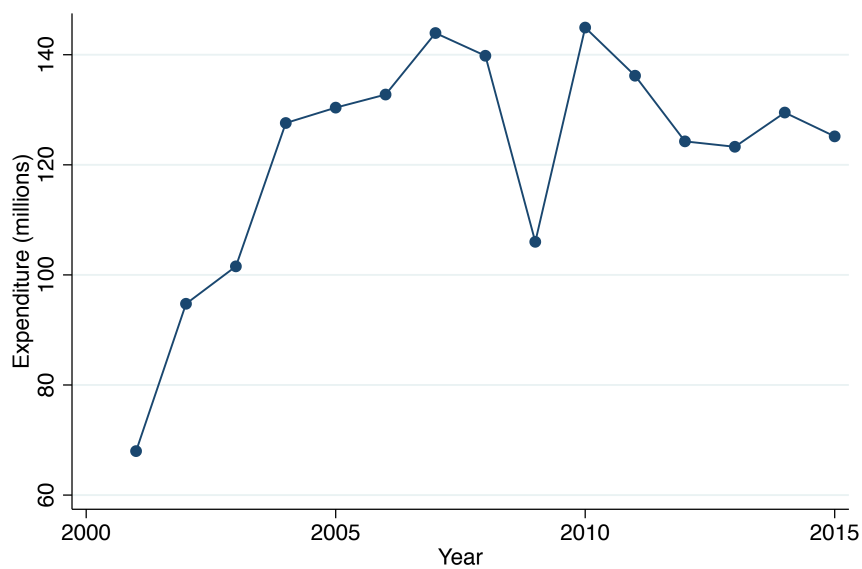
The top figure shows the percent of total U.S. R&D funding from each of four sources – the federal government (Federal), the private sector (Corporate), Universities, and Philanthropy – in each year from 2000 to 2018. The bottom figure shows the share of higher education R&D expenditures funded by the federal government in each year from 2010 to 2018. Data are from the NSF National Patterns of R&D Resources (https://ncses.nsf.gov/pubs/nsf19309) and the NSF Higher Education Research and Development (HERD) Survey (https://ncsesdata.nsf.gov/herd/).

Figure 2. Examples of CFDA-level Funding Histories

Panel A. CFDA Code 93.837: Cardiovascular Diseases Research

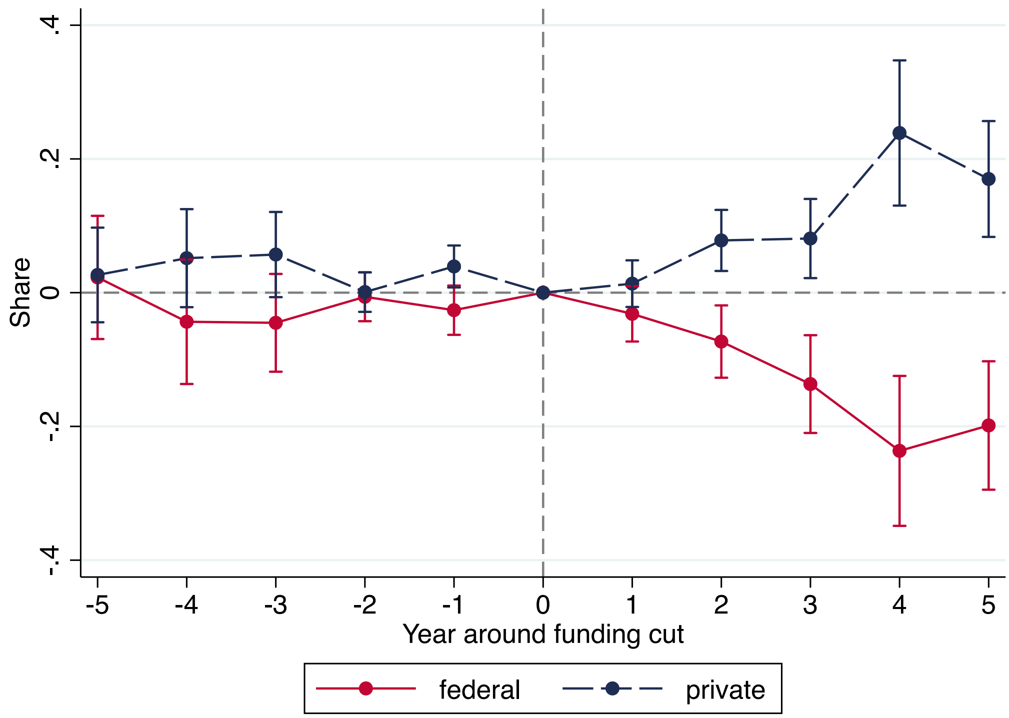


Panel B. CFDA Code 10.001: Agricultural Basic and Applied Research



This figure shows government-wide R&D expenditure in two CFDA codes, which provides the source of variation for the instrumental variables analysis. CFDAs are fields in which researchers receive funding. The top figure shows cardiovascular diseases research, a program at the National Institutes of Health. The bottom figure shows agricultural research, a program at the Department of Agriculture.

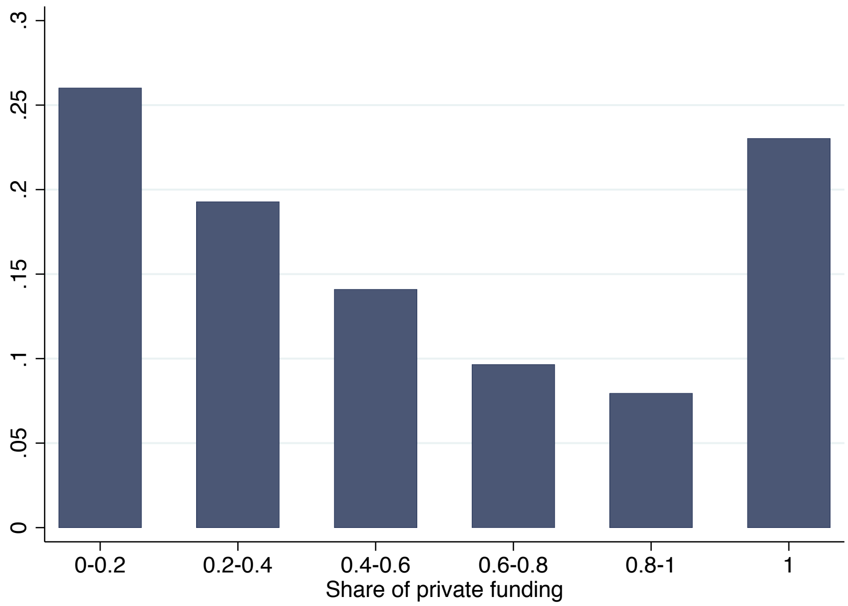
Figure 3. Event Study: Shares of Federal and Private Funding Around Negative, Large, and Temporary CFDA-level Shocks to Federal Funding



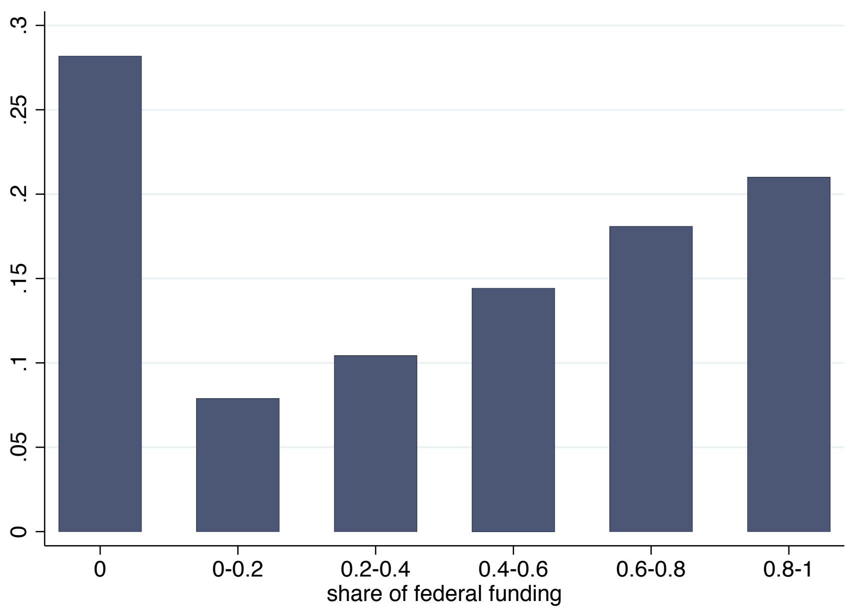
This figure shows an event study of changes in the shares of federal and private funding around negative, large, and temporary drops in the aggregate availability of CFDA-level federal funding at event time 0. CFDAs are fields in which the researchers receive funding. If a researcher received funding in multiple CFDA codes, we take her CFDA field in which she received the most money. The estimation equation is described in Section 3.2.

Figure 4. Distribution of the Private and Federal Share of Funding Among People With Some Private Funding

Panel A. Share of Private Funding



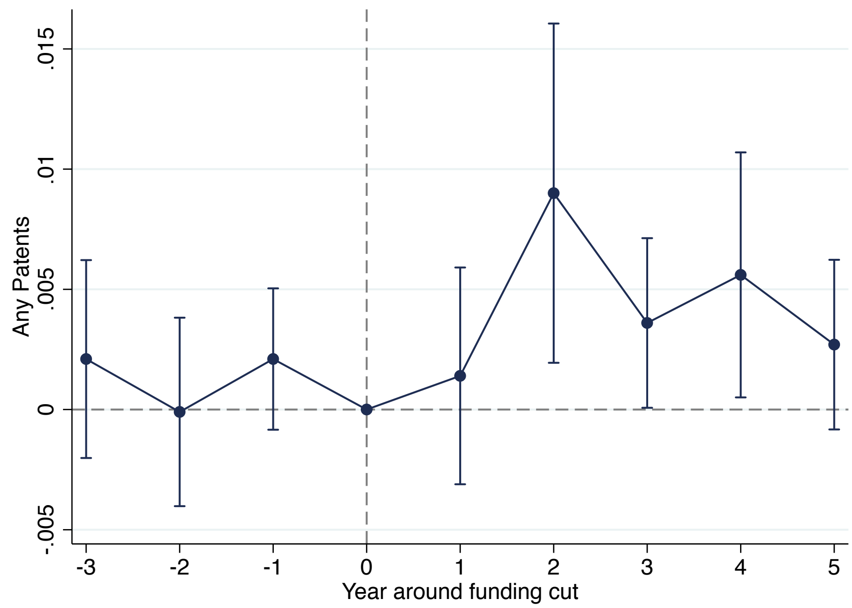
Panel B. Share of Federal Funding



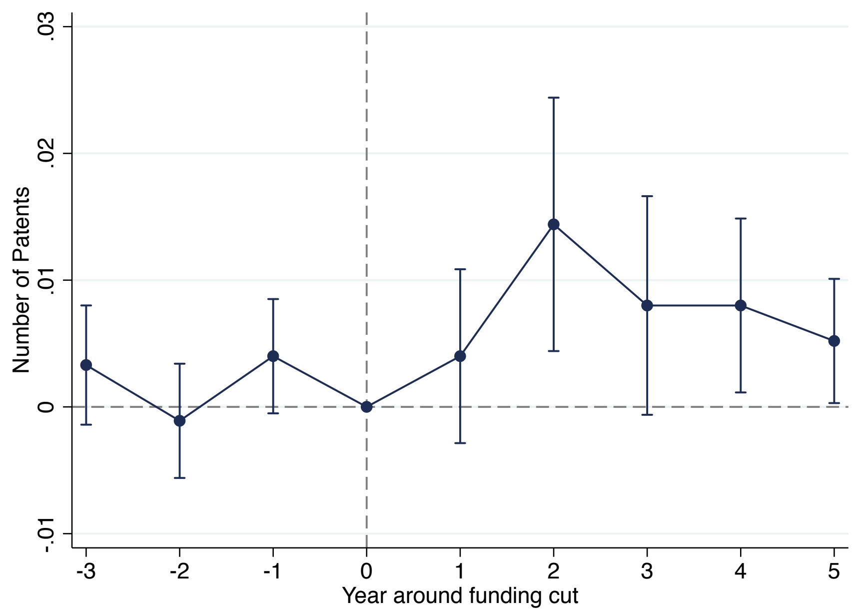
This figure shows the distribution of the private and federal share of funding among people with some private funding, which are 23% of researcher-years. Panel A shows the share of private funding, and Panel B shows the share of federal funding.

