Government (In)Efficiency in Facilitating Innovation

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Abstract

I study the effectiveness of federal R&D contracts in stimulating private sector innovation. I develop a model that outlines a firm's tradeoffs after receiving government funds. Winning a contract may signal that the firm has better R&D prospects, increasing R&D expense. Alternatively, the firm may divert existing R&D funds to other uses, muting its responsiveness to government funding. Using retirements of federal contracting officers as a negative shock to contract renewals, I estimate that an additional \$1 million in government contract revenue increases R&D spending by only \$6,700. The magnitude increases in more competitive contract awards with fixed-price cost structures, but overall, federal funding substitutes for private investment.

1 Introduction

While debate about the optimal size and scope of government has regained popularity since the start of the second Trump administration, it is by no means new. Milton Friedman argued on behalf of minimal government as early as the 1960s, with the conversation going back to the founding of the U.S., and even much further. The debate has lasted without resolution due to the complex nature of the problem. Properly addressing it means exploring each function of government separately, and understanding if it could be performed better by the private sector. In this paper, I move towards this goal by examining government's effectiveness in one particular aspect of the economy: facilitation of private-sector innovation through federal R&D contracts. Specifically, I use an instrumental variable to estimate the causal impact of an additional dollar of government funding on firm R&D activity, giving insight into whether government funding is actually increasing innovative activity.

Early theoretical considerations of government's role in innovation, from Arrow (1962) and Nelson (1959), outline some positive impacts that can arise from subsidization of private R&D. Specifically, they argue that government can alleviate market failures associated with "basic research", or research that has positive externalities, but also comes with the risk that the resulting innovation may not be useful in the firm's current operations. Both highlight government's comparative advantage in risk-bearing being a way for firms to offload some of this risk; Nelson (1959) goes further, and discusses how a wide technological base within the firm can also help firms reduce this risk. Restating their arguments in financial terms, there are some high-risk projects with large social benefits, whose costs of capital exceed the firm's required cost of capital, making them negative NPV (from the firm's perspective). In these cases, by sharing some of the risk with the government, the firm decreases its internalized cost of capital, making these projects positive NPV, and increasing its investment opportunity set.

However, the argument in favor of government subsidy of private R&D rests on one primary assumption: that government is successful in financing only the types of risky, high social benefit projects outlined by Nelson (1959) and Arrow (1962). If this assumption holds, then the firms receiving federal funding undertake more projects than they would otherwise. Stated as a testable prediction, receipt of funding should increase firm-level R&D expenditure by more than the value of the contract (complementarity between funding sources). Alternatively, if it does not hold – i.e. they are unsuccessful in targeting the "basic" projects – then the government may be financing projects which the firm would have undertaken on their own, and thus which could have been financed with external capital through the equity or debt markets (substitution). This would also imply that money is being compelled from taxpayers to pay for things that would be financed anyway, but instead by those *already willing* to finance it. In this case, firms are able to divert the previously designated funding to other uses. This paper seeks to test the validity of this assumption, thereby revealing how closely government adheres to the theoretical motivations for its involvement in the market for innovation.

To establish predictions and motivate the empirical analysis, I construct a model of firm investment with competitively allocated government contracts, where firms must choose to allocate scarce capital between R&D and other productive uses. Firms with additional valuable R&D projects, which they are unable to undertake because external financing is too costly, are more constrained, but also receive more government funding in equilibrium (i.e. receipt of cash flow is endogenous as in Moyen (2004)). Receipt of this cheap government financing widens the firm's investment opportunity sets, causing them to undertake more investment than they would otherwise. However, financially constrained firms also have an incentive to divert funds to other uses if they are sufficiently valuable at the margin, meaning that government funding may instead substitute for existing R&D expense, allowing firms to free up capital for these other opportunities. My empirical tests seek to to estimate the sensitivity of firm investment to cash flow from the government, and to understand which of these effects dominates.

The model also generates predictions about the role of competition in the contract allocation process. More offers being received in the bidding stage means that winning a contract is a stronger signal about firm R&D productivity, increasing the correlation between government contact revenue and marginal value of R&D investment. This leads to the hypothesis that more competition should increase the complementarity between funding sources, which I am able to test empirically. I measure the proportion of firm revenue which was allocated competitively, and show that as it increases, the causal impact of government funding on R&D investment increases by 125%.

In the existing empirical work on this topic, there is one central issue that remains unresolved, discussed by David, Hall, and Toole (2000): the endogeneity in who is awarded a government contract. If a firm's likelihood of being a government contractor and its spending on R&D are both related to an omitted variable, then a regression of firm spending on contract revenue may report a positive relationship where none truly exists. The literature has tried several methods to address this, such as matching (Almus and Czarnitzki (2003)), regression discontinuity (Bronzini and Piselli (2016)), and structural models (Takalo, Tanayama, and Toivanen (2013)). However, to my knowledge, this paper is the first to use an IV approach to properly address this issue, allowing me to explore government's causal impact on private innovation.

I use retirements of contract officers, identified using federal employee data from the Office of Personnel Management, as an exogenous shock to firm contract revenue. I combine this with detailed data on 742,262 federal contract awards for R&D work, sourced from USASpending.gov and linked to Compustat via fuzzy matching for the sample period 2001-2014. With these datasets, I connect employee retirements to subagency contract allocations at the state-level, allowing for a precise identification of within-state contract allocations. At the firm level, I document a significantly negative impact of retirements on firm contract revenue, with a firm receiving an average of $24 million less in contact revenue following the turnover of a subagency-state contract office. This effect is entirely through the revenue from contract modifications, highlighting these officers' influence over renegotiation terms, and aligning with the findings of Brogaard, Denes, and Duchin (2021) and others who document evidence of relationship effects in government contract allocations.

Before correcting for endogeneity, OLS regressions falsely suggest that $1 million in additional government funding increases firm R&D contemporaneously by a statistically significant $51,700[1]. Once the endogeneity is removed, I find that this figure decreases to $6,700, but remains significant; the magnitude increases for fixed-price contracts and those with more competitive bidding processes. On average, government positively impacts firm innovation spending, but the relatively minor economic magnitude suggests that they are generally ineffective in identifying the correct projects to fund.

In addition to research inputs, I also test the impact of government funding on firm patent activity. I find that federal R&D contracts have a slight positive impact on patenting activity, but that these patents are of lower quality in terms of future citations. Together, these results suggests that federal contracts incentivize patenting, but do not appear to meaningfully expand firms' investment opportunity sets or increase the quality of their research outputs.

[1]This is likely a lower bound, since the revenue measure I use is technically obligated funding, rather than that actually paid out.

The policy suggestion of this paper is a careful identification of which federal R&D contracts are funding the types of research studied by Nelson (1959) and Arrow (1962), leaving the others to be funded by firms, if they or the capital markets determine they are worth funding. Additionally, this paper suggests that researchers studying the impact of government contracts on firm activity should take endogeneity concerns seriously, and work carefully to address them, as failing to do so can lead to large over-estimations and false conclusions about the efficiency of government investment.

2 Literature

Two of the earliest theoretical considerations of government's optimal role in facilitating innovation come from Nelson (1959) and Arrow (1962). Both highlight the ability of government subsidies to help firms internalize the positive externalities associated with some R&D activities, leading them to increase their investment. Nelson (1959) argues that government should focus on funding basic research, for which the relevant technological field of the innovation could be any of a large number of possibilities. He also suggests that large firms, which have a wide technological base will undertake basic research without need of government subsidy[2]. Arrow (1962) focuses on subsidies as a way for firms to shift risk onto the government. He argues, among other things, that "the most risk-efficient outcome is not necessarily the most technically efficient one", as one effect of the risk, when borne by the inventor, is that it incentivizes more effort.

These theoretical predictions have been the subject of past empirical research, but there has been disagreement among researchers. Many find complementarity between government funding and firm spending on innovation, while many others

[2] Nelson (1959) cites historical anecdotes such as "Eastman Kodak enter[ing] the vitamin business after a research project resulted in a new way to synthesize Vitamin B"

find a crowding out effect. For example, Almus and Czarnitzki (2003) studied a sample of firms in East Germany during the rebuilding after the fall of the Berlin wall, and found evidence that government subsidies do increase private R&D spending, while Wallsten (2000), in a contemporaneous study of the Small Business Innovation Research (SBIR) program, finds evidence of an almost perfect crowding out of private spending by public subsidies.

One of the issues at the center of the literature on this topic, as discussed by David, Hall, and Toole (2000), is controlling for the selection bias in who receives a federal contract. If the government tends to contract with more innovative firms for some unobserved reason that also impacts innovation spending, then a regression of R&D expense onto firm contract revenue may suggest a positive and significant relationship where none exists. Several approaches have been tried to address this problem, including regression discontinuity (Bronzini and Piselli (2016)), structural estimation (Takalo, Tanayama, and Toivanen (2013), González, Jaumandreu, and Pazó (2005), Wallsten (2000)), and matching methods (Lach (2002), Almus and Czarnitzki (2003)). This paper is the first, to my knowledge, to identify a clear exogenous shock to firm revenue, and use it as an instrumental variable to clearly identify the causal impact of government funding.

Other papers which explore the USASpending.gov contract data include Brogaard, Denes, and Duchin (2021), who find that politically connected firms are able to make more competitive bids ex-ante, because they are able to more successfully renegotiate higher payments ex-post. My results are consistent with theirs, as I also document evidence that a firm's relationships with contract officers impact its future revenue from contract renegotiations. Liebman and Mahoney (2017) study intra-year spending patterns, and find that federal agencies engage in wasteful year-end spending to avoid budget cuts in the following period, while Goldman (2019) documents a stabilizing effect of government funding on firms who receive it during the Financial Crisis, with spillovers into the firm's local economies.

My paper also contributes to the literature on investment-cash flow sensitivity. In Moyen (2004) and related literature, different levels of financial constraints lead to differences in how firm investment responds to incoming cash flow. In this paper, I present a framework wherein firms may use cheap government financing as a way to alleviate financial constraints and expand their investment opportunity sets in equilibrium (complementarity). On the other hand, they may also use this government financing as a substitute for their own, allowing them to divert funds to other uses within the firm (substitution). More constrained firms – those faced with more projects which are only attractive with cheaper funding than is currently available – stand to benefit more from receipt of government contracts.

Hennessy and Whited (2007) structurally estimates the convex costs of external financing and demonstrates how those costs influence firms' issuance and investment policies. In my conceptual framework, I embed the same mechanism in reduced form: costly external financing makes government funds especially valuable at the margin, so firm's have an incentive to substitute them for money they otherwise would have spent on R&D, freeing up the capital for other uses that may have a high marginal value.

Finally, Almeida, Campello, and Weisbach (2004) models firms' demand for liquidity under financing frictions, offering an explanation for their saving behavior following cash inflows. My setting provides a complementary result for government cash flows specifically: upon winning a contract, firms facing stricter financial constraints will have an incentive to fund other projects, or backfill savings, resulting in the contract funding crowding out existing R&D expenditures.

3 Conceptual Framework

This section lays out a simplified model of endogenous government funding, and provides a baseline framework for understanding the sensitivity of firm spending on R&D to cash flow from federal contracts. Money from federal contracts may alleviate financing constraints, in which case firms will face a decision about how to allocate these funds across both their R&D projects and other uses. This competition between uses, as well as the endogenous relationship between a firm's ability to win a contract and its R&D quality allows me to characterize several possible predictions about the investment sensitivity. It may be less than one if the competition among uses dominates or if government money is acting as a substitute for private spending. Or, it may be greater than one if the endogenous information about firm R&D prospects dominates and there is complementarity between the federal and private funding sources. I formalize this notion below.

3.1 Setup

First, I assume that the firm has three possible funding sources for its investments: internal cash (C), external financing it can raise by issuing either debt or equity (E), and funds from government contracts (G). G is realized and publicly observed at the beginning of each period, and external financing can be raised at convex cost:

$$\psi(E) = \frac{\gamma}{2}E^2, \qquad \gamma > 0$$

I assume the firm chooses to allocate these funds between R&D investments (R), and other uses (X). The firms are faced with a multitude of projects, some of which are positive NPV and some of which are not. In the absence of financing constraints, the firm would like to accept all positive NPV projects. However, within the subset of negative NPV projects, there are some "marginal" projects which are unattractive when financed with costly external funds, but would be attractive if financed with cheaper governmental funds.

