Big G*

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Abstract

The literature typically uses "Big G" to refer to aggregate government spending on a homogeneous good. In this paper, we open the black box by analyzing the entire universe of procurements contracts of the US government and establish five facts. First, government spending is granular, that is, it is concentrated in relatively few firms and sectors. Second, relative to private expenditures its composition is biased. Third, procurement contracts are short-lived. Fourth, the fluctuation of spending is dominated by idiosyncratic variation. Last, government spending is concentrated in sectors with relatively sticky prices. Accounting for these facts within a stylized New Keynesian model offers new insights into the fiscal transmission mechanism: fiscal shocks hardly impact inflation, little crowding out of private expenditure exists, and the multiplier tends to be larger compared to a one-sector benchmark aligning the model with the empirical evidence.

Keywords: government spending, federal procurements, granularity, sectoral heterogeneity, fiscal policy transmission, monetary policy

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1 Introduction

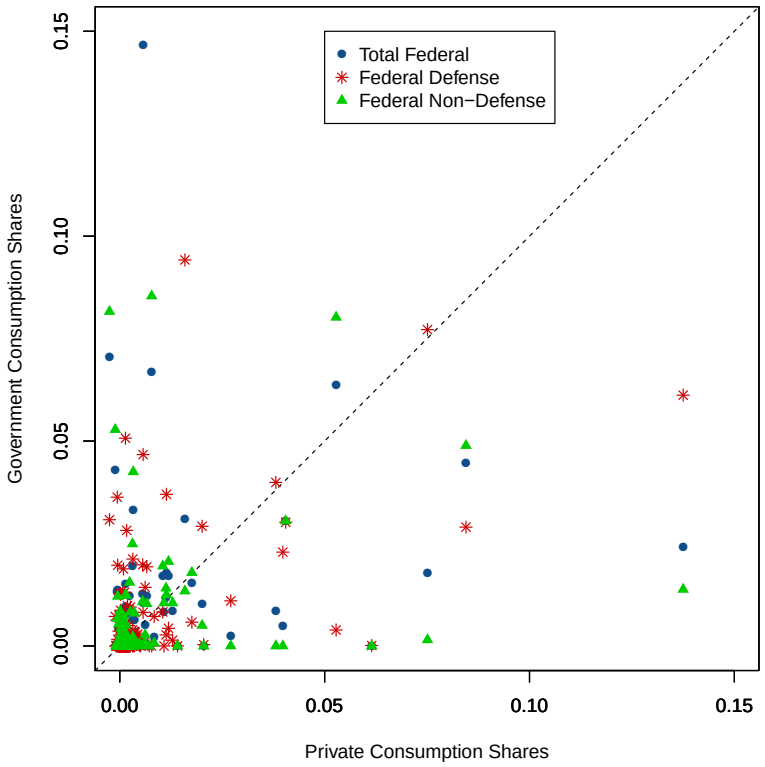
What is "Big G"? In the national accounts it refers to "government spending"—the part of GDP that comprises government expenditures. Perhaps because of this convention, the research on fiscal policy typically entertains a somewhat crude notion of government spending as a homogeneous good, isomorphic to GDP. In empirical and theoretical work it is frequently referred to as Big G, and the literature assumes policy makers can freely adjust it over time—in response to the business cycle, or for other reasons. The recent "renaissance of fiscal research" survey by Ramey (2019) has changed little in this regard. A number of recent contributions have started to study the role of heterogeneity in the fiscal transmission mechanism focusing exclusively on heterogeneity on the household side (McKay and Reis, 2016; Auclert et al., 2018; Hagedorn et al., 2019).

Starting point of our paper is the observation that Big G itself is fundamentally heterogeneous. Government spending is not simply one large transaction. It is composed of a large number of smaller transactions whose composition differs from the other components of aggregate demand. Empirically, we first establish five facts about government spending by characterizing the underlying components of Big G. In the second part of the paper, we then study the role of these facts for the through the lens of a stylized New Keynesian model. Accounting for the heterogeneity of government spending has first-order effects on the fiscal transmission mechanism aligning the model prediction with empirical evidence.

We construct our empirical anatomy of Big G using a database that has only recently become accessible: USASpending.gov. The database provides detailed information on the entire universe of procurements by the US federal government since 2001. These data capture about half of federal consumption expenditures which, in turn, account for about one half of general government spending. For each year, the database records several million government procurement transactions. We establish five facts on the basis of detailed analysis of these data.

The first of our five facts is government spending is granular in the sense of Gabaix (2011). Few firms and sectors supply a large share of government consumption: (i) The largest 20% of suppliers supply 99% of government consumption and their size distribution follows a power law. (ii) The top 10 firms—or the top 0.01% —supplying goods and services to the federal government receive more than 35% of all procurement contracts by value and the top 0.1% of firms receive almost 60%. (iii) The most important suppliers to the federal government are concentrated in few sectors: firms in the largest three out of the roughly 20 two-digit NAICS industries supply more than 60% of all government contracts and the top 1 percent of just over 1,000 six-digit NAICS industries make up around 40% of all government spending. Decomposing

Figure 1: Consumption Shares: Government vs Household



Notes. This figure shows the fraction of government spending in a certain sector on the y-axis and the fraction of private spending in a certain sector over total private spending on the x-axis. We separate total federal spending (blue circles) into defense spending (red asterisks) and non-defense spending (green triangles). We use the BEA *Use Table* to calculate private consumption shares. The sample represents averages over the period between 2001 and 2018.

the total cross-sectional variance of government contracts, we find almost 100% of the variation is "within" firms or sectors and almost none is "across" firms or sectors providing further evidence of the granular nature of government spending.

The second fact is the existence of a sectoral bias in government spending: the share of government spending in each sector differs substantially from the share consumers spend on the goods and services of that sector. Figure 1 shows the share of spending on output of a certain sector relative to total government spending on the vertical axis, and private consumption on the horizontal axis. We separate total federal spending (blue circles) into defense spending (red asterisks) and non-defense spending (green triangles). Both for overall federal spending, but also both subcomponents, we see a substantial difference in the spending patterns of consumers and the government. Some sectors that are negligible for the government make up for about 14% of private consumption, whereas sectors that are unimportant for consumers are big suppliers to the

government. This sectoral bias also holds for non-defense spending. Hence, government spending varies across sectors and does not purely mimic consumer spending. In earlier work, Ramey and Shapiro (1998) stressed the importance of sectoral bias for the fiscal transmission mechanism. Until now, however, no data was available to establish the sectoral bias of government spending systematically.

Third, we show government contracts have a short duration and are often modified. The median contract has a duration of 33 days, 80 percent of contracts last less than one year, and about 30 percent of contract transactions represent modifications to initial contracts. Hence, the government does not tend to enter long-term contracts with suppliers, and changes in spending across firms and industries are potentially important.

As a fourth fact we establish idiosyncratic shocks dominate the fluctuations in government spending over time – rather than in the cross section (addressed by our first fact). To establish this fact, we first estimate AR(1) processes for government spending at the sectoral level and study the correlations in the residual spending across sectors. Aggregate shocks, which we capture through time fixed effects, play a negligible role for changes in sectoral government spending over time. Hence, large variation of government spending over time exists that variation in Big G cannot account for. Instead, if an innovation occurs, it is idiosyncratic at the sectoral level. These innovations have both large negative as well as large positive correlations for many sector pairs. Overall, sectoral government spending is generally relatively persistent, consistent with our cross-sectional variance decomposition. Second, considering the aggregate level, we use growth rate decompositions such as Gabaix (2011) or Foerster et al. (2011) to show that idiosyncratic shocks, both at the firm and the sectoral level, are again key drivers of variation in government spending over time.

Our fifth and last fact is that government consumption tends to be concentrated in sectors with a relatively high-degree of price stickiness. The frequency of price changes in the top two NAICS two-digit sectors is 9% while it is on average 20% for the remaining sectors in the economy. The average frequency of price changes overall is 16% which corresponds to prices adjusting approximately every 6 months. Our detailed contract data allow us to further characterize the way in which prices are sticky. The contract data contain information on the types of contracts between buyer (the government) and sellers. We find that the majority of contracts—over 85 percent— are "fixed-price" in nature. This finding also speaks to a question at the heart of the New-Keynesian model of whether contracts are allocative or not, as pointed out by Barro (1977). When a contract fixes a price, but not necessarily a quantity, monetary policy shocks will affect quantities demanded. While this may not be the exact case for government

spending, information about the distribution of contracts is likely informative about the US private sector distribution as well, which so far has not been studied to the best of our knowledge.

The facts we establish might not appear surprising but so far, they have not been documented in the literature. To better understand whether they matter from a macro perspective, we feed in these facts into a two-sector Keynesian model with government spending (Woodford, 2011) and compare the implications of the model to a one-sector model. The model is deliberately stylized in order to account for the five facts as clearly as possible while only minimally departing from the conventional one-sector model. Importantly, rather than postulating a process for Big G, as is commonly done, we model government spending in each sector as a distinct variable.

Sectoral heterogeneity induces profound changes in the fiscal transmission mechanism in our two-sector model relative to the benchmark economy. We derive a number of closed-form results for the limiting case in which prices are completely flexible in one sector. If government spending is biased towards the flex-price sector, crowding out of private expenditure can be infinite. Empirically, however, government spending is biased towards the sticky-price sector. An increase of government spending in the sticky-price sector induces very little crowding out of private expenditure, and hence the output multiplier is considerably larger. We also run model simulations and show the sectoral heterogeneity of government spending matters quantitatively. Specially, we calibrate the model to capture key features of data, including the actual degree of price rigidities as well as the sectoral composition of government spending and the relative size of sectors. A fiscal shock in the relatively small and sticky-price sector towards which government spending is biased induces a multiplier effect about three times larger than a shock in the other sector. Moreover, and perhaps surprisingly, the multiplier effect becomes even bigger if prices are more flexible in the sector in which private expenditure is concentrated. Hence, just like Barsky et al. (2007) show for the transmission of monetary policy, we observe that the degree of price stickiness in the relevant sectors is essential, not the economy-wide stickiness.

At a conceptual level, the heterogeneity of government spending that we document makes the New Keynesian model "more Keynesian." In the New Keynesian model, monetary policy is at the heart of the fiscal transmission mechanism (Woodford, 2011; Christiano et al., 2011; Farhi and Werning, 2016). Government spending is inflationary and thus (generally) triggers a response of the central bank. The resulting interest rate increase crowds out private expenditure because of intertemporal substitution. As a result, the multiplier is smaller than unity—in contrast to the textbook IS-LM model where no intertemporal substitution takes place. Recently, a number of contributions introduce household heterogeneity and credit frictions in

New Keynesian models in order to limit intertemporal substitution (Galí et al., 2007; McKay et al., 2016; Kaplan et al., 2018). We show sectoral heterogeneity in spending by households and the government combined with sectoral heterogeneity in pricing frictions has a similar effect. In a nutshell, since the government spends in relatively sticky-price sectors and the private sector spends in relatively flexible-price sectors, inflation is more responsive to private expenditure than to government spending. Such differential heterogeneity in turn dampens the monetary response to a fiscal impulse: there is less intertemporal substitution, less crowding out, and the multiplier is larger.

Empirically, accounting for sectoral heterogeneity helps the model to generate predictions that align better with the time series evidence than predictions from the conventional one-sector model. Many studies have established that the response of interest rates, both nominal and real, as well as the response of inflation to fiscal shocks tend to be weak or even negative (Mountford and Uhlig, 2009; Corsetti et al., 2012; Ramey, 2016). This prediction is exactly what our model generates. Once we modify the model to account for the microevidence on government spending, it also gets the macroevidence right.

Our paper is related to recent work on the effect of regional fiscal policies in monetary unions (Galí and Monacelli, 2008; Nakamura and Steinsson, 2014; Hettig and Müller, 2018). In this literature, government spending is concentrated in some spatial partition of the economy, and its composition is biased relative to the composition of private expenditures. Just like in our analysis, the effects of fiscal policy turn out to be highly sensitive to the conduct of monetary policy. In contrast to this earlier work, we model private expenditure as being determined at the aggregate level rather than at the regional/ sectoral level. Chodorow-Reich (2019) surveys the recent empirical work on government spending multipliers based on cross-sectional data. Last, we also share modeling features with a number of recent papers that account for heterogeneity on the production side across sectors and firms, tracing out the implications for the business cycle (Acemoglu et al., 2012, 2016; Pasten et al., 2019a,b; Baqaee and Farhi, 2019; Ozdagli and Weber, 2017). Bouakez et al. (2018), in particular, study theoretically the transmission of fiscal policy shocks in a rich model featuring heterogeneity in sector size and input-output structure.

2 Data

2.1 Background on USASpending

In the first part of this paper, we undertake a comprehensive analysis of the USASpending.gov database—the official source for federal spending data.[1] The database was created in response to the Federal Funding Accountability and Transparency Act (FFATA), which was signed into law on September 26, 2006. FFATA required that federal contract, grant, loan, and other financial assistance awards of more than $25,000 are publicly accessible on a searchable website, in an effort to provide transparency to the American people on how the government spends their tax dollars.[2] In accordance with FFATA, federal agencies are required to collect and report data on federal procurements. Agencies must report award data—contracts, grants, loans, and other financial assistance— on a monthly basis through various government systems such as the Federal Procurement Data System (FPDS-NG) for contract data and the Data Act Broker for grant, loan, and other financial assistance data. Some agencies report frequently during a month, while others report oncen a month or even less frequently if they do not issue awards on a monthly basis. The USASpending.gov database which the Treasury Department hosts, compiles the data from the various government reporting systems. In addition to directly uploading the information which the federal agencies report to systems like the FPDS-NG, the site also utilizes information collected from the recipients of the awards themselves.[3] Though FFATA was not signed into law until 2006, data are available back to 2001.[4]

2.2 What are Government Contracts?

In this analysis, we focus on a subset of federal spending—spending on goods and services via government contracts. "Contract actions," as defined by the Federal Acquisition Regulation (FAR), are *"any oral or written action that results in the purchase, rent, or lease of supplies or equipment, services, or construction using appropriated dollars over the micro-purchase*

[1] Demyanyk et al. (2019) and Auerbach et al. (2019) also rely on this database but their focus is on estimating fiscal multipliers. They rely exclusively on contracts awarded by the Department of Defense. One average these account for about half of the transactions in the database by count and for about two thirds by value. Appendix A provides an overview of other similar data that have been used in the literature.

[2] The transparency efforts of FFATA were later expanded with the enactment of the Digital Accountability and Transparency Act (the DATA Act) of 2014, which expanded FFATA and improved the quality of data submitted to USASpending.gov by holding agencies accountable.

[3] Entities that receive awards directly from federal agencies submit data on their awards to the FFATA Sub-award Reporting System (FSRS), and some businesses are required to report their Highly Compensated Executives data to the System for Award Management (SAM).

[4] According to USASpending.gov, prior to 2006, certain aspects of the data were collected by an external organization. When FFATA was passed, the government licensed the external organization's software and incorporated the data into the USASpending database.

threshold, or modifications to these actions regardless of dollar value."[5] As the definition suggests, the goods and services that the government consumes through contracts span a wide range, from janitorial services for federal buildings to IT support services to airplanes and rockets. Contracts can be short-term—e.g., a one-month contact awarded by the Department of Agriculture Rural Housing Service to Sikes Property And Appraisal Service for single family housing appraisals in September 2008[6]—or longer-term relationships—e.g., the 43 year and 10 month contract awarded by the Department of Energy to Leland Stanford Junior University for the operation and management of the SLAC National Accelerator Laboratory[7]. In awarding contracts, federal agencies must abide by the guiding principles set forth in the Federal Acquisition Regulations (FAR). The FAR includes directives on every aspect of contracting, from how contracts should be structured and priced, to how they should be solicited to promote competition and encourage small business participation.

2.2.1 Type of Award

There are different types of awards the government can use to procure services. The majority of federal spending through contracts is done through either a definitive contract action (DCA) or a delivery order. A DCA is a legally binding agreement obligating the seller to furnish certain supplies or services and the buyer to pay for them. For example, on April 27, 2018, Lockheed Martin was awarded an $828,724,214 contract to build Guided Multiple Launch Rocket Systems for the Department of the Army. Funds for the project were obligated at the time of the award[8], and the expected time of completion is September, 2021.

A delivery order, on the other hand, is a contract that does not specify a firm quantity of property, but provides issuance of orders for the delivery of goods or services during the period of the contract. For example, on January 21, 2015, a company called Ace Maintenance & Services, Inc. was awarded a $13,663,688 contract for janitorial services at Naval Support Activity Bethesda. The work to be performed under the contract included all labor, supervision, management, tools, materials, equipment, facilities, incidental engineering, and other items necessary to provide janitorial services. The initial contract action was for a base period of one year and one month, with four additional option years. The contract stipulated a maximum

[5]The micro-purchase threshold is $3,500; higher in particular cases. We do observe transactions below the micro-purchase threshold, just not contracts as a whole. Contract actions do not include things like grants, cooperative agreements, real property leases, requisitions from Federal stock, training authorizations, or other transactions that are not based on the Federal Acquisition Regulations.

[6]This contract was for $15,000 between September 3, 2008 and September 30, 2008.

[7]So far, between November 20, 1978 and today, over $10.5 billion has been obligated. The period of performance of the contract extends to September 30,2022 and the total potential award amount is just under $12 billion.

[8]Since the time of the award, options have been exercised, and a total of about $1.9 billion has since been obligated.

dollar amount for the base period and four option years of $69,698,540.[9] DCAs tend to be used for larger, one-time purchases, while delivery orders are used for smaller and more frequent purchases. (See appendix B.1 for more details on different types of awards.)

2.2.2 Type of Contract Pricing

In addition to the type of award, a wide selection of types of contract pricing are available to the Government and contractors. Contract types are grouped into two broad categories: fixed-price contracts and cost-reimbursement contracts. Within those categories, specific contract types vary according to the degree of risk placed on the contractor for the costs of execution of the contract, and the nature of the incentives offered to the contractor for their performance. The most common type of contract is a firm-fixed-price contract, which details a price that is not subject to any adjustment, regardless of the contractor's actual cost experience in executing the contract. Fixed-price contracts can also include provisions for economic adjustment or incentive payments, somewhat reducing the risk placed on the contractor.

Cost-reimbursement contracts are also frequently implemented, and typically include a negotiated fixed fee or an award amount on top of the reimbursement payment. We discuss in further detail what the data on contract pricing look like when we discuss our fifth fact in the next section.