Figure 5. Event Studies of Patenting Around Large CFDA-level Negative Shocks to Federal Funding

Panel A. Any Patents

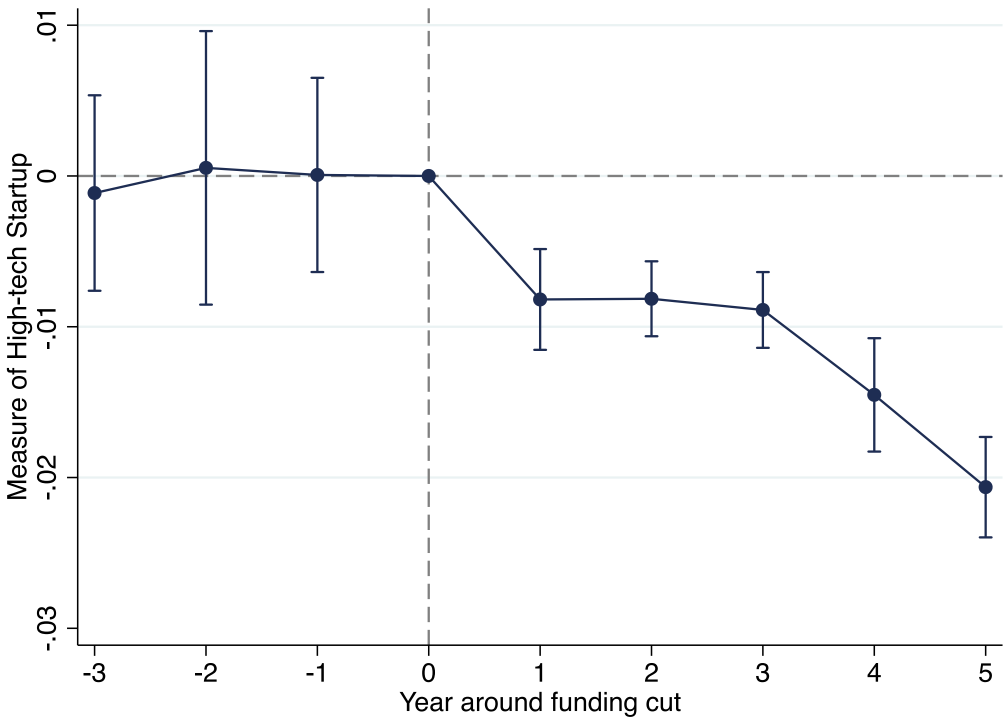


Panel B. Number of Patents



This figure shows patenting by researchers around large and temporary drops in the aggregate availability of CFDA-level federal funding at even time 0. CFDAs are fields in which the researchers receive funding. If a researcher received funding in multiple CFDA codes, we take her CFDA field in which she received the most amount of money. The top figure shows changes in the probability of patenting. The bottom figure shows changes in the number of patents. The estimation equation is described in Section 3.2

Figure 6. Event Study of High-tech Entrepreneurship Around Large CFDA-level Negative Shocks to Federal Funding



This figure shows changes in departure rates to high-tech startups by researchers around large and temporary drops in the aggregate availability of CFDA-level federal funding at even time 0. CFDAs are fields in which the researchers receive funding. If a researcher received funding in multiple CFDA codes, we take her CFDA field in which she received the most amount of money. The estimation equation is described in Section 3.2

Table 1. Summary Statistics

Panel A shows summary statistics for the UMETRICS sample, Panel B for the patent data matched to the UMETRICS sample, and Panel C for the restricted-use US Census data matched to the UMETRICS sample. All three samples are person-year panels from 2001 through 2016. Share Federal is the share of funding from the U.S. Federal Government. Share Private is the share of funding from the private sector. All patent measures indicate whether the person was an inventor of a patent (or patent of certain type) in current year. Statistics for patents with a private assignee are based on a sub-sample of person-years with positive patents. High-tech Entrepreneur is an indicator for a person working at an age 0 high-tech firm, Entrepreneur is an indicator for a person working at any age 0 firm (not necessarily high-tech), Work for Incumbent is an indicator for a person working at a non-university age 5+ firm, and Work for University is an indicator for a person working at a university. Each of these career outcomes indicate whether the employment event occurred in any of the next 3 years starting from this year.

	Number of Observations	Mean	Median	Standard Deviation
Panel A. Umetrics				
Number of Universities	22			
Number of Unique People	235,000			
Number of Unique People with Federal Funding	230,000			
Number of Unique People with Private Funding	58,000			
Number of Unique People with Both Federal and Private Funding	54,000			
Faculty	571,000	0.193		
Graduate Students	571,000	0.445		
Undergraduate Students	571,000	0.134		
Staff	571,000	0.288		
Total Direct Expense$_{i,t}$	571,000	57,000	29,000	21,000
Overhead Charged$_{i,t}$	571,000	16,000	7,000	27,000
Share Federal$_{i,t-1}$	571,000	0.816	1	0.345
Share Private$_{i,t-1}$	571,000	0.111	0	0.276
Share Other$_{i,t-1}$	571,000	0.073	0	0.233
Number of CFDA Codes	571,000	2.19	2	1.86
Δ Log(Amount R&D$_{i,t-1}$)	571,000	0.057	0.028	1.14
Δ Log(Amount R&D$_{i,t-2}$)	571,000	0.092	0.050	1.11
Log(Expenditure$_{i,t}$)	571,000	9.95	10.27	1.64
Panel B. Patents				
Any Patents$_{i,t}$	571,000	0.0090		
Number of Patents$_{i,t}$	571,000	0.0117		
Any Cited Patents$_{i,t}$	571,000	0.0047		
Any Highly Cited Patents$_{i,t}$	571,000	0.0010		
Any Original Patents$_{i,t}$	571,000	0.0038		
Any General Patents$_{i,t}$	571,000	0.0016		
Any Patents with Private Assignee$_t$	571,000	0.0004		
Patents with Private Assignee$_t$	5,000	0.0403		
Any Patents$_{i,t}$ (Faculty)	110,000	0.026		
Any Patents$_{i,t}$ (Graduate Students)	255,000	0.0078		
Any Patents$_{i,t}$ (Undergraduate Students)	76,000	0.0011		
Any Patents$_{i,t}$ (Staff)	130,000	0.0015		

	Number of Observations	Mean	Quasi-Median	Standard Deviation
Panel C. Census				
Number of Unique Piks	149,000			
High-tech Entrepreneur$_{i,[t,t+2]}$	457,000	0.0074		
Entrepreneur$_{i,[t,t+2]}$	457,000	0.031		
Work for Young Firm$_{i,[t,t+2]}$	457,000	0.080		
Work for Young High-tech Firm$_{i,[t,t+2]}$	457,000	0.022		
Work for Incumbent Firm$_{i,[t,t+2]}$	457,000	0.553		
Work for Incumbent High-tech Firm$_{i,[t,t+2]}$	457,000	0.137		
Work for University$_{i,[t,t+2]}$	457,000	0.831		
Real Wage$_{i,t}$	457,000	56,000	36,000	70,000
Number of Jobs$_{i,t}$	457,000	1.19	1	0.501
Faculty	457,000	0.192		
Graduate Students	457,000	0.462		
Undergraduate Students	457,000	0.153		
Staff	457,000	0.202		

Table 2. First Stage Effect of Total Federal R&D Funding in Field on Individual's Share of Funding

This table reports the first stage results of the IV regression. The instrument is federal funding shocks in the researcher's narrow program (as described in Section 3). The baseline sample is a person-year panel from 2001 through 2016. The dependent variables are the share of total funding amount, for a researcher in a given year, from the federal government (column 1), private companies (column 2), or other sources (column 3). All regressions include university-by-year-by-department fixed effects. Standard errors are clustered at the person level, and reported in parentheses. ***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Share Federal$_{i,t}$	Share Private$_{i,t}$	Share Other$_{i,t}$
	(1)	(2)	(3)
Δ Log(Amount R&D$_{i,t}$)	0.0018***	-0.0021***	0.0002
	(0.0004)	(0.0003)	(0.0003)
Δ Log(Amount R&D$_{i,t-1}$)	0.0040***	-0.0026***	-0.0014***
	(0.0003)	(0.0003)	(0.0002)
Δ Log(Amount R&D$_{i,t-2}$)	0.0041***	-0.0028***	-0.0013***
	(0.0003)	(0.0002)	(0.0002)
Log(Expenditure$_{i,t-1}$)	0.0059***	0.0039***	-0.0099***
	(0.0005)	(0.0004)	(0.0004)
University$\times$Year$\times$Department FE	Yes	Yes	Yes
Number of Observations	571,000	571,000	571,000
Mean of Dependent Variable	0.816	0.111	0.073
Adjusted R-squared	0.156	0.101	0.245
F-statistic	117	93.7	25.3

Table 3. Second Stage IV Effect of the Share of Federal Funding on Patent Outcomes

This table reports the second stage results of the IV regressions of the share of federal funding on researcher's innovation outcomes. The baseline sample is a person-year panel from 2001 through 2016. The dependent variables are innovation outcomes indicating whether the person is an inventor of a patent (or of a patent of certain type) in current year. The key independent variable, Share Federal, is the share of the funding coming from Federal US Government sources. Share Federal is instrumented with aggregate changes in federal funding for narrow fields (CFDA codes) in which the researcher received funding in the previous two years. F-statistics refers to the F-statistic of the instrument in the first-stage. Standard errors are clustered at the person level, and reported in parentheses. ***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Any Patents$_{i,t}$	Number of Patents$_{i,t}$	Any Highly Cited Patents$_{i,t}$	Any Original Patents$_{i,t}$	Any General Patents$_{i,t}$	Any Patents with Private Assignee$_{i,t}$
	(1)	(2)	(3)	(4)	(5)	(6)
Share Federal$_{i,t-1}$	-0.0509***	-0.0803***	-0.0015	-0.0168*	0.0107*	-0.0086***
	(0.0140)	(0.0200)	(0.0047)	(0.0094)	(0.0060)	(0.0028)
Log(Expenditure$_{i,t}$)	0.0034***	0.0051***	0.0004***	0.0015***	0.0005***	0.0002***
	(0.0002)	(0.0004)	(0.0001)	(0.0001)	(0.0001)	(0.0000)
University × Year × Department FE	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	571,000	571,000	571,000	571,000	571,000	571,000
Mean of Dependent Variable	0.0090	0.0117	0.0010	0.0038	0.0016	0.0004
F-statistic	117	117	117	117	117	117

Table 4. Second Stage IV Effect of Share of Federal Funding on Patent Outcomes by Occupation

This table reports the second stage results of the IV regressions of the share of federal funding on researcher's innovation outcomes by occupation: faculty, graduate students, staff, and undergraduate students. The baseline sample is a person-year panel from 2001 through 2016. The dependent variables are innovation outcomes indicating whether the person is inventor of at least one patent (odd columns), or the number of invented patents by the person (even columns) in current year. The key independent variable, Share Federal, is the share of the funding coming from Federal US Government sources. Share Federal is instrumented with aggregate changes in federal funding for narrow fields (CFDA codes) in which the researcher received funding in the previous two years. F-statistics refers to the F-statistic of the instrument in the first-stage. Standard errors are clustered at the person level, and reported in parentheses. ***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Faculty		Graduate Students		Undergraduate Students		Staff	
	Any Patents$_{i,t}$	Number of Patents$_{i,t}$	Any Patents$_{i,t}$	Number of Patents$_{i,t}$	Any Patents$_{i,t}$	Number of Patents$_{i,t}$	Any Patents$_{i,t}$	Number of Patents$_{i,t}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Share Federal$_{i,t-1}$	-0.1005	-0.2095**	-0.0283	-0.0208	0.0147	0.0156	-0.0071	-0.0115
	(0.0622)	(0.0993)	(0.0277)	(0.0374)	(0.0199)	(0.0209)	(0.0062)	(0.0071)
Log(Expenditure$_{i,t}$)	0.0094***	0.0167***	0.0017***	0.0019**	0.0004	0.0005	0.0003**	0.0004**
	(0.0010)	(0.0020)	(0.0006)	(0.0008)	(0.0004)	(0.0004)	(0.0001)	(0.0002)
University×Year×Department FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	110,000	110,000	255,000	255,000	76,000	76,000	130,000	130,000
Mean of Dependent Variable	0.026	0.037	0.008	0.009	0.001	0.001	0.001	0.002
F-statistic	14.8	14.8	39.1	39.1	41.9	41.9	41.7	41.7

Table 5. Second Stage IV Effect of Share of Federal Funding on Patent Outcomes by Field