The total amount of spending a firm does on R&D has a productivity function Π_R, in which risk-adjusted benefit from their investment is quadratic (concave in the input):

$$\Pi_R(R, \mu) = \mu R - \frac{\eta}{2} R^2, \qquad \eta > 0$$

where the receipt of government funding, G, shifts the intercept:

$$\mu = \mu_0 + \sigma G, \qquad \sigma \geq 0$$

This allows for the possibility that winning the contract is endogenously related to the firm's R&D prospects. This is likely in a scenario where the government official receives proposals from multiple firms, and awards them competitively based on the submitted bids. The total amount of G the firm is awarded in a period is a signal of the officers' perceptions of the overall quality of the firm's investment opportunities. As pointed out by Moyen (2004), a study of investment-cash flow sensitivity and financing constraints must consider this endogeneity in receiving cash flows, otherwise conclusions are subject to selection bias. This is in addition to the evidence of selection bias discussed in Section 2, as it relates to analysis of this question specifically.

I assume the risk-adjusted benefit from other uses of funding, X, is also quadratic:

$$\Pi_X(X) = (\omega + \phi)X - \frac{\delta}{2} X^2, \qquad \delta > 0$$

where ω captures normal uses of capital that are not R&D, and ϕ captures private benefits or agency motives that increase the incentive to divert funding away from R&D.

The firm's budget constraint is such that spending on R&D and other sources must not exceed the total funding available from all internal and external sources

(C, E, and G):

$$R + X \leq C + G + E$$

If this constraint does not bind, the firm will pay out the excess as dividends, or use it to repurchase shares. The timing is as follows: (i) the amount of government funding is realized and publicly observed, (ii) the firm chooses how much external financing to raise and how to allocate funding between the two uses (R, X, E), (iii) the payoffs are realized.

3.2 Solving The Firm's Optimization Problem

The firm optimizes by maximizing the total risk-adjusted benefit from R&D, R, and other funding uses, X, net of financing costs, after winning government contracts of total value G.

$$\begin{aligned} \max_{R,X,E\geq 0} \quad & \mu R - \frac{\eta}{2}R^2 + (\omega + \phi)X - \frac{\delta}{2}X^2 - \frac{\gamma}{2}E^2 \\ s.t. \quad & R + X \leq C + G + E \end{aligned}$$

Solving via the Lagrange method, let $\lambda \geq 0$ be the multiplier on the budget constraint. The Lagrangian takes the form:

$$\mathcal{L} = \mu R - \frac{\eta}{2}R^2 + (\omega + \phi)X - \frac{\delta}{2}X^2 - \frac{\gamma}{2}E^2 + \lambda(C + G + E - R - X)$$

and the first-order conditions are:

$$\frac{\partial \mathcal{L}}{\partial R} = \mu - \eta R - \lambda = 0 \quad \Rightarrow \quad R^* = \frac{\mu - \lambda}{\eta} \tag{1}$$

$$\frac{\partial \mathcal{L}}{\partial X} = (\omega + \phi) - \delta X - \lambda = 0 \quad \Rightarrow \quad X^* = \frac{(\omega + \phi) - \lambda}{\delta} \tag{2}$$

$$\frac{\partial \mathcal{L}}{\partial E} = -\gamma E + \lambda = 0 \quad \Rightarrow \quad E^* = \frac{\lambda}{\gamma} \tag{3}$$

Substituting the FOCs into the budget constraint which binds in equilibrium yields:

$$\frac{\mu-\lambda}{\eta}+\frac{(\omega+\phi)-\lambda}{\delta}=C+G+\frac{\lambda}{\gamma} \quad \Rightarrow \quad \lambda=\frac{\frac{\mu}{\eta}+\frac{\omega+\phi}{\delta}-C-G}{\frac{1}{\eta}+\frac{1}{\delta}+\frac{1}{\gamma}} \tag{4}$$

This can be substituted back into the FOCs to generate comparative statics. Specifically, because I am interested in how spending on R&D sensitivity to government contracts ($\frac{\partial R}{\partial G}$), I focus on $R^*=\frac{\mu-\lambda}{\eta}$. It increases with the quality of the firm's R&D prospects, as revealed by μ through the observed value of government contracts awarded to the firm (recall: $\mu=\mu_0+\sigma G$). The optimal R^* is decreasing in λ, since receipt of the contract also relaxes the budget constraint. Finally, it is inversely related to the parameter η, which governs the speed at which the marginal benefits of an additional dollar of R&D spending decrease as the level of R increases; if marginal benefits of R decrease faster, R^* is lower. Formally stated as a proposition:

Proposition 1: (R&D Sensitivity to Cash Flow from Government) *In equilibrium, the optimal level of R&D spending, R^*, increases with the level of government funding according to:*

$$\frac{\partial R^*}{\partial G} \quad = \quad \frac{1}{\eta}\sigma-\frac{1}{\eta}\frac{\frac{\sigma}{\eta}-1}{\frac{1}{\eta}+\frac{1}{\delta}+\frac{1}{\gamma}} \quad = \quad \frac{\frac{\sigma}{\eta}\left(\frac{1}{\gamma}+\frac{1}{\delta}\right)+\frac{1}{\eta}}{\frac{1}{\eta}+\frac{1}{\delta}+\frac{1}{\gamma}} \quad >0 \tag{5}$$

Proof: Substitute (4) into (1), and let $\mu=\mu_0+\sigma G$. This gives:

$$R^*=\frac{1}{\eta}\left[\mu_0+\sigma G-\left(\frac{\frac{\mu_0+\sigma G}{\eta}+\frac{\omega+\phi}{\delta}-C-G}{\frac{1}{\eta}+\frac{1}{\delta}+\frac{1}{\gamma}}\right)\right]$$

Differentiating with respect to G and simplifying yields (5). □

While always positive, the magnitude of the slope depends on the relative magnitudes of σ and η, or how much the signal term increases demand for R&D relative to how much decreasing returns to scale is present in the R&D productivity function. The sensitivity may be greater than, equal to, or less than one.

$$\frac{\partial R^*}{\partial G} = \begin{cases} < 1 & \text{iff} \quad \sigma < \eta \\ = 1 & \text{iff} \quad \sigma = \eta \\ > 1 & \text{iff} \quad \sigma > \eta \end{cases}$$

$\frac{\partial R^*}{\partial G} > 1$ implies that government funding is complementing private funding, while $\frac{\partial R^*}{\partial G} < 1$ implies there is a substitution effect. Complementarity occurs when the firm has many quality investment opportunities that it cannot take because the budget constraint is binding, and additional external financing would be too costly. By providing the firm with a cheaper source of capital, the government allows them to undertake the additional projects, increasing their R&D outlays by more than the amount of the award. Complementarity is also more likely when the award process is more competitive, as this is when winning an award strongly indicates the firm has better R&D prospects.

Alternatively, substitution occurs when the firm's additional quality investment opportunities are limited ($\sigma < \eta$). This is the case when the contract funds are either directly diverted to other uses (X), or when they are used on projects the firm was already going to finance, allowing the planned funds to be used elsewhere. This leads to the primary testable hypothesis:

Hypothesis 1: *Government's efficiency in stimulating firm R&D through federal contracts is revealed by the magnitude of the causal relationship between receiving contract awards and firm R&D expenses.*

Efficiency, following from the theoretical literature discussed in Section 2, is when the government funding can complement firm spending by allowing them to take on projects they would not have been able to otherwise. Thus, efficient government allocation should manifest as a causal increase in R&D outlays by the firm. If this is not empirically observed, then government funding is likely inefficient, as it is being diverted to other uses, either directly or by substituting for funds which would have been spent on R&D, but which were freed up following the contract receipt.

The magnitude of the σ parameter also correlates with how competitive the award process is. A more competitive process means that winning an award signals greater productivity of the firm's R&D investments. To understand the intuition, consider two firms: one wins an award for which 50 firms submitted bids, and the other wins an award for which it was the only bidder. The first firm's R&D productivity must be very high for them to be selected for the contract. Alternatively, the solo-bidding firm will win the bid even if their R&D prospects are of lower quality. An increase in σ increases the sensitivity between firm R&D and government funding. This observation leads to an additional testable hypothesis:

Hypothesis 2: *The complementarity between public and private R&D spending increases as the awards are allocated more competitively.*

The federal contract data provides information on the number of bids received for each awarded contract. In Section 6, I use this data to measure the proportion of firm revenue which was allocated competitively (more than one firm bid on the contract) to understand how much a competitive bidding process increases the efficiency of government R&D funding.

Next, I extend this model to include a case where a portion of the funds *must* be spent on R&D and cannot be diverted.

3.3 Extension: Earmark Constraint

When a firm is awarded a federal contract, it begins accruing costs due to its work on the contract, which are reimbursed by the contract funds once documented and reviewed by contract monitoring officers. Importantly, only "allowable" costs are eligible to be funded by the contract. Rules defining allowable and unallowable costs are defined under Federal Acquisition Regulation (FAR) Part 31.2[3]. To be considered allowable, costs must be: (i) reasonable: "not exceed that which would be incurred by a prudent person in the conduct of competitive business"; (ii) allocable: "incurred specifically for the contract,...benefits the contract and other work...[or] is necessary for the overall operation of the business"; (iii) recorded in accordance with GAAP; (iv) in line with the terms of the contract. This definition, specifically allocability, allows some diversion of funds to uses other than direct R&D. On the other hand, (i) and (iv) ensure that at least some portion should appear in R. To capture this, I include an additional constraint in the model which earmarks some fraction of the contract value, G, for mandatory use on R&D projects.

Let e be the minimum portion of G which must be used for R&D expense. Intuitively, the solution has two regions. When G is small, the constraint is irrelevant, and the optimal level of R is the same as above (R^*). Alternatively, when G (and therefore eG) is large, the constraint binds, meaning that $R = eG > R^*$. In this case, $\frac{\partial R}{\partial G} = e$. Strictly enforced spending rules can make firms spend more than the first-best for large levels of government contracts. Empirically, minimum spending requirements should manifest as a slight increase in the average level of complementarity. The next section defines the various data sources I rely on to estimate the sensitivity of R&D investment to cash flows from government.

4 Data

I bring together data from several sources to construct the panel which I use to test the causal impact of federal funding on private innovation. The primary data for my study, is information on United Stated Federal R&D contracts awarded to private-sector firms in the years 1975-2023, which are available for download from

[3] https://www.acquisition.gov/far/subpart-31.2

the Federal Procurement Data System (FPDS) through USASpending.gov. The data for 2008-2023 can be downloaded through the Award Data Archive[4], while years prior to 2007 must be accessed through a Custom Query[5]. Though the data are technically available as early as 1975, the data earlier than 2001 only contain broad information, as the system was updated to include additional, more detailed fields around this time. The total sample of R&D contracts consists of 742,262 federal R&D awards, totalling $792 billion in obligated funds (inflation adjusted to 2001). The remainder of this section describes how I link the contract data to firm-level spending, and the employee-level data I use to identify an exogenous shock to firm revenue.

4.1 Identifying Government Contractors in Compustat

Among other details, FPDS reports both the name of the firm receiving the award and the name of the recipient's parent company. I extract the unique list of parent names that received a contract in the sample period 2001-2023 (420,228 unique names), and follow the methodology of Brogaard, Denes, and Duchin (2021) to fuzzy match the names to Compustat's *conm*. To prepare the strings for matching, I remove punctuation and common characters or phrases from both sets of names[6].

Next, I calculate the Levenshtein ratio between each possible pair of matches. This ratio, LR, is defined as:

$$LR = 1 - \frac{LD}{S_1 + S_2}$$

where LD is the minimum number of single-character edits needed to change one string into the other (the Levenshtein Distance), and S_1 and S_2 are the lengths of the parent company name, and Compustat name, respectively. $LR = 1$ would

[4] https://www.usaspending.gov/download_center/award_data_archive

[5] https://www.usaspending.gov/download_center/custom_award_data

[6] The common characters/phrases I remove are: INC, LLC, CORPORATION, LTD, CORP, COMPANY, CO, INCORPORATED, GMBH, LIMITED, COLTD, LP, LLP, PLC, PLLC

correspond to a perfect match. After calculating the Levenshtein ratio for each pairwise combination, I keep only those for which $LR > 0.95$, and manually verify the validity of each match. I identify 3,447 unique *gvkeys* in Compustat as having received at least some government contract revenue during the sample, representing roughly 1/4 of public firms. I then create an indicator variable, $GovContractor$, which equals 1 if a firm was identified to be government contractor, and zero otherwise. Figure 1 plots the proportion of Compustat firms which are government contractors over time. Interestingly, government has done business with an increasingly lower share of public firms in the years since the financial crisis.