The pricing structure of a contract depends on many factors—price competition, the complexity and urgency of the requirement, and the length of the contract, to name a few. Many contracts are complex and require hybrid pricing structures—the Multiple Launch Rocket System contract mentioned above, for example, is a "cost-plus-fixed-fee, firm-fixed-price, and fixed-price-incentive" hybrid. According to the FAR, "the objective is to negotiate a contract type and price (or estimated cost and fee) that will result in reasonable contractor risk and provide the contractor with the greatest incentive for efficient and economical performance."

2.2.3 Extent Competed

Federal regulations[10] also require, with certain exceptions, contracting officers promote and provide for full and open competition in soliciting offers and awarding Government contracts. In most cases, agencies are directed to use sealed bids, competitive proposals or some combination of competitive procedures to solicit and issue awards. Ultimately, about half of the contracts

[9] The option years were not exercised. A total of $14,401,212 was awarded during the base period between January 21, 2015 and February 29, 2016.

[10] Specifically, the Competition in Contracting Act (CICA) of 1984 (41 U.S.C. 253).

that are awarded are done so under full and open competition via negotiated proposal.[11] The Ace Maintenance & Services, Inc. contract for janitorial services, for example, was solicited using the Navy Electronic Commerce Online website, and seven proposals were received.[12]

A number of cases, however, exist, in which full and open competition is not required. A large number of contracts are deemed "not available for competition," in which case agencies are authorized by statute to solicit bids from only one source.[13] Solicitation from one source is authorized if, for example, the supplies or services required by the agency are available from only one responsible source or, for the Department of Defense, NASA, and the Coast Guard, from only one or a limited number of responsible sources. Supplies can also be deemed available from only the original source if the contract is a follow-on to an existing contract for the continued development or production of a major system or highly specialized equipment. This was the case for the Lockheed Martin contract for Guided Multiple Launch Rocket Systems.

Finally, for smaller awards—those below a certain dollar threshold[14]—federal agencies are required to use "Simplified Acquisition Procedures (SAPs)," which reduce administrative costs, increase efficiency, and improve opportunities for small and minority-owned businesses. (See appendix B.2 for more detail.)

2.3 Scope of the Dataset

The dataset we use includes the universe of federal government contract transactions from fiscal years 2001 through 2018[15] On average, 3.2 million individual contract transactions records exist each year—with almost 5 million annual contracts toward the end of the sample period. The contracts are awarded to over 160 thousand recipient parent companies each year, spanning almost 1400 six-digit NAICS sectors. The median transaction value is just under $2,300, while the mean transaction value is just under $140,000, suggesting the distribution is heavily skewed right. The majority of contract transactions (82 percent) represent positive obligations from the government to firms, but there are also transactions with negative value, or deobligations, which occurs when a modification to an initial contract is performed (see section 3.3 for more on this). Government consumption in the form of federal contract obligations represents 12 to

[11] This is true both by count and by value of contracts.

[12] The FAR provides guidance on how agencies should evaluate submitted proposals and ultimately negotiate contracts with the best candidate.

[13] International agreements, utilities, and authorized retail can also fall under the "not available for competition" exception.

[14] The SAP threshold is $150,000, though this can vary by situation. A lower bound to the threshold exists—$3,000—below which a purchase is considered a "micro purchase," and different acquisition procedures apply.

[15] Data for fiscal years 2008-2018 can be downloaded from the "Award Data Archive" on the USASpending.gov site. Prior to fiscal year 2008, we use the Custom Award Data download to download all prime award contracts for fiscal years 2001 through 2007.

18 percent of general government spending, or about 2 to 4 percent of GDP over the sample period. Figure 2a shows contract obligations are roughly equivalent to total federal government expenditures and gross investment (from the National Income and Product Accounts) less compensation of employees and consumption of capital.

Each observation in the data traces a contract action from its origin (the parent agency) to the recipient firm (which can be a subsidiary of a parent firm) and the sector and zip code within which the award is employed (see figure 23 in appendix B.3 for a schematic representation of the data). Six variables uniquely identify each observation: (1) an award identification number, (2) a modification number, (3) a transaction number, (4) a parent award identification number, (5) an awarding sub agency code, and (6) a parent award modification number.

In our analysis, we outline a number of facts about what we refer to as individual transactions (the observation level of the data), firm-level statistics—in which we aggregate by the recipient parent firm, and sector-level statistics—in which we aggregate by the two-digit NAICS sector. The value of each contract transaction, or obligation, is given by the "federal action obligation"—the government's liability for an award transaction. Each transaction is associated with a start and end date for the period of performance of that transaction (barring any subsequent modifications), which we use to calculate "duration." Finally, a transaction will have a "modification number" if it represents an action that makes a change to an initial award. In section 3, we use these detailed data to document a number facts about the idiosyncratic nature of this portion of government spending.

3 Facts on Government Spending

Government spending is conventionally viewed as a homogeneous good—a relatively stagnant fraction of GDP that is determined by an ethereal government entity, "G." In this section, we will describe five facts about government spending that illustrate that government spending is in fact heterogeneous in nature. The granularity in government spending echoes the recent focus on granularity in the firm-size distribution and the input-output structure of the economy but is distinct from it as we show below (Gabaix (2011) and Acemoglu et al. (2012)).

3.1 Granularity

This subsection presents our first and most fundamental fact, that government spending is "granular". We use different methods to illustrate this fact, reflecting that we can define granularity in several ways. A common definition of granularity is that a few sectors or firms

are disproportionately larger than others. A stricter definition of granularity is in terms of fat tails (see for example Gabaix (2011)): When the size distribution of sectors or firms follows a power law and exhibits fat tails, then some firms or sectors are disproportionately large and granular.[16]

Government spending is granular according to both definitions. First, it is concentrated among a few firms and sectors. Second, we show that statistically, the government spending distribution at the contract level is well approximated by a power law.

Fact 1 *Government spending is "granular:"*

1. *The top 1% of firms receive 80% of all contract obligations and the top 1% of six-digit sectors receive 40% of all contract obligations (where rank is defined in terms of firm or sector sales). The top 0.01% of firms receive 30% of contract obligations.*

2. *Nearly 100% of cross-sectional variation in contract spending is within firms or sectors, rather than across.*

3. *The size distribution of contracts has fat tails. It follows a power law with a decay parameter of* 0.67.

3.1.1 Spending is Concentrated Among Firms and Sectors

The first sense in which government consumption is granular is that it is highly concentrated among firms and sectors. The data support this hypothesis: The ten largest suppliers (or top 0.01%) of goods and services to the government account for about one third of total government consumption, and the top 0.1% of firms account for just under one half of total government consumption. Figure 3 illustrates this unequal distribution in the left panel. To put this into perspective, we note on average some 140,000 firms exists in our sample.

Spending is similarly concentrated among sectors. The right panel of Figure 3 shows over 60% of contract obligations are directed toward the top three (of roughly 25) two-digit NAICS sectors: 33—manufacturing; 54—professional, scientific, and technical services; and 56—administrative and waste management. The middle panel of Figure 3 shows similar patterns at the more disaggregated sector level—the top 1% (of roughly 1200) six-digit sectors account for about 40% of government consumption, while the top 10% of six-digit sectors account for

[16]Suppose that government contracts, G, are distributed according to a power law. Then $P(G > x) = ax^{-\zeta}$ for $x > x_m$ where $x_m = a^{\frac{1}{\zeta}}$. This distribution has fat tails if the shape parameter ζ is small such that the distribution is characterized by excess kurtosis or skewness, relative to normal or exponential distributions. For example, for $\zeta < 2$ skewness and variance are not defined and infinite in the tail, hence the power law has fat tails.

over 80% of government consumption. Figure 3 also shows the concentration of spending among firms and sectors has been fairly stable over time.

3.1.2 Large Contracts and Firms drive Cross-sectional Variance

We can show further evidence of the granular nature of government spending by looking at a decomposition of the variance of government contracts into the variation that occurs within firms, and the variation that occurs across firms. We also consider variation that occurs within sectors versus across sectors. The first decomposition starts with the contract transaction level as the smallest unit of observations, the second with the firm. Specifically, we first calculate:

$$\sum_f \sum_{i \in f} (g_{if,t} - \bar{g}_t)^2 = \underbrace{\sum_f \sum_{i \in f} (g_{if,t} - \bar{g}_{f,t})^2}_{\text{Within Firm}} + \underbrace{\sum_f \sum_{i \in f} (\bar{g}_{f,t} - \bar{g}_t)^2}_{\text{Across Firm}}$$

where $g_{if,t}$ is the total amount given to individual contract i at firm f in year t, $\bar{g}_{f,t}$ is the firm average in year t, and $\bar{g}_t$ is the overall average in year t. Figure 4 shows this decomposition for all contracts in the left panel, for the top 20% of contracts (which represent 97% of the total value of contracts) in the middle panel, and for the bottom 80% of contracts in the right panel. We find a striking result due to fat tails in the distribution of contract size: when we look at the within-firm versus across-firm breakdown for all firms, almost 100% of the variation is "within"—meaning substantial variation exists in the range of contract sizes that an individual firm receives, which completely outweighs any variation in the size of contracts across different firms.

The fat right tail of the contracts data fully drives this result. The empirical variance at the granular level is large and dominates the decomposition. The left panel of Figure 5 shows the density of the log of individual contracts, the density of the log of the average contract amount by firm, and the log of the average contract amount overall. The fat right tail of individual contracts is visually apparent, and it gets averaged out at the firm level, creating the high within-firm variation. Looking at the middle and right panels of Figure 5, the top 20% of contracts fully determine this within result. When we restrict our attention to the bottom 80% of contracts, the fat tails are absent and both within- and across-firm variation are present.

Granularity across firms also has strong implications for the variance decomposition within and across sectors. Instead of looking at the variance of the size of individual contracts within and across firms, we can sum contracts up to the firm level, and decompose the overall variance

into the within-sector and across-sector components. Specifically, we calculate:

$$\sum_s \sum_{f \in s} (g_{fs,t} - \bar{g}_t)^2 = \underbrace{\sum_s \sum_{f \in s} (g_{fs,t} - \bar{g}_{s,t})^2}_{\text{Within Sector}} + \underbrace{\sum_s \sum_{f \in s} (\bar{g}_{s,t} - \bar{g}_t)^2}_{\text{Across Sector}}$$

where $g_{fs,t}$ is the total amount given to firm f in sector s in year t, $\bar{g}_{s,t}$ is the sector average in year t, and $\bar{g}_t$ is the overall average in year t. Figure 6 shows "within sector" variation dominates across all parts of the distribution. Hence, larger variation exists across firms within a sector, than across sectors within the economy.

Just as in the firm-level exercise, the fat right tail in the data again drives this result. Figure 7 shows the density of firm size has a fat right tail in the case of the full dataset (left panel) and top 20% of firms (middle panel) but a fat left tail in the case of the bottom 80% of firms. In all cases, the fat tail is averaged out at the sector level, creating the high within-sector variation that we see across the board.

3.1.3 The Size Distribution of Contracts Has Fat Tails

Government spending is granular in the sense that the distribution of government contracts is fat tailed. The simplest way to quantitatively illustrate this point is to show that a power law with shape parameter $\zeta < 2$ approximates the distribution of government contracts well. The density of a simple power law is given by $f(x) = \zeta a x^{-(\zeta+1)}$, so the log density is given by:

$$\ln\left(f(x)\right) = -(\zeta + 1)\ln(x) + C$$

where C is a constant. Thus, when we plot the empirical log contract size against the log frequency of that contract size, we should expect to see a straight line.

The left panel of Figure 8 documents a linear relationship between the log size of firm obligations and the log frequency when we use the top 20% of suppliers that supply 99% of government consumption. The right panel of the figure shows the same relationship also holds at the contract level (for the top 20% of contracts, which account for 97% of government consumption).

Assuming the data do, indeed, follow a pareto distribution, we can estimate the parameters of the distribution via maximum likelihood. We estimate a shape parameter of $\zeta = 0.67$ which indicates fat tails. The estimated distribution provides a good fit to the data. Figure 9 shows the histogram of (the log of) contract obligations and the simulated probability density function using the estimated parameters.

3.2 Sectoral Bias: Differential Granularity

So far we have shown that government spending is skewed towards a few firms and sectors. The second fact we present in this section establishes that government consumption is special in this respect compared to household consumption. The composition of government spending across sectors is distinct from the composition of the private consumer basket, which is a natural benchmark for economic activity. The most important firms and sectors as suppliers to the government differ substantially from the most important firms and sectors supplying to private households.

Fact 2 *Government spending is sectorally biased."*

1. *The top 0.01% of recipients of government obligations account for 17% of average annual government consumption, but only 2% of average annual sales.*[17]

2. *The sector with the largest share in government spending (NAICS 33 — manufacturing) receives 31% of government obligations, but accounts for only 6% of value added. The sector with the largest share in private consumption (NAICS 53 — real estate, rental, and leasing) accounts for 13% of value added, but less than 1% of government obligations.*

We illustrate this result in figure 1. The vertical axis measures the share of a (six-digit) sector k, in total government spending, $\frac{G_k}{G}$. The horizontal axis measures the share of the same sector in private consumption $\frac{C_k}{C}$. In the figure we also distinguish between total federal spending (blue circles) and defense spending (red asterisks) and non-defense spending (green triangles).

For overall federal spending and each of its subcomponents, the public and private sectoral spending shares differ substantially. That is, $\frac{G_k}{G} \neq \frac{C_k}{C}$. Some sectors that are big suppliers to the government are almost negligible for private consumers. Sector 541300—Architectural, Engineering, and Related Services, for example, accounts for 15% of government consumption but less than one percent of private consumption. The converse is also true.

In a similar vein, Table 2 shows that in 2017, the bias in government spending runs both ways.[18] Manufacturing (NAICS 33), for example, accounted for over 30% of government consumption in 2017, but under 7% of value added. Conversely, in that same year, real estate, rental, and leasing (NAICS 53) accounted for 13% of value added, but less than 1% of government consumption. Finally, this feature holds at the firm level as well—Table 3 compares the top 35 firms in terms of average annual contract obligations to the top 35 non-oil firms from Compustat

[17] Based on sales of all firms in Compustat.

[18] Value added shares come from the National Income and Product Accounts.

in terms of average annual sales between 2001 and 2018. Little overlap exists in the firm lists, with only a few firms like Boeing and General Electric showing up in both lists, albeit in very different orders. Table 7 in appendix section C.1 presents further details on the exact shares for the government and private sector consumption shares of the top 10 firms. Taken together, the evidence indicates the government spending varies across sectors and its composition does not mimic that of private consumption.

3.3 Short Duration

So far, we have documented that government spending is skewed towards very specific sectors and firms. We now turn to the variation of spending over time. The third fact we establish is that government contracts tend to be relatively short lived. Moreover, they are frequently modified.

Fact 3 *Government spending is characterized by short contract durations:*

1. *The median contract has a duration of 33 days.*
2. *80% of contracts last less than 1 year.*

To arrive at this result, we carefully consider the difference between transactions and the overarching contract structure. Each "contract" can be made up of a bundle of transactions—the observation level of the data. Some simple purchases may be made with a single transaction, while others may have hundreds of transactions over the life of the contract that continuously modify the order or relationship. Each transaction is associated with an action date—the date when the reported action was issued, a period of performance start date—the date that the transaction begins, and a period of performance end date—the current date when the transaction ends (barring subsequent modifications). We calculate the "duration" of a transaction as the difference between the period of performance start date and the current end date. Similarly, we calculate the duration of a contract as the difference between the period of performance start date of the earliest underlying transaction and the current end date of the latest underlying transaction.

Durations of transactions and contracts can range from 0 days—this might be a transaction that makes an administrative change, closes out an order, or represents a one time purchase of a commercially manufactured good—to over a decade—a contract funding research and development, for example. The length of the transaction depends entirely on the nature of the relationship and the provided product or service. Overall, however, contracts tend to have short lifespans. Over the entire sample, the median contract has a duration of only 33 days.

Figure 10 shows in each year, about 80% of contracts have durations of less than one year.[19] The figure and Table 4 also show the distribution at the transaction level is almost identical. The similar statistics at the transaction and contract level implies that only very large contracts include multiple transactions.

In addition to being relatively short, contracts are frequently modified. An observation in the data will have a "modification number" if it represents a transaction that makes a change to an initial award. There are twenty different types of modifications, some of which reflect no change to the initial value of the contract, like a change of address, and some of which reflect either additional obligations or deobligations, like an order for additional work. Figure 12 shows the time series of spending summing only modification spending, as well as the series of spending summing the disjoint non-modification spending. Spending through modification transactions is substantial, and is in fact higher than spending from initial (non-modification) transactions.

Occasionally, modifications are used to correct data entry errors. In these cases, we see (sometimes large) obligations that are almost immediately followed by a de-obligation of similar magnitude, under the same award identification number and directed to the same recipient. For example, Figure 20 in the Appendix shows the individual transactions that made up a contract given by the Department of the Army to Emerson Construction Company for the construction of the Army Reserve Center in Fort Worth, Texas. Line 1 shows an obligation of $13,917,176,427 was made on September 29, 2008. Line 2, however, shows that on January 7, 2009, most of this was offset by a $13,901,924,427 de-obligation. The description of the de-obligation transaction says that the modification was made to "correct subclins", or sub-contract line item numbers. In other words, it sounds like an administrative error was made. Netting these two roughly $13 billion transactions out, and combining the sum with the rest of the transactions associated with that contract, it appears that a total of $16.3 million was ultimately obligated to Emerson Construction Company. The Emerson Construction Company website advertises that they completed the construction of the Army Reserve Center for exactly this amount.[20] Over the entire sample period, there are about 1 million observations (or less than 2% of observations) that are part of these "offsetting transaction pairs."

Our general approach to deal with such errors is the following: in cases where two potentially offsetting contracts are within 0.5% of each other, we combine the two transactions into one, and apply the net amount to the date of the earlier of the two offsetting transactions.[21] This correction serves solely to smooth out some of the time series.

[19] We drop contracts that have either negative durations or durations that are over 15 years or 5500 days for reporting the statistics in this section. The remaining observations represent 95% of the total value of obligations.

[20] http://www.eccinc.com/projects/army-reserve-center-fort-worth

[21] Applying the net amount to the earlier or later action date makes no difference.

3.4 Idiosyncratic Shocks Drive Aggregate Variation over Time

The fourth fact we establish is that idiosyncratic (rather than aggregate) shocks drive the variation in spending over time. We document this fact in several ways. First, at the sectoral level, we show aggregate time fixed effects explain little of sectoral government spending dynamics. Instead, idiosyncratic innovations drive changes in sectoral spending which can have large positive and negative correlations across sectors. Second, at the aggregate level, we show that granularity of firms and sectors is an important origin for the growth rate of aggregate government spending, consistent with our previous fact on granularity: A few firms or sectors drive the dynamics of aggregate government spending.