This table reports the second stage results of the IV regressions of the share of federal funding on researcher's innovation outcomes by broad field: Science (all sciences such as physics and chemistry; columns 1 and 2), Bio/Med/Pharma (biology, medicine, or pharmaceuticals; columns 3 and 4), Engineering, (columns 5 and 6), and Liberal Arts/Other (liberal arts or other; columns 7 and 8). The categories are mutually exclusive. The baseline sample is a person-year panel from 2001 through 2016. The dependent variables are innovation outcomes indicating whether the person is inventor of at least one patent (odd columns), or the number of invented patents by the person (even columns) in current year. The key independent variable, Share Federal, is the share of the funding coming from Federal US Government sources. Share Federal is instrumented with aggregate changes in federal funding for narrow fields (CFDA codes) in which the researcher received funding in the previous two years. F-statistics refers to the F-statistic of the instrument in the first-stage. Standard errors are clustered at the person level, and reported in parentheses. ***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Science		Bio/Med/Pharma		Engineering		Liberal Arts/Other	
	Any Patents$_{i,t}$	Number of Patents$_{i,t}$	Any Patents$_{i,t}$	Number of Patents$_{i,t}$	Any Patents$_{i,t}$	Number of Patents$_{i,t}$	Any Patents$_{i,t}$	Number of Patents$_{i,t}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Share Federal$_{i,t-1}$	-0.2371***	-0.2636**	-0.0605***	-0.0839***	-0.0547	-0.2181*	-0.0039	-0.0060
	(0.0897)	(0.1319)	(0.0203)	(0.0299)	(0.0939)	(0.1233)	(0.0173)	(0.0226)
Log(Expenditure$_{i,t}$)	0.0024***	0.0055***	0.0041***	0.0055***	0.0093***	0.0176***	0.0014***	0.0019***
	(0.0007)	(0.0019)	(0.0003)	(0.0005)	(0.0012)	(0.0029)	(0.0003)	(0.0004)
University × Year × Department FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	49,700	49,700	175,000	175,000	56,600	56,600	290,000	290,000
Mean of Dependent Variable	0.011	0.015	0.01	0.012	0.027	0.038	0.004	0.006
F-statistic	6.2	6.2	72	72	14.2	14.2	38.9	38.9

Table 6. Second Stage IV Effect of the Share of Federal Funding on Career Outcomes

This table reports the second stage results of the IV regressions of the share of federal funding on researcher's career outcomes. The baseline sample is a person-year panel from 2001 through 2016. The dependent variables are measured from the restricted-use US Census data matched with the UMETRICS data. High-tech Entrepreneur is an indicator for a person working at an age 0 high-tech firm, Work for Incumbent is an indicator for a person working at a non-university age 5+ firm, and Work for University is an indicator for a person working at a university. Each of these career outcomes indicate whether the employment event occurred in any of the next 3 years starting from this year. The key independent variable, Share Federal, is the share of the funding coming from Federal US Government sources. Share Federal is instrumented with aggregate changes in federal funding for narrow fields (CFDA codes) in which the researcher received funding in the previous two years. F-statistics refers to the F-statistic of the instrument in the first-stage. Standard errors are clustered at the person level, and reported in parentheses. ***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	High-tech Entrepreneur$_{i,[t,t+2]}$	Work for Incumbent Firm$_{i,[t,t+2]}$	Work for University$_{i,[t,t+2]}$
	(1)	(2)	(3)
Share Federal$_{i,t-1}$	0.0421**	-0.527***	0.157**
	(0.0198)	(0.0993)	(0.0706)
Log(Expenditure$_{i,t-1}$)	0.000134	-0.0574***	0.0548***
	(0.000196)	(0.0011)	(0.0007697)
University×Year×Department FE	Yes	Yes	Yes
Number of Observations	457,000	457,000	457,000
Mean of Dependent Variable	0.0074	0.553	0.831
F-statistic	125	125	125

Table 7. Second Stage IV Effect of Share of Federal Funding on Career Outcomes by Occupation

This table reports the second stage results of the IV regressions of the share of federal funding on researcher's innovation outcomes by occupation: faculty, graduate students, staff, and undergraduate students. The baseline sample is a person-year panel from 2001 through 2016. The dependent variables are measured from the restricted-use US Census data matched with the UMETRICS data. High-tech Entrepreneur is an indicator for a person working at an age 0 high-tech firm, Work for Incumbent is an indicator for a person working at a non-university age 5+ firm, and Work for University is an indicator for a person working at a university. Each of these career outcomes indicate whether the employment event occurred in any of the next 3 years starting from this year. The key independent variable, Share Federal, is the share of the funding coming from Federal US Government sources. Share Federal is instrumented with aggregate changes in federal funding for narrow fields (CFDA codes) in which the researcher received funding in the previous two years. F-statistics refers to the F-statistic of the instrument in the first-stage. Standard errors are clustered at the person level, and reported in parentheses. ***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A. Graduate and Undergraduate Students

	Graduate Student			Undergraduate Students		
	High-tech Entrepreneur$_{i,[t,t+2]}$	Work for Incumbent Firm$_{i,[t,t+2]}$	Work for University$_{i,[t,t+2]}$	High-tech Entrepreneur$_{i,[t,t+2]}$	Work for Incumbent Firm$_{i,[t,t+2]}$	Work for University$_{i,[t,t+2]}$
	(1)	(2)	(3)	(4)	(5)	(6)
Share Federal$_{i,t-1}$	0.106**	-0.01603	0.0064	0.062	-0.6237***	0.241
	(0.0458)	(0.179)	(0.129)	(0.049)	(0.209)	(0.192)
Log(Expenditure$_{i,t-1}$)	0.00024***	0.00038	-0.0058***	0.0016	-0.0392***	0.0434***
	(0.000057)	(0.00025)	(0.00019)	(0.00104)	(0.0045)	(0.0041)
University×Year×Department FE	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	211,000	211,000	211,000	70,000	70,000	70,000
Mean of Dependent Variable	0.0091	0.5236	0.8337	0.0094	0.7596	0.6031
F-statistic	45	45	45	30	30	30

Panel B. Faculty and Staff

	Faculty			Staff		
	High-tech Entrepreneur$_{i,[t,t+2]}$	Work for Incumbent Firm$_{i,[t,t+2]}$	Work for University$_{i,[t,t+2]}$	High-tech Entrepreneur$_{i,[t,t+2]}$	Work for Incumbent Firm$_{i,[t,t+2]}$	Work for University$_{i,[t,t+2]}$
	(1)	(2)	(3)	(4)	(5)	(6)
Share Federal$_{i,t-1}$	-0.0046	-0.301**	0.0114	-0.0025	0.171	-0.085
	(0.028)	(0.153)	(0.0971)	(0.0204)	(0.133)	(0.093)
Log(Expenditure$_{i,t-1}$)	0.000097	-0.00077	0.0124***	0.00027	-0.0372***	0.038***
	(0.00026)	(0.0015)	(0.00096)	(0.0003)	(0.00196)	(0.0013)
University×Year×Department FE	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	87,000	87,000	87,000	92,500	92,500	92,500
Mean of Dependent Variable	0.0037	0.5164	0.9548	0.0053	0.4942	0.884
F-statistic	23	23	23	54	54	54

Table 8. Second Stage IV Effect of Share of Federal Funding on Career Outcomes by Field

This table reports the second stage results of the IV regressions of the share of federal funding on researcher's innovation outcomes by broad field: Science (all sciences such as physics and chemistry; columns 1, 2 and 3 of Panel A), Bio/Med/Pharma (biology, medicine, or pharmaceuticals; columns 4, 5 and 6 of Panel A), Engineering, (columns 1, 2 and 3 of Panel B), and Liberal Arts/Other (liberal arts or other; columns 4, 5 and 6 of Panel B). The categories are mutually exclusive. The baseline sample is a person-year panel from 2001 through 2016. The dependent variables are measured from the restricted-use US Census data matched with the UMETRICS data. High-tech Entrepreneur is an indicator for a person working at an age 0 high-tech firm, Work for Incumbent is an indicator for a person working at a non-university age 5+ firm, and Work for University is an indicator for a person working at a university. Each of these career outcomes indicate whether the employment event occurred in any of the next 3 years starting from this year. The key independent variable, Share Federal, is the share of the funding coming from Federal US Government sources. Share Federal is instrumented with aggregate changes in federal funding for narrow fields (CFDA codes) in which the researcher received funding in the previous two years. F-statistics refers to the F-statistic of the instrument in the first-stage. Standard errors are clustered at the person level, and reported in parentheses. ***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A. Science and Bio/Med/Pharma Fields

	Science			Bio/Med/Pharma		
	High-tech Entrepreneur$_{i,[t,t+2]}$	Work for Incumbent Firm$_{i,[t,t+2]}$	Work for University$_{i,[t,t+2]}$	High-tech Entrepreneur$_{i,[t,t+2]}$	Work for Incumbent Firm$_{i,[t,t+2]}$	Work for University$_{i,[t,t+2]}$
	(1)	(2)	(3)	(4)	(5)	(6)
Share Federal$_{i,t-1}$	-0.0246	-0.4996*	0.1644	0.06583*	-0.34**	-0.1461
	(0.03794)	(0.2922)	(0.2162)	(0.03429)	(0.1573)	(0.1092)
Log(Expenditure$_{i,t-1}$)	-0.000592	-0.0715***	0.05456***	-0.0001175	-0.04725***	0.05349***
	(0.00055)	(0.0034)	(0.00244)	(0.0002288)	(0.00146)	(0.00097)
University×Year×Department FE	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	43,500	43,500	43,500	158,000	158,000	158,000
Mean of Dependent Variable	0.00997	0.4019	0.8183	0.0149	0.6154	0.7844
F-statistic	12.4	12.4	12.4	54.5	54.5	54.5

Panel B. Engineering and Liberal Arts/Other Fields

	Engineering			Liberal Arts/Other		
	High-tech Entrepreneur$_{i,[t,t+2]}$	Work for Incumbent Firm$_{i,[t,t+2]}$	Work for University$_{i,[t,t+2]}$	High-tech Entrepreneur$_{i,[t,t+2]}$	Work for Incumbent Firm$_{i,[t,t+2]}$	Work for University$_{i,[t,t+2]}$
	(1)	(2)	(3)	(4)	(5)	(6)
Share Federal$_{i,t-1}$	0.1884*	-0.6113**	0.6329**	0.009495	-0.5997***	0.304***
	(0.1061)	(0.3038)	(0.2657)	(0.02431)	(0.1429)	(0.106)
Log(Expenditure$_{i,t-1}$)	0.0004866	-0.0434***	0.06273***	-0.0001522	-0.06451***	0.0553***
	(0.000777)	(0.002784)	(0.00235)	(0.000341)	(0.00215)	(0.0016)
University×Year×Department FE	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	49,500	49,500	49,500	207,000	207,000	207,000
Mean of Dependent Variable	0.00536	0.5286	0.8711	0.00666	0.5881	0.8141
F-statistic	16	16	16	57	57	57

Table 9. Second Stage IV Effect of the Share of Private Funding on Patent Outcomes

This table reports the second stage results of the IV regressions of the shift from federal to private funding on researcher's innovation outcomes. The baseline sample is a person-year panel from 2001 through 2016. The dependent variables are innovation outcomes indicating whether the person is an inventor of a patent (or of a patent of certain type) in current year. The key independent variable, Share Private, is the share of the funding coming from private sources. Share Private is instrumented with aggregate changes in federal funding for narrow fields (CFDA codes) in which the researcher received funding in the previous two years. F-statistics refers to the F-statistic of the instrument in the first-stage. Standard errors are clustered at the person level, and reported in parentheses. ***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Any $\text{Patents}_{i,t}$	Number of $\text{Patents}_{i,t}$	Any Highly Cited $\text{Patents}_{i,t}$	Any Original $\text{Patents}_{i,t}$	Any General $\text{Patents}_{i,t}$	Any Patents with Private $\text{Assignee}_{i,t}$
	(1)	(2)	(3)	(4)	(5)	(6)
$\text{Share Private}_{i,t-1}$	0.0746***	0.1174***	0.0024	0.0240*	-0.0159*	0.0126***
	(0.0207)	(0.0297)	(0.0070)	(0.0139)	(0.0088)	(0.0041)
$\text{Log}(\text{Expenditure}_{i,t-1})$	0.0028***	0.0041***	0.0004***	0.0013***	0.0006***	0.0001***
	(0.0002)	(0.0003)	(0.0001)	(0.0001)	(0.0001)	(0.0000)
University × Year × Department FE	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	571,000	571,000	571,000	571,000	571,000	571,000
Mean of Dependent Variable	0.0090	0.0117	0.0010	0.0038	0.0016	0.0004
F-statistic	93.7	93.7	93.7	93.7	93.7	93.7

Table 10. Second Stage IV Effect of the Share of Private Funding on Career Outcomes

This table reports the second stage results of the IV regressions of the shift from federal to private funding on researcher's career outcomes. The baseline sample is a person-year panel from 2001 through 2016. The dependent variables are measured from the restricted-use US Census data matched with the UMETRICS data. High-tech Entrepreneur is an indicator for a person working at an age 0 high-tech firm, Work for Incumbent is an indicator for a person working at a non-university age 5+ firm, and Work for University is an indicator for a person working at a university. Each of these career outcomes indicate whether the employment event occurred in any of the next 3 years starting from this year. The key independent variable, Share Private, is the share of the funding coming from private sources. Share Private is instrumented with funding shocks coming from aggregate changes in federal funding for narrow fields (CFDA codes) in which the researcher received funding in the previous two years. F-statistics refers to the F-statistic of the instrument in the first-stage. Standard errors are clustered at the person level, and reported in parentheses. ***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	High-tech Entrepreneur$_{i,[t,t+2]}$	Work for Incumbent Firm$_{i,[t,t+2]}$	Work for University$_{i,[t,t+2]}$
	(1)	(2)	(3)
Share Private$_{i,t-1}$	-0.0735**	0.499***	-0.154
	(0.0313)	(0.149)	(0.109)
Log(Expenditure$_{i,t-1}$)	0.000076	-0.05514***	0.05416***
	(0.00017)	(0.00095)	(0.00067)
University×Year×Department FE	Yes	Yes	Yes
Number of Observations	457,000	457,000	457,000
Mean of Dependent Variable	0.0074	0.553	0.831
F-statistic	234	234	234