[*INSERT FIGURE 1 HERE*]

4.2 Firm Contract Revenue and Characteristics

To make my analysis as precise as possible, I would like to know which federal contracts are specifically associated with R&D efforts. Fortunately, the government reports a product classification code for each contract, along with a written description, which is very well-populated. These 4-character codes have a nested structure, with those beginning with "A" corresponding to Research and Development. For example, A is "R&D"; AC is "Defense R&D", and AC21 is "Atomic energy defense activities; Basic Research". Under this definition, an average level of $56B was spent on R&D per year in the sample.

To assess the impact of this funding on firm activity, the ideal measure of contract revenue would be the actual dollar amount that has been paid out to firms each quarter, as this would be the actual cash flow that either substitutes for or complements the firm's R&D spending. The contract data include such a variable (total amount outlayed), but it is missing for the vast majority of contracts. As a next-best alternative, I use a measure of federal funds which are assigned when contracts are awarded. In general, it is intuitive to expect a large positive correlation between obligated and outlayed funds, so this measure should be a reasonable proxy, though it does mean the results should be interpreted as lower bounds.

Finally, I aggregate the total revenue received from federal R&D contracts to the firm-quarter level, while also measuring that from newly initiated contracts separately from renegotiations, as federal employee's may differ in their ability to influence one over the other. From Compustat, I gather annual data on firm R&D expenses, total assets, total revenue, capital expenditures, and net operating cash flow, keeping only observations with non-missing positive total assets. I winsorize all non-indicator variables at the 1% level, and inflation-adjust all dollar values to 2001, to maintain comparability across time.

4.3 OPM Contracting Officer Data

To address the endogeneity concerns highlighted by past work on this question, I use retirement events of federal contracting officers as a shock to a firm's contract revenue. I measure this using quarterly data on federal employee positions, which is now publicly available through the Office of Personnel Management (OPM) data archive following a series of Freedom of Information Act (FOIA) requests[7]. These data contain information from 1973-2014 on each federal employee's name, id number, the subagency they work for, and their age and length of service in groups of 5 years (e.g. 30-34), among other variables, and are made available in two formats: static and dynamic. The static files are a quarterly panel of every employee, while the dynamic file contains accession events of new additions and departures from each agency. Within these files are several variables which allow me to identify contracting employees and link them to contracts in the USASpending data at a

[7] https://archive.org/download/opm-federal-employment-data/

granular level: Occupation Code, Subagency, and Duty Station. To understand what each of these means, I refer to the relevant statutes. Occupation codes identify the type of work done by the employee; the associated responsibilities for each are detailed in the "classification standards" found on the OPM website[8]. This documentation explains that code "1102 - Contracting" identifies those officers with influence over the intensive margin of contract allocation. Interestingly, the decision of whether or not procurement is needed to complete a program objective is made by one of the multiple program offices within each subagency, before decisions on "soliciting, negotiating, awarding, terminating, and administering" the contracts are made by the contracting officers.

Sub-agencies are reported in the OPM data with a 4-character alphanumeric code, with the first two being letters representing the overall agency, and the last two being numbers corresponding to the sub-element (e.g. AG11 denoting the Forest Service within the Department of Agriculture). However, these OPM subagencies cannot be directly linked to those reported in federal contracts, as the contracts instead use 4-digit numeric codes (e.g. 1226 for Forest Service), with no linking table currently available. Therefore, to prepare the data for matching, I manually link the two agency definitions using the FedScope Agency Code table and the unique list of agencies found in the OPM data. Duty Station codes are 9 digits, and represent the geographical location to which an officer is assigned at the city level. Using these three data points, I extract the set of contracting officers and identify which funding decisions they are likely to have influence over, which allows me to construct a robust, precisely defined instrument in Section 5.

[8] https://www.opm.gov/policy-data-oversight/classification-qualifications/classifying-general-schedule-positions/#url=1100

4.4 Research Outputs

By just exploring the impact of government subsidies on firm research inputs, it is not possible to get a complete picture of their effectiveness. A negligible impact of subsidy on firm R&D expenditure may not imply inefficiency, as it is possible that government funding is more efficient in generating research outputs. For example, there may be some information spillovers that come with being a government contractor which allow the same level of expense to generate more/better patents. In this case, government funding would be efficiently increasing research productivity, even while substituting for private sector funding.

To explore this idea, I rely on a patent dataset constructed by Dyevre and Seager (2023), who identify Compustat firms in PatentsView data through firm names, linking the patent identification numbers in USPTO data to Compustat gvkeys. They have graciously made this data available on their GitHub page.[9]. Using these files, I count the number of approved patents that each government contractor in my sample is awarded, by quarter in which the patent is filed. I focus on filing date instead of awarding date, as the filing date better represents when the new technology is discovered. I also retain information on the time-to-approval for each of the firm's patents, which allows me to test if R&D firms with more government backing are able to expedite the approval process.

Next, I construct a forward-looking measure of patent importance to help understand how effective government funding is at generating quality patents, in addition to quantity as defined above. I measure the average number of future patents which cite the firm's current patents. Citations should be correlated with the usefulness of the technology, as research outputs with broad technological applications will act as a jumping off point for more future development. With these measures, I am able to expand my analysis of the impact of government fund-

[9] https://github.com/arnauddyevre/compustat-patents

ing beyond a distinction between substitution and complementarity, and into an exploration of both the quantity and quality of research outputs.

5 Identifying Contracting Officer Retirements

The regulations governing retirement ages for federal employees were defined by Congress in the Federal Employees Retirement System Act in 1986[10]. Within this legislation were rules describing the minimum, early, and immediate retirement ages. Interestingly, they vary with employee tenure: a federal employee can retire with full benefits as early as 55 if they have 30+ years of service. To identify retirement events, I rely on the separation definitions provided in the dynamic OPM files. They take on one of 12 values, depending on the reason for employee departure:

Separation Indicators	
SA: Transfer Out - Individual	SG: Retirement - Other
SB: Transfer Out - Mass	SH: Reduction in Force
SC: Quit	SI: Termination (Discipline/Performance)
SD: Retirement - Voluntary	SJ: Termination (Expired Appointment/Other)
SE: Retirement - Early Out	SK: Death
SF: Retirement - Disability	SL: Other Separation

Figure 2 shows the number of separation events by type. The vast majority are either Individual Transfers, Quits, or Voluntary Retirements (SA, SC, and SD, respectively). Transfers and Quits are very likely to have endogeneity issues, as an employee may be transferred or quit in response to their performance, which would link the event to firm contract receipts. However, voluntary retirements are likely driven by the employee reaching retirement age for their level of service, rather

[10] https://www.opm.gov/retirement-center/fers-information/eligibility/

than anything related to their job performance or specific firms' operations. For this reason, I restrict my identification to these events. In total, 13,251 contracting employees appear in the sample, of which 1,956 retire voluntarily. In order to match the aggregation level of the R&D investment data from Compustat, I need to construct a firm-quarter level retirement measure. To do this, I begin by matching the panel of retirement events to the FPDS contract data at the subagency-state level. Then, I construct a measure which I refer to as $RetirementIntensity_{i,t}$, which is defined as the number of contract officers in period t that retire from the sub-agencies firm i receives contracts from, scaled by the total number of employees in those sub-agencies assigned to the relevant states. In the following section, I test the relevance condition for this aggregated instrument and argue that the exclusion restriction holds in this setting.

[*INSERT FIGURE 2 HERE*]

5.1 Instrumental Variable Conditions

Using several measures of firm contract revenue (total revenue, in addition to revenue from new contracts, modifications of existing contracts, and clawbacks of previous awards), I demonstrate that the relevance condition is satisfied. Specifically, I run the following panel regression:

$$GovRevenue_{i,t} = \beta_0 + \beta_1 * RetirementIntensity_{i,t-1} + \beta_2 * GovRevenue_{i,t-1} + + \eta_i + \delta_t + \varepsilon_{i,t}$$

where $GovRevenue_{i,a,s,t}$ is the dollar value of R&D contract revenue received by firm i in period t, in millions adjusted for inflation The coefficient β_1 is interpreted as the average dollar change in contract revenue following departure of 100% of the contract officers in a subagency-state.

The total average impact of retirements on federal revenue, shown in Table 1, is significantly negative, with 1% turnover from retirements decreasing revenue the following period by $249,000 (t = -4.31), which is 73% of the mean. Past revenue positively predicts current revenue, suggesting some degree of persistence. This can also be interpreted as evidence in support of the instrument, as it suggests that there is some consistency to the distribution of awards which can be disrupted by the contract officer retirement.

[*INSERT TABLE 1 HERE*]

However, as discussed previously, the documentation on Contracting Officer responsibilities states that these officers negotiate the content of contracts *after* the determination that procurement is necessary has been made by a separate program office. This leads to a testable hypothesis concerning their heterogeneous impact: they may have more influence over renegotiations (intensive margin) than initiations of new contracts (extensive margin). Table 2 tests the above regression for revenue from new contracts and contract modifications separately. The insignificant coefficient on $RetirementIntensity_{i,t-1}$ -0.85 (t = -0.73) in Column (3) suggests that retirements do not affect a the amount of new contracts that a firm receives. However, Column (2) suggests that firm's ability to renegotiate modifications (62% of federal actions in sample) to their existing contracts is negatively impacted. These finding are consistent with Brogaard, Denes, and Duchin (2021) who find a relationship between a firm's political influence and its contract renegotiation terms. Column (4) decomposes this result further by exploring the subset of contract modifications which are clawbacks of previously awarded funds (identified by a negative federal action value). Retirements predict an increase in the magnitude of clawed back funds. Specifically, 1% turnover of a subagency-state level contract office predicts an average of $21,300 in previously awarded funds being canceled per firm (0.6% of mean revenue). In conjunction with the results in Column (2), this suggests that the large negative impact of retirements on contract modifications manifests primarily through firms receiving smaller amounts of additional funds than they otherwise would, rather than previously awarded funds being clawed back.

[*INSERT TABLE 2 HERE*]

Additionally, I provide insight into the types of work for which contracts are most sensitive to officer retirements. To do so, I exploit the high level of detail provided in the nested FPDS product codes. Each 4-digit code also includes a verbal description, which I use to categorize the various codes into 5 categories. The contracted work is either for basic research (discovering new technology), applied research (finding a use for discovered technology), development following applied research, general support of R&D activities, and commercialization (bringing developed products to market). Table 3 shows the impact of contract officer retirements on the various types. It appears to manifest through impact on funding for basic research and commercialization. This supports the theoretical basis for the instruments, as much of the early work on this topic (e.g. Nelson (1959) and Arrow (1962)) focuses on basic research and the discovery of new technology.

[*INSERT TABLE 3 HERE*]

In Section 6, I use estimated total revenue, predicted based on the coefficients in Table 1, to test the causal impact of government funding on firm's R&D activity. However, before I can implement the instrument, I must first argue that it satisfies the exclusion restriction. To do this, I appeal to the definition of retirement eligibility in the OPM dynamic file, which is determined by two key factors: the age of the employee, and their tenure with the federal government, both of which are determined by events likely several decades in the past (birth date and start date). While their birth date is more clearly unrelated to firm revenue, it is possible that their departure date will not actually be a shock, if a contract officer tends to retire after their influence has deteriorated. However, if employees retire at the minimum age where they can receive full benefits, then departure date is linked to birth date, making it more plausibly exogenous. Figure 3 shows the distribution of employee departures by age group. There is a clear grouping around the federal minimum retirement age. It appears that many employees choose to retire at the earliest opportunity, suggesting the departure decision is largely uncorrelated with their degree of influence.