Fact 4 *Idiosyncratic shocks drive aggregate variation over time:*

1. *Idiosyncratic shocks drive variation in sectoral government spending over time.*
2. *The "granular residual" explains more than 50% of aggregate government spending growth.*

3.4.1 Shock Structure of the Spending Process

First, we examine the shock structure of the sectoral government spending process. Our analysis shows that idiosyncratic variation dominates this process, and that these shocks are often strongly positively or negatively correlated. To see this, we examine the shock structure of the following processes:

$$g_{s,t+1} = \alpha_s + \alpha_t + \rho_s g_{s,t} + \varepsilon_{s,t+1} \tag{1}$$

where $g_{s,t}$ is the log of government consumption of output from two-digit sector s in year t. Variables α_s and α_t take into account sectoral and aggregate time fixed effects. We calculate the residuals $\varepsilon_{s,t}$ and the variance-covariance matrix $\frac{1}{T}\varepsilon'\varepsilon$.

Our findings are twofold. First, we find that inclusion of time fixed effects in the specification raises the R^2 from 97.94% to only 98.34%. Hence,aggregate trends do not explain much of sectoral variation over time – instead, idiosyncratic shocks are far more important, accounting for almost four times as much of total variation. Second, we find idiosyncratic innovations can have large positive and negative correlations for many sector pairs. Figure 13 shows the distribution of correlations across sector pairs. They are centered around 0, but can be both large negative and positive. A lot of the correlation mass resides between -0.5 and 0.5. Appendix section C.2 describes the estimation results in further detail.

Our previous, cross-sectional variance decomposition ("Fact 1") suggests that across sector variation is relatively unimportant. Indeed, we document in the appendix sectoral processes we estimate here are quite persistent with a median persistence of 0.73. We note our previous cross-sectional result is perfectly consistent with the dynamic fact that *when* an innovation to sectoral spending occurs, it is often strongly negatively or positively correlated with another sector's spending level. The fat-tailed distribution of individual contracts determines this finding.

3.4.2 Granular Origin of Government Spending Fluctuations

Next, we use the notion of granularity to show idiosyncratic shocks matter if we want to account for the growth of aggregate government spending, instead of getting washed out in the aggregate. We follow both the approaches in Gabaix (2011) and Foerster et al. (2011).

Granular Residual Approach First, as in Gabaix (2011), we calculate the empirical "granular residual", Γ_t, to show that the shocks to the top suppliers of government consumption are drivers of fluctuations in aggregate government spending. To see this, let $g_{i,t}$ be the total obligations to recipient firm i in year t. Then, the growth rate of obligations is given by:

$$z_{i,t} = \ln(g_{i,t}) - \ln(g_{i,t-1})$$

The granular residual is then given by:

$$\Gamma_t = \sum_{i=1}^{K} \frac{g_{i,t-1}}{G_{t-1}}(z_{i,t} - \bar{z}_t) \tag{2}$$

where G_t is aggregate government consumption in year t, and $\bar{z}_t = Q^{-1}\sum_{i=1}^{Q} z_{i,t}$ is the average growth rate over the top Q firms. In other words, the granular residual is the weighted difference in growth rates for the top K firms relative to the average growth rate for the top Q firms, where $Q \geq K$.

As in Gabaix (2011), we run a regression of aggregate growth—$Z_t = \ln(G_t) - \ln(G_{t-1})$—on the granular residual and its lags. The granular hypothesis suggets idiosyncratic shocks, captured by the granular residual, account for much of the aggregate movement of government spending. Specifically, we estimate:

$$Z_t = \beta_0 + \beta_1\Gamma_t + \beta_2\Gamma_{t-1} + \beta_3\Gamma_{t-2}$$

Following Gabaix (2011), we estimate this specification for $K = 100$, $Q = 100$ and $Q = 1000$ firms, and on one and two lags of the granular residual term. We see in Table 5 the

granular residual explains about 50% of the variation in aggregate government consumption across specifications. These results are in line with the estimates of Gabaix (2011) for the explanatory power of the granular residual for the top firms on GDP growth.

Decomposition of Government Consumption Growth Second, as in Foerster et al. (2011), we perform a different set of exercises to decompose changes in aggregate government spending growth into components arising from aggregate and idiosyncratic (sector-specific) shocks. This second approach delivers results that are consistent with the results we find using the granular residual approach of Gabaix (2011). Using the methodology of Foerster et al. (2011), we decompose aggregate government consumption growth, Z_t, as follows:

$$Z_t = \underbrace{\sum_{i=1}^{N} \omega_{i,t} z_{i,t}}_{\text{(1) Actual}} = \underbrace{\frac{1}{N}\sum_{i=1}^{N} z_{i,t}}_{\text{(2) Equal Weights}} + \underbrace{\sum_{i=1}^{N} \left(\bar{\omega}_i - \frac{1}{N}\right) z_{i,t}}_{\text{(3) Granular Residual}} + \underbrace{\sum_{i=1}^{N} (\omega_{i,t} - \bar{\omega}_i) z_{i,t}}_{\text{(4) Share Deviation}} \tag{3}$$

where i denotes firms or sectors. The term $(1/N)\sum_{i=1}^{N} z_{it}$ weights each sector equally. If z_{it} are uncorrelated, this component has a variance proportional to N^{-1}. The second term, the "granular residual term," $\sum_{i=1}^{N} [\omega_{it} - (1/N)]_{it}$ will be large if the cross-sectional variance of sectoral shares is large at date t.

Figure 14 plots the individual components of equation (3) over time. In Foerster et al. (2011), the equally weighted component tracks the series for aggregate industrial production growth more closely than the granular residual term. In our case, both series exhibit fluctuations of a similar magnitude to the aggregate growth rate, indicating that both idiosyncratic shocks and covariability among sectors are important drivers of aggregate growth.

3.5 Government Consumption is Concentrated in Sticky Sectors

The fifth fact documents a new fact about government consumption and pricing frictions: Government consumption tends to be concentrated in "sticky" sectors—that is, sectors in which price changes are relatively less frequent. We document this result in two complementary ways. We use micro data underlying the producer price data from the Bureau of Labor Statistics (BLS) to study to construct frequencies of price adjustments for the sectors from which the government purchases. Moreover, the dominance of "fixed-price" contracts reflects the stickiness at the micro level of the individual contracts.

Fact 5 *Government spending is concentrated in sticky sectors*

1. *The monthly frequency of price changes in the top two supplying sectors is 9% while it is 20%, on average, for the remaining sectors.*

2. *80% of all contracts are fixed-price in nature.*

Our main result for this fifth fact is government spending is concentrated in sticky-price sectors. Figure 15 shows the average annual share of government spending in each two-digit sector (x-axis) plotted against the frequency of price changes in those sectors from the BLS. The size of the bubble corresponds to the average sectoral share of annual aggregate spending—a larger bubble means the sector supplies a larger proportion of government consumption. The figure shows the goverment spends the vast majority of dollars in the sectors with the low frequencies of price changes. The frequency of price changes in the largest 2 sectors is 9% while it is 20% on average.

This finding is micro-founded by the type of contracts firms use to set their prices. Table 6 summarizes our findings. It shows the distribution by both count and value of pricing types for government contracts. The first two columns show the distribution for all firms, while the last two columns show the distribution of pricing type for the top 10 firms.

By count, the majority of contracts are "firm fixed price" contracts—the pricing type that places all of the risk on the contractor. This is followed by fixed price contracts with economic adjustment. The total share of contracts that are of a fixed-price type is over 85%. As discussed below, no comparable benchmark for the private sector exists to the best of our knowledge.

By value, a similar picture emerges: a somewhat larger share of contracted funds are cost-reimbursement contracts (cost plus an award fee or cost plus a fixed fee), but fixed-price type contracts still dominate the contracting environment. Larger transactions are relatively more likely to be awarded under a cost-reimbursement contract, while smaller award transactions are relatively more likely to be fixed price. Still, the total share of spending under some form of fixed price agreement amounts to over 62%.

This finding justifies using a sticky-price setting to model the effect of government spending. More profoundly, it also speaks to the question that goes to the heart of the New-Keynesian model whether contracts are allocative or not as pointed out by Barro (1977): When a price is fixed, but not necessarily quantities, monetary policy shocks will increase quantities demanded. While it is unclear whether the government changes quantities demanded, information on the distribution of contracts might be informative for the US private sector distribution as well which has not been studied so far due to lack of viable data.

4 A New Keynesian Model with Sectoral Government Spending

We now develop a two-sector New Keynesian model to interpret the relevance of the five facts through the lense of a model. The model is deliberately stylized departing as little as possible from the one-sector textbook model. Importantly, rather than postulating a process for "big G", we model government spending in each sector as distinct variables. Sectors differ in several respects: First, they differ in size. This allows us to capture "granularity" in the simplest possible way (fact #1). Second, both the sectoral weights of private and public consumption are generally not equal, a sectoral bias exists (fact #2). Third, sector-specific shocks to government consumption occur (facts #3 and #4). Finally, sectors differ in terms of price rigidities, and we assume—consistent with fact #5—that the large supplier of government consumption has relatively sticky prices.

4.1 Setup

We focus on key equations of the model because it is a simple extension of the textbook version of the New Keynesian model (Woodford, 2003; Galí, 2015). A representative household choose consumption and labor effort in order to solve an infinite horizon problem subject to a budget constraint and given a maximum labor endowment normalized to unity:

$$\max_{\{C_{1t},C_{2t},L_{1t},L_{2t}\}_{t=0}^{\infty}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\ln \left(\frac{C_{1,t}^{\omega} C_{2,t}^{1-\omega}}{\omega^{\omega}(1-\omega)^{1-\omega}} \right) - \xi_1 \frac{L_{1t}^{1+\varphi}}{1+\varphi} - \xi_2 \frac{L_{2t}^{1+\varphi}}{1+\varphi} + f(G_{1t}, G_{2t}) \right),$$

subject to

$$\begin{aligned} W_{1t}L_{1t} + W_{2t}L_{2t} + \Pi_t + I_{t-1}B_{t-1} &= B_t + P_{1t}C_{1t} + P_{2t}C_{2t} + P_{1t}G_{1t} + P_{2t}G_{2t} \\ L_{1t} + L_{2t} &\leq 1. \end{aligned}$$

Here, C_{kt} and G_{kt} denote private and public consumption of sector-k goods, with $k = \{1, 2\}$, respectively. G_{kt} is determined exogenously. Lump-sum taxes finance government consumption for which we substitute in the household budget constraint. Government spending provides utility, but independently of private consumption and leisure. P_{kt} is the price index in sector k. L_{kt} and W_{kt} are labor employed and wages paid in sector k. Our specification assumes sectoral segmentation of labor markets. Below, we set parameters ξ_k to ensure a symmetric steady state across all firms. Households own firms and receive net income, Π_t, as dividends. Bonds, B_{t-1}, pay a nominal gross interest rate of I_{t-1}. We rule out Ponzi schemes.

The optimal allocation of consumption expenditures across sectors requires:

$$C_{1t} = \omega \left(\frac{P_{1t}}{P_{Ct}} \right)^{-1} C_t \text{ and } C_{2t} = (1-\omega) \left(\frac{P_{2t}}{P_{Ct}} \right)^{-1} C_t, \tag{4}$$

where $P_{Ct} = P_{1t}^{\omega} P_{2t}^{1-\omega}$ is the consumer price index.

The household first-order conditions determine labor supply and define the Euler equation:

$$\frac{W_{kt}}{P_{Ct}} = \xi_k L_{kt}^{\varphi} C_t \text{ for } k = \{1, 2\}, \tag{5}$$

$$1 = \mathbb{E}_t \left[\beta \left(\frac{C_{t+1}}{C_t} \right)^{-1} I_t \frac{P_{Ct}}{P_{Ct+1}} \right]. \tag{6}$$

Total demand for sectoral output is given by:

$$Y_{kt} = C_{kt} + G_{kt}. \tag{7}$$

Sectoral output, in turn, is defined as a CES aggregate of differentiated goods indexed by $j \in [0, n]$ in sector 1 and $j \in (n, 1]$ for sector 2:

$$Y_{1t} \equiv \left[n^{-1/\theta} \int_0^n Y_{j1t}^{1-\frac{1}{\theta}} dj \right]^{\frac{\theta}{\theta-1}}, \quad Y_{2t} \equiv \left[(1-n)^{-1/\theta} \int_n^1 Y_{j2t}^{1-\frac{1}{\theta}} dj \right]^{\frac{\theta}{\theta-1}}. \tag{8}$$

Cost minimization implies the demand for differentiated goods:

$$Y_{j1t} = n \left(\frac{P_{j1t}}{P_{1t}} \right)^{-\theta} Y_{1t}, \quad Y_{j2t} = (1-n) \left(\frac{P_{j2t}}{P_{2t}} \right)^{-\theta} Y_{2t} \tag{9}$$

and defines the sectoral price index:

$$P_{1t} = \left[\frac{1}{n} \int_0^n P_{j1t}^{1-\theta} dj \right]^{\frac{1}{1-\theta}}, \quad P_{2t} = \left[\frac{1}{1-n} \int_n^1 P_{j1t}^{1-\theta} dj \right]^{\frac{1}{1-\theta}}. \tag{10}$$

Differentiated goods are produced on the basis of the following production function: $Y_{jkt} = L_{jkt}$. Firms are constrained in their ability to set prices. With probability α_k, which may differ across sectors, a firm may not adjust its price in the next period. The pricing problem of firm j in sector k is:

$$\max_{P_{jkt}} \mathbb{E}_t \sum_{s=0}^{\infty} Q_{t,t+s} \alpha_k^s \left[P_{jkt} Y_{jkt+s} - \mathcal{C}_{t+s}(Y_{t+s|t}) \right].$$

Here $Q_{t,t+s}$ is the stochastic discount factor between periods t and $t+s$ and $\mathcal{C}_{t+k}(\cdot)$ are costs of

production. The first order condition is given by

$$\sum_{\tau=0}^{\infty} Q_{t,t+\tau}\alpha_k^{\tau} Y_{jkt+\tau}\left[P_{kt}^{*} - \mathcal{M}\Psi_{kt+\tau}\right] = 0, \tag{11}$$

where $Y_{jkt+\tau}$ is the total production of firm jk in period $t+\tau$, $\mathcal{M} \equiv \frac{\theta}{\theta-1}$ denotes the desired markup and $\Psi_{t+k} = \mathcal{C}'_{t+k}(Y_{t+k})$ are marginal costs.[22] Hence, the optimal price, P_{kt}^{*}, is the same for all firms in a given sector. Thus, aggregating among all prices within a sector yields

$$P_{kt} = \left[(1-\alpha_k)\, P_{kt}^{*1-\theta} + \alpha_k P_{kt-1}^{1-\theta}\right]^{\frac{1}{1-\theta}}. \tag{12}$$

We define (nominal) GDP as follows:

$$P_{Yt}Y_t \equiv P_{1t}Y_{1t} + P_{2t}Y_{2t}, \tag{13}$$

where $P_{Yt} \equiv P_1^n P_2^{1-n}$ is the GDP deflator.

Analogously, we define aggregate government spending ("Big G") as follows:

$$P_{Gt}G_t \equiv P_{1t}G_{1t} + P_{2t}G_{2t}. \tag{14}$$

Assuming the average weight of sector 1 in total government spending is γ, we define the deflator for government spending as $P_{Gt} \equiv P_1^{\gamma} P_2^{1-\gamma}$.

Lastly, we close the model by specifying an inflation target (of zero):

$$\Pi_{Yt} = \frac{P_{Yt}}{P_{Yt-1}} = 0. \tag{15}$$

In the spirit of Svensson (2003), we assume monetary policy adjusts short term interest rates in order to make sure that the inflation target is met at all times.

4.2 Approximate equilibrium conditions

We now consider an approximation of the equilibrium conditions around a symmetric steady state in which relative prices are unity and inflation is zero (see Appendix C.4 for details). Let γ denote the fraction of government spending in sector-1 in the steady state: $\gamma = G_1/G$. ζ, in turn, is the steady-state ratio of consumption to output: $\zeta = C/Y$, such that $1-\zeta = G/Y$. The steady-state sizes of sector 1 and 2 are then given by the weighted average of each sector's

[22] Because production in linear marginal costs are independent on the level of production.

share in private and public spending, respectively:

$$n = \omega\zeta + \gamma(1-\zeta) \tag{16}$$

$$1-n = (1-\omega)\zeta + (1-\gamma)(1-\zeta). \tag{17}$$

Below, we state the equilibrium conditions in terms of deviations from steady state. For this purpose we use lowercase letters to denote percentage deviations from steady state. *Market clearing* in each sector implies:

$$ny_{1,t} = -\omega\zeta(1-\omega)\tau_t + \omega\zeta c_t + (1-\zeta)\gamma g_{1,t} \tag{18}$$

$$(1-n)y_{2,t} = (1-\omega)\zeta\omega\tau_t + (1-\omega)\zeta c_t + (1-\zeta)(1-\gamma)g_{2,t}. \tag{19}$$

where $\tau_t = p_{1,t} - p_{2,t}$ are the terms of trade. In deriving the expressions we use $p_{1,t} - p_t = (1-\omega)\tau_t$.

The New Keynesian *Phillips curves* in each sector are given by:

$$\alpha_1\pi_{1,t} = \alpha_1\beta E_t\pi_{1,t+1} + (1-\alpha_1)(1-\beta\alpha_1)\psi_{1t} \tag{20}$$

$$\alpha_2\pi_{2,t} = \alpha_2\beta E_t\pi_{2,t+1} + (1-\alpha_2)(1-\beta\alpha_2)\psi_{2t}, \tag{21}$$

where *marginal costs*, ψ_{kt}, are in real terms (deflated with the producer price in each sector). After substituting for the real wage we have:

$$\psi_{1t} = c_t + \varphi y_{1t} - (1-\omega)\tau_t \tag{22}$$

$$\psi_{2t} = c_t + \varphi y_{2t} + \omega\tau_t. \tag{23}$$

An approximation of the Euler equation yields

$$c_t = E_t c_{t+1} - (i_t - E_t\pi_{Ct+1}) \tag{24}$$

$$\pi_{Ct} = \omega\pi_{1,t} + (1-\omega)\pi_{2,t}, \tag{25}$$

where the second equation is consumer price inflation. Eqs. (13) and (14) and the definition of the deflators for GDP and government spending imply the following equations for real GDP and real aggregate government spending:

$$y_t = ny_{1,t} + (1-n)y_{2,t} \tag{26}$$

$$g_t = \gamma g_{1,t} + (1-\gamma)g_{2,t}. \tag{27}$$

Regarding monetary policy, we assume an inflation targeting rule:

$$\pi_{Yt} = 0 \tag{28}$$

For government spending we assume an exogenous AR(1) process for both sectors:

$$g_{1,t+1} = \rho g_{1,t} + \varepsilon_{1,t+1} \tag{29}$$

$$g_{2,t+1} = \rho g_{2,t} + \varepsilon_{2,t+1}, \tag{30}$$

with persistence parameter $\rho \in [0, 1)$.