A Appendix: Additional Tables and Figures

Table A.1. Second Stage IV Effect of the Share of Federal Funding on Additional Career Outcomes

This table reports the second stage results of the IV regressions of the share of federal funding on researcher's career outcomes. The baseline sample is a person-year panel from 2001 through 2016. The dependent variables are measured from the restricted-use US Census data matched with the UMETRICS data. Entrepreneur is an indicator for a person working at any age 0 firm (not necessarily high-tech) and Work for Young (High-tech, Patenting) is an indicator for a person working at a firm (High-tech, Patenting) that is between 1 and 5 years old. Work for R1 University is an indicator for person working at a Research 1 (R1) university, defined using the Carnegie Classifications: R1 institutions are doctoral granting universities with "very high research activity." Each of these career outcomes indicate whether the employment event occurred in any of the next 3 years starting from this year. In column 5, Work for Research University is defined within the full sample and in column 6, we limit the sample to only people who are working for universities. Log(Wage) is the log of real wage in 2014 dollars, where wage is the maximum wage revived from any single source in the first year a wage is observed. The key independent variable, Share Federal, is the share of the funding coming from Federal US Government sources. Share Federal is instrumented with funding shocks coming from aggregate changes in federal funding for narrow fields (CFDA codes) in which the researcher received funding in the previous two years. F-statistics refers to the F-statistic of the instrument in the first-stage. Standard errors are clustered at the person level, and reported in parentheses. ***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	$\text{Entrepreneur}_{i,[t,t+2]}$	Work for Young $\text{Firm}_{i,[t,t+2]}$	Work for Young High-tech $\text{Firm}_{i,[t,t+2]}$	Work for Young Patenting $\text{Firm}_{i,[t,t+2]}$	Work for Research $\text{University}_{i,[t,t+2]}$		$\text{Log}(\text{Wage}_{i,t})$
					All People	If Work for Any University	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\text{Share Federal}_{i,t-1}$	-0.02751	-0.057	0.0821**	0.059**	0.2693***	0.1529***	-2.025***
	(0.03689)	(0.056)	(0.0324)	(0.02341)	(0.0748)	(0.0413)	(0.4319)
$\text{Log}(\text{Expenditure}_{I,t-1})$	-0.0068***	-0.0199***	-0.00131***	-0.00036	0.0573***	0.00923***	0.3307***
	(0.00039)	(0.00062)	(0.00033)	(0.00022)	(0.0008)	(0.00035)	(0.0047)
University×Year×Department FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	457,000	457,000	457,000	457,001	457,000	380,000	457,000
Mean of Dependent Variable	0.031	0.08	0.022	0.0086	0.703	0.846	10.04
F-statistic	125	125	125	125	125	88.8	125

Table A.2. Robustness. Second Stage IV Effect of the Share of Federal Funding on Patent Outcomes: Placebo Test, Controls for Long-term Trends, Use Large Federal Funding Shocks, and Control for Past Values of Dependent Variables

This table reports robustness tests for the second stage results of the IV regressions of the share of federal funding on researcher's key innovation outcomes. The baseline sample is a person-year panel from 2001 through 2016. The dependent variables are innovation outcomes indicating whether the person is an inventor of a patent (or the number of patents) in current year. In columns 1–2, the sample is all researchers who receive 100% of their funding from the federal government in every year observed in the data, and the independent variables, Log-change Amount R&D are two lags of the researcher weighted average of funding changes in CFDA programs as described in Section 3, and used as the instruments (for share federal) measuring funding shocks coming from the aggregate changes in federal funding of narrow fields (CFDA codes) in which the researcher received funding in the previous two years. In columns 3–8, the independent variable, Share Federal, is the share of the funding coming from Federal US Government sources. Share Federal is instrumented with funding shocks (the two lags of Log-change Amount R&D) coming from aggregate changes in federal funding for narrow fields (CFDA codes) in which the researcher received funding in the previous two years. Columns 3–4 include controls for the long-term trends in CFDA funding categories (defined as funding changes from six years ago to one year ago) in which the researcher had funding as of a year ago. Columns 5–6 are only estimated off the CFDA changes that are at least 30% in absolute value; the changes with smaller than 30% change are set to zero. Columns 7–8 include controls for 3-year lag of the dependent variable. In columns 3–8, the estimates of all control variables are suppressed for readability. F-statistics refers to the F-statistic of the instrument in the first-stage. Standard errors are clustered at the person level, and reported in parentheses. ***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Placebo: Non-Switchers		Control for Long-term Trends in Shocks		Large Federal Funding Shocks		Control for Past Patenting	
	Any $Patents_{i,t}$	Number of $Patents_{i,t}$	Any $Patents_{i,t}$	Number of $Patents_{i,t}$	Any $Patents_{i,t}$	Number of $Patents_{i,t}$	Any $Patents_{i,t}$	Number of $Patents_{i,t}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ Log(Amount $R\&D_{i,t-1}$)	-0.0001	-0.0001						
	(0.0001)	(0.0001)						
Δ Log(Amount $R\&D_{i,t-2}$)	-0.0001	-0.0001						
	(0.0001)	(0.0001)						
Log($Expenditure_{i,t-1}$)	0.0011***	0.0013***	0.0034***	0.0051***	0.0034***	0.0051***	0.0025***	0.0034***
	(0.0001)	(0.0001)	(0.0002)	(0.0004)	(0.0002)	(0.0004)	(0.0002)	(0.0002)
Share $Federal_{i,t-1}$			-0.0579***	-0.0883***	-0.0519***	-0.0810***	-0.0436***	-0.0678**
			(0.0164)	(0.0232)	(0.0144)	(0.0205)	(0.0137)	(0.0183)
University×Year×Department FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	282,000	282,000	552,000	552,000	571,000	571,000	558,000	558,000
Mean of Dependent Variable	0.0090	0.0117	0.0090	0.0117	0.0090	0.0117	0.0090	0.0117
F-statistic	NA	NA	81	81	111	111	111	111

Table A.3. Robustness. Alternative Controls in Second Stage IV Effect of the Share of Federal Funding on Patent Outcomes

Table shows that the second stage results of the IV regressions of the share of federal funding on researcher's innovation outcomes are robust to using different control variables. In columns 1, 4, and 7, we control for changes in the researcher's total expenditures from *t-1* to *t*. In columns 2, 5, and 8, we control for two lags of the researcher's total expenditure. Columns 3, 6, and 9 do not control for the total expenditures. The baseline sample is a person-year panel from 2001 through 2016. In both panels, he dependent variables are innovation outcomes indicating whether the person is an inventor of a patent (or of a patent of certain type) in current year. The key independent variable, Share Federal, is the share of the funding coming from Federal US Government sources. Share Federal is instrumented with funding shocks coming from aggregate changes in federal funding for narrow fields (CFDA codes) in which the researcher received funding in the previous two years. F-statistics refers to the F-statistic of the instrument in the first-stage. Standard errors are clustered at the person level, and reported in parentheses. ***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A

	Any Patents$_{i,t}$			Number of Patents$_{i,t}$			Any Highly Cited Patents$_{i,t}$		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Share Federal$_{i,t-1}$	-0.0260**	-0.0454***	-0.0207	-0.0379**	-0.0726***	-0.0347*	0.0025	-0.0007	0.0019
	(0.0129)	(0.0142)	(0.0128)	(0.0181)	(0.0202)	(0.0179)	(0.0045)	(0.0048)	(0.0044)
Δ Log(Expenditure$_{i,t-1}$)	-0.0006***			-0.0009***			-0.0001***		
	(0)			(0.0001			(0)		
Log(Expenditure$_{i,t-1}$)		0.0026***			0.0041***			0.0003***	
		(0.0002)			(0.0004)			(0.0001)	
Log(Expenditure$_{i,t-2}$)		0.0005***			0.0006***			0.0001***	
		(0)			(0.0001)			(0)	
University×Year×Department FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	565,000	565,000	571,000	565,000	565,000	571,000	565,000	565,000	571,000
Mean of Dependent Variable	0.0090	0.0090	0.0090	0.0117	0.0117	0.0117	0.0010	0.0010	0.0010
F-statistic	131	131	131	131	131	131	131	131	131

Panel B

	Any Original Patents$_{i,t}$			Any General Patents$_{i,t}$			Any Patents with Private Assignee$_{i,t}$		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Share Federal$_{i,t-1}$	-0.0014	-0.0139	-0.0038	0.0162***	0.0122**	0.0151***	-0.0066***	-0.0084***	-0.0068***
	(0.0089	(0.0096)	(0.0088	(0.0057)	(0.0061)	(0.0057)	(0.0025)	(0.0028)	(0.0025)
Δ Log(Expenditure$_{i,t-1}$)	-0.0003***			-0.0001***			-0.0000***		
	(0)			(0)			(0)		
Log(Expenditure$_{i,t-1}$)		0.0011***			0.0003***			0.0002***	
		(0.0001)			(0.0001)			(0)	
Log(Expenditure$_{i,t-2}$)		0.0002***			0.0001***			0.0000***	
		(0)			(0)			(0)	
University×Year×Department FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	565,000	565,000	571,000	565,000	565,000	571,000	565,000	565,000	571,000
Mean of Dependent Variable	0.0038	0.0038	0.0038	0.0016	0.0016	0.0016	0.0004	0.0004	0.0004
F-statistic	131	131	131	131	131	131	131	131	131

Table A.4. Robustness. Alternative Controls in Second Stage IV Effect of the Share of Federal Funding on Career Outcomes

Table shows that the second stage results of the IV regressions of the share of federal funding on researcher's career outcomes are robust to using different control variables. In columns 1, 4, and 7, we control for changes in the researcher's total expenditures from *t-1* to *t*. In columns 2, 5, and 8, we control for two lags of the researcher's total expenditure. Columns 3, 6, and 9 do not control for the total expenditures. The baseline sample is a person-year panel from 2001 through 2016. The dependent variables are measured from the restricted-use US Census data matched with the UMETRICS data. High-tech Entrepreneur is an indicator for a person working at an age 0 high-tech firm, Work for Incumbent is an indicator for a person working at a non-university age 5+ firm, and Work for University is an indicator for a person working at a university. Each of these career outcomes indicate whether the employment event occurred in any of the next 3 years starting from this year. The key independent variable, Share Federal, is the share of the funding coming from Federal US Government sources. Share Federal is instrumented with funding shocks coming from aggregate changes in federal funding for narrow fields (CFDA codes) in which the researcher received funding in the previous two years. F-statistics refers to the F-statistic of the instrument in the first-stage. Standard errors are clustered at the person level, and reported in parentheses. ***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	High-tech Entrepreneur$_{i,[t,t+2]}$			Work for Incumbent Firm$_{i,[t,t+2]}$			Work for University$_{i,[t,t+2]}$		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Share Federal$_{i,t-1}$	0.04607**	0.04519**	0.04308**	-0.9421***	-0.535***	-0.8969***	0.44***	0.03608	0.5129***
	(0.02108)	(0.01998)	(0.02081)	(0.1203)	(0.09997)	(0.1176)	(0.08336)	(0.07)	(0.08454)
Δ Log(Expenditure$_{i,t-1}$)	-0.0001748***			0.002991***			0.004342***		
	(0.0000358)			(0.0002151)			(0.0001591)		
Log(Expenditure$_{i,t-1}$)		-0.0000707			-0.05671***			0.06292***	
		(0.0001933)			(0.001093)			(0.000771)	
Log(Expenditure$_{i,t-2}$)		0.0001704***			-0.0005468***			-0.006743***	
		(0.0000337)			(0.0001747)			(0.0001394)	
University × Year × Department FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	457,000	457,000	457,000	457,000	457,000	457,000	457,000	457,000	457,000
Mean of Dependent Variable	0.0074	0.0074	0.0074	0.553	0.553	0.553	0.831	0.831	0.831
F-statistic	112	124	114	112	124	114	112	124	114

Table A.5. Robustness. Effect of the Instruments on Patent and Career Outcomes Controlling for Funding Levels