[*INSERT FIGURE 3 HERE*]

I also consider the possibility that replacements are hired preemptively, which may negate the validity of the instrument. If new-hires are brought in and trained to allocate contracts by the previous employees, then the departure of the contracting officer would not end the relationship with the firm. To see if this is the case, I collect additional data from the OPM dynamic file which categorizes accessions into several categories, such as new hires, mass transfers, or individual transfers (defined with indicators beginning with "A"). Using this in combination with the data on voluntary retirements, I construct a balanced panel of the number of retirements and new-hires at the subagency-state level, and look at the retirement activity's correlation with various lags ranging from 5 quarters in the past to 5 quarters in the future.[11] Figure 4 shows the average correlation across subagency-states between the numbers of retirements, and hires of various lags. Positive values on the x-axis represent retirements preceding hirings. There is a clear and statistically significant spike in hirings following the retirements, suggesting that new employees are most often brought in in the one or two quarters *following* the departure of past employees, rather than preemptively. I interpret this as evidence that the allocation behavior of new contracting officers is not directly affected by that of previous employees. For these reasons, the exclusion restriction is likely to be satisfied in this setting.

[*INSERT FIGURE 4 HERE*]

In sum, both the officers' birth dates and initial start dates are plausibly uncorrelated with the firm's R&D investment decisions, except through their impact on the firm's receipt of federal funding. In addition, the impact is significantly negative, satisfying the relevance condition. These findings together support the validity of the instrument.

6 Estimating the Impact of Government Funding

This section defines the second-stage regression, and uses it to explore the relationship between government R&D funding and firm R&D expenditures. It presents results both with and without instrumenting for contract revenue, finding evidence that endogeneity does in fact lead to significant overestimation of the impact of government funding. However, while the magnitude of the effect becomes economically small in the IV estimation, it remains positive and significant, suggesting the estimate is precise.

[11] I make sure to include observations for each quarter where there are no new hires or retirements to maintain consistency.

The second stage regression takes the form:

$$R\&DIntensity_{i,t} = \beta_0 + \beta_1 * GovRevenue_{i,t} + \beta_2 * GovRevenue_{i,t-1} + \Gamma \mathbf{X}_{i,t} + \eta_i + \delta_t + \varepsilon_{i,t}$$

where $GovRevenue_{i,t}$ is either the realized value of firm contract revenue, or its expected value as predicted by the first stage regression coefficients in Column (4) of Table 1. $R\&DIntensity_{i,t}$ is firm i's R&D expense in period t, scaled by total assets at the end of the period. $GovRevenue_{i,t-1}$ is the contract revenue the firm received in the previous period, and $X_{i,t}$ is a vector of control variables: Peters and Taylor (2017) Total q, operating cash flow, capital expenditures, other revenue (this includes non-R&D government revenue and other sales), logarithm of firm age and total assets, measured in quarters and millions of dollars, respectively, total liabilities, and the number of Compustat business segments. All variables measured in millions are scaled by total assets.

To understand what endogeneity may be present, I first run the non-instrumented regression to establish a baseline estimate of the impact of government funding on firm R&D for comparison. For this test, I let $GovRevenue_{i,t}$ equal the realized value of R&D contract revenue, and explore the impact four quarters into the future, including the quarter contemporaneous with the funding receipt. This horizon matches the most common contract lengths, illustrated in Figure 5. This figure plots the number of quarters between predicted start and end date at the time an award is made; by law, allowable costs may only be incurred within that period, so any R&D expense caused by the contract receipt should also appear within that horizon.

[*INSERT FIGURE 5 HERE*]

The results of this test are shown in Table 4. The impact of government funding appears positive and significant in each of the four quarters. In dollar terms, an increase of \$1 million in funding is associated with spending \$51,700 more on R&D in the same quarter, with this estimate monotonically decreasing to \$26,400 in the fourth quarter following receipt. This estimate suggests that receiving an average contract (\$1.3M) appears to increase R&D spending by 77% of the mean (\$87,000), implying that the government contracts on average complement private innovation.

[*INSERT TABLE 4 HERE*]

Next, I replace the measure of realized contract revenue with the fitted values implied by Column (4) in Table 1, which will allow me to make a causal statement about the impact of government funding. I find that the magnitude of the impact decreases from \$51,700 to \$6,700, though it remains significant. The two coefficients are significantly different from one another, suggesting that endogeneity does bias estimates of the immediate impact of government funding upward by approximately 500%. While statistically significant, the \$6,700 increase in expenditure for every \$1 million in contract revenue is not economically large (receiving an average contract increases R&D by 10% of mean). The significance of the effect varies by horizon, suggesting that there is likely a large degree of substitution occurring with the funds from these government R&D contracts.

[*INSERT TABLE 5 HERE*]

6.1 Fixed-Price vs. Cost-Plus Contracts

One key part of the contracting process is the government's choice of pricing structure. They almost always choose from one of two general options: cost-plus or fixed-price. Cost-plus contracts (71% of the sample) pay the firm some fixed amount above and beyond their incurred costs, offering flexibility in the face of risky research and development which are likely to incur cost overruns. On the other hand, fixed-price contracts (25% of the sample) pay a pre-specified amount, meaning any cost overruns diminish the firm's profit margin. Thus, these contracts lessen the incentives to divert the funds, since fulfilling the contract with minimal costs is the way to maximize profit. Below, I estimate the impact of each type of contract on firm investment separately.

Similar to Table 4, I use retirements to create instrumented values of quarterly revenue from both cost-plus and fixed-price contracts. Table 6 gives the results for cost-plus. These types of contracts cause smaller increases in R&D spending, with only 0.44% of contract value flowing through, which is smaller than the overall average treatment effect. It remains small, becoming insignificant or negative at the 3 and 4 quarter horizons, respectively.

[*INSERT TABLE 6 HERE*]

Compared to this, Table 7 shows the results for fixed-price contracts. They predict an increase in investment of as much as 7.7% of contract value in Q4. Though insignificant at the shorter horizon, the coefficients become large and significant relative to the average treatment effect over the following periods. Overall, these results suggest that fixed-price contracts are a much more efficient choice of structure for aligning firm incentives. However, they only make up 25% of the contracts I observe.

[*INSERT TABLE 7 HERE*]

6.2 Heterogeneity in the Effectiveness of Government Funding

The model presented in Section 3 provides additional predictions about how the level of complementarity should vary across several dimensions. Hypothesis 2 predicts that increased competition in the allocation process should increase the effectiveness of government R&D funding. To capture the level of competition empirically, I construct a variable, *Competition*, which measures the percentage of firm contracts, in terms of total revenue, for which they had to compete against at least one other firm (number of bids received > 1).

As Table 8 reports, the interaction between the instrumented contract revenue and the level of competition is significantly positive at all four reported horizons. This suggests that a more competitive allocation process does increase the effectiveness of government R&D contracts. Specifically, it increases the magnitude of the R&D sensitivity by 300%, to $15,200 per $1 million of revenue. Competitive contracts also appear to be the sole driver of the effect at longer horizons.

[*INSERT TABLE 8 HERE*]

Next, I test the predictions of Nelson (1959) and Arrow (1962) regarding the interaction between the breadth of the firm's technological base and the efficiency of government subsidies. As discussed in Section 2, the primary theoretical mechanism by which subsidy should enhance private investment in R&D is through risk-sharing. Specifically, the government is more equipped to bear the risk associated with basic research – the risk that technology resulting from R&D projects is not usable by the firm in its current industries. This leads Nelson (1959) to postulate that government subsidy should benefit concentrated firms more, as they operate in fewer industries, and thus are more exposed to this risk.

To explore this idea empirically, I test the interaction between government funding and the breadth of the firm's operations, as measured by the number of distinct Compustat segments they operate in each quarter. Table 9 presents the results for instrumented revenue up to a four quarter horizon. The coefficient on $GovRevenue_t$ represents the baseline effect for concentrated firms, while the coefficient on the interaction $GovRevenue_t * NumSegments_t$ is interpreted as how much the effect varies on average as the breadth of the firm's operations increases. Interestingly, the interaction coefficient is positive and significant, implying that government contracts allocated to more diverse firms have a larger impact on R&D spending. This evidence counters the theoretical prediction, suggesting that the funding is not actually targeting marginal projects in more concentrated firms, where we would expect them to be most effective in adding value.

[*INSERT TABLE 9 HERE*]

Overall, properly instrumenting for contract revenue decreases the estimated impact of government funding on firm R&D by a factor of 5, suggesting there is indeed selection in who is awarded government contracts. The corrected causal impact, while statistically significant, is modest, with only 0.5% of every dollar of additional funding flowing through to firm expenditures. Also, the impact is larger for firms which have broader operations, countering what the theory would predict if subsidies were being efficiently targeted. These results suggest that the complementarity between funding sources is limited in practice. However, I cannot conclude that government funding is ineffective at stimulating R&D without exploring the impact on research outputs. It is possible that funding from government sources is more productive than others in terms of research *output* (patents, publications, etc.). This may be due to government's dual role as patent granter and research funding agent, or due to its broad operations in many industries. If this were the case, it could lead to more output for a similar level of expenditures, meaning there is some efficiency gain. I explore this idea below.

6.3 Government Funding and Research Outputs

I begin by testing the impact of government funding on research output with a simple measure of patent quantity, as measured by patent applications filed each quarter. As mentioned in Section 4, I focus on patent application dates, as this more closely aligns with when the technologies are generated than do approval dates. I restrict the patent sample to those patents which are ultimately approved, as including applications which are eventually denied may lead to overestimation of the firm's research outputs. For this test in Table 10, I replace the dependent variable in Tables 4 and 5 with the quantity of patent applications over four quarters, beginning with that which is contemporaneous with the funding receipt. The results suggest that a 100% increase in contract revenue should increase patent applications by a statistically significant amount at each of the included horizons, with funding increasing total applications by 3.67 (t = 4.33) on average the same quarter in which it is received. This suggests that in terms of quantity, government funding does have a positive impact on research outputs.

[*INSERT TABLE 10 HERE*]

Because patent output may not be immediate following increased investment, it is also important to understand the time trend of applications following receipt of government funding. The final three columns present the causal estimates of this impact up to 4 quarters into the future. The impact stays consistently positive and significant, suggesting that government funding does increase patent applications not only immediately, but also for technologies that may take longer to develop.

Next I explore the firm's research outputs through the *quality* of patents, rather than just the quantity. Because government controls both the funding and patent assigning organizations, contractors may have increased incentives to apply for patents on technology that they otherwise may not have. This possibility means that the number of patents alone may lead to an inaccurate portrayal of the impact of subsidies on research outputs. Adding a measure of quality allows me to get a clearer picture of the true effect of funding on research outputs.

Among other things, higher quality patents are those which are able to be used as the basis for more future technology. In Table 11, I explore government funding's impact on future patent citations, which proxies for this aspect of patent quality. I measure citations as the average number of future citations of the firm's patents this quarter. Each column estimates the causal impact of an increase of 100% in R&D contract revenue on the average number of future patents which cite those applied for by the firm in the indicated quarter. The coefficient is insignificant, suggesting that government contracts are producing more patents, without a noticeable decline in average quality. However, this could be due to an increase in real research outputs, or less stringent approval standards for government-funded patents.

[*INSERT TABLE 11 HERE*]

Overall, this evidence suggests that, while contract revenue may increase the number of patent applications, these patents are of lower quality, as measured by how much they are cited by future patent applications. Taken together with the evidence on the substitution between government and private sector funding, my results suggest a great deal of inefficiency in R&D contract funding.

7 Conclusion

This paper contributes to the national conversation about the ideal size and scope of government by exploring the effectiveness of government in one specific area: facilitating private sector innovation. Theoretical foundations suggest a complementarity between government funding and firm innovation spending. In practice, whether government funding acts as a substitute or complement has been the subject of many existing studies. However, this paper is the first to properly address the endogeneity problem in who is awarded a federal contract, which I achieve with a precisely defined IV.

Specifically, I estimate the causal impact of additional government revenue on firm R&D spending by identifying retirements of federal contract officers as negative shocks to firm contract revenue. I link firms to agency-state level employee departures, and estimate that turnover of a contract office reduces firm revenue in the following quarter by $24 million, on average. I also find evidence that this impact manifests through contract renegotiations, rather than initiation of new programs.

Endogeneity overestimates the impact of government funding both for research inputs and outputs. Causal estimates suggest that $1 million in additional contract revenue increases R&D expenditures by only $6,700 ($t = 7.49$), but additional tests highlight increased competition in the allocation process as a way to increase this impact. While doubling revenue leads to the firm submitting 2 more patent applications, on average, this increase in revenue predicts fewer citations. These results suggest that the government contracts are mostly substituting for firm innovation spending, and that these contracts slightly increase their patenting activity. The policy prescription from this paper is a careful identification of the high-risk, socially beneficial projects which are ideal candidates for government funding, leaving others to the private sector. For researchers, this paper also demonstrates the importance of properly controlling for endogeneity when examining the impact of government contracts on firm activity. Failing to do so can lead to large over-estimations and false conclusions about the effectiveness.