4.3 Results

In this section, we derive a number of closed-form results. We focus on the effect of an exogenous variation in government spending, that is, we state the solution in terms of g_{1t} and g_{2t}. The goal is to illustrate how idiosyncratic variation in government spending at the sectoral level impacts the aggregate economy. To facilitate the algebra we assume $\alpha_1 = 0$, that is, prices are fully flexible in sector 1. We relax this assumption when we present numerical results in Section 4.4 below. We do not restrict the extent of price rigidity in sector 2. Instead we have $\alpha_2 \in [0, 1]$.

In order to solve the model, we first derive the solution for the terms of trade. The terms of trade are the only endogenous state variable in the model. Keeping track of how they adjust is essential to capture the dynamics of the model. Intuitively, since prices are (potentially) sticky in sector 2, the adjustment to even purely transitory shocks takes time and dynamics of the terms of trade govern the adjustment process. Inflation targeting implies $\pi_{Yt} = n\pi_{1,t} + (1-n)\pi_{2,t} = 0$. This equations allows us to rewrite the Phillips curve in sector 2 (equation (21)) as:

$$\omega(\tau_t - \tau_{t-1}) = \omega\beta(E_t(\tau_{t+1} - \tau_t)) - \kappa_2\psi_{2t}. \tag{31}$$

Marginal costs in sector 2 drive the dynamics of the terms of trade, which in turn are given by:

$$\psi_{2t} = \left(1 + \frac{\zeta\varphi(1-\omega)}{1-n}\right) c_t + \left(1 + \frac{\zeta\varphi(1-\omega)}{1-n}\right) \omega\tau_t + (1-\zeta)(1-\gamma)\frac{\varphi}{1-n} g_{2,t}. \tag{32}$$

We use the market clearing condition in equation (19) to substitute for output in equation (23). To substitute for consumption, we exploits that firms in sector 1 are fully flexible in setting their prices and hence, charge a constant markup over marginal costs. As a result, marginal costs are

constant in real terms and we obtain the following expression for consumption:

$$c_t = (1-\omega)\tau_t - \left(1 + \frac{\zeta\varphi\omega}{n}\right)^{-1}(1-\zeta)\gamma\frac{\varphi}{n}g_{1t}. \tag{33}$$

Intuitively, this expression captures the dynamics of the labor market. Higher government spending induces upward pressure on wages as production and the demand for labor rise. For real marginal costs to remain constant in equilibrium, labor supply must also increase. An increase in the marginal utility of wealth, or equivalently, a drop in consumption delivers the increase in labor supply. This accounts for the negative impact of government spending on consumption in expression (33) for given terms of trade.

Using equation (33) in equation (32) and substituting in equation (31) we obtain a second-order difference equation in the terms of trade:

$$\{(1+\beta)+\kappa A_2\}\,\tau_t - \tau_{t-1} - \beta E_t\tau_{t+1} \;=\; \kappa\frac{A_2}{A_1}\frac{\varphi}{n}(1-\zeta)\gamma g_{1t} - \frac{\kappa\varphi}{1-n}(1-\zeta)(1-\gamma)g_{2,t}, \tag{34}$$

where $\kappa \equiv \kappa_2/n$, $A_2 = 1 + \frac{\zeta\varphi(1-\omega)}{1-n}$ and $A_1 = 1 + \frac{\zeta\varphi\omega}{n}$. The A-coefficients increase with the weight of a sectors' share in private consumption as well as with its size. We solve equation (34) to obtain a solution for the terms of trade in government spending. The following proposition summarizes our first result.

Proposition 1 (Solution for terms of trade) *Assuming that prices in sector 1 are fully flexible ($\alpha_1 = 0$) and that monetary policy targets producer price inflation ($\pi_{Yt} = 0$), the solution for the terms of trade is given by*

$$\tau_t = \Lambda_0\tau_{t-1} + \Lambda_1(1-\zeta)\gamma g_{1,t} - \Lambda_2(1-\zeta)(1-\gamma)g_{2,t}, \tag{35}$$

where $\Lambda_0 \in (0,1)$ and $\Lambda_1, \Lambda_2 \geq 0$.

Proof. See Appendix C.6 ■

The intuition for this case is straightforward: government spending in sector 1 increases the prices of sector 1, thereby raising the terms of trade, while spending in sector 2 reduces the terms of trade.

We now substitute in expression (33) for the terms of trade using equation (35) and obtain our second result. Government spending crowds out private consumption—independently of the sector in which spending occurs.

Proposition 2 (Crowding out of consumption) *Assuming prices in sector 1 are fully flexible ($\alpha_1 = 0$) and monetary policy targets producer price inflation ($\pi_{Yt} = 0$),*
(1) *the solution for consumption is given by*

$$c_t = \Theta_0 \tau_{t-1} - \Theta_1(1-\zeta)\gamma g_{1,t} - \Theta_2(1-\zeta)(1-\gamma)g_{2,t} \tag{36}$$

where $\Theta_0 \in (0,1)$;
(2) *$\Theta_1 \in [0,\infty)$, and $\Theta_2 \in [0,\zeta^{-1})$, that is, government spending in either sector crowds out private consumption. The limiting case $\Theta_1 \to \infty$ occurs if $n \to 0$, while $\Theta_2 \to \zeta^{-1}$ obtains if $1-n \to 0$;*
(3) *if $\omega \geq \gamma$, then $\Theta_1 > \Theta_2$, that is, crowding out is stronger in response to sector 1 spending. Also, if $\kappa \to 0$, $\Theta_1 > 0$ and $\Theta_2 = 0$.*

Proof. See Appendix C.6 ■

Expression (36) shows, all else equal, higher terms of trade implies higher consumption ($\Theta_0 > 0$). Intuitively, since the terms of trade reduce marginal costs in the flex-price sector, constant marginal costs require consumption to go up in order to put upward pressure on the real wage.

Next, we observe from expression (36) that government spending tends to crowd out private consumption, since both Θ_1 and Θ_2 are non-negative. To understand this result, note that an increase in government spending in either of the two sectors raises production and employment as well as marginal costs in the sector.[23] As a result, upward pressure on inflation occurs, which induces monetary policy to raise interest rates and, in turn, induces households to reduce their current consumption in both sectors. Put differently, a shock in one sector spills over to the other sector because monetary policy can only manage aggregate demand rather than demand in a specific sector.

Against this backdrop, it becomes clear why $\Theta_2 \to 0$ as $\kappa \to 0$. $\kappa \to 0$ implies prices are completely sticky in the limit. Hence, government spending in sector 2 does not generate inflationary pressure. Monetary policy remains unresponsive, and private consumption is invariant to the fiscal impulse. For the same reason, crowding out is stronger in the flex-price sector ($\Theta_1 > \Theta_2$) provided $\omega \geq \gamma$, that is, whenever private consumption is relatively concentrated in the flex-price sector which is the empirically relevant case (facts #2 and #5). This condition also holds in the absence of sectoral bias, that is, when $\omega = \gamma$. Intuitively,

[23] Utility that is linear in labor ($\varphi = 0$) is an exception. In this case, marginal costs are independent of the level of production and $\Theta_1 = \Theta_2 = 0$.

consumption drops more in response to an increase of government spending in sector 1, because the higher flexibility in prices results in stronger inflationary pressure. Hence, the monetary authority has to raise interest rates by more to keep inflation in check.

Theoretically, crowding out of consumption in response to sector 1 spending can be arbitrarily large. Specifically, we find $\Theta_1 \to \infty$ if $n \to 0$ (which also implies that $\omega \to 0$). Assuming the weight of sector 1 approaches zero, private consumption is concentrated in the sticky sector. Given the inflationary impact of government spending in the flex-price sector, the reduction in consumption necessary to offset the impact on inflation becomes arbitrarily large because inflation is relatively inelastic to changes in sticky-sector consumption, both public and private. Instead, when $1 - n \to 0$, the crowding out of consumption in response to sector 2 spending, captured by Θ_2, does not exceed ζ^{-1}. At this point, the drop in consumption matches the increase of government spending such that marginal costs, and hence inflation, remains constant. This happens for a relatively modest reduction of consumption because inflation is very elastic to changes in both public and private spending in the flexible sector.

Finally, we establish the effect of government spending on output.

Proposition 3 (Output multipliers) *Assuming prices in sector 1 are fully flexible ($\alpha_1 = 0$) and monetary policy targets producer price inflation ($\pi_{Yt} = 0$), the solution for output is given by*

$$y_t = \Gamma_0 \tau_{t-1} + \Gamma_1 (1-\zeta)\gamma g_{1,t} + \Gamma_2 (1-\zeta)(1-\gamma) g_{2,t} \tag{37}$$

where $\Gamma_0 \in (0,1)$, and

$$\Gamma_1 = 1 - \zeta\Theta_1 \text{ and } \Gamma_2 = 1 - \zeta\Theta_2. \tag{38}$$

Moreover, we find $\Gamma_0 \in (0,1)$, Γ_1 has full support in $(-\infty, 1]$, and Γ_2 has full support in $(0,1]$.

In expression (37), the effect of the lagged terms of trade on output is positive ($\Gamma_0 > 0$) because, as discussed above, their effect on consumption is also positive (see Proposition 2). The coefficients Γ_1 and Γ_2 directly capture the impact multiplier of government spending on output, that is, the change in output divided by the change in government spending.[24] Also, as equation (38) shows, the multipliers are simply given by the sum of the direct effect of higher spending on output and the indirect effect on private consumption, which is negative.

Given our results regarding Θ_1 and Θ_2, stated in Proposition 2, it follows immediately that Γ_1 may actually be negative, while Γ_2 is bounded from below by zero, just as in the one-sector New Keynesian model. Moreover, we also stress the multiplier may not exceed unity, again,

[24] While $g_{k,t}$ measures the deviation of government spending from its steady-state level in percent, multiplying with $(1-\zeta)\gamma$ and $(1-\zeta)(1-\gamma)$, in turn, transforms this into units of steady-state output.

just like in the one-sector model unless the zero lower bound on interest rates binds (Woodford, 2011).

4.4 Quantitative illustration

We now illustrate to what extent the results established in the previous section matter quantitatively. For this purpose, we assign parameter values and solve the model numerically. In the process, we relax some of the assumptions we imposed in the previous section, for instance, that prices sector 1 are completely flexible. We also consider alternative specifications for how monetary policy operates.

We calibrate the parameters of the model in order to capture the essential facts established in Section 3. Specifically, we assume that a period in the model is one quarter and set $\beta = 0.99$. Government spending is biased towards sector 2, which we model as an aggregate of the three most important sectors in terms of government spending. Table 1 shows these sectors account for about 70 percent of government spending. In terms of the model, this implies that $1 - \gamma = 0.69$ (the weight of sector 2 goods in government spending) or equivalently, $\gamma = 0.31$. At the same time, we observe from Table 1, the sectors that make up for sector 2 in the model account for only about 16 percent of value added. Hence, we set size of sector 1 to $n = 0.84$.

We assume government spending accounts for 20 percent of GDP and set $\zeta = 0.8$. Given these parameter values, restriction (16) implies $\omega = 0.9875$. Note the values for γ and ω induce—in line with the evidence—substantial sectoral bias, or differential granularity: private spending is concentrated in sector 1, while public spending is concentrated in sector 2. We set $\alpha_1 = 0.47$ and $\alpha_2 = 0.724$. In this way, we capture the average price rigidity in the two sectors.[25] Importantly, in the model government spending is concentrated in the sector in which prices are relatively sticky—in line with fact #5. Government spending follows an exogenous AR(1) process with a persistence parameter $\rho = 0.85$. This implies a half-life of about 1 year.[26] Lastly, we set $\varphi = 4$, in line with estimates for the Frisch elasticity of labor supply (Chetty et al., 2011).

We display the impulse responses of selected variables to government spending shocks in Figure 16. The solid line represents the scenario in which government spending increases in sector 1, while the dashed line refers to the adjustment to a spending shock in sector 2. In both cases, we normalize the size of the shock in such a way that aggregate government spending ("Big G") increases by one percent of GDP. In the figure, we measure the percentage point deviations from steady state along the vertical axis (of steady-state output in case of quantities). The upper-left

[25] See Table 1 which reports the frequency of monthly price changes of 14 and 22 percent, respectively.

[26] Table 1 suggests government spending is somewhat more persistent in the sectors where it tends to be concentrated. We abstract from heterogeneity in the persistence parameter in what follows.

panel shows the impulse response of aggregate government spending. Since government spending is exogenous, the dynamics are the same for both shock scenarios. Instead, the output responses, shown in the upper-right panel, differ considerably. Output increases only mildly in response to a shock in sector 1. On impact, the response is about 3 times as large in case the shock originates in sector 2. Since both output and government spending are measured in the same units, the output response provides a direct measure of the fiscal multiplier (on output).

The crowding out of private expenditure determines the size of the multiplier. We show the response of consumption in the lower-left panel of the figure. Strong crowding out occurs in response to a spending shock in the flex-price sector, and much less of it if the spending increase takes place in the sticky sector. This observation can be rationalized by the difference in the response of monetary policy across the two shocks: the lower-right panel shows the response of the interest rate by which monetary policy ensures its inflation target. The interest rate response is considerably stronger in case of a shock in sector 1. Because inflation is zero at all times, the change in the policy rate corresponds to a change in the real interest rate. These results confirm our theoretical predictions in the simplified model of the previous section.

Our discussion so far also suggests the extent of crowding out, and hence the multiplier, depends on the degree of price stickiness. To investigate this further, we contrast the results for our baseline scenario to a counterfactual in which we assume prices in sector 1 are fully flexible, just like in Section 4.3. We show the results in Figure 17. The thin lines represent the baseline, the lines with circles refer to the counterfactual; the organization of the figure otherwise mimics that of Figure 16. One result is particularly remarkable: A government spending shock in sector 2 has stronger output effects if prices in sector 1 are more flexible, even though we keep price stickiness in sector 2 unchanged relative to the baseline calibration. Intuitively, this result occurs consumption needs to drop less to keep inflation in check if prices in sector 1 are more flexible.

Until now we have maintained the assumption that monetary policy follows a strict inflation target. Formally, $\pi_t = 0$, simplifying the algebra considerably and allowing us to derive closed-form results. Also, in our discussion of the results we have focused on the importance of the inflation target for the conduct of monetary policy and the fiscal transmission mechanism. The assumption the inflation target is fully met at each point in time may appear overly restrictive. We therefore consider an alternative specification of monetary policy, namely a simple Taylor rule according to which the policy rate adjusts to inflation with a reaction coefficient of 1.5.[27]

Figure 18 shows the results. Lines with circles refer to the scenario in which monetary policy follows a Taylor rule. The lines without markers reproduce the results for the inflation

[27]Formally, equation $i_t = 1.5\pi_t$ replaces equation (28) as an equilibrium condition.

targeting rule. In each instance, as before, the solid lines represent the adjustment to a shock in sector 1 while the dashed lines the adjustment to a shock in sector 2. In the lower-left panel we no longer show the response of consumption, but instead the response of inflation, which is zero in the case of inflation targeting and positive in the Taylor-rule scenario. Monetary policy under the Taylor rule is more accommodating than under the targeting rule. The overall effect on output (upper-right panel), however, is quite small.[28] Overall, we conclude our main results are robust once we relax the assumption of inflation-targeting.

In order to illustrate further to what extent sectoral heterogeneity matters for the fiscal transmission mechanism we contrast the dynamic adjustment to an "aggregate" government spending shock across two model specifications. In each case, we raise government spending by the same amount, namely by one percent of steady state output and proportionally to the steady-state level of spending in each sector. In the first scenario we assume that sectors are homogeneous in order to mimic a one-sector model. We set $\gamma = \omega = 0.5$ and, as a result, $n = 0.5$. Also, we assume the degree of price rigidity is the same in both sectors: $\alpha_1 = \alpha_2 = 0.51$, equal to the average price rigidity in our baseline economy. In the second scenario we study the adjustment of the baseline economy to an aggregate spending shock.

Figure 19 shows the results. The solid lines correspond to the case of homogeneous sectors, and the dashed lines correspond to our baseline calibration. The dynamics differ markedly across scenarios. In particular, the output effect of the aggregate shock is stronger in our baseline model and the crowding out is weaker. To understand this result, recall our baseline calibration implies that sector 2 accounts for a larger share of government spending ($1 - \gamma = 0.8$). For this reason, it also accounts for a larger fraction of any additional government spending (assuming, as we do, that spending is raised in equal proportions across sectors). At the same time, sector 2 is the sector in which prices are more sticky. Put differently, an aggregate shock has effects comparable to a sector 2 shock of the strong sectoral bias. The output multiplier is still a bit smaller than in case of a sector 2 shock (Figure 16) simply because in our baseline model only 80 (rather than 100) percent of the additional expenditure is spent on sector 2 goods.

5 Conclusion

In this paper, we dissect the anatomy of Big G. A systematic analysis of the entire universe of procurement contracts of the US federal government allows us to establish five basic facts

[28] Differences across policies are larger if the degree of price rigidity is assumed to be larger but for the modest degree of price rigidity in our baseline calibration responses are remarkably similar. The gap in the output response across shock scenarios is robust also for alternative assumptions regarding the degree of pricing frictions (not reported).

regarding the nature of government spending. To summarize, the five facts are:

1. **Government spending is granular;**
2. **Government spending has a sectoral bias;**
3. **Spending contracts are characterized by short duration;**
4. **Idiosyncratic shocks at the firm/ sectoral level drive aggregate variation; and**
5. **Government spending is concentrated in sectors with relatively sticky prices**.

We believe accounting for these facts is important and will improve our understanding of how fiscal policy works. As a first step in this direction, we put forth a simple two-sector version of the basic New Keynesian model. The model is deliberately simple, but allows us to capture the five facts. We assume, in particular, the consumption of private and public spending has different sectoral weights. This allows us to capture both granularity and sectoral bias in a way that is stylized but consistent with the data. We capture the last fact by assuming that the degree of price rigidity differs across sectors, and we capture facts 3 and 4 by studying the impact of sectoral shocks.

The impact of fiscal shocks, that is, the fiscal transmission mechanism, differs considerably depending which sector the shock hits. Importantly, while private expenditure is crowded out independently of where the shock originates, the crowding out can become arbitrarily large if the shock hits the sector in which private expenditure is concentrated and prices are flexible. Crowding out, instead, is limited in the case in which the shock hits the sticky sector. In this case, the output multiplier is also considerably larger—about three times as large—according to our calibrated model. We leave a more systematic quantitative exploration for future work.