Table shows the reduced form analysis of regressing innovation and career outcomes on the instruments, which are lagged researchers' weighted average of funding changes in CFDA programs as described in Section 3. All regressions control for lagged log expenditure, as well as three lags of change in log expenditure. The baseline sample is a person-year panel from 2001 through 2016. In columns 1–2, the dependent variables are innovation outcomes in current year. In columns 3–5, the dependent variables are career outcomes: High-tech Entrepreneur is an indicator for a person working at an age 0 high-tech firm, Work for Incumbent is an indicator for a person working at a non-university age 5+ firm, and Work for University is an indicator for a person working at a university. Each of these career outcomes indicate whether the employment event occurred in any of the next 3 years starting from this year. Standard errors are clustered at the person level, and reported in parentheses. ***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Patent Outcomes		Career Outcomes		
	Any Patents$_{i,t}$	Number of Patents$_{i,t}$	High-tech Entrepreneur$_{i,[t,t+2]}$	Work for Incumbent Firm$_{i,[t,t+2]}$	Work for University$_{i,[t,t+2]}$
	(1)	(2)	(3)	(4)	(5)
Log(Expenditure$_{i,t-1}$)	0.00199***	0.00305***	-0.0002537**	-0.0536***	0.05652***
	(0.00013)	(0.00027)	(0.0001271)	(0.000745)	(0.000545)
Δ Log(Expenditure$_{i,t}$)	0.00018***	0.000121***	-0.0001714***	0.001857***	0.005241***
	(0.00003)	(0.00004)	(0.0000475)	(0.0002318)	(0.0001887)
Δ Log(Expenditure$_{i,t-1}$)	0.00025***	0.00035***	-0.0000368	0.002936***	-0.002743***
	(0.00004)	(0.00006)	(0.0000444)	(0.0002131)	(0.0001831)
Δ Log(Expenditure$_{i,t-2}$)	0.00058***	0.00093***	9.78e-07	0.001166***	-0.001838***
	(0.00005)	(0.00009)	(0.0000414)	(0.0001936)	(0.000182)
Δ Log(Amount R&D$_{i,t}$)	-0.00008	-0.00010	0.000013	-0.005151***	0.001064***
	(0.00008)	(0.00011)	(0.0000627)	(0.0004055)	(0.0003445)
Δ Log(Amount R&D$_{i,t-1}$)	-0.00017**	-0.00025***	0.0003263***	-0.000801	-0.0000661
	(0.00008)	(0.00009)	(0.0001189)	(0.0005691)	(0.0004416)
Δ Log(Amount R&D$_{i,t-2}$)	-0.00013**	-0.00024**	0.0003376***	-0.0000498	-0.00123***
	(0.00007)	(0.00011)	(0.0001243)	(0.0005803)	(0.0004736)
University$\times$Year$\times$Department FE	Yes	Yes	Yes	Yes	Yes
Number of Observations	571,000	571,000	457,000	457,000	457,000
Mean of Dependent Variable	0.0090	0.0117	0.0074	0.553	0.831
Adjusted R-squared	0.015	0.013	0.003	0.309	0.103

Table A.6. Robustness. Second Stage IV Effect of the Share of Federal Funding on Patent and Career Outcomes: Cluster Standard Errors at University-By-Department Level

Table shows that the second stage results of the IV regressions of the share of federal funding on researcher's outcomes are robust to clustering standard errors at university-by-department level. The baseline sample is a person-year panel from 2001 through 2016. In columns 1–6, the dependent variables are innovation outcomes indicating whether the person is an inventor of a patent (or of a patent of certain type) in current year. In columns 7–9, the dependent variables are career outcomes: High-tech Entrepreneur is an indicator for a person working at an age 0 high-tech firm, Work for Incumbent is an indicator for a person working at a non-university age 5+ firm, and Work for University is an indicator for a person working at a university. Each of these career outcomes indicate whether the employment event occurred in any of the next 3 years starting from this year. The key independent variable, Share Federal, is the share of the funding coming from Federal US Government sources. Share Federal is instrumented with funding shocks coming from aggregate changes in federal funding for narrow fields (CFDA codes) in which the researcher received funding in the previous two years. F-statistics refers to the F-statistic of the instrument in the first-stage. Standard errors are clustered at the person level, and reported in parentheses. ***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Patent Outcomes						Career Outcomes		
	Any Patents$_{i,t}$	Number of Patents$_{i,t}$	Any Highly Cited Patents$_{i,t}$	Any Original Patents$_{i,t}$	Any General Patents$_{i,t}$	Any Patents with Private Assignee$_{i,t}$	High-tech Entrepreneur$_{i,[t,t+2]}$	Work for Incumbent Firm$_{i,[t,t+2]}$	Work for University$_{i,[t,t+2]}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Share Federal$_{i,t-1}$	-0.0509**	-0.0803**	-0.0015	-0.0168	0.0107	-0.0086*	0.0449**	-0.9710**	0.5287*
	(0.0258)	(0.0370)	(0.0034)	(0.0127)	(0.0079)	(0.0049)	(0.0207)	(0.3969)	(0.3051)
Log(Expenditure$_{i,t-1}$)	0.0034***	0.0051***	0.0004***	0.0015***	0.0005**	0.0002	0.0002***	-0.0083***	0.0018**
	(0.0008)	(0.0013)	(0.0001)	(0.0003)	(0.0002)	(0.0001)	(0.0001)	(0.0016)	(0.0008)
University × Year × Department FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	571,000	571,000	571,000	571,000	571,000	571,000	457,000	457,000	457,000
Mean of Dependent Variable	0.0090	0.0117	0.0010	0.0038	0.0016	0.0004	0.0074	0.553	0.831
F-statistic	26	26	26	26	26	26	19	19	19

Table A.7. Robustness. Second Stage IV Effect of the Share of Federal Funding on Patent and Career Outcomes: Cluster Standard Errors at CFDA Level

Table shows that the second stage results of the IV regressions of the share of federal funding on researcher's outcomes are robust to clustering standard errors at CFDA code level. CFDAs are federal programs from which the researchers receive funding. If a researcher received funding from multiple CFDA codes, we take the CFDA code from which she received the most money. The baseline sample is a person-year panel from 2001 through 2016. In columns 1–6, the dependent variables are innovation outcomes indicating whether the person is an inventor of a patent (or of a patent of certain type) in current year. In columns 7–9, the dependent variables are career outcomes: High-tech Entrepreneur is an indicator for a person working at an age 0 high-tech firm, Work for Incumbent is an indicator for a person working at a non-university age 5+ firm, and Work for University is an indicator for a person working at a university. Each of these career outcomes indicate whether the employment event occurred in any of the next 3 years starting from this year. The key independent variable, Share Federal, is the share of the funding coming from Federal US Government sources. Share Federal is instrumented with funding shocks coming from aggregate changes in federal funding for narrow fields (CFDA codes) in which the researcher received funding in the previous two years. F-statistics refers to the F-statistic of the instrument in the first-stage. Standard errors are clustered at the person level, and reported in parentheses. ***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Patent Outcomes						Career Outcomes		
	Any Patents$_{i,t}$	Number of Patents$_{i,t}$	Any Highly Cited Patents$_{i,t}$	Any Original Patents$_{i,t}$	Any General Patents$_{i,t}$	Any Patents with Private Assignee$_{i,t}$	High-tech Entrepreneur$_{i,[t,t+2]}$	Work for Incumbent Firm$_{i,[t,t+2]}$	Work for University$_{i,[t,t+2]}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Share Federal$_{i,t-1}$	-0.0509***	-0.0803***	-0.0015	-0.0168*	0.0107	-0.0086**	0.0421*	-0.527*	0.1571
	(0.0198)	(0.0279)	(0.0054)	(0.0104)	(0.0099)	(0.0035)	(0.02148)	(0.3009)	(0.2246)
Log(Expenditure$_{i,t-1}$)	0.0034***	0.0051***	0.0004***	0.0015***	0.0005***	0.0002***	0.0001339	-0.05739***	0.05481***
	(0.0004)	(0.0008)	(0.0001)	(0.0002)	(0.0001)	(0.0001)	(0.0002461)	(0.009993)	(0.00358)
University×Year×Department FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	571,000	571,000	571,000	571,000	571,000	571,000	457,000	457,000	457,000
Mean of Dependent Variable	0.0090	0.0117	0.0010	0.0038	0.0016	0.0004	0.0074	0.553	0.831
F-statistic	14	14	14	14	14	14	87	87	87

B Appendix: Description of Data Sources and Sample Construction

This section discusses the data sources and how they are combined to create our estimation sample. Our analysis is based on human resource records from universities (Section B.1). We first merge the data with expenditures in federal assistance programs from Single Audit (Section B.2). We then link the university researchers to inventors to get patenting outcomes (Section B.3). Finally, we obtain career outcomes from confidential administrative data at the U.S. Census Bureau (Section B.4).

B.1 UMETRICS Data

We use new grant administration accounting records from the IRIS UMETRICS program to measure funding of university researchers. Universities contribute grant-level accounting data to this program, which is administered by the Institute for Research on Innovation and Science (IRIS) at the University of Michigan. Currently, 49 universities, accounting for more than 40% of federal R&D expenditures, are committed to participating, but the project is expected to become a national program.

For each grant, we observe both the name of the external funding source as well as the CFDA code for federal agency sponsors. We use the CFDA codes and names of external funders to determine if a grant came from a federal government agency, private firm, state or local government, foreign government, or university.[27] We observe all of the research grants received by each researcher in each year as well as the expenditures for each grant. We calculate the fraction of a researcher's expenditures that comes from the federal government, as well as the fraction that is accounted for by private firms and other sources. We also observe each researcher's occupation classification (e.g. faculty, graduate student or post-doc, undergraduate student, and other) and department (e.g. physics, biology, etc). For simplicity of exposition, we refer to graduate students and post-docs as simply "graduate students."

The final sample from the UMETRICS data consists of 22 universities and around 235,000

[27] We also use funder names to categorize industry funders into for-profit firms and nonprofit organizations, although in many cases it is ambiguous whether the company is for-profit or nonprofit from the names. Nonprofits not explicitly categorized as such are included in the private category. While the coverage of federal grants is complete, the coverage of non-federal grants is incomplete at some universities. Since our instrument only applies to people who have ever got funding from federal government, we exclude from our sample universities that do not supply information on funding from non-federal sources.

researchers from 2001 to 2016. Table 1 Panel A presents summary statistics on the sample used in estimation. Among the researchers, 19.3% are faculty, 44.5% are graduate students or post-docs, 13.4% are undergraduate, and 28.8% are staff members. Occupations defining our "graduate students and post-docs" category include: Graduate Student, Post Graduate Research, and Research (Staff Scientist, Research Analyst, Technician). Occupations defining our "staff" category include:: Clinical, Research Facilitation (Research Support, Research Administration, Research Coordinator), Technical Support, Instructional, and Other Staff. More than 20% of the researchers have received funding from both federal government agencies and private companies. On average researchers receive funding from two federal assistance programs from the CFDA list.

B.2 Spending Shock Instruments

We measure federal funding shocks at CFDA-program level using Single Audits. All non-federal entities that spend $500,000 or more of federal awards in a year ($300,000 for fiscal years ending on or before December 30, 2003) are required to obtain an annual audit in accordance with the Single Audit Act Amendments of 1996. A Single Audit includes an examination of a recipient's financial records, financial statements, federal award transactions and expenditures, the general management of its operations, internal control systems, and federal assistance it received during the year.

We collect our data from the Federal Audit Clearinghouse, to which the Single Audits are submitted. The data contains both R&D and non-R&D expenditures by CFDA program, by recipient, and by year. We aggregate R&D expenditures by CFDA programs across all recipients to measure the total expenditure of each CFDA program in a given year. Our instrument is the weighted average of changes in log expenditures across a researcher's CFDA programs (see Equation 1). Total expenditures within CFDA programs fluctuate dramatically – the standard deviation of our instrument is approximately 1.1, compared to means of 0.06 and 0.09 for the first two lags (see Table 1). Two characteristic examples (discussed above) are in Figure 2.

B.3 Patent Data

Patent data are from the PatentsView database, which contains bibliographic information on all patents granted by the United States Patent and Trademark Office (USPTO).[28] Data on patent inventors from PatentsView were linked linked to UMETRICS employees, allowing us to measure each researcher's patenting activity.[29]

In addition to the number of granted patents, we construct several variables to measure characteristics of patents that are standard in the literature. The first is the number of forward citations, which we normalize by patent class and by year to adjust for the systematic differences across classes and years.[30] Forward citations are informative about the impact of a patent on future research. The second measure is generality. A high generality score indicates that the patent influenced subsequent innovations in a variety of fields (Trajtenberg et al. 1997).[31] The third measure is originality. The originality score will be low if a patent cites previous patents in a narrow set of technologies, whereas citing patents in a wide range of fields leads to a high score.[32] The last measure is whether the assignee is a private company. We use the name of the assignees to identify whether a patent is assigned to a private company or other entities (e.g. universities).

Panel B of Table 1 presents the summary statistics for patents. About half of the patents receive zero citations. We define a patent as *highly cited* if its standardized citation count is in the top 10% of the (standardized) citation distribution. We define a patent as *original* or *general* if the originality or generality score is above the median in a given year.[33] About 1% of researchers have been granted

[28] Established in 2012, PatentsView longitudinally links inventors, assignees, locations and patenting activity using bulk data from the USPTO on published patent applications (2001-present) and granted patents (1976-present).

[29] The matches were obtained by comparing names, affiliations, and grant numbers and constructing a similarity measure based on the textual similarity of the last names, middle initials, and first names. In addition, our matching algorithm examined the university affiliation of the employee with the assignee name listed on the patent and the geographic location listed for the inventor. After comparing names and affiliations, the decision of whether or not a pair matches was based on empirical probabilities from a training dataset of known matches.