Bibliography

Almeida, Heitor, Murillo Campello, and Michael S. Weisbach, 2004, The cash flow sensitivity of cash, *Journal of Finance* 59, 1777–1804.

Almus, Matthias, and Dirk Czarnitzki, 2003, The effects of public r&d subsidies on firms' innovation activities, *Journal of Business & Economic Statistics* 21, 226–236.

Arrow, Kenneth, 1962, Economic welfare and the allocation of resources for invention, *The Rate and Direction of Inventive Activity: Economic and Social Factors* Princeton University Press, 609–626.

Brogaard, Jonathan, Matthew Denes, and Ran Duchin, 2021, Political influence and the renegotiation of government contracts, *Review of Financial Studies* 34, 3095–3137.

Bronzini, Raffaello, and Paolo Piselli, 2016, The impact of r&d subsidies on firm innovation, *Research Policy* 45, 442–457.

David, Paul, Bronwyn Hall, and Andrew A. Toole, 2000, Is public r&d a complement or substitute for private r&d? a review of the econometric evidence, *Research Policy* 29, 497–529.

Dyevre, Arnaud, and Oliver Seager, 2023, 70 years of patents matched to compustat firms: Methodology and insights about firm heterogeneity, *Working Paper*.

Goldman, Jim, 2019, Government as customer of last resort: The stabilizing effects of government purchases on firms, *The Review of Financial Studies* 33, 610–643.

González, Xulia, Jordi Jaumandreu, and Consuelo Pazó, 2005, Barriers to innovation and subsidy effectiveness, *The RAND Journal of Economics* 36, 930–950.

Hennessy, Christopher A., and Toni M. Whited, 2007, How costly is external financing? evidence from a structural estimation, *Journal of Finance* 62, 1705–1745.

Lach, Saul, 2002, Do r&d subsidies stimulate or displace private r&d? evidence from israel, *The Journal of Industrial Economics* 50, 369–390.

Liebman, Jeffrey B., and Neale Mahoney, 2017, Do expiring budgets lead to wasteful year-end spending? evidence from federal procurement, *American Economic Review* 107, 3510—-49.

Moyen, Nathalie, 2004, Investment–cash flow sensitivities: Constrained versus unconstrained firms, *Journal of Finance* 59, 2061–2092.

Nelson, Richard R., 1959, The simple economics of basic scientific research, *Journal of Political Economy* 67, 297–306.

Peters, Ryan H., and Lucian A. Taylor, 2017, Intangible capital and the investment-q relation, *Journal of Financial Economics* 123, 251–272.

Takalo, Tuomas, Tanja Tanayama, and Otto Toivanen, 2013, Estimating the benefits of targeted r&d subsidies, *Review of Economics and Statistics - REV ECON STATIST* 95, 255–272.

Wallsten, Scott J., 2000, The effects of government-industry r&d programs on private r&d: The case of the small business innovation research program, *The RAND Journal of Economics* 31, 82–100.

Figure 1: **Share of Public Firms Identified as Government Contractors**

This chart plots the prominence of government contractors among public firms each year. They are identified using the fuzzy matching method described in Section 3. I compute the Levenshtein ratio between each pair of Compustat firm names and contract recipient names, keep the reasonably close matches, and manually verify them. The line shows the number of firms with government revenue from federal contracts as a fraction of the total number of public firms in that year.

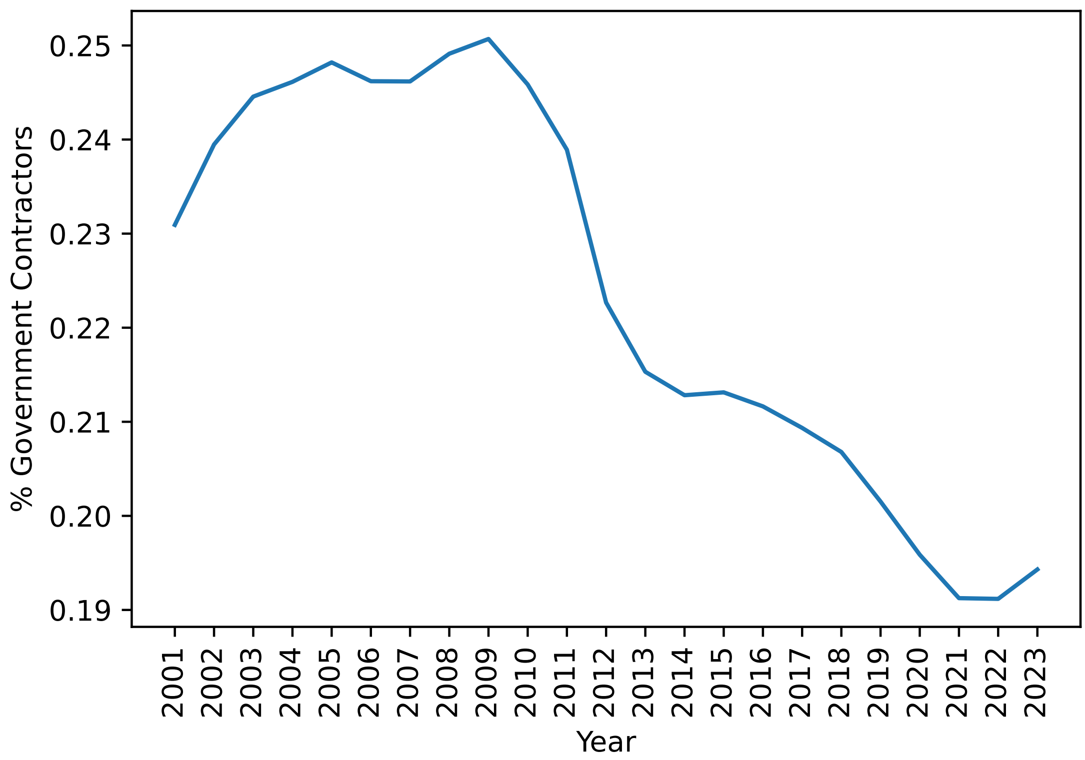

Figure 2: **Federal Employee Separations by Reason for Departure**

This chart is a histogram showing the distribution of employee departures by type, as classified in the OPM dynamic file. The sample is the group of employees working in contracting (OPM Occupation Code = 1102 described in Section 3). The majority of events are designated SA, SC, or SD (individual transfers, quits, and voluntary retirements). Of these, voluntary retirements are most likely to satisfy the exclusion restriction, so I focus on these for the construction of the instrumental variable.

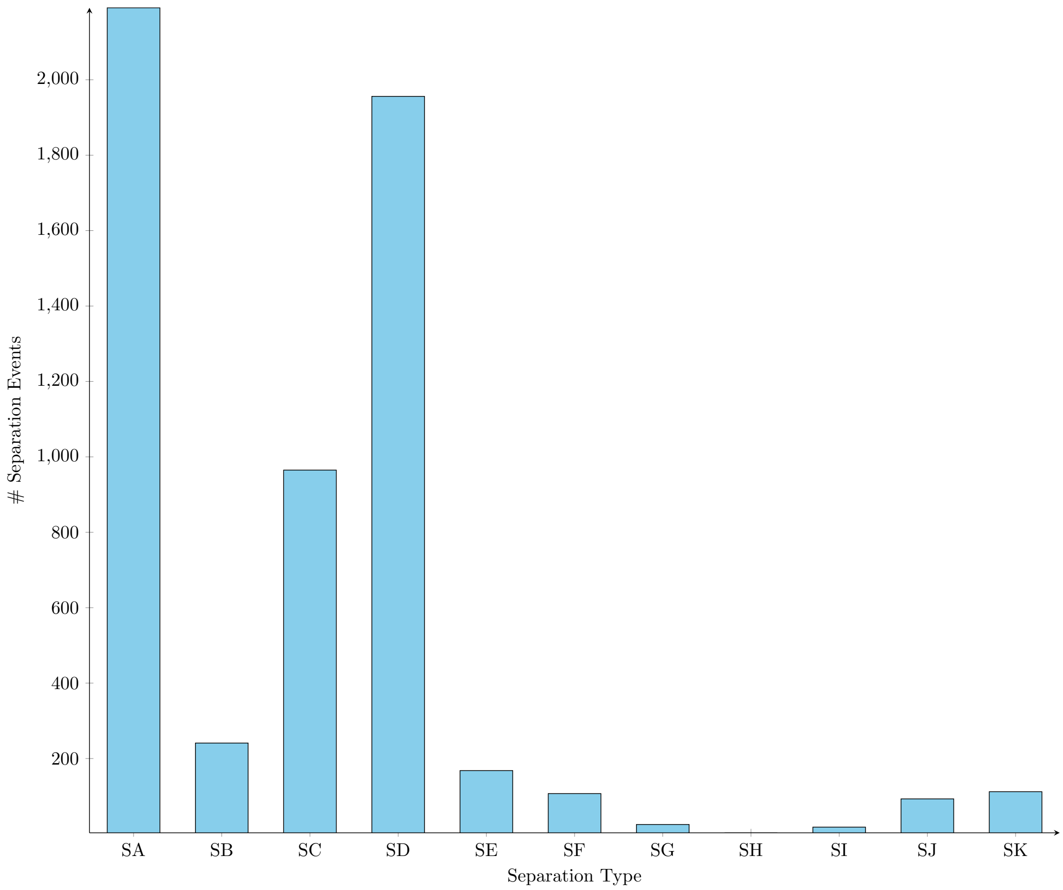

Figure 3: **Federal Employee Retirements by Age Group**

This chart is a histogram showing the distribution of employee departures by their age in groups of 5 years. The sample is the group of employees working in contracting (OPM Occupation Code = 1102 described in Section 3), who have retired voluntarily and receive full benefits. There is a peak around the federal minimum retirement ages of 55 and 60 (depending on length of service), which is interpreted as supporting evidence for retirements as a valid instrument for firm contract revenue.

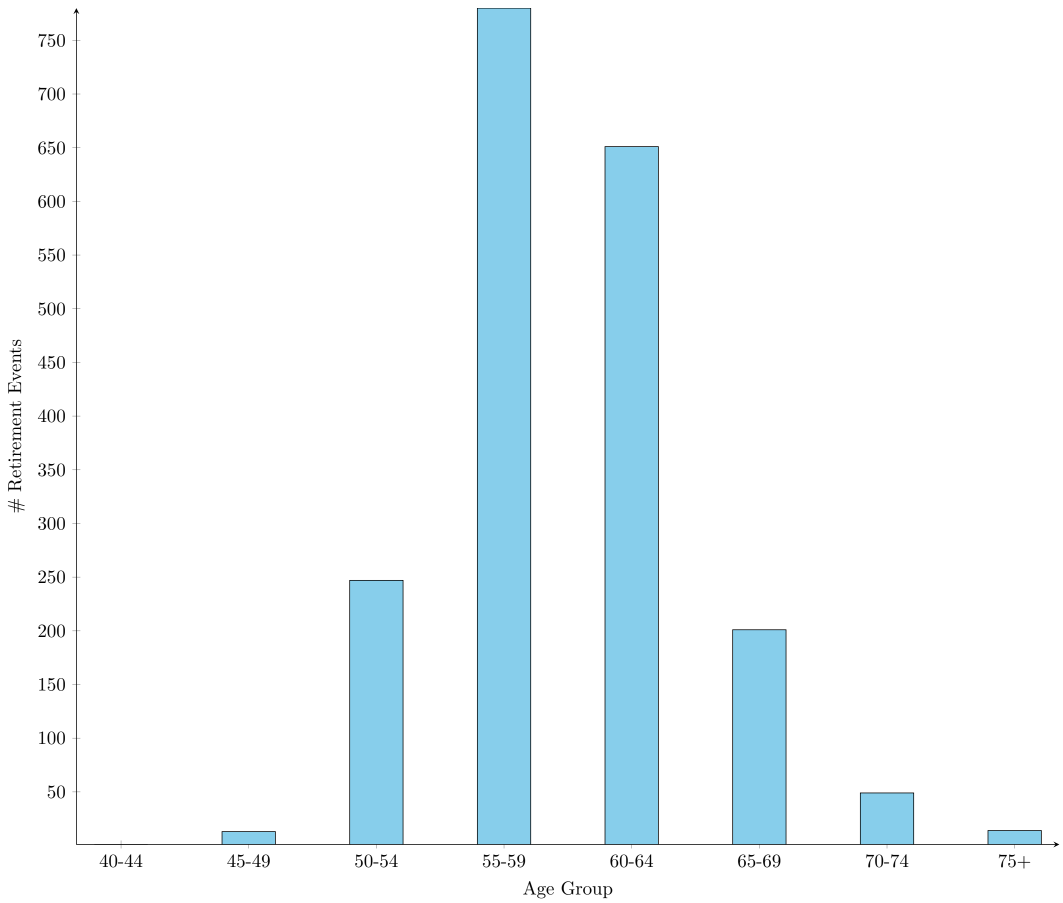

Figure 4: **Average Correlation Between Retirements and Lagged New Hires**

This chart is a plot of the average correlation between the number of retirements and the number of new hires, by the number of periods between the timing of the hires and retirements. Positive values represent retirements preceding hirings. The spike in average correlation at values of 1 and 2 is interpreted as further evidence of the validity of retirements as an instrumental variable.