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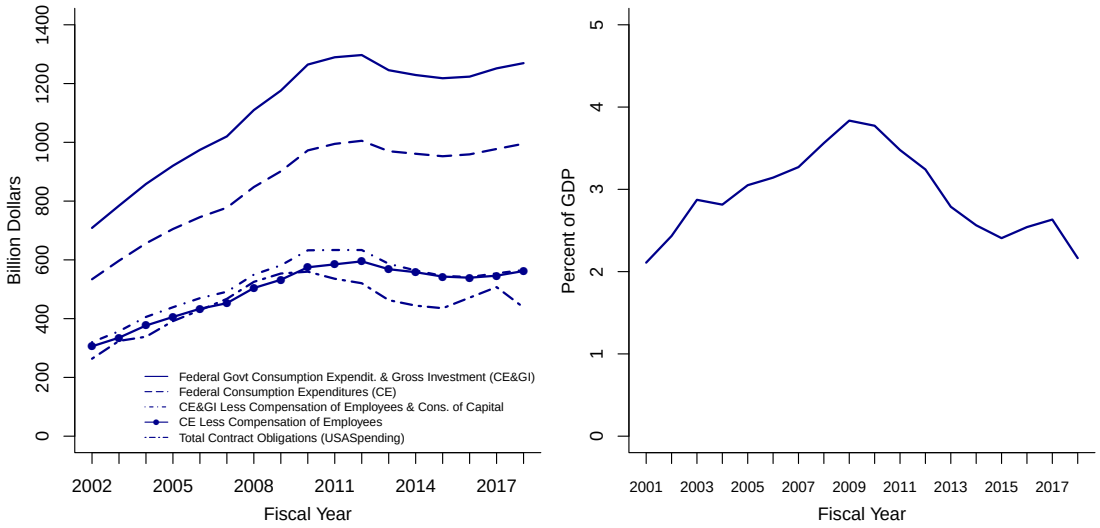
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6 Figures and Tables

Figure 2: Comparison of USASpending Data with General Government Expenditures

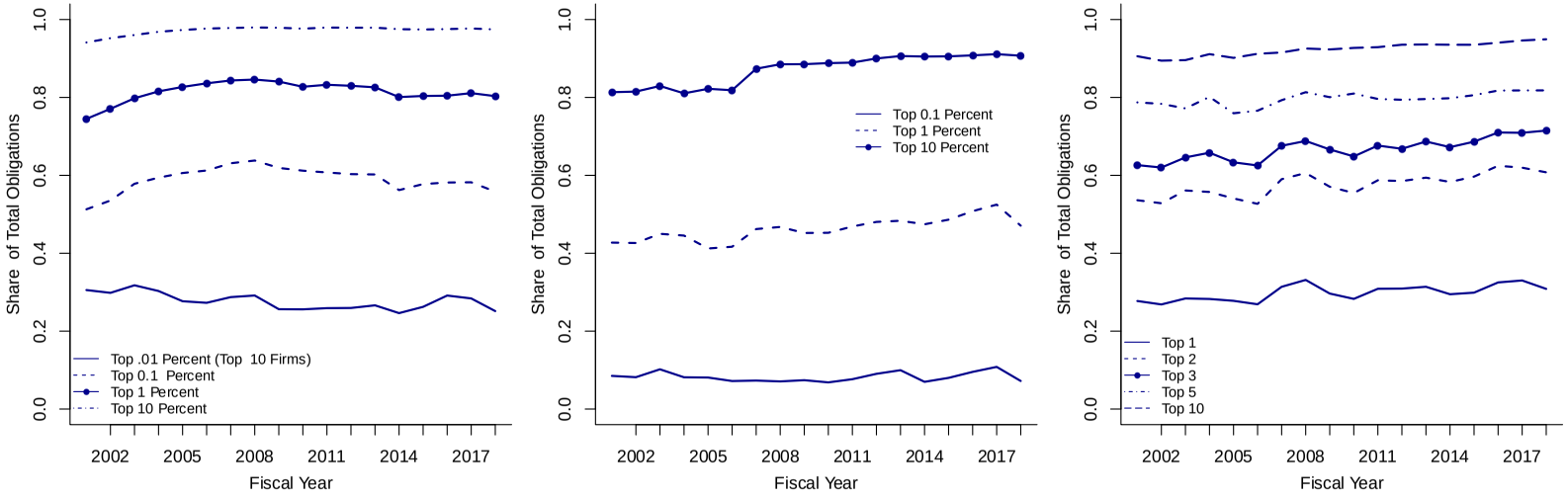


(a) USASpending vs NIPA Accounts

(b) Contracts as a Share of GDP

Note. This figure shows how aggregate contract obligations compare to Government spending as defined in the National Income and Product Accounts (NIPAs). The left panel shows that total contract obligations are roughly equivalent to total federal government expenditures and gross investment less compensation of employees and consumption of capital. The right panel shows that contract obligations account for about 2 to 4 percent of GDP.

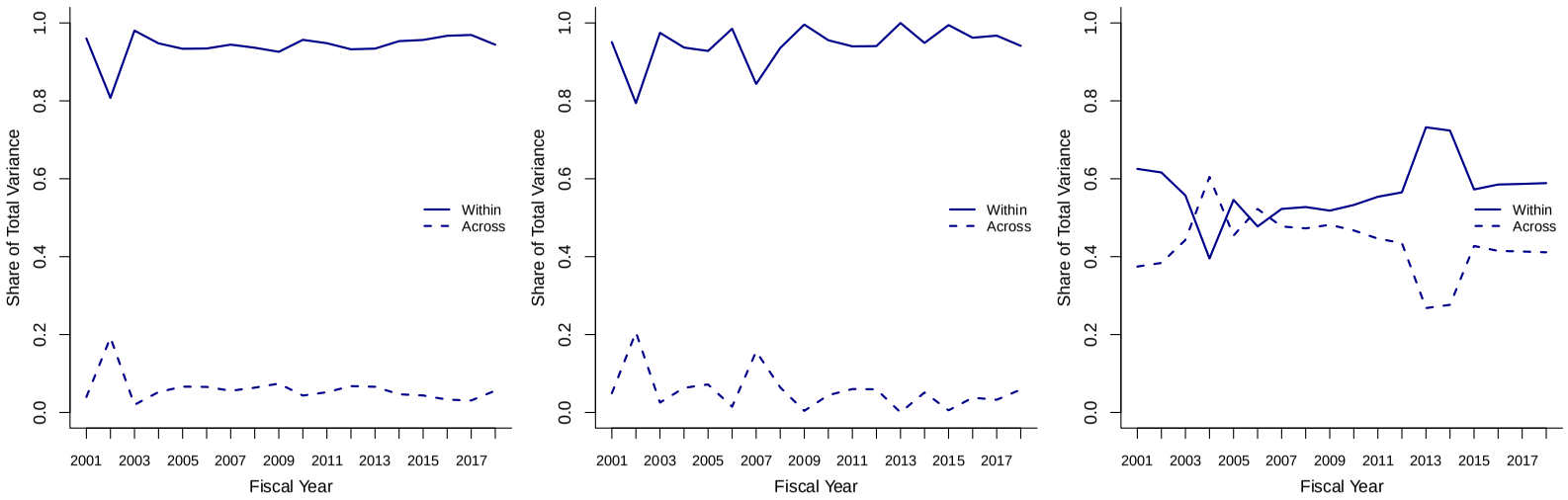
Figure 3: Share of Obligations by Top Firms and Sectors



(a) Firms (b) NAICS 6 Sectors (c) NAICS 2 Sectors

Note. This figure shows the share of contract obligations given to the top shares of firms (the left panel) six-digit NAICS sectors (the middle panel) and two-digit NAICS sectors (the bottom panel).

Figure 4: Variance Decomposition: Within and Across Firms



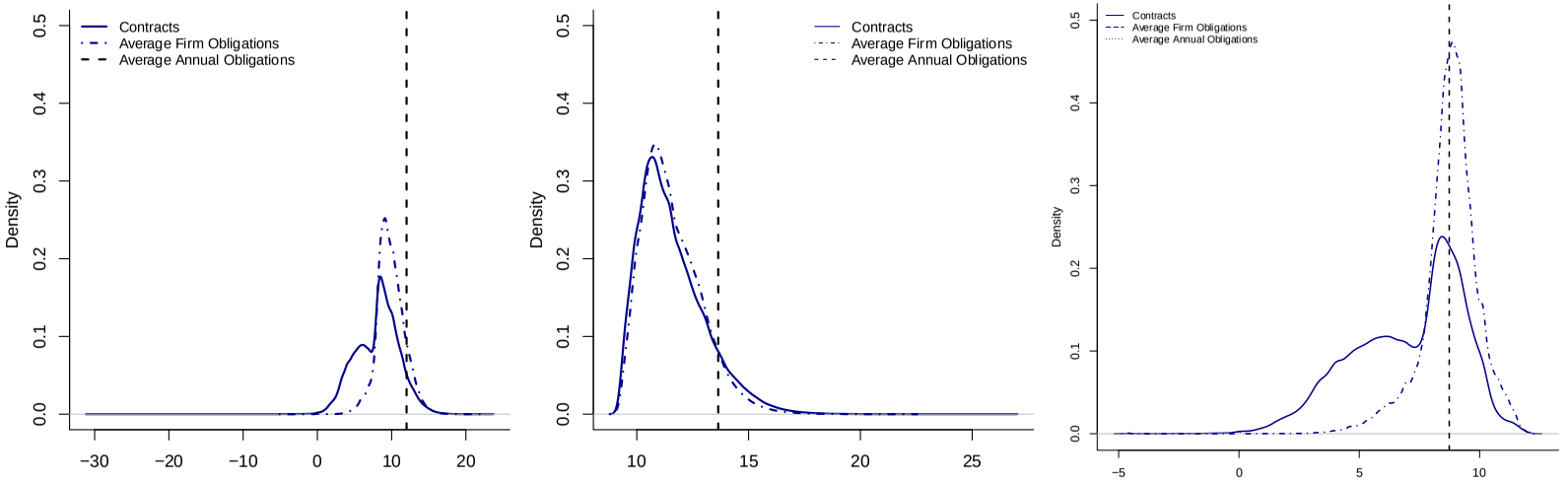
(a) Full Dataset (b) Top 20 Percent (c) Bottom 80 Percent

Note. This figure shows a decomposition of the variance of government spending into "within-firm" and "across-firm" variation. Specifically, total variance is given by:

$$\sum_f \sum_{i \in f} (g_{if,t} - \bar{g}_t)^2 = \underbrace{\sum_f \sum_{i \in f} (g_{if,t} - \bar{g}_{f,t})^2}_{\text{(a) Within Firm}} + \underbrace{\sum_f \sum_{i \in f} (\bar{g}_{f,t} - \bar{g}_t)^2}_{\text{(b) Across Firm}}$$

Where i is an individual contract transaction and f is a firm. We plot each of the two RHS components as a share of the LHS. Panel (a) shows this decomposition for the full dataset, panel (b) restricts the sample to the top 20 percent of transactions, and panel (c) shows only the bottom 80 percent of transactions.

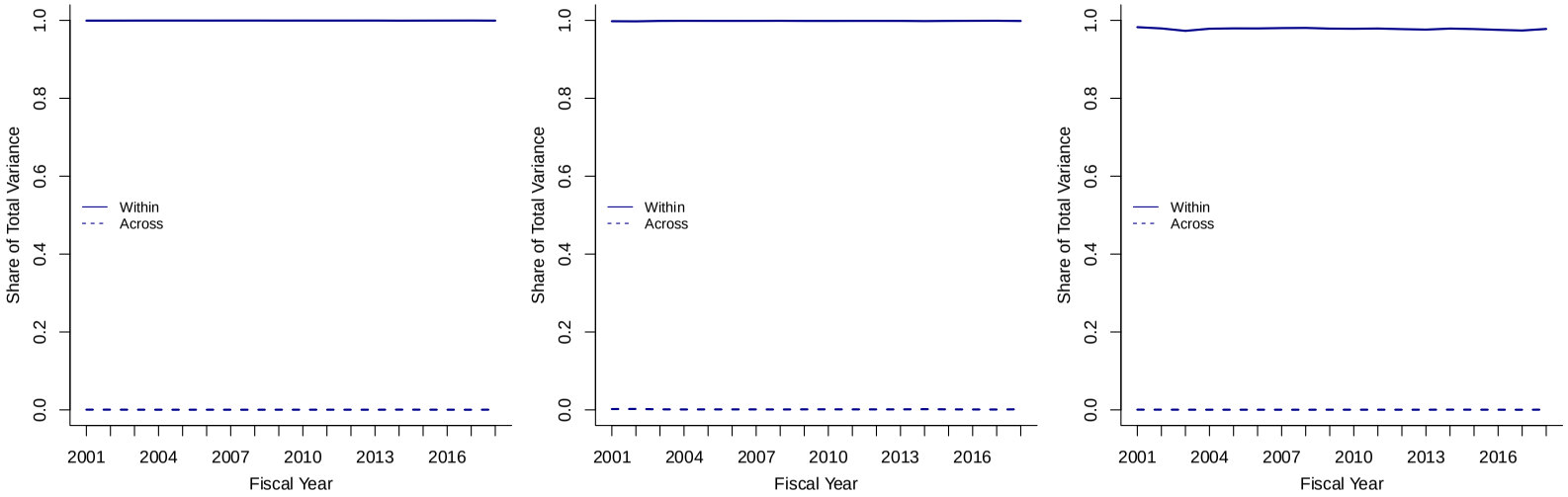
Figure 5: Density of Variance Decomposition Components



(a) Full Dataset (b) Top 20 Percent (c) Bottom 80 Percent

Note. This figure shows the density of each of the three components that underly the variance decomposition above. The blue line shows the density of the individual contract transactions—$g_{if,t}$, the red line shows the density of average firm obligations—$\bar{g}_{f,t}$, and the black line shows the density of average annual obligations—$\bar{g}_t$. Panel (a) shows these densities for the full dataset, panel (b) restricts the sample to the top 20 percent of contract transactions, and panel (c) shows only the bottom 80 percent of transactions.

Figure 6: Variance Decomposition: Within and Across Sectors



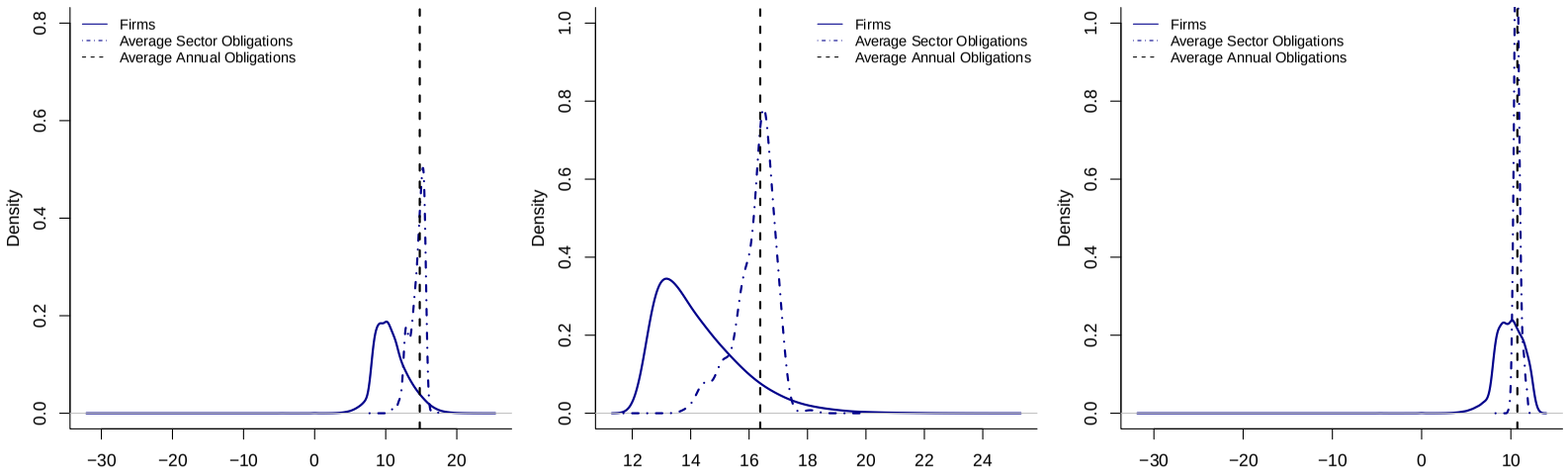
(a) Full Dataset (b) Top 20 Percent (c) Bottom 80 Percent

Note. This figure shows a decomposition of the variance of government spending into "within-sector" and "across-sector" variation. Specifically, total variation is given by:

$$\sum_s \sum_{f \in s} (g_{fs,t} - \bar{g}_t)^2 = \underbrace{\sum_s \sum_{f \in s} (g_{fs,t} - \bar{g}_{s,t})^2}_{\text{Within Sector}} + \underbrace{\sum_s \sum_{f \in s} (\bar{g}_{s,t} - \bar{g}_t)^2}_{\text{Across Sector}}$$

Where f is a firm and s is a sector. We plot each of the two RHS components as a share of the LHS. Panel (a) shows this decomposition for the full dataset, panel (b) restricts the sample to the top 20 percent of firms, and panel (c) shows only the bottom 80 percent of firms.

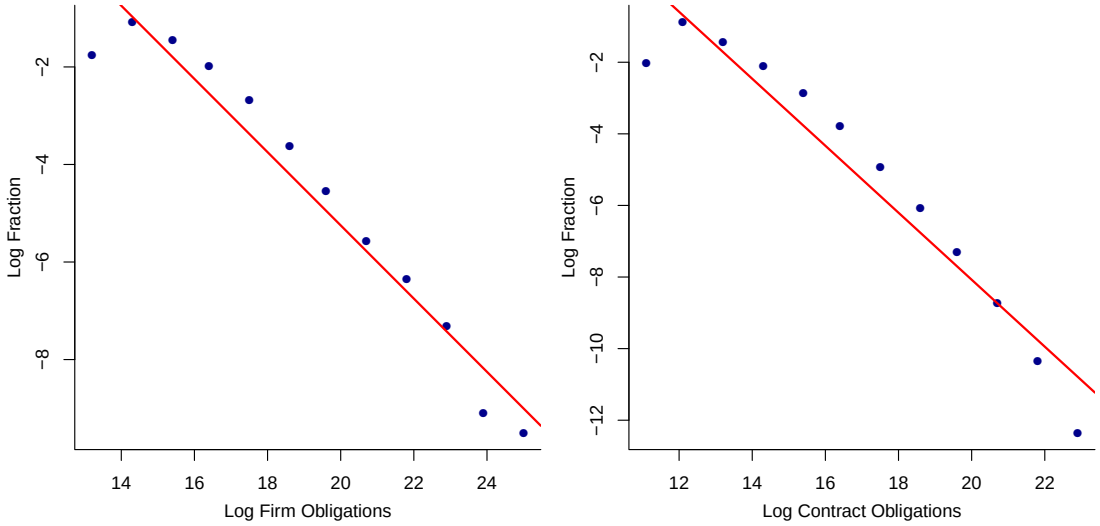
Figure 7: Density of Variance Decomposition Components



(a) Full Dataset (b) Top 20 Percent (c) Bottom 80 Percent

Note. This figure shows the density of each of the three components that underly the variance decomposition above. The blue line shows the density of the firm obligations—$g_{fs,t}$, the red line shows the density of average sector obligations—$\bar{g}_{s,t}$, and the black line shows the density of average annual obligations—$\bar{g}_t$. Panel (a) shows these densities for the full dataset, panel (b) restricts the sample to the top 20 percent of firms, and panel (c) shows only the bottom 80 percent of firms.