[30] The citations data, from Babina et al. (2019), are updated as of the end of 2019.

[31] Generality for patent i is defined as $1 - \sum_j s_{ij}^2$, where s_{ij} is the percentage of citations received by patent i that belong to patent class j. Thus, if a patent is cited by subsequent patents that belong to a wide range of fields the measure will be high, whereas if most citations are concentrated in a few fields it will be low (close to zero).

[32] Originality for patent i is defined as $1 - \sum_j c_{ij}^2$, where c_{ij} is the percentage of citations that patent i makes that belong to patent class j.

[33] These are based on within-year comparisons, because the generality and originality measures tend to be positively correlated with the number of citations made (for originality) or received (for generality) and therefore correlated with

a patent, and around 4% of all granted patents are assigned to private companies. Intuitively, faculty are much more likely to patent (the probability of 2.6%) than graduate students (0.8%), undergrads (0.11%) and staff (0.15%).

B.4 Entrepreneurship and Employment

We obtain career outcomes from confidential administrative data at the U.S. Census Bureau and the Internal Revenue Service (IRS), including the Business Register (BR), the Longitudinal Business Database (BR/LBD), W-2 tax records, and unemployment insurance wage records as captured through the Longitudinal Employer Household Dynamics (LEHD) program.

We construct career outcomes for each UMETRICS individual by first linking them to employment and wage information contained in W-2 tax records and the LEHD Person History File (PHF).[34] The W-2 records are crucial for our setting because, unlike the LEHD PHF, they include graduate student stipends. By linking UMETRICS individuals to these administrative data sources, we are able, with a high degree of confidence, to track each person's full domestic job history.

Both the W-2 records and the LEHD PHF include identifiers that allow us to link firm-level information to each record. Characteristics of employers include age, industry, annual number of employees, annual payroll, and whether the employer is a university. This information is sourced from the BR/LBD, the LEHD Employer Characteristics File (ECF), and the Integrated Postsecondary Education Data System (IPEDS).[35] Crucial for our analysis, IPEDS provides the EIN for a

the year of the patent.

[34]The LEHD PHF is derived from state unemployment insurance (UI) records and contains quarterly information on wages for nearly the universe of individuals in participating states as well as from the federal government (McKinney and Vilhuber, 2011). The W-2 records include annual wages with complete coverage for all states from 2005 to 2017. They are reported to the IRS by individuals' employers and are required for any employee with tax withholdings or for whom taxes would have been withheld if not for an exemption claim. This includes industries and workers who are not covered by unemployment insurance.

[35]The BR is the Census Bureau's comprehensive list of all business establishments in the United States and contains information on each establishment's employment, payroll, industry (NAICS code), EIN, and a firm identifier developed by the Census Bureau (DeSalvo et al., 2016). The LBD links establishments in the BR over time, which allows us to obtain the age of each firm (Jarmin and Miranda, 2002). The LEHD ECF is the universe of establishments that report earnings to state unemployment insurance agencies, and contains information on employment, payroll, industry, and the Census-developed firm identifier (McKinney and Vilhuber, 2011). IPEDS is a database maintained by the National Center for Education Statistics (NCES), and provides a wide variety of information on colleges, universities, and technical and vocational schools in the United States.

comprehensive list of universities, allowing us to identify earnings that UMETRICS individuals receive from universities. These datasets are combined to create a complete job history panel.

Using this full panel of linked data, we construct the following key outcome variables: 1) an indicator for whether the individual works at an age-zero high-tech firm (*high-tech entrepreneurship*)[36]; 2) an indicator for whether the individual works at an age-five or older firm (*incumbent employment*); and 3) an indicator for whether the individual works at a university (*university employment*).[37] These indicators take a value of 1 if the employment event takes place this year or in the next two years, a lag structure similar to that in (Babina, 2020; Babina and Howell, 2019). Together, these outcomes characterize the entrepreneurial and employment activity of each person-year.

To supplement our main analysis, we also define several additional career outcome variables: 4) an indicator for whether the individual works at a firm aged zero (*entrepreneurship*), 5) an indicator for whether the individual works at a firm aged greater than zero but five years or fewer (*employment at young firm*), 6) an indicator for whether the individual works at a high-tech firm aged greater than zero but five years or fewer (*employment at young high-tech firm*), 7) an indicator for whether the individual works at a patenting firm aged greater than zero but five years or fewer (*employment at young patenting firm*),[38] 8) an indicator for whether the individual works at a high-tech firm that is at least five years old (*employment at incumbent high-tech firm*), and 8) log wages, in real 2014 dollars, 9) an indicator for whether the individual works for a Research 1 institution according to the Carnegie Classification of Institutions of Higher Education.[39] We define an individual's wage using their dominant job—that is the job from which they are paid the most. Panel C of Table 1 provides statistics on these career outcomes.

[36]High-tech NAICS are defined according to the NSF classification: See https://www.nsf.gov/statistics/seind14/index.cfm/chapter-8/tt08-a.html

[37]A person is defined as working at a university in the W-2 data if their highest wage in that year is from a university EIN.

[38]See Dreisigmeyer et al. (2018)for a description of the firm to patent link

[39]The information on a institution's Carnegie Classification is provided by IPEDS, this is matched to our data by EIN. Some EINs have institutions of several classifications associated with them (for instance, several state university systems report everything in the system on one EIN). We perfrance the "highest" Carnegie Classification assoated with an EIN.

C Appendix: Ordinary Least Squares Results

In this appendix, we examine the ordinary least squares (OLS) relationship between funding source and outcomes. Recall that the instrumental variables estimation is based on a set of marginal compliers who are pushed towards or away from federal funding as a result of changes in the supply of federal funding. In contrast, the mean relationship between federal funding and outcomes will primarily reflect selection into funding sources. An important factor is the greater prestige and perceived value to academics of federal funding. This may reflect the federal funding providing the researcher more control, more ability to do basic research, or a longer grant time horizon. As a result, we expect that on average higher quality and more senior researchers will have more federal funding. For these reasons, selection into funding should be associated with quite different effects than forced shifts among compliers.

The OLS relationship for patent outcomes is shown in Appendix Table C.1. The effects are in same direction as the IV and all significant at the .01 level but are smaller in magnitude. This indicates that relative to people who select into more federal funding, those who are pushed in by the instrument are less likely to patent. That is, the OLS relationship governed by selection and the causal effects governed by compliers seem to reflect the same mechanism but attenuated under selection.

For career outcomes, shown in Appendix Table C.2, the OLS relationships are quite different. In the IV results discussed Section 5.3 in the researchers pushed to federal funding by the instrument are more likely to become high-tech entrepreneurs, less likely to work for incumbents, and more likely to work at a university. In contrast, those who select into more federal funding are no more likely to become entrepreneurs (column 1), are more likely to work for incumbents (column 2), and are less likely to work for a university (column 3). These different OLS results for career outcomes are intuitive given the institutional facts about the two types of funding. Usually federally-funded teams are larger and have a higher ratio of staff and undergraduates. The former are less likely to become high-tech entrepreneurs, and the latter are less likely to work at a university and more likely to work for an incumbent. In other words, compliers with the instrument are more likely to be on margin to enter high-tech entrepreneurship.

Table C.1. OLS Effect of the Share of Federal Funding on Patent Outcomes

This table reports OLS regressions of the share of federal funding on researcher's innovation outcomes. The baseline sample is a person-year panel from 2001 through 2016. The dependent variables are innovation outcomes indicating whether the person is an inventor of a patent (or of a patent of certain type) in current year. The key independent variable, Share Federal, is the share of the funding coming from Federal US Government sources. Standard errors are clustered at the person level, and reported in parentheses. ***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	Any Patents$_{i,t}$	Number of Patents$_{i,t}$	Any Highly Cited Patents$_{i,t}$	Any Original Patents$_{i,t}$	Any General Patents$_{i,t}$	Any Patents with Private Assignee$_{i,t}$
	(1)	(2)	(3)	(4)	(5)	(6)
Share Federal$_{i,t-1}$	-0.0015***	-0.0030***	-0.0002**	-0.0010***	-0.0003**	-0.0005***
	(0.0003)	(0.0006)	(0.0001)	(0.0002)	(0.0001)	(0.0001)
Log(Expenditure$_{i,t-1}$)	0.0025***	0.0038***	0.0003***	0.0011***	0.0004***	0.0001***
	(0.0001)	(0.0002)	(0.0000)	(0.0001)	(0.0000)	(0.0000)
University×Year×Department FE	Yes	Yes	Yes	Yes	Yes	Yes
Number of Observations	764,000	764,000	764,000	764,000	764,000	764,000
Mean of Dependent Variable	0.0090	0.0117	0.0010	0.0038	0.0016	0.0004
Adjusted R-squared	0.014	0.012	0.003	0.007	0.008	0.002

Table C.2. OLS Effect of the Share of Federal Funding on Career Outcomes

This table reports OLS regressions of the share of federal funding on researcher's career outcomes. The baseline sample is a person-year panel from 2001 through 2016. The dependent variables are measured from the restricted-use US Census data matched with the UMETRICS data. High-tech Entrepreneur is an indicator for high-tech entrepreneurship (person at high-tech firm when firm age equals zero, in any of next three years starting from this year). Work for Incumbent is an indicator for person being at firm in next 3 years that is more than 5 years old, and not a university. Work for University is an indicator for person being at university in next 3 years starting from this year. The key independent variable, Share Federal, is the share of the funding coming from Federal US Government sources. Standard errors are clustered at the person level, and reported in parentheses. ***, **, * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

	High-tech Entrepreneur$_{i,[t,t+2]}$	Work for Incumbent Firm$_{i,[t,t+2]}$	Work for University$_{i,[t,t+2]}$
	(1)	(2)	(3)
Share Federal$_{i,t-1}$	-0.000881	0.03125***	-0.04579***
	(0.000563)	(0.002914)	(0.001993)
Log(Expenditure$_{I,t-1}$)	-0.0001952	-0.05311***	0.05326***
	(0.0001247)	(0.000738)	(0.000532)
University×Year×Department FE	Yes	Yes	Yes
Number of Observations	457,000	457,000	457,000
Mean of Dependent Variable	0.0074	0.553	0.831
Adjusted R-squared	0.003	0.309	0.099

D Appendix: Industry-University Sponsored Research Contract Example

(Redacted)

SPONSORED RESEARCH AGREEMENT

THIS SPONSORED RESEARCH AGREEMENT (the ***"Agreement"***) is entered into as of _________, 2020 (the ***"Effective Date"***) by and between [redacted], a [redacted] corporation having its principal place of business at [redacted] (***"Company"***), and _________ University, an education corporation with offices at ______________ (***"Institution"***).

WHEREAS, Company desires that Institution conduct, and Institution desires to conduct, research relating to Company's proprietary [redacted] inhibitor (the ***"Research"***), as described more fully in the research plan attached hereto as ***Exhibit A*** (the ***"Research Plan"***);

WHEREAS, the Research will further Institution's instructional and research objectives in a manner consistent with its status as a non-profit, tax-exempt educational institution; and

WHEREAS, Company and Institution desire to enter into this Agreement under which Company will fund the Research at Institution, and Institution shall grant to Company certain rights with respect to inventions and discoveries of Institution arising from the Research.

NOW, THEREFORE, in consideration of the foregoing premises and the mutual covenants set forth below, and for other good and valuable consideration, receipt of which is hereby acknowledged, Company and Institution agree as follows:

1. SPONSORED RESEARCH. Institution agrees to use reasonable efforts perform the Research described in the Research Plan, as amended from time to time upon mutual written consent of the parties, and will furnish the staff, facilities, know-how, equipment, instruments, supplies and technical skill necessary for performance of the Research. Institution shall use reasonable efforts to perform the Research in full compliance with all applicable laws, rules and regulations and good scientific practices. Nothing contained in this Agreement shall be construed as a warranty on the part of the Institution that any Results or Inventions will be achieved by the Research, or that any Results of Inventions achieved by the Research, if any, are or will be commercially exploitable and furthermore, Institution makes no warranties whatsoever as to the commercial or scientific value of any results which may be achieved in the Research. Institution hereby excludes any and all warranties, implied or express, including warranties of MERCHANTIBILITY or FITNESS FOR A PARTICULAR PURPOSE or of non-infringement of patents or other proprietary rights. Institution and the Principal Investigator shall use reasonable efforts to distinguish the Research performed under this Agreement from other work the Principal Investigator performs for academic and industrial purposes (collectively, ***"Other Work"***), and shall keep records pertaining to such Other Work separately from the records to be maintained pursuant to Section 0

2. PRINCIPAL INVESTIGATOR. The Research is to be conducted by Institution under the direction of Institution employee [redacted PI name] (the ***"Principal Investigator"***). The Principal Investigator is considered essential to the Research being performed, and no substitution may be made without the prior written agreement of Company. If for any reason the Principal Investigator becomes unavailable, or cannot conduct or complete the Research, Institution will propose a successor whose appointment as Principal Investigator shall be subject to the approval of Company. If the parties are unable to agree upon a successor within thirty (30) calendar days after the Principal Investigator ceases his or her involvement in the Research, this Agreement may be terminated by Company pursuant to Section 9.2. Nothing herein contained shall be deemed to impose an obligation on Institution to find a replacement for the Principal Investigator.