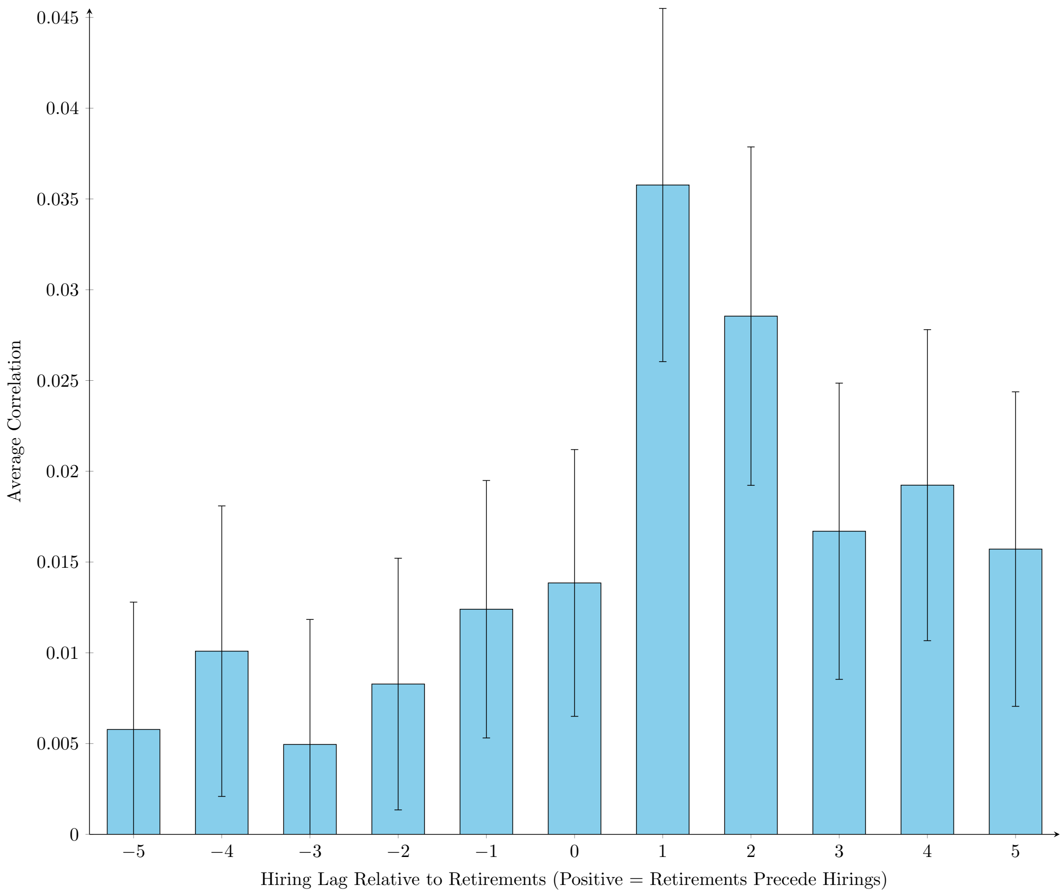

Figure 5: **Distribution of Federal R&D Contract Horizons**

This figure illustrates the distribution of time a federal contractor has to complete the work assigned in the contract. The x-axis represents the number of quarters between the start and end date at the time of contract action. Negative numbers are contract modifications where the government has recalled part of a contract's funding. Under the Federal Acquisition Regulation (FAR), only costs accrued as part of the contractual work, within the contractual period are eligible to be covered as part of the contract payment. Thus, this histogram gives a broad picture of how aggregate R&D expenses by firms for work on federal contracts should be spaced out over time relative to contract receipt.

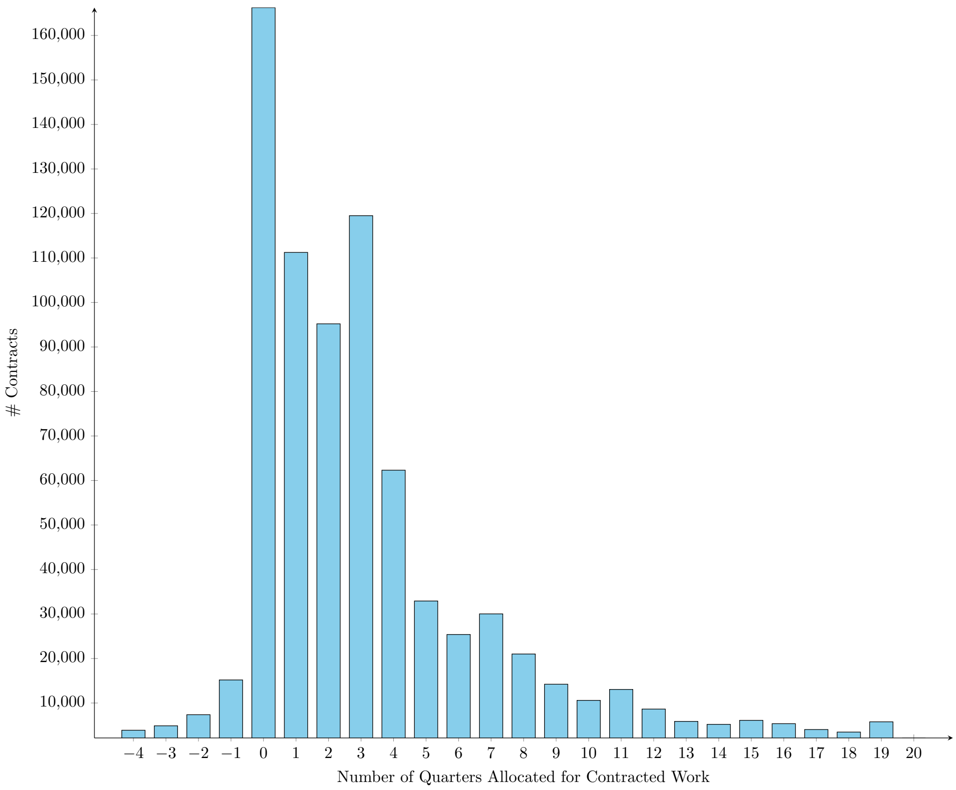

Table 1: **The Impact of Retirement on Firm Revenue**

This table presents the results of the first-stage regression for the instrumental variable constructed in Section 4. GovRev_t is the total dollar amount of R&D contract revenue received by the firm from the federal government, in millions, inflation-adjusted to 2001. $\text{RetirementIntensity}_{i,t-1}$ is the proportion of contract officers who retire from the sub-agency state pairs from which the firm received contract revenue, and GovRevenue_{t-1} measures the total revenue a firm received in the past quarter. *,**, and *** indicate significance at the 10, 5, and 1% levels, respectively.

Dep. Var: GovRevenue_t	**(1)**	**(2)**	**(3)**	**(4)**
$\text{RetirementIntensity}_{t-1}$	-23.9799***	-24.8999***	-24.8851***	-24.8641***
	(-4.31)	(-4.31)	(-4.30)	(-4.30)
GovRevenue_{t-1}	0.3900***	0.3901***	0.3901***	0.3899***
	(75.53)	(74.01)	(74.00)	(73.94)
Total q_t		0.0005	0.0005	0.0002
		(0.05)	(0.04)	(0.02)
FCF_t		0.6664	0.4078	0.1335
		(0.36)	(0.21)	(0.07)
Other Revenue_t			0.9138	1.0448
			(0.82)	(0.92)
$\log(\text{Assets})_t$			-0.0057	-0.0012
			(-0.03)	(-0.01)
$\text{TotalLiabilities}_t$				-0.2659
				(-0.66)
$\log(\text{Age})_t$				0.1898
				(0.33)
NumSegments_t				-0.0964
				(-1.17)
Constant	2.1435***	2.2233***	2.0381	1.6355
	(25.96)	(25.02)	(1.34)	(0.60)
Observations	35,536	34,105	34,105	34,097
R^2	0.8403	0.8403	0.8403	0.8403

Table 2: **The Impact of Retirement on Firm Revenue by Contract Type**

This table presents the results of the first-stage regression for the instrumental variable constructed in Section 4, estimated separately for contract modifications, new awards, and clawbacks of previously allocated funds. GovRev_t is the dollar amount of R&D contract revenue received by the firm from the federal government of each type, in millions, inflation-adjusted to 2001. $\text{RetirementIntensity}_{i,t-1}$ is the proportion of contract officers who retire from the sub-agency state pairs from which the firm received contract revenue, and GovRevenue_{t-1} measures the total revenue a firm received in the past quarter. *,**, and *** indicate significance at the 10, 5, and 1% levels, respectively.

Dep. Var: GovRevenue_t	**Total Revenue**	**Contract Mods**	**New Contracts**	**Clawbacks**
$\text{RetirementIntensity}_{t-1}$	-24.8641***	-40.1607***	-0.8497	-2.1316***
	(-4.30)	(-5.78)	(-0.72)	(-5.04)
GovRevenue_{t-1}	0.3899***	0.3679***	0.0510***	-0.0148***
	(73.94)	(58.06)	(47.44)	(-38.53)
Total q_t	0.0002	0.0002	-0.0001	0.0000
	(0.02)	(0.01)	(-0.03)	(0.05)
FCF_t	0.1335	-0.8418	0.2301	-0.0908
	(0.07)	(-0.36)	(0.57)	(-0.63)
Other Revenue_t	1.0448	1.6221	0.1535	-0.0066
	(0.92)	(1.18)	(0.66)	(-0.08)
$\log(\text{Assets})_t$	-0.0012	-0.0517	0.0268	0.0003
	(-0.01)	(-0.19)	(0.59)	(0.02)
$\text{TotalLiabilities}_t$	-0.2659	-0.4274	0.0110	-0.0053
	(-0.66)	(-0.88)	(0.13)	(-0.18)
$\log(\text{Age})_t$	0.1898	-0.0417	-0.0448	0.0115
	(0.33)	(-0.06)	(-0.38)	(0.27)
NumSegments_t	-0.0964	-0.1747*	-0.0168	0.0101*
	(-1.17)	(-1.77)	(-1.00)	(1.68)
Constant	1.6355	3.1888	0.3892	-0.1489
	(0.60)	(0.97)	(0.70)	(-0.74)
N	34,097	34,097	34,097	34,097
R^2	0.8403	0.8225	0.6609	0.6065

Table 3: **The Impact of Retirement on Firm Revenue by Work Type**

This table presents the results of the first-stage regression for the instrumental variable constructed in Section 4, estimated separately for different types of work: basic vs. applied research, development, support for R&D activities, and commercialization of developed products. GovRev_t is the dollar amount of R&D contract revenue received by the firm from the federal government of each type, in millions, inflation-adjusted to 2001. $\text{RetirementIntensity}_{i,t-1}$ is the proportion of contract officers who retire from the sub-agency state pairs from which the firm received contract revenue, and GovRevenue_{t-1} measures the total revenue a firm received in the past quarter. *,**, and *** indicate significance at the 10, 5, and 1% levels, respectively.