Figure 8: Log Frequency vs. Log Contracts

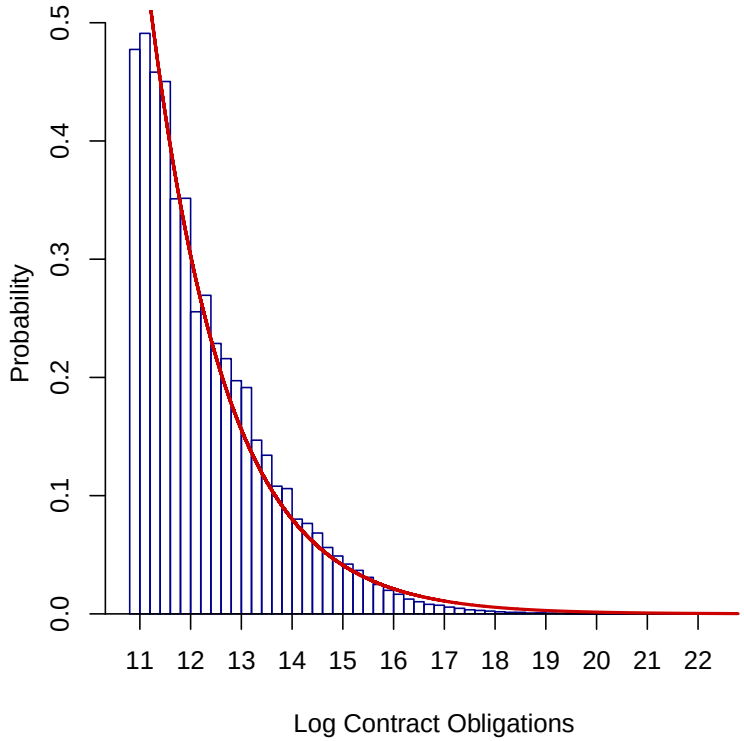


(a) Top 20 Percent of Firms

(b) Top 20 Percent of Transactions

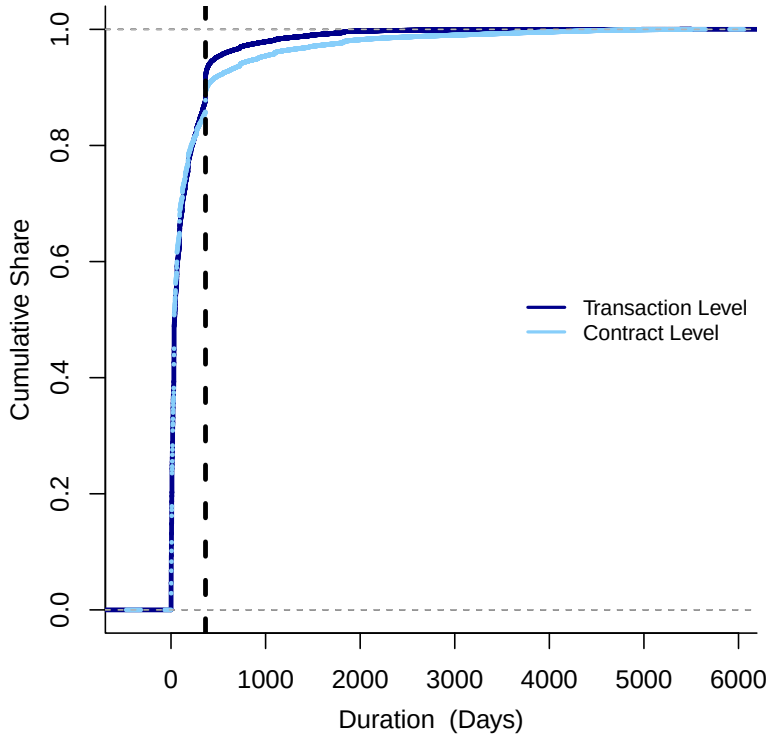
Note. The left panel of this figure shows that there is a linear relationship between the log size of firm obligations and the log frequency of that size. The right panel shows that the same is true for individual contract transactions. Showing that there is a linear relationship between log-size and log-frequency is a simple way of showing that government contracts are well-approximated by a power law.

Figure 9: Histogram of Log Contracts and Simulated Probability Density Function



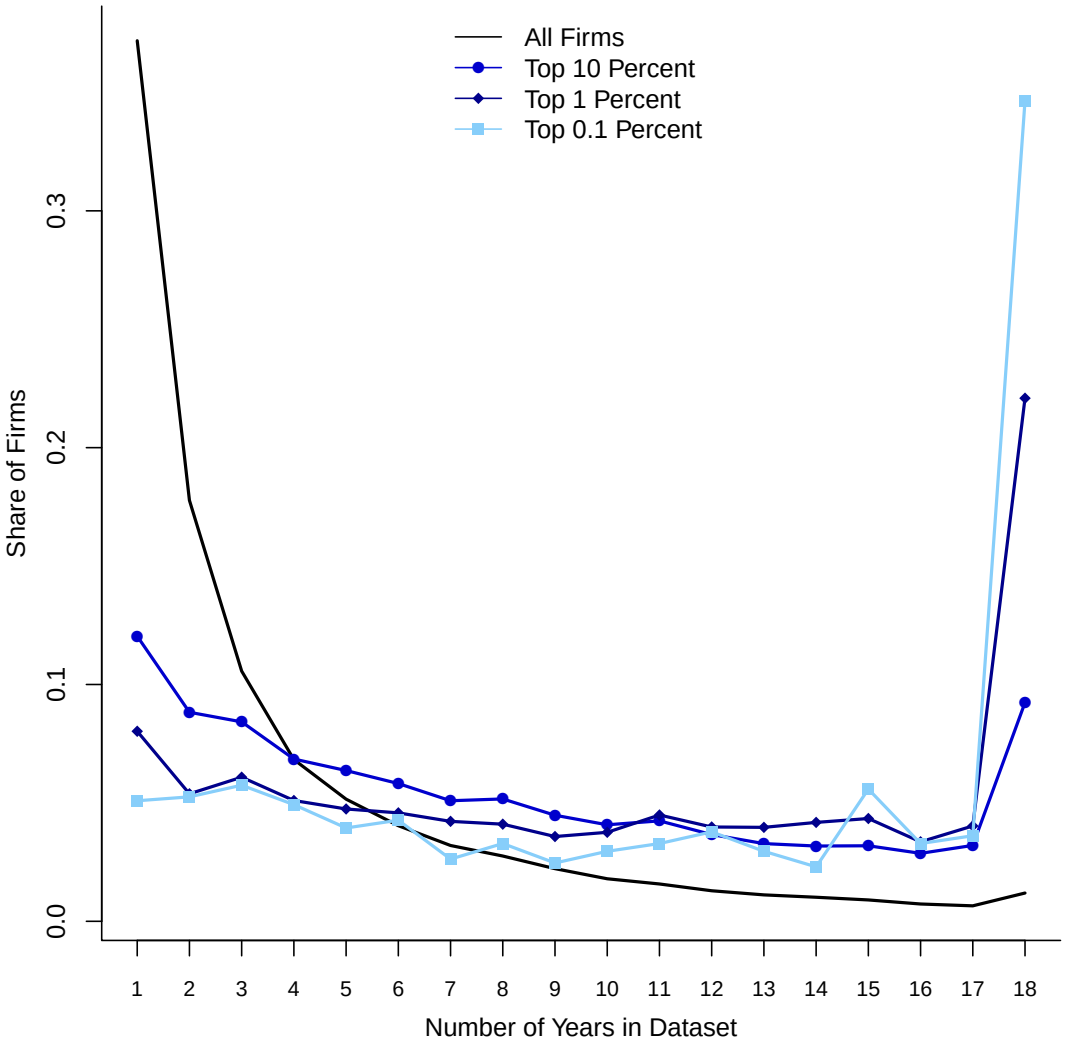
Note. This figure shows a histogram of log contract transactions and the simulated density function of the associated pareto distribution with parameters estimated using MLE. We estimate a shape parameter of $\alpha = 0.67$. Note that since we plot the log of contract obligations, if contracts are distributed Pareto(α, x_m), the log contracts follow a two-parameter exponential distribution with parameters (λ, θ), where $\lambda = \frac{1}{\alpha}$ and $\theta = \ln(x_m)$.

Figure 10: Empirical CDF of Contract Durations



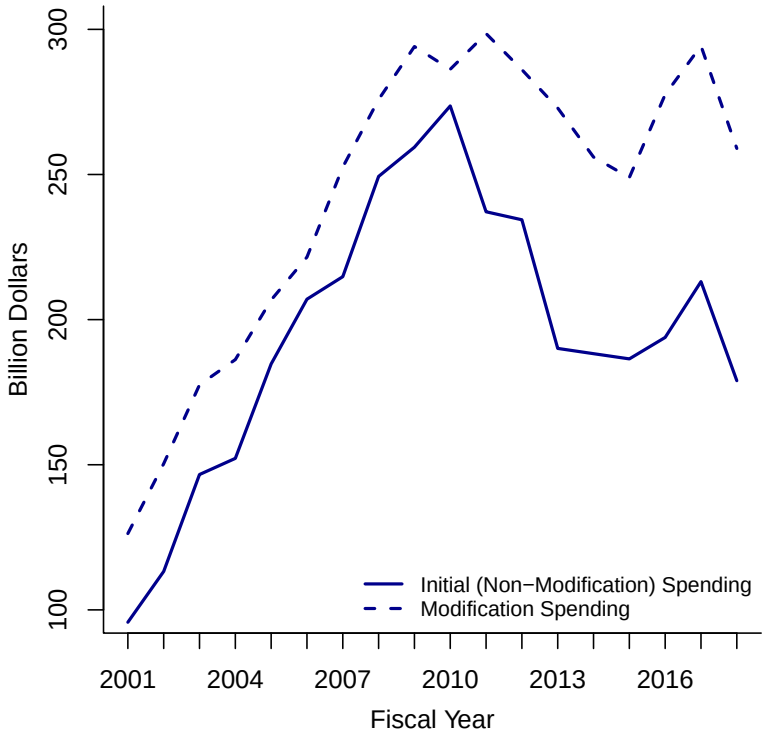
Note. This figure shows the empirical cumulative distribution function of the duration—the number of days between the start- and end-date—of transactions and contracts. The dashed black line marks 365 days. Contracts with negative durations or durations more than 5500 days (15 years) are excluded.

Figure 11: Government-Supplier Relationships



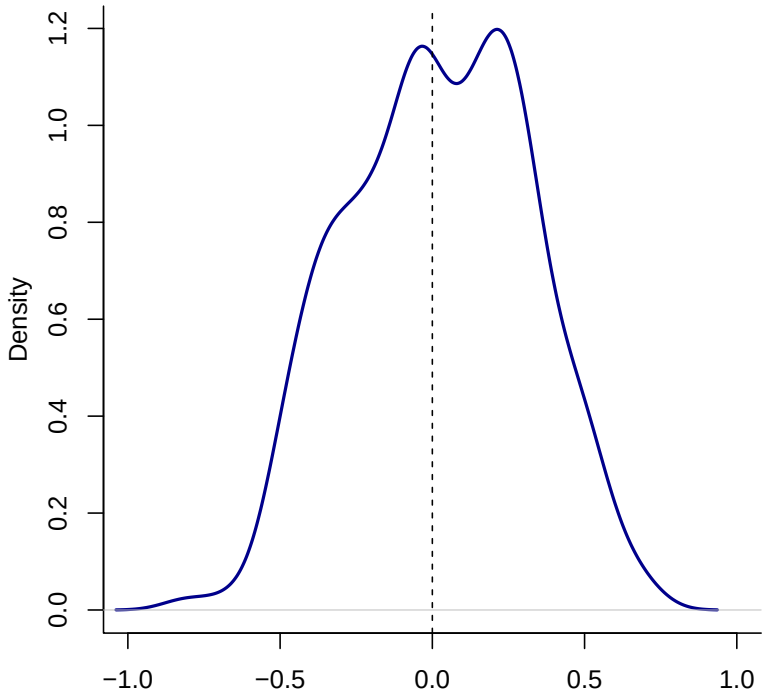
Note. This figure shows the share of firms that show up in the dataset (are involved in a contract transaction) for 1,2,...,18 years. The solid black line shows that among all firms, there is high turnover—the majority of firms show up in only 1 to 3 years. Conversely, relationships with the top 0.1 percent of suppliers to the government are much more long-term in nature.

Figure 12: Initial and Modification Spending



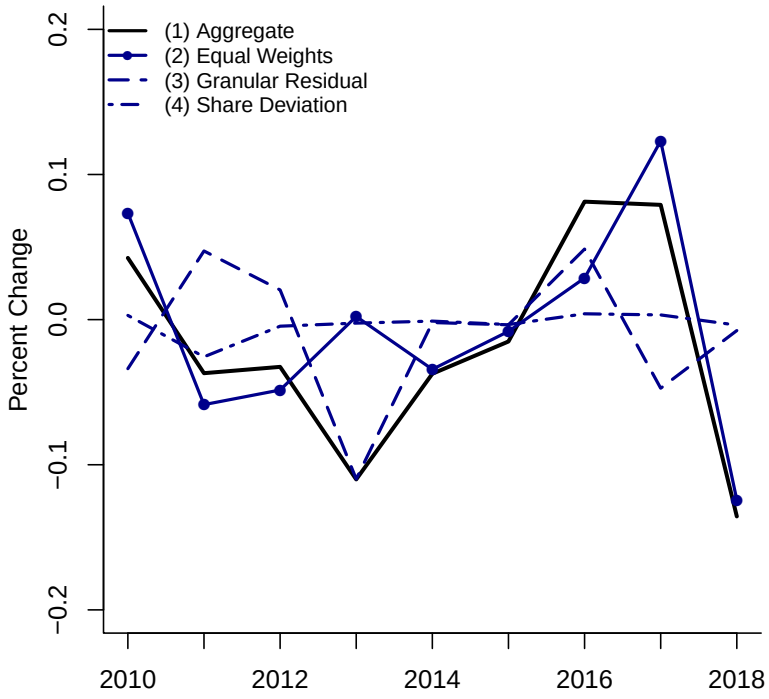
Note. This figure shows the levels of initial spending (any transaction that is *not* delineated a modification) and modification spending (transactions that are classified as modifications.

Figure 13: Density of Error Term Correlation Coefficients



Note. This figure shows the distribution of correlation across sector pairs that result from examining the sectoral process: $g_{s,t+1} = \alpha_s + \alpha_t + \rho_s g_{s,t} + \varepsilon_{s,t+1}$, where $g_{s,t}$ is the log of government consumption of output from two-digit sector s in year t. The figure shows the distribution of the correlation coefficients of the residuals for all sector pairs.

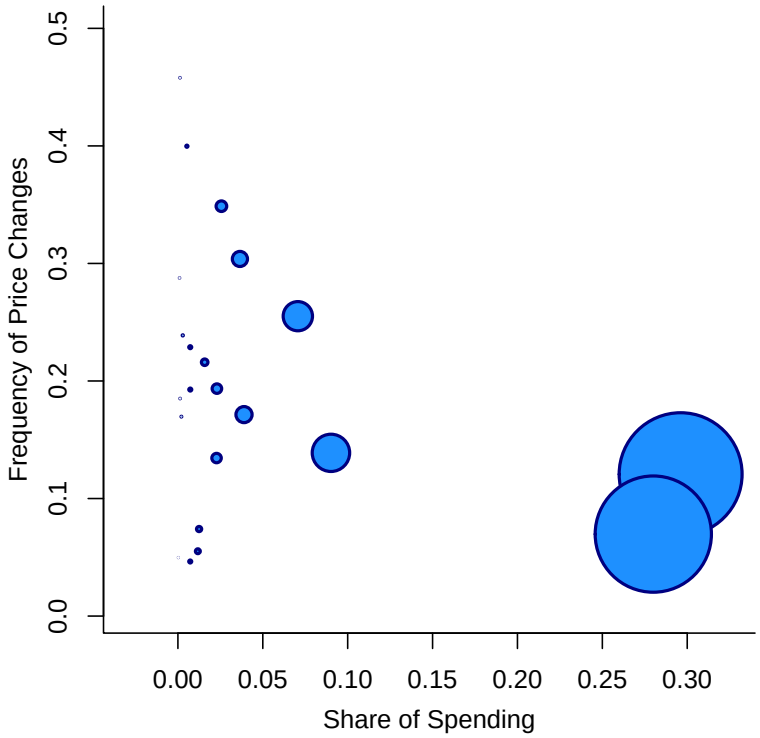
Figure 14: Decomposition of Sectoral Spending Growth



Note. This figure plots the individual components of government consumption growth, decomposed as in Foerster et al. (2011) as follows:

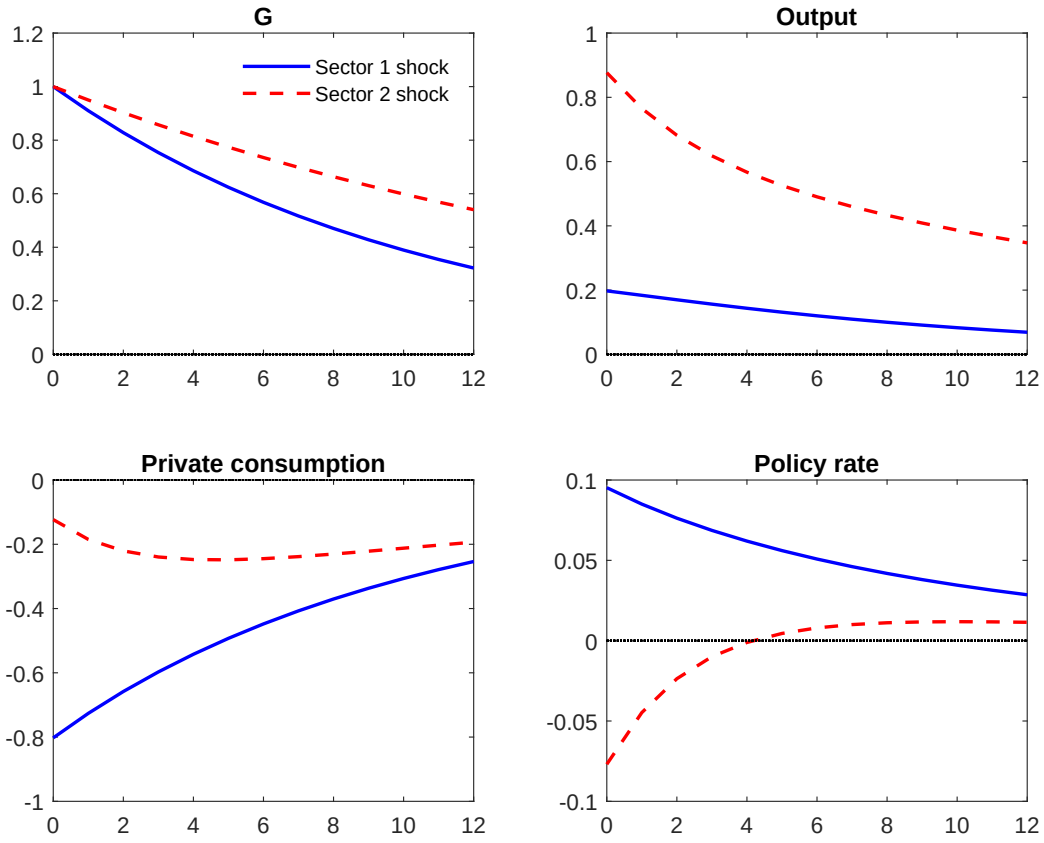
$$Z_t = \underbrace{\sum_{i=1}^{N} \omega_{i,t} z_{i,t}}_{\text{(1) Actual}} = \underbrace{\frac{1}{N} \sum_{i=1}^{N} z_{i,t}}_{\text{(2) Equal Weights}} + \underbrace{\sum_{i=1}^{N} \left(\bar{\omega}_i - \frac{1}{N} \right) z_{i,t}}_{\text{(3) Granular Residual}} + \underbrace{\sum_{i=1}^{N} (\omega_{i,t} - \bar{\omega}_i) z_{i,t}}_{\text{(4) Share Deviation}}$$

Figure 15: Sectoral Spending and Price Rigidity



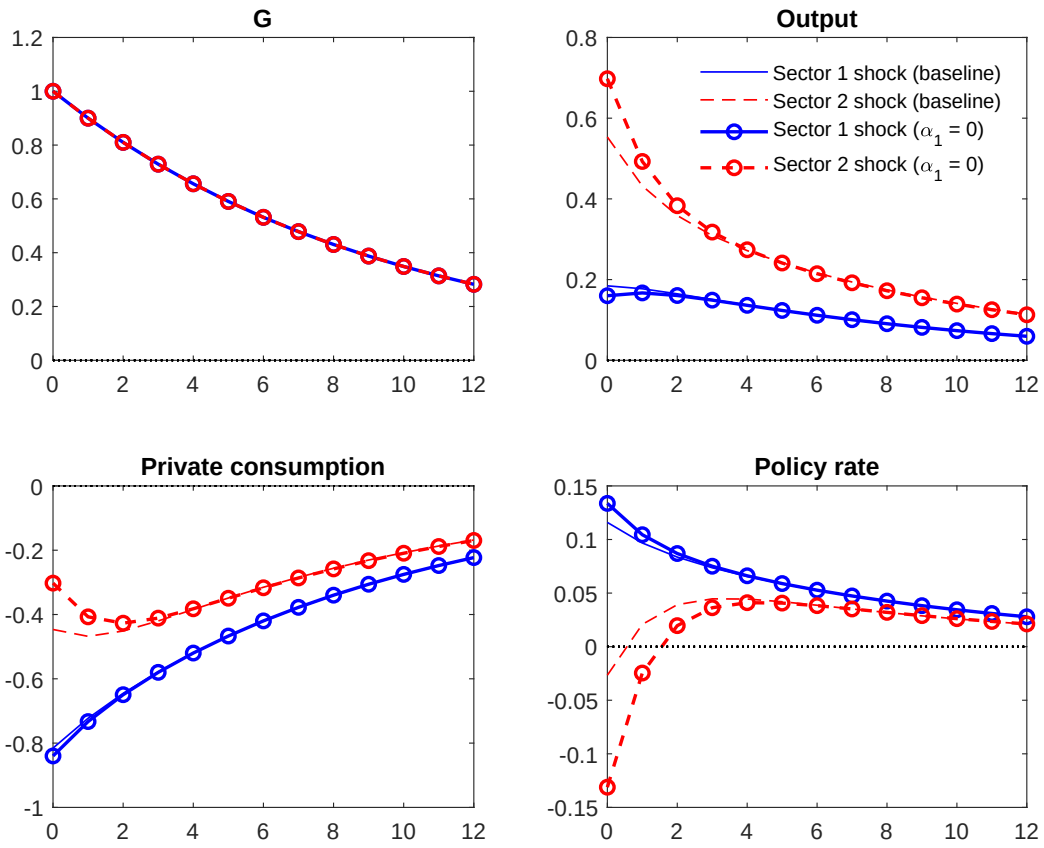
Note. This figure shows the average annual share of government spending in each two-digit sector (x-axis) plotted against the frequency of price changes in those sectors, based on BLS data. The size of the bubble corresponds with the average sectoral share of annual aggregate spending.

Figure 16: Dynamic effect of sectoral shocks



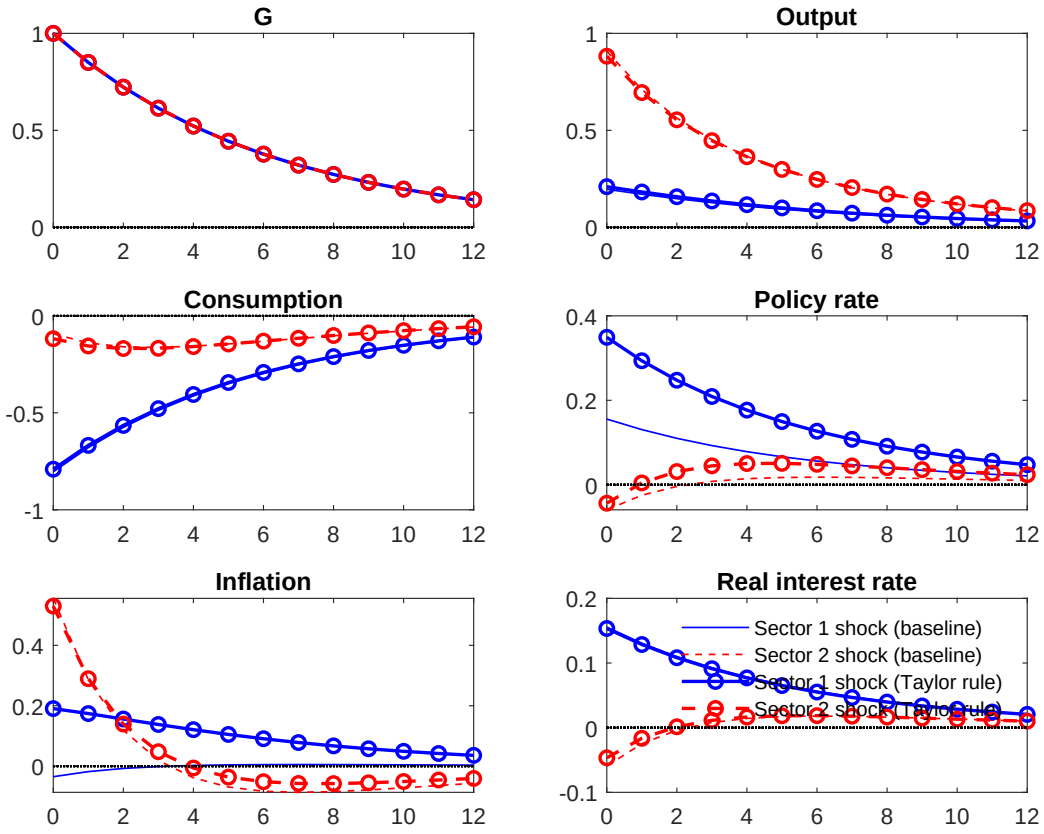
Note. Impulse response to government spending shocks in two-sector model: sector 1 (solid line) vs sector 2 (dashed line). Shock is one percent of output. Horizontal axis measures time in quarters. Vertical axis measures deviation from steady state in percentage points (of steady-state output in case of quantities).

Figure 17: Dynamic effect of sectoral shocks, baseline vs flexible prices in Sector 1



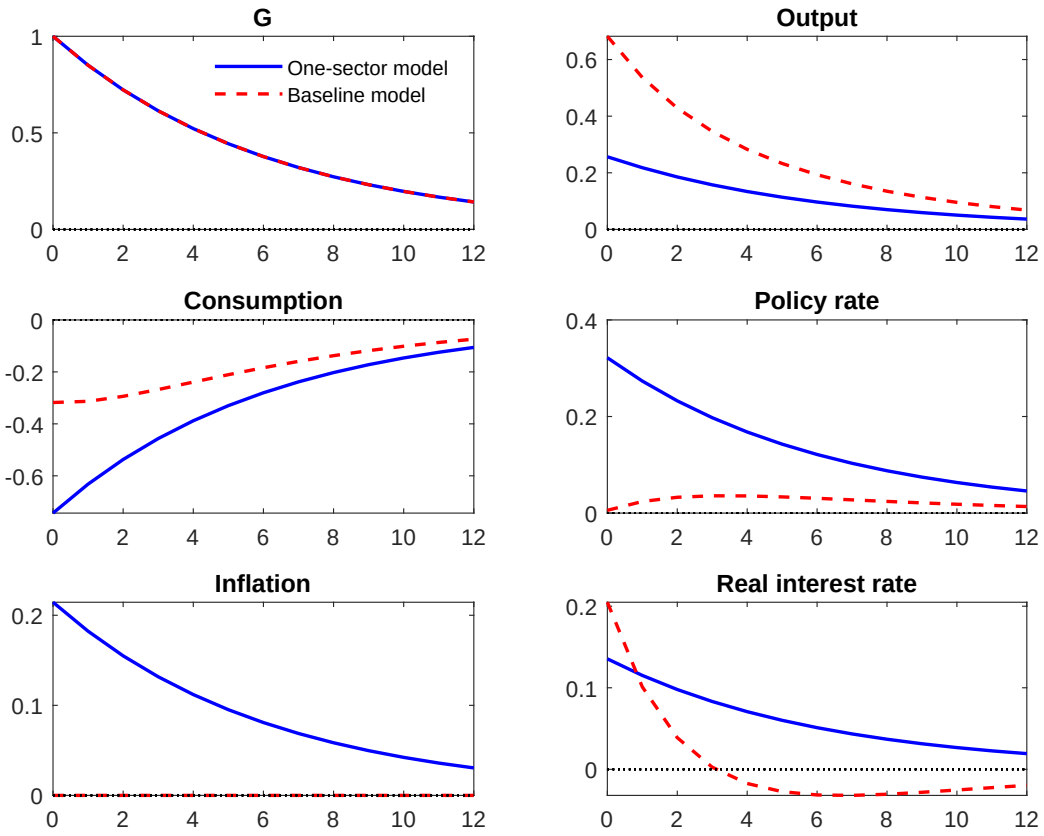
Note. Impulse response to government spending shocks in two-sector model: sector 1 (solid line) vs sector 2 (dashed line). Shock is one percent of output. Horizontal axis measures time in quarters. Vertical axis measures deviation from steady state in percentage points (of steady-state output in case of quantities).

Figure 18: Dynamic effect of sectoral shocks, alternative monetary policy



Note. Impulse response to government spending shocks in two-sector model: sector 1 (solid line) vs sector 2 (dashed line). Shock is one percent of output. Horizontal axis measures time in quarters. Vertical axis measures deviation from steady state in percentage points (of steady-state output in case of quantities).

Figure 19: Dynamic effect of aggregate shock



Note. Impulse response to aggregate government spending shocks in two-sector model: homogenous sectors (solid line) vs baseline with heterogenous sectors (dashed line). Shock is one percent of output. Horizontal axis measures time in quarters. Vertical axis measures deviation from steady state in percentage points (of steady-state output in case of quantities).

Table 1: Spending Shares and Frequency of Price Changes

# of Sectors	**% of G**	% Value Added	Avg. Freq. In	Avg. Freq. Out	Avg. ρ In	Avg. ρ Out
1	30.7	6.29	0.12	0.15	0.95	0.92
2	59.53	13.3	0.09	0.2	0.96	0.89
3	68.74	16.22	0.1	0.22	0.96	0.87
4	76.05	20.39	0.13	0.21	0.94	0.87
5	80.17	24.72	0.14	0.22	0.93	0.87
6	84.08	30.66	0.17	0.2	0.91	0.88
8	89.23	40.5	0.19	0.16	0.91	0.84
12	95.62	55.3	0.17	0.21	0.93	0.79

Note. Avg. Frequency In refers to the average frequency of price changes in sectors within the given % of government spending. Avg. Frequency Out is the average frequency of price changes for all other sections. The same interpretation is true for ρ, the persistence parameter estimated in the AR1.

Table 2: Percent of Government Consumption versus Percent of Value Added (2017)

Sector Name	**NAICS 2**	**% of G**	**% Value Added**
Manufacturing	33	30.7	6.29
Professional, Scientific, and Technical Services	54	28.83	7.01
Administrative and Waste Management	56	9.21	2.92
Construction	23	7.31	4.17
Manufacturing	32	4.12	4.33
Wholesale Trade	42	3.91	5.94
Transportation and Warehousing	48	2.67	2.67
Finance and Insurance	52	2.48	7.17
Information	51	2.34	4.98
Manufacturing	31	1.59	1.67
Health Care, Social Assistance	62	1.32	6.98
Educational Services	61	1.14	1.17
Other Services, ex. Government	81	0.73	2.26
Real Estate, Rental Leasing	53	0.72	12.88
Retail Trade	44	0.71	1.98
Utilities	22	0.53	1.66
Accommodation and Food Services	72	0.29	2.82
Transportation and Warehousing	49	0.22	0.29
Agriculture, Forestry, Fishing, Hunting	11	0.12	1.01
Retail Trade	45	0.12	4
Mining	21	0.09	1.78
Arts, Entertainment, Recreation	71	0.03	1.02

Table 3: Top Firms for Government Consumption vs Top (Non-Oil) Firms in Compustat

Government Contracts	Compustat Sales
LOCKHEED MARTIN CORPORATION	WALMART INC
THE BOEING COMPANY	TOYOTA MOTOR CORP
GENERAL DYNAMICS CORPORATION	VOLKSWAGEN AG
RAYTHEON COMPANY	GENERAL MOTORS CO
NORTHROP GRUMMAN CORPORATION	DAIMLER AG
BAE SYSTEMS PLC	FORD MOTOR CO
UNITED TECHNOLOGIES CORPORATION	GENERAL ELECTRIC CO
L-3 COMMUNICATIONS HOLDINGS INC.	AXA SA
BECHTEL GROUP INC.	ALLIANZ SE
SAIC INC.	MCKESSON CORP
MCKESSON CORPORATION	AT&T INC
HUNTINGTON INGALLS INDUSTRIES INC.	NIPPON TELEGRAPH & TELEPHONE
MISCELLANEOUS FOREIGN CONTRACTORS	VERIZON COMMUNICATIONS INC
COMPUTER SCIENCES CORPORATION	APPLE INC
VERITAS CAPITAL FUND II L.P. THE	HONDA MOTOR CO LTD
COINS 'N THINGS, INC.	CVS HEALTH CORP
BOOZ ALLEN HAMILTON HOLDING CORPORA	SIEMENS AG
HUMANA INC.	ENGIE SA
KBR INC.	E.ON SE
URS CORPORATION	INTL BUSINESS MACHINES CORP
NATIONAL TECHNOLOGY & ENGINEERING S	CARDINAL HEALTH INC
HEALTH NET INC.	HP INC
GENERAL ELECTRIC COMPANY	HITACHI LTD
HONEYWELL INTERNATIONAL INC.	NISSAN MOTOR CO LTD
LOS ALAMOS NATIONAL SECURITY LLC	FIAT CHRYSLER AUTOMOBILES NV
BELL BOEING JOINT PROJECT OFFICE	NESTLE SA/AG
OSHKOSH CORPORATION	VALERO ENERGY CORP
CALIFORNIA INSTITUTE OF TECHNOLOGY	AMERISOURCEBERGEN CORP
STATE OF CALIFORNIA	COSTCO WHOLESALE CORP
HUNTINGTON INGALLS INDUSTRIES, INC.	KROGER CO
HEWLETT-PACKARD COMPANY	DEUTSCHE TELEKOM
BATTELLE MEMORIAL INSTITUTE INC	PANASONIC CORP
HARRIS CORPORATION	HOME DEPOT INC
TRIWEST HEALTHCARE ALLIANCE CORP.	ENEL SPA
ITT CORPORATION	BOEING CO

Table 4: Distribution of Transaction and Contract Durations (Days)

	Transactions	Contracts
Mean	146.4	200.2
10th Percentile	0	1
Median	30	33
90th Percentile	364	379