3. **RESEARCH FUNDING.** In consideration of Institution's (including Principal Investigator's) performance of the Research, Company shall pay Institution the maximum sum of $[redacted] (inclusive of all overhead and direct and indirect costs of Research activities) to fund the Research, which shall be payable on the schedule set forth in ***Exhibit B*** hereto. Company shall not be obligated to make any payments to Institution (including, without limitation, any overhead or direct or indirect costs) except as expressly set forth in this Article 0 and ***Exhibit B***, unless the parties otherwise mutually agree in writing. All payments pursuant to this Article 0 shall be by wire transfer or check to such account or address as Institution may specify in writing. The parties agree and acknowledge that the compensation provided under the terms of this Agreement is consistent with the fair market value of the services under the Agreement negotiated in arm's-length transactions, and has not been determined in any manner which takes into account the value or volume of any business generated between the parties, including any of their affiliates.

4. **RECORDS; REPORTS.**

4.1 Records. Institution shall use reasonable efforts keep complete and accurate financial and scientific records relating to the Research and to maintain such records in accordance with good scientific practices.

4.2 Reports. The Principal Investigator shall submit to Company: (a) oral updates regarding Research activities and Results (as defined herein) on a regular basis, as reasonably agreed upon by the parties; and (b) written reports detailing Research status, activities and Results, including all data and conclusions, at the intervals specified in the Research Plan, but in any event at least once per calendar quarter, within sixty (60) calendar days after the end of the period to which the report relates. The Principal Investigator shall submit to Company a comprehensive final report detailing the Research activities, accomplishments and Results within ninety (90) calendar days after the earlier of: (i) the date the Research is completed, or (ii) the date that this Agreement expires or terminates. The final report will also include a summary, by major cost categories, of expenses directly related to the Research. Company may freely utilize all information submitted or made available to it pursuant to this Article 0 in any manner.

5. **PUBLICATION.**

5.1 By Institution. Institution is free to publish the Results of the Research conducted hereunder and agrees that any proposed publication will be provided to Company at least thirty (30) calendar days in advance of submission to any publisher or presentation (as applicable). Company shall have the opportunity to review and comment on any proposed manuscripts or the substance of any presentations describing the Research or the Results. The Company shall notify Institution in writing within thirty (30) calendar days of receipt of such draft whether such draft contains Company Confidential Information (which shall be removed from the draft at Company's written request) or information that, if published within thirty (30) calendar days, would have an adverse effect on a patent application in which the Company owns full or part interest. In the latter case, if such draft for publication describes an Invention, or if submission of such manuscript for publication or delivery of such presentation would preclude the Company from obtaining patent protection for patentable Inventions arising from the Research unless an application is filed with relevant patent authorities, Institution shall, at Company's option, either delete the enabling portion of the proposed publication or presentation or withhold publication or delay presentation for up to an additional sixty (60) calendar days until a patent application covering such Invention(s) is completed and filed. Upon Institution's request, Company and Institution shall work in good faith to develop substitute language that is scientifically comparable but does not disclose Company's Confidential Information or the enabling portion of a proposed patent application. For the purpose of this provision only, the term Confidential Information shall not include the data, results, materials, or description of the Research methodology necessary for a meaningful publication, which may otherwise come within the definition of Confidential Information contained in Section 5.

5.2 By Company. Company shall be free to publish or present the Results at its discretion. Company shall acknowledge Institution's and the Principal Investigator's role in the Research in any such publication or presentation and shall include the Principal Investigator as an author, if appropriate, consistent with standard practice for scientific publications.

5.3 Company Technology. Notwithstanding the provisions of Section 0, if any Company Technology (as defined herein) is provided to or generated by Institution for use in connection with the Research or any portion thereof, then in light of the proprietary nature of such Company Technology, the parties agree that Company shall have the first right, in Company's sole discretion, to publish or present Company Technology and, as and to the extent applicable, Company shall acknowledge Institution's and the Principal Investigator's role in the Research in such publication or presentation and shall include the Principal Investigator as an author, if appropriate, consistent with standard practice for scientific publications.

6. CONFIDENTIAL INFORMATION AND MATERIALS.

6.1 Confidentiality and Non-Use of Confidential Information. Confidential Information shall mean all proprietary information of a party (the ***"Disclosing Party"***) that is disclosed to the other party (the ***"Receiving Party"***), in written, oral or other form, as background for or in conjunction with the Research, after the Effective Date and whether such information is provided by the Disclosing Party directly or on the Disclosing Party's behalf by a third party (***"Confidential Information"***); *provided, however,* that all Company Technology shall be deemed Confidential Information of Company, subject to Section 6.2, and the Receiving Party and Disclosing Party with respect to such Company Confidential Information shall be deemed to be Institution and Company, respectively. During the Term and for seven (7) years thereafter, subject to the last sentence of Section 0, the Receiving Party shall:

(a) exercise, and use reasonable efforts to cause its employees, agents and consultants to exercise, reasonable care to hold in confidence and not disclose Confidential Information of the Disclosing Party to third parties or release it for publication or presentation without the prior written consent of the Disclosing Party;

(b) not use, and use reasonable efforts to cause its employees, agents and consultants not to use, Confidential Information of the Disclosing Party for any purpose not expressly contemplated by this Agreement without the prior written consent of the Disclosing Party; and

(c) be responsible for any breach of this Article 0 by any of its employees, agents and consultants.

6.2 **Exclusions from Confidentiality and Non-Use Obligations.** Confidential Information of a Disclosing Party shall not include any information that the Receiving Party can demonstrate by competent evidence:

(a) was already known to the Receiving Party, other than under an obligation of confidentiality, at the time of disclosure to the Receiving Party by or on behalf of the Disclosing Party, as demonstrated by competent evidence;

(b) was generally available to the public or otherwise part of the public domain at the time of its disclosure to the Receiving Party by or on behalf of the Disclosing Party;

(c) became generally available to the public or otherwise part of the public domain after its disclosure and other than through any act or omission of the Receiving Party in breach of this Agreement;

(d) is independently discovered or developed by the Receiving Party (outside of the Research, in the case of Institution) without the use of Confidential Information of the Disclosing Party, including, without limitation, if Institution is the Receiving Party, any Materials, as demonstrated by competent evidence; or

(e) is disclosed to the Receiving Party, on a non-confidential basis, by a third party who had no obligation to the Disclosing Party not to disclose such information to others.

6.3 **Authorized Disclosure.** The Receiving Party shall not be prohibited from disclosing Confidential Information to the extent such information is required to be disclosed by court order or by applicable law or government regulation; *provided, however,* that in such event, the Receiving Party shall give reasonable advance notice (except where impracticable) to the Disclosing Party of such required disclosure and, at the Disclosing Party's request and expense, shall cooperate with the Disclosing Party's efforts to contest such disclosure, and/or to obtain a protective order or other confidential treatment of the Confidential Information required to be disclosed.

6.4 **Materials.** Institution acknowledges that it may receive certain materials, including without limitation chemical, biological and other compounds (collectively, "Materials") from Company or from third parties on Company's behalf for use in performing the Research. Institution shall exercise, and shall use reasonable efforts to cause the Principal Investigator and other employees, agents and consultants of Institution to exercise, reasonable care to use the Company Technology and Materials only for such purpose and shall not transfer or otherwise provide access to the Company Technology or Materials to any person other than the Principal Investigator and other employees, agents and consultants of Institution performing Research hereunder without the prior written consent of Company. Upon conclusion of the Research, Institution shall return to Company or destroy, as directed by Company, all Company Technology including without limitation remaining Materials, except that Institution may retain one copy of the Company Technology that is not Materials solely for archival purposes, and Institution may retain in Confidence any electronic files of Company Technology that is not Materials, each of which are automatically saved pursuant to legal, regulatory or policy requirements. Institution acknowledges that the Materials may have biological or chemical properties that are unpredictable, that they are to be used with prudence and caution and that they are not to be used in humans. Institution shall not commingle the Materials with other materials from any source. Company shall retain ownership of the Materials. THE MATERIALS ARE PROVIDED WITH NO WARRANTIES OF ANY KIND, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, OR THAT THEY ARE FREE FROM THE RIGHTFUL CLAIM OF ANY THIRD PARTY, BY WAY OF INFRINGEMENT OR THE LIKE.

7. INTELLECTUAL PROPERTY.

7.1 Definitions. In this Agreement, (a) "Company Technology" shall mean the Materials and any proprietary technology or information relating to such Materials, including without limitation information, inventions and discoveries that, in each case, relate to the identities, structures, composition or activity of such Materials and any method of manufacturing or using such Materials; (b) "Results" shall mean all data, results, information and materials, and all associated intellectual property, that are generated, developed or discovered by Institution, its employees, agents, affiliates or contractors, in conducting the Research, whether in written, graphic or electronic form or contained in any computer database or in any computer readable form; (c) "Inventions" shall mean all ideas, inventions, techniques, improvements and other technology, whether or not patentable, and all associated intellectual property, that are conceived, discovered, developed, or reduced to practice by Institution, its employees, agents, affiliates or contractors in connection with performance of this Agreement or in conducting the Research and that are severable from the Company Technology; (d) "Joint Inventions" shall mean all ideas, inventions, techniques, improvements and other technology, whether or not patentable, and all associated intellectual property, that are conceived, discovered, developed, or reduced to practice jointly by Institution, its employees, agents, affiliates or contractors, on the one hand, and Company, its employees, agents or contractors, on the other hand, in connection with performance of this Agreement or in conducting the Research, and (e) "Company Technology Inventions" shall mean all Inventions and Joint Inventions directed to, covering, based on or derived from the Company Technology and/or the Materials, including without limitation Inventions and Joint Inventions directed to or covering any process, composition of matter, or method of use related to the Materials.

7.2 Ownership and License of Certain Rights.

(a) Company Technology. Institution understands and agrees that the underlying intellectual property rights to any Company Technology that is the subject of the Research are owned solely by Company. Except as may be provided herein, neither Institution nor Principal Investigator shall acquire any rights of any kind whatsoever with respect to any Company Technology as a result of conducting the Research or as a result of this Agreement. Institution agrees not to seek or obtain patent protection directed to or covering Company Technology, including without limitation the Materials, without the prior written consent of Company, which Company may withhold in its sole discretion.

(b) Results. Company shall have and retain all right, title and interest in and to the Results, and Institution hereby assigns to Company all of its right, title and interest in and to the Results. All information regarding the Results shall be Confidential Information of the Company. Company hereby grants to the Institution a limited, non-exclusive, and fully-paid license to use the Results for its internal academic, research and educational purposes.

(c) Institution Inventions. Institution shall have and retain all right, title and interest in and to all Inventions other than Company Technology Inventions ("Institution Inventions"). Institution hereby grants to the Company a non-exclusive, worldwide, fully-paid, irrevocable license, including the right to sublicense through multiple tiers of sublicense, to practice the Institution Inventions for all purposes. To the extent permitted by law and any other conflicting obligations, Institution also grants to the Company an exclusive option to obtain an exclusive license to and under Institution's rights in any such Institution Inventions for which Company elects to bear all patent costs pursuant to Section 7.4, on commercially reasonable terms to be negotiated by the parties in good faith.

(d) Company Technology Inventions. Company shall have and retain all right, title and interest in and to all Company Technology Inventions.

(e) Joint Inventions. Institution and Company shall jointly own all right, title and interest in and to all Joint Inventions other than Company Technology Inventions ("Jointly-Owned Joint Inventions"). To the extent permitted by law and any conflicting obligations, Institution hereby grants to the Company an exclusive option to obtain an exclusive license to and under Institution's rights, title and interest in and to such Jointly-Owned Joint Inventions for all purposes on commercially reasonable terms to be negotiated by the parties in good faith.