Dep. Var: GovRevenue_t	**Basic**	**Applied**	**Development**	**Support**	**Commercial**
$\text{RetirementIntensity}_{t-1}$	-7.8088***	-0.9857	5.5998	-0.6671	-12.1478***
	(-7.15)	(-0.91)	(0.71)	(-0.95)	(-9.31)
GovRevenue_{t-1}	0.3657	0.3370	2.1804	0.1614	0.5744*
	(1.37)	(1.28)	(1.13)	(0.94)	(1.80)
Total q_t	0.0005	0.0001	-0.0007	0.0001	-0.0003
	(0.23)	(0.07)	(-0.04)	(0.09)	(-0.10)
FCF_t	-0.5334	-0.3239	-0.5843	0.1204	-0.0776
	(-1.43)	(-0.88)	(-0.21)	(0.50)	(-0.17)
Other Revenue_t	0.2235	0.0513	0.3105	0.0817	-0.1240
	(0.81)	(0.19)	(0.16)	(0.46)	(-0.38)
$\log(\text{Assets})_t$	0.1571***	0.0720*	-0.2114	0.0048	-0.0228
	(3.72)	(1.73)	(-0.69)	(0.17)	(-0.45)
$\text{TotalLiabilities}_t$	-0.1553**	0.0044	-0.3741	0.0399	-0.0599
	(-2.03)	(0.06)	(-0.67)	(0.81)	(-0.66)
$\log(\text{Age})_t$	0.0296	-0.1246	-0.5390	-0.2347***	-0.2088
	(0.27)	(-1.16)	(-0.68)	(-3.33)	(-1.60)
NumSegments_t	-0.0661***	-0.0181	-0.2520**	-0.0272***	-0.0371**
	(-4.27)	(-1.18)	(-2.24)	(-2.72)	(-2.01)
Constant	-0.5065	0.3907	7.4150**	1.1566***	1.3423**
	(-0.98)	(0.76)	(1.97)	(3.45)	(2.16)
N	34,097	34,097	34,097	34,097	34,097
R^2	0.6181	0.7354	0.7932	0.4526	0.6874

Table 4: **The Non-Instrumented Impact of Government Funding**

This table presents the results from a regression of firm R&D intensity onto *realized* firm revenue from federal R&D contracts in that quarter, along with a vector of control variables. R&D intensity is measured as firm R&D expense scaled by total Assets. $\text{GovRev}_{i,(t,t-1)}$, $\text{FCF}_{i,t}$, and $\text{OtherRevenue}_{i,t}$ measure firm revenue from the government, free cash flow (operating cash flow - capex), and revenue from other sources. All are scaled by total assets. Age is measured in quarters, assets are measured in millions, and Total q is the Peters and Taylor (2017) Total q measure, available through WRDS. All dollar values are inflation adjusted to 2001. *,**, and *** indicate significance at the 10, 5, and 1% levels, respectively. These coefficients represent the impact of government funding on firm R&D activity, before correcting for potential endogeneity.

Dep Var: RDIntensity_t	**1Q**	**2Q**	**3Q**	**4Q**
GovRevenue_t	0.0517***	0.0454***	0.0340***	0.0264***
	(15.34)	(13.29)	(9.68)	(7.42)
GovRevenue_{t-1}	0.0047***	0.0039***	0.0054***	0.0015
	(4.94)	(4.06)	(5.48)	(1.55)
Total q_t	0.0000	0.0000	0.0000	0.0000
	(1.60)	(0.76)	(0.24)	(0.23)
FCF_t	-0.1005***	-0.0798***	-0.0653***	-0.0543***
	(-39.65)	(-30.52)	(-24.52)	(-20.02)
Other Revenue_t	0.0178***	0.0118***	0.0076***	0.0081***
	(12.12)	(7.78)	(4.89)	(5.13)
$\log(\text{Assets})_t$	-0.0061***	-0.0052***	-0.0046***	-0.0040***
	(-21.54)	(-17.75)	(-15.35)	(-13.05)
$\text{TotalLiabilities}_t$	0.0120***	0.0066***	0.0042***	0.0020***
	(23.05)	(12.06)	(7.49)	(3.37)
$\log(\text{Age})_t$	-0.0061***	-0.0053***	-0.0048***	-0.0062***
	(-8.15)	(-6.91)	(-6.14)	(-7.64)
NumSegments_t	0.0006***	0.0004***	0.0003**	0.0002*
	(5.37)	(3.82)	(2.41)	(1.68)
Constant	0.0713***	0.0669***	0.0638***	0.0667***
	(20.24)	(18.37)	(17.07)	(17.42)
N	34,097	33,201	32,317	31,461
R^2	0.7390	0.7299	0.7267	0.7271

Table 5: **The Instrumented Impact of Government Funding**

This table presents the results from a regression of firm R&D intensity onto *fitted* values of firm revenue from federal R&D contracts in that quarter, along with a vector of control variables. $\widehat{GovRev}_{i,t}$ is the value of federal revenue, predicted by the first stage regression shown in Table 1 R&D intensity is measured as firm R&D expense scaled by total Assets. $\text{GovRev}_{i,t}$, $\text{FCF}_{i,t}$, and $\text{OtherRevenue}_{i,t}$ measure firm revenue from the government, free cash flow (operating cash flow - capex), and revenue from other sources in period t. All are scaled by total assets. Age is measured in quarters, assets are measured in millions, and Total q is the Peters and Taylor (2017) intangible-adjusted q measure, available through WRDS. All dollar values are inflation adjusted to 2001. *,**, and *** indicate significance at the 10, 5, and 1% levels, respectively. These coefficients represent the impact of government funding on firm R&D activity, after correcting for potential endogeneity using SCO retirements and an instrumental variable.

Dep Var: RDIntensity_t	**1Q**	**2Q**	**3Q**	**4Q**
$\widehat{\text{GovRevenue}}_t$	0.0067***	0.0037***	0.0013	0.0025**
	(7.49)	(3.92)	(1.30)	(2.54)
GovRevenue_{t-1}	0.0028***	0.0030***	0.0051***	0.0008
	(2.85)	(2.94)	(4.98)	(0.80)
Total q_t	0.0000	0.0000	0.0000	0.0000
	(1.46)	(0.68)	(0.25)	(0.21)
FCF_t	-0.0996***	-0.0799***	-0.0662***	-0.0544***
	(-38.80)	(-30.20)	(-24.55)	(-19.81)
Capex_t	0.1695***	0.1292***	0.0967***	0.0827***
	(12.78)	(9.47)	(6.99)	(5.92)
Other Revenue_t	0.0154***	0.0107***	0.0074***	0.0072***
	(10.14)	(6.83)	(4.61)	(4.41)
$\log(\text{Assets})_t$	-0.0057***	-0.0050***	-0.0046***	-0.0039***
	(-19.66)	(-16.67)	(-14.83)	(-12.37)
$\text{TotalLiabilities}_t$	0.0116***	0.0065***	0.0044***	0.0019***
	(21.80)	(11.67)	(7.57)	(3.17)
$\log(\text{Age})_t$	-0.0056***	-0.0050***	-0.0046***	-0.0060***
	(-7.57)	(-6.43)	(-5.79)	(-7.35)
NumSegments_t	0.0006***	0.0004***	0.0003***	0.0002*
	(5.72)	(4.07)	(2.57)	(1.85)
Constant	0.0655***	0.0629***	0.0612***	0.0641***
	(18.44)	(17.11)	(16.23)	(16.62)
N	34,097	33,201	32,317	31,461
R^2	0.7389	0.7293	0.7264	0.7270

Table 6: **The Impact of Cost-Plus Contracts**

This table presents the results from a regression of firm R&D intensity onto *fitted* values of firm revenue from federal R&D contracts in that quarter with cost-plus structures, along with a vector of control variables. $\widehat{GovRev_{i,t}}$ is the value of cost-plus revenue, predicted by a first stage regression similar to that in Table 1, and R&D intensity is measured as firm R&D expense scaled by total Assets. GovRev$_{i,t}$, FCF$_{i,t}$, and OtherRevenue$_{i,t}$ measure firm revenue from the government, free cash flow (operating cash flow - capex), and revenue from other sources in period t. All are scaled by total assets. Age is measured in quarters, assets are measured in millions, and Total q is the Peters and Taylor (2017) intangible-adjusted q measure, available through WRDS. All dollar values are inflation adjusted to 2001. *,**, and *** indicate significance at the 10, 5, and 1% levels, respectively. These coefficients represent the impact of government funding on firm R&D activity, after correcting for potential endogeneity using SCO retirements and an instrumental variable.

Dep Var: RDIntensity$_t$	**1Q**	**2Q**	**3Q**	**4Q**
$\widehat{\text{GovRevenue}}_t$	0.0044***	0.0013**	-0.0012*	-0.0011
	(7.39)	(2.14)	(-1.86)	(-1.64)
GovRevenue$_{t-1}$	0.0036***	0.0037***	0.0058***	0.0019*
	(3.74)	(3.78)	(5.86)	(1.91)
Total q$_t$	0.0000	0.0000	0.0000	0.0000
	(1.42)	(0.70)	(0.31)	(0.27)
FCF$_t$	-0.0978***	-0.0795***	-0.0669***	-0.0556***
	(-37.81)	(-29.85)	(-24.66)	(-20.13)
Other Revenue$_t$	0.0166***	0.0121***	0.0090***	0.0093***
	(11.02)	(7.76)	(5.64)	(5.72)
log(Assets)$_t$	-0.0058***	-0.0052***	-0.0048***	-0.0041***
	(-20.15)	(-17.29)	(-15.55)	(-13.23)
TotalLiabilities$_t$	0.0110***	0.0064***	0.0047***	0.0024***
	(20.04)	(11.21)	(7.98)	(3.94)
log(Age)$_t$	-0.0060***	-0.0053***	-0.0050***	-0.0063***
	(-8.00)	(-6.89)	(-6.26)	(-7.75)
NumSegments$_t$	0.0006***	0.0004***	0.0003**	0.0002*
	(5.59)	(3.96)	(2.46)	(1.73)
Constant	0.0694***	0.0666***	0.0647***	0.0674***
	(19.58)	(18.16)	(17.21)	(17.55)
N	34,097	33,201	32,317	31,461
R^2	0.7376	0.7285	0.7259	0.7267

Table 7: **The Impact of Fixed Price Contracts**

This table presents the results from a regression of firm R&D intensity onto *fitted* values of firm revenue from federal R&D contracts in that quarter with fixed-price structures, along with a vector of control variables. $\widehat{GovRev}_{i,t}$ is the value of fixed-price revenue, predicted by a first stage regression similar to that in Table 1, and R&D intensity is measured as firm R&D expense scaled by total Assets. $\mathrm{GovRev}_{i,t}$, $\mathrm{FCF}_{i,t}$, and $\mathrm{OtherRevenue}_{i,t}$ measure firm revenue from the government, free cash flow (operating cash flow - capex), and revenue from other sources in period t. All are scaled by total assets. Age is measured in quarters, assets are measured in millions, and Total q is the Peters and Taylor (2017) intangible-adjusted q measure, available through WRDS. All dollar values are inflation adjusted to 2001. *,**, and *** indicate significance at the 10, 5, and 1% levels, respectively. These coefficients represent the impact of government funding on firm R&D activity, after correcting for potential endogeneity using SCO retirements and an instrumental variable.

Dep Var: $\mathrm{RDIntensity}_t$	**1Q**	**2Q**	**3Q**	**4Q**
$\widehat{\mathrm{GovFixed}}_t$	0.0066	0.0282***	0.0564***	0.0766***
	(1.05)	(4.24)	(8.12)	(10.46)
$\mathrm{GovRevenue}_{t-1}$	0.0048***	0.0034***	0.0041***	-0.0004
	(4.89)	(3.45)	(4.08)	(-0.38)
Total q_t	0.0000	0.0000	0.0000	0.0000
	(1.62)	(0.84)	(0.41)	(0.40)
FCF_t	-0.1015***	-0.0813***	-0.0676***	-0.0569***
	(-39.86)	(-30.98)	(-25.31)	(-20.95)
Other $\mathrm{Revenue}_t$	0.0188***	0.0121***	0.0069***	0.0067***
	(12.68)	(7.92)	(4.44)	(4.24)
$\log(\mathrm{Assets})_t$	-0.0061***	-0.0051***	-0.0042***	-0.0035***
	(-21.11)	(-16.83)	(-13.79)	(-11.14)
$\mathrm{TotalLiabilities}_t$	0.0123***	0.0072***	0.0051***	0.0030***
	(23.25)	(12.96)	(8.98)	(5.13)
$\log(\mathrm{Age})_t$	-0.0063***	-0.0060***	-0.0061***	-0.0078***
	(-8.27)	(-7.64)	(-7.63)	(-9.54)
$\mathrm{NumSegments}_t$	0.0006***	0.0004***	0.0003**	0.0002*
	(5.50)	(3.94)	(2.52)	(1.81)
Constant	0.0719***	0.0683***	0.0661***	0.0697***
	(20.31)	(18.65)	(17.64)	(18.17)
N	34,097	33,201	32,317	31,461
R^2	0.7372	0.7286	0.7265	0.7276

Table 8: **The Effect of Greater Competition in the Award Process**

This table presents the results of a regression of firm R&D intensity onto *fitted* values of firm revenue, interacted with the degree to which a firm's contract revenue from federal R&D contracts was won competitively. $\widehat{GovRev}_{i,t}$ is the value of federal revenue, predicted by the first stage regression shown in Table 1, and is interacted with Competition_t, defined as the proportion of contract revenue for which more than 1 bid was received. R&D intensity is measured as firm R&D expense scaled by total Assets. $\text{GovRev}_{i,t}$, $\text{FCF}_{i,t}$, and $\text{OtherRevenue}_{i,t}$ measure firm revenue from the government, free cash flow (operating cash flow - capex), and revenue from other sources in period t. All are scaled by total assets. Age is measured in quarters, assets are measured in millions, and Total q is the Peters and Taylor (2017) intangible-adjusted q measure, available through WRDS. All dollar values are inflation adjusted to 2001. *,**, and *** indicate significance at the 10, 5, and 1% levels, respectively. These coefficients represent the impact of government funding on firm R&D activity, after correcting for potential endogeneity using SCO retirements and an instrumental variable.

Dep Var: RDIntensity_t	**1Q**	**2Q**	**3Q**	**4Q**
$\widehat{\text{GovRevenue}}_t$	0.0050***	0.0020**	-0.0000	0.0010
	(5.45)	(2.17)	(-0.01)	(0.96)
frac_competed_t	0.0003	-0.0003	0.0003	-0.0005
	(0.90)	(-0.66)	(0.72)	(-1.27)
$\widehat{\text{GovRevenue}}_t \times \text{frac\_competed}_t$	0.0152***	0.0158***	0.0124***	0.0164***
	(10.48)	(10.43)	(8.02)	(10.44)
GovRevenue_{t-1}	0.0032***	0.0033***	0.0054***	0.0012
	(3.23)	(3.26)	(5.26)	(1.14)
Total q_t	0.0000	0.0000	0.0000	0.0000
	(1.49)	(0.71)	(0.26)	(0.24)
FCF_t	-0.0981***	-0.0786***	-0.0652***	-0.0536***
	(-38.19)	(-29.74)	(-24.23)	(-19.57)
Other Revenue_t	0.0160***	0.0110***	0.0076***	0.0073***
	(10.51)	(7.02)	(4.74)	(4.44)
$\log(\text{Assets})_t$	-0.0058***	-0.0050***	-0.0046***	-0.0039***
	(-19.89)	(-16.80)	(-14.95)	(-12.44)
$\text{TotalLiabilities}_t$	0.0113***	0.0063***	0.0042***	0.0017***
	(21.21)	(11.21)	(7.20)	(2.77)
$\log(\text{Age})_t$	-0.0062***	-0.0054***	-0.0049***	-0.0062***
	(-8.32)	(-6.98)	(-6.16)	(-7.65)
NumSegments_t	0.0006***	0.0004***	0.0003**	0.0002*
	(5.57)	(3.97)	(2.48)	(1.79)
Constant	0.0700***	0.0662***	0.0636***	0.0662***
	(19.82)	(18.13)	(16.98)	(17.28)
N	34,097	33,201	32,317	31,461
R^2	0.7385	0.7295	0.7265	0.7277

Table 9: **Testing Predictions about the Impact of Firm Diversity**

This table presents the results from a regression of firm R&D intensity onto *fitted* values of firm revenue from federal R&D contracts in that quarter, along with a vector of control variables, this time testing the interaction between the contract revenue and the width of the firm's technological base. Columns (1) and (2) use the realized value of contract revenue, and (3) and (4) use the value predicted by the first stage regression shown in Table 1. $\text{GovRev}_{i,t}$, $\text{FCF}_{i,t}$, and $\text{OtherRevenue}_{i,t}$ measure firm revenue from the government, free cash flow (operating cash flow - capex), and revenue from other sources in period t. All are scaled by total assets. Age is measured in quarters, assets are measured in millions, Total q is the Peters and Taylor (2017) intangible-adjusted q measure, available through WRDS, and $NumSegments$ is the number of distinct Compustat business segments in which the firm operates in that period. All dollar values are inflation adjusted to 2001. *,**, and *** indicate significance at the 10, 5, and 1% levels, respectively. These coefficients represent the impact of government funding on firm R&D outputs, and demonstrates the over-estimation that occurs when failing to account for endogeneity.

Dep Var: RDIntensity_t	**1Q**	**2Q**	**3Q**	**4Q**
$\widehat{\text{GovRevenue}}_t$	-0.0038***	-0.0026*	-0.0044***	-0.0022
	(-2.74)	(-1.84)	(-3.02)	(-1.47)
NumSegments_t	0.0004***	0.0003***	0.0002	0.0001
	(3.55)	(2.79)	(1.47)	(0.97)
$\widehat{\text{GovRevenue}}_t \times \text{NumSegments}_t$	0.0094***	0.0056***	0.0051***	0.0042***
	(9.71)	(5.60)	(4.97)	(4.05)
GovRevenue_{t-1}	0.0031***	0.0032***	0.0052***	0.0009
	(3.14)	(3.13)	(5.13)	(0.91)
Total q_t	0.0000	0.0000	0.0000	0.0000
	(1.51)	(0.71)	(0.27)	(0.22)
FCF_t	-0.0977***	-0.0786***	-0.0650***	-0.0533***
	(-38.02)	(-29.69)	(-24.11)	(-19.43)
Other Revenue_t	0.0155***	0.0108***	0.0074***	0.0072***
	(10.19)	(6.89)	(4.58)	(4.35)
$\log(\text{Assets})_t$	-0.0056***	-0.0050***	-0.0045***	-0.0039***
	(-19.30)	(-16.51)	(-14.67)	(-12.26)
$\text{TotalLiabilities}_t$	0.0119***	0.0066***	0.0045***	0.0020***
	(22.14)	(11.80)	(7.75)	(3.35)
$\log(\text{Age})_t$	-0.0061***	-0.0053***	-0.0049***	-0.0062***
	(-8.19)	(-6.92)	(-6.14)	(-7.68)
Constant	0.0689***	0.0657***	0.0632***	0.0660***
	(19.47)	(17.96)	(16.85)	(17.19)
N	34,097	33,201	32,317	31,461
R^2	0.7383	0.7288	0.7261	0.7268

Table 10: **The Impact of Government Contracts on Patent Activity**

This table presents the results from a regression of firm patent activity onto firm revenue from federal R&D contracts in that quarter, along with a vector of control variables. Columns (1) and (2) use the realized value of contract revenue, and (3) and (4) use the value predicted by the first stage regression shown in Table 1 Patent output is measure by number of patents. $\text{GovRev}_{i,t}$, $\text{FCF}_{i,t}$, and $\text{OtherRevenue}_{i,t}$ measure firm revenue from the government, free cash flow (operating cash flow - capex), and revenue from other sources in period t. All are scaled by total assets. Age is measured in quarters, assets are measured in millions, Total q is the Peters and Taylor (2017) intangible-adjusted q measure, available through WRDS, and $NumSegments$ is the number of distinct Compustat business segments in which the firm operates in that period. All dollar values are inflation adjusted to 2001. *,**, and *** indicate significance at the 10, 5, and 1% levels, respectively. These coefficients represent the impact of government funding on firm R&D outputs, and demonstrates the over-estimation that occurs when failing to account for endogeneity.

Dep Var: # Patents_t	**1Q**	**2Q**	**3Q**	**4Q**
$\widehat{\text{GovRevenue}}_t$	3.6732***	3.9479***	4.0172***	4.3381***
	(4.33)	(4.57)	(4.57)	(4.88)
GovRevenue_{t-1}	-0.5077	-0.5667	-0.5760	-0.7637
	(-0.54)	(-0.61)	(-0.62)	(-0.83)
Total q_t	-0.0117	-0.0106	-0.0091	-0.0076
	(-0.82)	(-0.75)	(-0.65)	(-0.55)
FCF_t	-9.3859***	-8.4465***	-5.5380**	-4.6340*
	(-3.88)	(-3.46)	(-2.26)	(-1.88)
Other Revenue_t	6.4880***	4.8992***	4.6388***	2.8098*
	(4.54)	(3.38)	(3.17)	(1.91)
$\log(\text{Assets})_t$	4.7988***	4.6418***	4.4439***	4.2216***
	(17.49)	(16.71)	(15.84)	(14.98)
$\text{TotalLiabilities}_t$	-1.4610***	-1.5787***	-1.7870***	-1.9726***
	(-2.90)	(-3.06)	(-3.39)	(-3.68)
$\log(\text{Age})_t$	-0.3532	-0.0218	0.2064	0.5187
	(-0.50)	(-0.03)	(0.29)	(0.72)
NumSegments_t	-0.4990***	-0.4481***	-0.4651***	-0.4567***
	(-5.01)	(-4.48)	(-4.63)	(-4.55)
Constant	-13.7089***	-13.7462***	-13.1551***	-12.4919***
	(-4.12)	(-4.07)	(-3.85)	(-3.63)
N	34,097	33,201	32,317	31,461
R^2	0.9088	0.9110	0.9134	0.9168

Table 11: **The Impact of Government Contracts on Patent Citations**

This table presents the results from a regression of firm future patent relevance onto firm revenue from federal R&D contracts in the current quarter, along with a vector of control variables. Columns (1) and (2) use the realized value of contract revenue, and (3) and (4) use the value predicted by the first stage regression shown in Table 1. Patent citations is measured by the average number of future citations the firm's patents received, capturing how influential the patents will be going forward. $\text{GovRev}_{i,t}$, $\text{FCF}_{i,t}$, and $\text{OtherRevenue}_{i,t}$ measure firm revenue from the government, free cash flow (operating cash flow - capex), and revenue from other sources in period t. All are scaled by total assets. Age is measured in quarters, assets are measured in millions, Total q is the Peters and Taylor (2017) intangible-adjusted q measure, available through WRDS, and $NumSegments$ is the number of distinct Compustat business segments in which the firm operates in that period. All dollar values are inflation adjusted to 2001. *,**, and *** indicate significance at the 10, 5, and 1% levels, respectively. These coefficients represent the impact of government funding on firm R&D outputs, and demonstrates the over-estimation that occurs when failing to account for endogeneity.

Dep Var: Avg Citations_t	**1Q**	**2Q**	**3Q**	**4Q**
$\widehat{\text{GovRevenue}}_t$	-0.6117	-0.6474	-0.4470	-0.8522
	(-1.05)	(-1.10)	(-0.75)	(-1.42)
GovRevenue_{t-1}	0.1588	-0.0083	0.5619	0.3450
	(0.25)	(-0.01)	(0.89)	(0.56)
Total q_t	-0.0058	-0.0053	-0.0031	-0.0026
	(-0.59)	(-0.55)	(-0.32)	(-0.28)
FCF_t	0.7307	-0.6207	1.9263	1.2806
	(0.44)	(-0.37)	(1.15)	(0.77)
Other Revenue_t	-0.7834	-0.3557	-0.5421	0.1451
	(-0.80)	(-0.36)	(-0.54)	(0.15)
$\log(\text{Assets})_t$	-1.3007***	-1.2659***	-1.3435***	-1.3144***
	(-6.89)	(-6.67)	(-7.04)	(-6.90)
$\text{TotalLiabilities}_t$	-0.1293	-0.0926	0.0457	0.0821
	(-0.37)	(-0.26)	(0.13)	(0.23)
$\log(\text{Age})_t$	-2.9660***	-3.0927***	-2.6897***	-2.5362***
	(-6.15)	(-6.37)	(-5.49)	(-5.18)
NumSegments_t	0.1343*	0.1538**	0.1751**	0.1813***
	(1.96)	(2.25)	(2.56)	(2.67)
Constant	26.9005***	26.9103***	25.4421***	24.2861***
	(11.74)	(11.67)	(10.95)	(10.46)
N	34,097	33,201	32,317	31,461
R^2	0.4678	0.4695	0.4686	0.4723