(f) Option Period and Option Exercise. The options specified in paragraphs 7.2(c) and (e) above, with respect to any specific Institution Invention or Jointly-Owned Joint Invention, shall extend for a period of six (6) months following the date of written disclosure to Company of such Institution Invention or Jointly-Owned Joint Invention (the "Option Period"). Institution agrees that, during the Option Period for an Institution Invention or Jointly-Owned Joint Invention, and during the applicable Negotiation Period (as defined herein) for such Invention, it shall not offer to any third party the opportunity to obtain a license, or enter into any license with any third party, with respect to such Institution Invention or Jointly-Owned Joint Invention, unless Company expressly rejects in writing its exclusive option set forth herein. Company may exercise the options specified in paragraphs 7.2(c) and (e) above with respect to any Institution Invention or Jointly-Owned Joint Invention by sending written notice of such exercise (the "Option Notice") to Institution at any time during the Option Period with respect to the applicable Institution Invention or Jointly-Owned Join Invention. Upon exercise of such option, Company and Institution shall negotiate in good faith and execute the definitive agreement regarding such exclusive license within ninety (90) calendar days after Company sends the Option Notice to Institution (the "Negotiation Period"). If the parties do not conclude a license agreement prior to the expiration of the applicable Negotiation Period or any extension mutually agreed upon by the parties, Institution may then offer to third parties the opportunity to obtain a license to such Institution Invention or Jointly-Owned Joint Invention; *provided, however,* that, during the nine (9) month period following such expiration of the applicable Negotiation Period, Institution shall not grant any third party a license with respect to such Institution Invention or Jointly-Owned Joint

Invention on terms which in the aggregate are more favorable to such third party than the terms offered by Institution to Company without first offering Company the opportunity to license such Institution Invention or Jointly-Owned Joint Invention on such more favorable terms; and provided further that in such case Company shall have the period of sixty (60) calendar days following receipt of Institution's notice of such more favorable terms to decide to take such a license. Neither any failure by Company to exercise its option with respect to any particular Institution Invention or Jointly-Owned Joint Invention, nor any failure of the parties to enter into a license agreement with respect to any particular Institution Invention or Jointly-Owned Joint Invention, shall be deemed a waiver of Company's option with respect to any other Institution Invention or Jointly-Owned Joint Invention.

(g) **Execution of Documents; Assistance.** Institution agrees promptly to execute such documents and perform such other acts as the Company may reasonably request to obtain, perfect and enforce Company's rights to the Company Technology, Results, Inventions, Joint Inventions, and Company Technology Inventions set forth above. Institution shall require that any employee, agent, affiliate or contractor of Institution that receives or uses the Company Technology, including without limitation the Materials, as permitted herein or performs any aspect of the Research shall agree to assign, and shall assign, to Institution all of his/her/its right, title and interest in and to the Company Technology, Results, Institution Inventions, Joint Inventions and Company Technology Inventions, such that Institution is able to satisfy its obligations to Company hereunder. Each party further agrees to assist the other party in obtaining and enforcing patents and other intellectual property rights and protections relating to Company Technology, Results, Institution Inventions and Joint Inventions in all countries.

7.3 Disclosure of Inventions. Within thirty (30) days of the Executive Director of the Office of Industrial Liaison/Technology Transfer at Institution becoming aware or reasonably believing that an Institution Invention, Joint Invention or Company Technology Invention has been made hereunder, Institution shall disclose such invention in writing to Company in sufficient detail to allow Company to evaluate its significance.

7.4 Patent Prosecution.

(a) **Institution Inventions.** Institution shall have the first right to prosecute patent applications covering any Institution Invention. Within sixty (60) calendar days after written disclosure of an Institution Invention to Company, Company shall notify Institution in writing if it wants the Institution to pursue patent protection for such Institution Invention. Institution shall then prepare, file and prosecute patent applications as requested by Company to protect such Institution Invention. Company shall bear all reasonable expenses incurred by Institution, in connection with such preparation, filing, prosecution and maintenance of patent applications claiming such Institution Invention. Institution shall have the right but not the obligation, to assume responsibility for making decisions regarding the scope and content of such applications and the prosecution thereof subject to Company's right to review and comment on the draft patent application prior to filing, such comments to be considered in good faith by Institution. Company, however, shall have the right to discontinue the financial support of the prosecution or maintenance of any such patent or patent application upon thirty (30) calendar days' written notice to Institution. If Company elects not to bear all reasonable expenses in connection with the preparation, filing prosecution and maintenance of patent applications claiming an Institution Invention, or otherwise discontinues the financial support of the prosecution or maintenance of any such patent or patent applications claiming such Institution Invention, such Institution Invention shall not be subject to the option set forth in Section 7.2, and Company shall have no rights thereto.

(b) Joint Inventions. Company shall have the first right to prosecute patent applications covering any Joint Invention at its own expense. If Company fails to file a patent application to protect a Joint Invention within ninety (90) calendar days after written disclosure of such Joint Invention to Company, Institution shall be free to file, prosecute or maintain any patents covering such Joint Invention at its own expense. If Company fails to file a patent application on a Joint Invention as set forth above, or elects not to bear all reasonable expenses in connection with the preparation, filing, prosecution and maintenance of patent applications claiming such Joint Invention, or otherwise elects to discontinue the financial support or the prosecution or maintenance of any such patent or patent applications claiming such Joint Invention, such Joint Invention shall not be subject to the option set forth in Section 7.2, and Company shall have no rights thereto.

(c) Company Technology Inventions. Company shall have the sole right (but not the obligation) to prosecute patent applications covering any Company Technology Inventions.

8. INDEMNIFICATION.

8.1 Indemnification by Company. Company agrees to indemnify, defend and hold harmless Institution, its officers, trustees, employees and agents (collectively, the ***"Institution Indemnitees"***) from and against any and all liability, loss, costs (including reasonable attorneys' fees) and damages (collectively, ***"Losses"***) that any such Institution Indemnitee may suffer as the result of third party claims, demands, or judgments against such Institution Indemnitee arising out of (i) Institution's conduct of the Research; (ii) Company's use of the information supplied pursuant to Article 4, and Company's use, disposition or commercialization of any Invention or any intellectual property rights granted to Company hereunder; or (iii) any failure of Company to meet its obligations under this Agreement; except, in each case, to the extent that any such claim, demand, cost or judgment arises from the negligence, recklessness or willful misconduct on the part of any Institution Indemnitee.

8.2 Responsibility of Institution. Institution shall be solely responsible for its acts or omissions and the acts or omissions of the Institution Indemnitees in the performance of the Research hereunder.

8.3 General Conditions of Indemnification. Company's agreement to indemnify, defend and hold harmless Institution and the Indemnitees is conditioned upon Institution: (a) providing written notice to Company of any claim, demand or action arising out of the indemnified activities within thirty (30) calendar days after Institution has knowledge of such claim, demand or action, provided, however, that failure to do so does not relieve Company of its indemnification obligations hereunder, except to the extent Company has been materially prejudiced; (b) permitting Company to assume full responsibility and authority to investigate, prepare for and defend against any such claim or demand, provided that Company shall not agree to any settlement that requires an admission of fault by an Institution Indemnitee without the prior written consent of Institution; (c) reasonably assisting Company, at Company's reasonable expense, in the investigation of, preparation for and defense of any such claim or demand; and (d) not compromising or settling such claim or demand without Company's written consent.

9. TERM; TERMINATION.

9.1 Term of Agreement. The term of this Agreement shall begin on the Effective Date and, unless this Agreement is earlier terminated pursuant to this Article 9, shall continue until the date that is the later of: (i) two (2) years after the Effective Date, or (ii) the date that the Research is completed (the ***"Term"***).

9.2 Termination by Company. Company may terminate this Agreement either (a) upon thirty (30) calendar days' prior written notice to Institution in the event Company and Institution are unable to agree upon a suitable replacement for the Principal Investigator pursuant to Article 0, or (b) for any reason or for no reason upon sixty (60) calendar days' prior written notice to Institution.

9.3 Termination by Institution. Institution may terminate this Agreement upon forty-five (45) calendar days' prior written notice to Company in the event Company materially breaches this Agreement and fails to cure such breach before expiration of such 45-day notice period.

9.4 Effects of Termination. Termination of this Agreement shall not affect the rights and obligations of the parties that accrued prior to the effective date of such termination, including, without limitation, Institution's right to receive, and Company's obligation to pay, amounts due under this Agreement with respect to work completed and for non-cancellable obligations incurred prior to such termination. In the event of any termination of this Agreement prior to the expiration date set forth herein, Company shall pay the reasonable costs incurred by Institution in winding down and terminating the Research, including the reasonable costs of the Research during the wind-down period and all reasonable and documented costs and non-cancelable commitments made in accordance with the Research Plan prior to termination. After termination, Institution will submit a final report of all costs incurred and all funds received under this Agreement as set forth in Section 0. The report shall be accompanied by a check for any funds remaining which were paid to Institution under Article 0 with respect to Research Plan activities not performed by Institution, if any, after allowable costs and non-cancelable commitments have been paid.

9.5 Survival. The provisions of Sections 4.2, 6.1 – 6.3, 9.4 and 9.5 and Articles 0, 0, 0, **Error! Reference source not found.**, and 10 shall survive termination or expiration of this Agreement.

10. MISCELLANEOUS.

10.1 Relationship of Parties. The relationship between the parties is that of independent contractors, and neither party shall have the authority to bind or act on behalf of the other party. This Agreement shall not constitute, create, or in any way be interpreted as a joint venture, partnership or business organization of any kind.

10.2 Use of Other Party's Name. Each party agrees that it will not under any circumstance use the name of the other party or its employees in any advertisement, press release or publicity with reference to this Agreement without prior written approval of the other party, except as required by law.

10.3 No Implied Licenses. Except as expressly set forth in this Agreement, nothing in this Agreement shall be construed as conferring on either party an express or implied license, option to license, or other right with respect to, any technology, information, patent application, patent or intellectual property rights of the other party.

10.4 Choice of Law. This Agreement shall be governed by the laws of the State of New York, excluding its conflicts of laws principles.

10.5 Entire Agreement. This Agreement, together with all Exhibits attached hereto and hereby incorporated herein, constitutes the final, complete and exclusive agreement of the parties with respect to the subject matter hereof and supersedes all prior understandings and agreements relating to its subject matter. This Agreement may not be changed, modified, amended or supplemented except by a written instrument signed by an authorized representative of each party.

10.6 Assignment; Delegation. Neither party may assign this Agreement without the prior written consent of the other party; *provided, however,* that Company may assign this Agreement without Institution's consent (a) in connection with the transfer or sale of all or substantially all of the business of Company to which this Agreement relates, whether by merger, sale of stock, sale of assets or otherwise, or (b) to an affiliate of Company, provided that Company shall promptly provide written notice of such assignment to Institution within ten (10) business days post execution. Any attempted assignment of this Agreement not in compliance with this Section 10.6 shall be null and void. No assignment shall relieve either party of the performance of any accrued obligation that such party may then have under this Agreement. This Agreement shall inure to the benefit of and be binding upon each party signatory hereto, its successors and permitted assigns, subsidiaries and affiliates. Institution may not delegate or subcontract any of its obligations under this Agreement to any third party, except upon Company's prior written consent (which Company may withhold in its sole discretion). Institution shall at all times be responsible for the payment of its permitted delegatees and subcontractors, and for the compliance of its permitted delegatees and subcontractors with the terms and conditions of this Agreement.

10.7 Severability. If any provision of this Agreement is found by a court of competent jurisdiction to be unenforceable, then such provision will be construed, to the extent feasible, so as to render the provision enforceable, and if no feasible interpretation would save such provision, it will be severed from the remainder of this Agreement. The remainder of this Agreement will remain in full force and effect, unless the severed provision is essential and material to the rights or benefits received by either party. In such event, the parties will negotiate, in good faith, and substitute a valid and enforceable provision or agreement that most nearly implements the parties' intent in entering into this Agreement.

10.8 Notices. Any notices required or permitted hereunder shall be given to the appropriate party at the address specified below or at such other address as the party shall specify in writing. Such notice shall be deemed given upon personal delivery, or upon receipt by certified or registered mail, postage prepaid, or upon receipt by Federal Express or an equivalent overnight delivery.

If to Company: [redacted]

With a copy to: [redacted]

If to Institution:

With a copy to:

And to PI:

All notices shall be deemed made upon receipt by the addressee as evidenced by the applicable written receipt or, in the case of a facsimile, as evidenced by the confirmation of transmission.

10.9 Non-Waiver; Force Majeure. No failure or delay of one of the parties to insist upon strict performance of any of its rights or powers under this Agreement shall operate as a waiver thereof, nor shall any other single or partial exercise of such right or power preclude any other further exercise of any rights or remedies provided by law. Neither party shall be liable for any failure to perform as required by this Agreement to the extent such failure to perform is due to circumstances reasonably beyond such party's control, including, without limitation, labor disturbances, or labor disputes of any kind, accident, failure to obtain any governmental approval required for full performance, civil disorders or commotions, acts of aggression or terrorism, acts of God, energy other conservation measures imposed by law or regulation, explosions, failure of utilities, mechanical breakdowns, material shortages, disease, or other such occurrences.

10.10 English Language. This Agreement has been prepared in the English language, and the English language shall control its interpretation.

10.11 Counterparts. This Agreement may be executed in counterparts, each of which shall be deemed an original, but all of which together shall constitute one and the same instrument.

[Signature page follows]

IN WITNESS WHEREOF, the parties have executed this Agreement as of the date and year first above written.

COMPANY	**UNIVERSITY**
By:______________________________	By:____________________________________
Name:____________________________	Name:__________________________________
Title:____________________________	Title:__________________________________

As Principal Investigator under this Agreement, I attest that I have read this Agreement in its entirety, that I consent to the terms hereof, and that I shall use my best efforts to perform my obligations and responsibilities hereunder:

By:______________________________
[redacted PI name]
Principal Investigator

EXHIBIT A

Research Plan

EXHIBIT B

Schedule of Payments

Payment Due Date	Amount of Payment