AWARD ID: W912QR08C0053			RECIPIENT: Emerson Construction Company, Inc.	AWARDING AGENCY: Department of Defense (Department of the Army)
Line	Action Date	Amount	Reason for Modification	Description
1	9/29/08	$13,917,176,427	--	CONSTRUCT ARC FT. WORTH TX
2	1/7/09	($13,901,924,427)	M: OTHER ADMINISTRATIVE ACTION	CONSTRUCT ARC FT. WORTH TX MOD CORRECT SUBCLINS
3	3/3/09	$11,899	M: OTHER ADMINISTRATIVE ACTION	PROVIDE CANOPY FASCIA COVERS AND INCREASE SIZE OF METAL W...
4	3/4/09	$29,070	B: SUPPLEMENTAL AGREEMENT FOR WORK WITHIN SCOPE.	REMOVE ASPHALT PAVING AND COMPENSATE FOR ROCK REMOVAL...
5	3/26/09	$1,487	B: SUPPLEMENTAL AGREEMENT FOR WORK WITHIN SCOPE.	RAISE SS MH #5 TO MATCH NEW GRADE, U.S. ARMY RESERVE CENTE...
6	3/30/09	$2,200	B: SUPPLEMENTAL AGREEMENT FOR WORK WITHIN SCOPE.	ELECTRICAL POLE SURVEY FOR EASEMENT, U.S. ARMY RESERVE CE...
7	4/27/09	($14,448)	B: SUPPLEMENTAL AGREEMENT FOR WORK WITHIN SCOPE.	REALIGN SITE ELECTRICAL, U.S. ARMY RESERVE CENTER, FT. WORT...
8	4/29/09	($379)	B: SUPPLEMENTAL AGREEMENT FOR WORK WITHIN SCOPE.	REMOVE TREE ON ACCESS ROAD INTERFERING WITH OVERHEAD EL...
9	4/30/09	($1,400)	B: SUPPLEMENTAL AGREEMENT FOR WORK WITHIN SCOPE.	DELETE DAY GATE IN ARMS VAULT, U.S. ARMY RESERVE CENTER, FT...
10	5/20/09	$0	C: FUNDING ONLY ACTION	CHANGE ACCOUNTING AND APPROPRIATION INFORMATION ON DE...
11	6/18/09	$0	B: SUPPLEMENTAL AGREEMENT FOR WORK WITHIN SCOPE.	CHANGE PROGRAMMING PROTOCOL FOR THE DIRECT DIGITAL CON...
12	7/14/09	$14,292	B: SUPPLEMENTAL AGREEMENT FOR WORK WITHIN SCOPE.	PROVIDE TEMPORARY GENERATORS UNTIL UTILITY COMPANY CAN...
13	7/15/09	$0	M: OTHER ADMINISTRATIVE ACTION	CONSTRUCT ARC FT. WORTH TX
14	7/29/09	$20,185	B: SUPPLEMENTAL AGREEMENT FOR WORK WITHIN SCOPE.	INCREASE SIZE OF FIRE LINES, U.S. ARMY RESERVE CENTER, FT. WO...
15	7/30/09	$0	B: SUPPLEMENTAL AGREEMENT FOR WORK WITHIN SCOPE.	TIME EXTENSION DUE TO WEATHER DELAYS, U.S. ARMY RESERVE C...
16	8/26/09	$394,000	G: EXERCISE AN OPTION	CONSTRUCT ARC FT. WORTH TX OPTION 4 EXERCISED
17	9/2/09	$34,119	B: SUPPLEMENTAL AGREEMENT FOR WORK WITHIN SCOPE.	ADD 12" DOUBLE-CHECK BACKFLOW PREVENTER AND VAULT, U.S. A...
18	10/15/09	$22,039	B: SUPPLEMENTAL AGREEMENT FOR WORK WITHIN SCOPE.	PROVIDE STC RATED WALLS IN ROOMS 140, 140A AND 140B, U.S. AR...
19	2/4/10	$4,096	B: SUPPLEMENTAL AGREEMENT FOR WORK WITHIN SCOPE.	RELOCATE WATER METER VAULT, U.S. ARMY RESERVE CENTER, FT...
20	2/10/10	$5,177	D: CHANGE ORDER	CONSTRUCT ARC FT. WORTH TX
21	2/11/10	$5,992	A: ADDITIONAL WORK (NEW AGREEMENT...)	CONSTRUCT ARC FT. WORTH TX
22	2/18/10	$0	B: SUPPLEMENTAL AGREEMENT FOR WORK WITHIN SCOPE.	TIME EXTENSION DUE TO WEATHER DELAYS, U.S. ARMY RESERVE C...
23	3/2/10	$8,959	A: ADDITIONAL WORK (NEW AGREEMENT...)	CONSTRUCT ARC FT. WORTH TX
24	8/3/10	$64,670	B: SUPPLEMENTAL AGREEMENT FOR WORK WITHIN SCOPE.	CONSTRUCT MOBILE KITCHEN TRAILER, U.S. ARMY RESERVE CENTE...
25	11/29/10	$43,547	B: SUPPLEMENTAL AGREEMENT FOR WORK WITHIN SCOPE.	CASE 027 MODIFY CHILL PIPE, VANITY, TRIM SHOWER; CASE 029 CR...
26	4/6/11	$0	M: OTHER ADMINISTRATIVE ACTION	CONSTRUCT ARC FT. WORTH TX-MOD TO EXTEND POP
27	11/15/11	$396,023	B: SUPPLEMENTAL AGREEMENT FOR WORK WITHIN SCOPE.	CASE 032 PAYMENT FOR ALL UTILITY CHARGES ASSOCIATED WITH...
	TOTAL:	**$16,293,528**		

Figure 20: Example of Offsetting Transactions

Table 5: Explanatory Power of the Granular Residual

	ΔG_t			
	Q=1000		Q=100	
	(1)	(2)	(3)	(4)
$\Gamma_t^{Q=1000}$	0.282^{***}	0.280^{***}		
	(0.080)	(0.079)		
$\Gamma_{t-1}^{Q=1000}$	-0.043	-0.046		
	(0.080)	(0.079)		
$\Gamma_{t-2}^{Q=1000}$	0.089			
	(0.080)			
$\Gamma_t^{Q=100}$			0.289^{***}	0.278^{***}
			(0.084)	(0.082)
$\Gamma_{t-1}^{Q=100}$			-0.030	-0.038
			(0.083)	(0.083)
$\Gamma_{t-2}^{Q=100}$			0.105	
			(0.084)	
Constant	0.169^{*}	0.136^{*}	0.154^{*}	0.117^{*}
	(0.083)	(0.068)	(0.076)	(0.064)
Observations	15	16	15	16
R^2	0.558	0.506	0.539	0.478
Adjusted R^2	0.438	0.430	0.414	0.397
Residual Std. Error	0.192 (df = 11)	0.190 (df = 13)	0.196 (df = 11)	0.196 (df = 13)
F Statistic	4.630^{**} (df = 3; 11)	6.669^{**} (df = 2; 13)	4.292^{**} (df = 3; 11)	5.941^{**} (df = 2; 13)
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 6: Distribution of Contract Pricing Types

	All Contracts		Top 10 Firms	
Pricing Type	Share (Count)	Share (Value)	Share (Count)	Share (Value)
Combination	0.28	1.19	1.53	1.88
Cost No Fee	0.63	2.74	1.59	1.49
Cost Award Fee	0.94	11.52	6.44	17.38
Cost Fixed Fee	3.37	13.02	15.61	16.22
Cost Incentive	0.25	4.31	2.56	8.24
Cost Sharing	0.05	0.09	0.03	0.03
Firm Fixed Price	70.54	48.77	47.93	33.99
Fixed Price	1.09	1.85	1.06	2.65
Fixed Price Award	0.11	0.4	0.39	0.52
Fixed Price Incentive	0.22	4.56	2.72	12.53
Fixed Price Level of Effort	0.07	0.19	0.13	0.2
Fixed Price Redetermination	0.19	0.16	0.32	0.15
Fixed Price Economic Adj.	13.27	5.02	10.24	1.48
Labor Hours	1.19	1.18	1.23	0.42
Order Dependent	0.41	0.04	0.34	0.02
Time and Materials	2.28	3.6	5.66	2.13
Other or Not Reported	5.12	1.37	2.1	0.61
Total Fixed Price Contracts	85.49	60.95	62.79	51.52

Appendix

A USASpending vs. Other Data in the Literature

While, to our knowledge, no one has employed the USASpending database in the way that we do in this paper, there are a number of papers that make use of similar types of data on government spending. Most recently, Auerbach et al. (2019), use part of the USASpending database, in a more aggregated fashion. Specifically, they use only contracts that originate at the U.S. Department of Defense (DOD). To extend their time series backward, they supplement the USASpending data on DOD contracts with data that comes directly from the Federal Procurement Data System (FPDS). For their analysis, they aggregate the transaction-level data to create city-level measures of federal defense spending. Nakamura and Steinsson (2014) also use data on defense procurement contracts from an older database to compile data on total military procurement at the state level from 1966 to 2006. The data that Nakamura and Steinsson (2014) employ is from the DD Form 350, the procurement reporting form that preceded the FPDS forms that are in the USASpending database and Auerbach et al. (2019) and so contain very comparable information about the defense procurement contracts. The DOD transitioned from the DD Form 350 to the FPDS in 2007. While Auerbach et al. (2019) aggregate to the city level, Nakamura and Steinsson (2014) aggregate to the state level.[29]

Cohen et al. (2011) also look at a state level measure of government spending, but these authors use data on congressional earmarks—also known as "pork"—from Citizens Against Government Waste (CAGW) to identify the impact of government spending on the private sector. Instead of providing detailed information about the contract that the government enters into with suppliers, as do the USASpending data, the earmark data show line items in appropriations bills that are designated for specific purposes and are included in those bills in such a way that circumvents the established budgetary procedure. Cohen et al. (2011) also use some data on government procurement contracts from 1992-2008[30], aggregated at the state level.

B What are Government Contracts?

B.1 Award Types

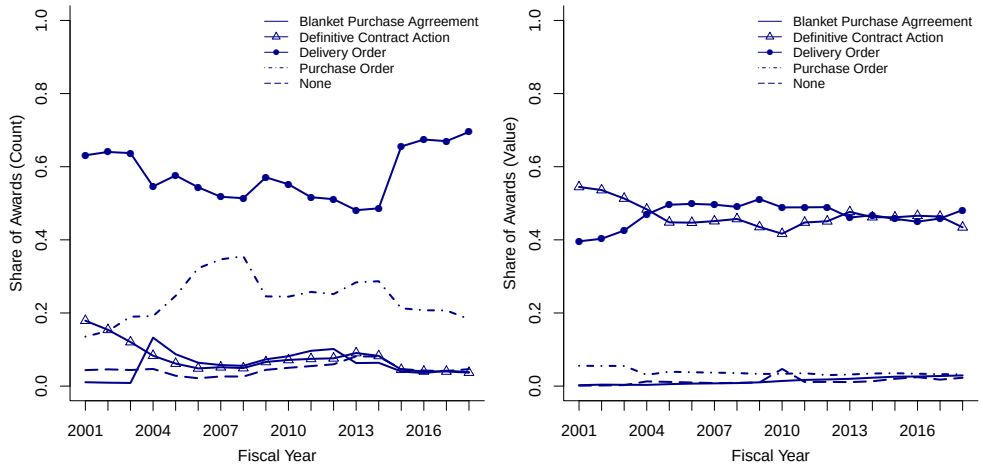
The figures below show the share of each type of award by count and value for all firms (top two panels) and the top ten firms (bottom two panels). By count, delivery orders and purchase orders are the most common type of award. By value, however, definitive contract actions account for about half of the dollars spent. This is even more the case when looking solely at the top 10 firms. This makes perfect sense, as delivery orders are usually used for smaller, more frequent, purchases (think of opening a "tab" with a company for supplies or services), while definitive contract actions are used for large one-time purchases. Shown in figure 21, there was a notable jump in the number of delivery orders in Fiscal Year 2015, largely explained by two indefinite delivery vehicle contracts that were awarded, respectively, to Lockheed Martin Corporation and Sikorsky Aircraft Corporation. The Lockheed Martin Corporation contract was

[29]Since the inception of USASpending.gov, most other sources of federal government procurement data that are published by government entities have now been transferred to the USASpending database, which links data from all around the federal government. Data are pulled directly from more than a hundred federal agencies' financial systems, and pulled from other government systems like FPDS, the Federal Assistance Broker system (FABS), the FFATA Sub-award Reporting System (FSRS) and the System for Award Management (SAM).

[30]These data come from a private company called Eagle Eye.

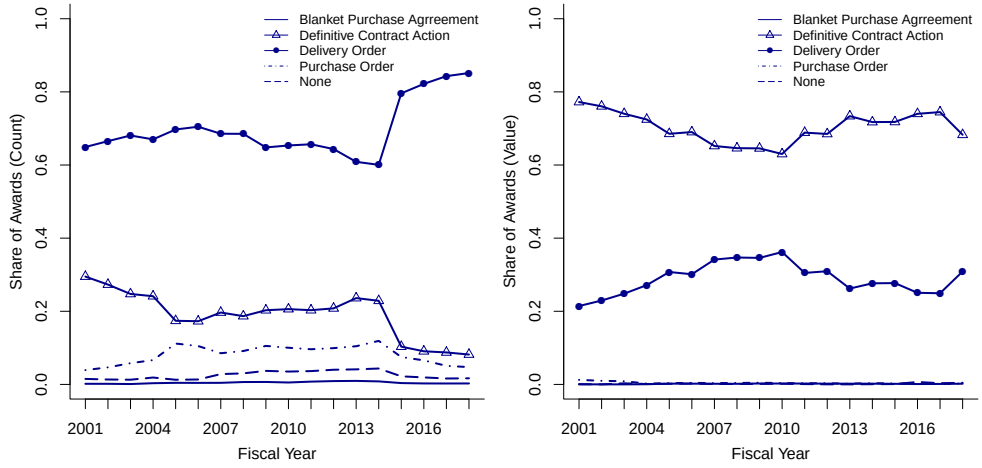
for "miscellaneous fire control equipment," and comprised almost 50,000 individual transactions in Fiscal Year 2015 for small items like a "switch, toggle" or "padlock." Similarly, the Sikorsky Aircraft Corporation contract for "airframe structural components," comprised around 13,000 individual transactions. By nature, these delivery order transactions are small in value, which is why we see only an increase in the delivery order count, but not a large increase in the share of delivery orders by value[31].

Figure 21: Award Types



(a) Share by Count, Full Dataset

(b) Share by Value, Full Dataset



(c) Share by Count, Top 10 Firms

(d) Share by Value, Top 10 Firms

Note. This figure shows the breakdown of award type by count and by value. The top two panels show the breakdown for all firms, while the bottom two panels reflect only the top 10 firms in terms of average receipts of government obligations.

[31]Sikorsky PIID: SPE4AX14D9421; Lockheed Martin PIID: SPE7L114D0002

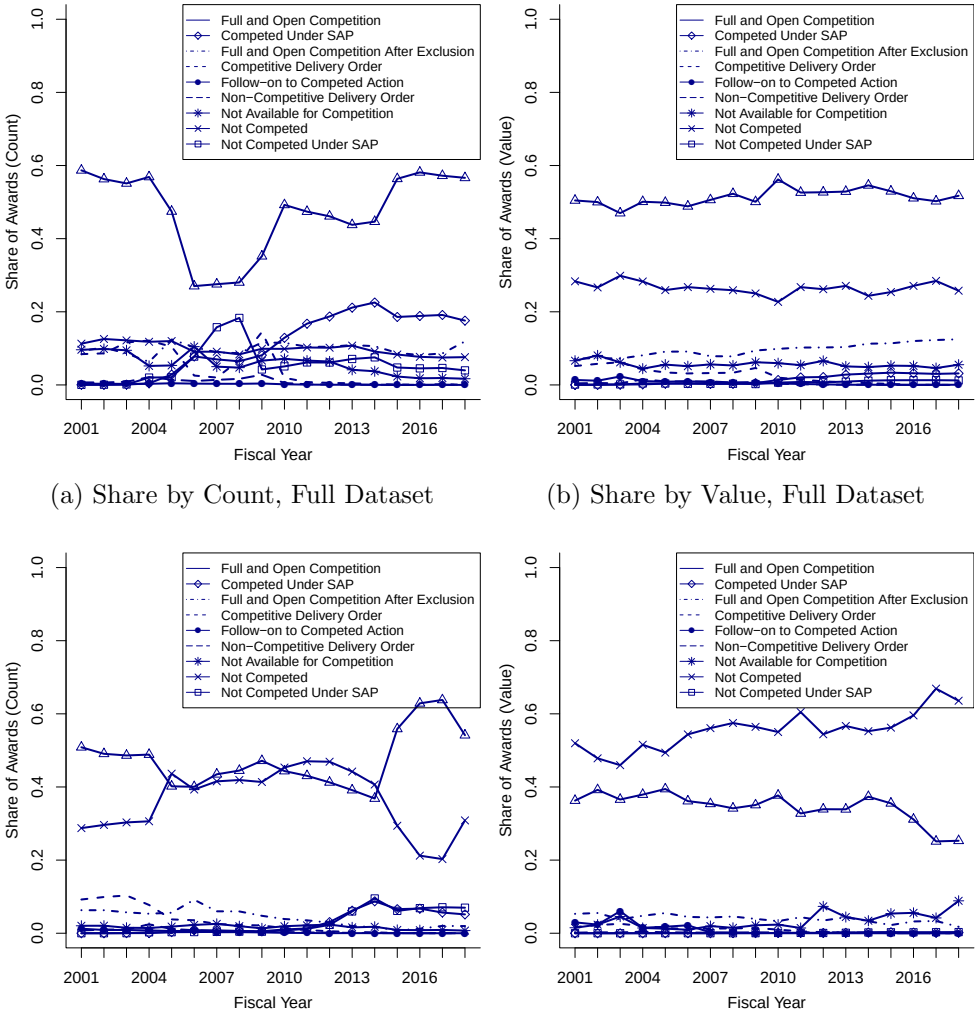
B.2 Extent Competed

By law — the Competition in Contracting Act (CICA) of 1984 (41 U.S.C. 253)—the government is required to provide for full and open competition through the use of competitive procedures or combination of competitive procedures that is best suited to the circumstances of the contract action. There are only a limited number of exceptions to this rule in which agencies can be given authorization to use single-source or limited competition. For smaller awards—those below a certain dollar threshold—federal agencies are required to use "Simplified Acquisition Procedures (SAPs)." These procedures are typically used for purchase of commonly purchased supplies such as office supplies, computer software, and groundskeeping services. SAPs reduce administrative costs, improve opportunities for small and minority-owned businesses, and increase efficiency. The SAP threshold is $150,000, though this can vary by situation[32]. There is a lower bound to the threshold also—$3,000—below which a purchase is considered a "micro purchase", and different acquisition procedures apply.

Figure 22 shows that both for all firms and for the top 10 firms, about half of transactions are awarded under "full and open competition." This is true both by count and by value of transaction. By value, slightly more of the contracts awarded to the top 10 firms are "not available for competition." This is no surprise, given that the top 10 firms include places like Lockheed Martin and General Dynamics—companies that are building specialized equipment for the military and are often the sole source of a given product. Similar to what we saw in section B.1, there is a sharp increase in the number of full and open competition transactions to the top 10 firms around 2015. The transactions comprising the large indefinite delivery vehicle contracts that were discussed in section B.1 were all deemed to be under full and open competition, helping to explain the increase.

[32]For example, for supplies or services supporting a contingency operation or facilitating defense against or recovery from nuclear, biological, chemical, or radiological attack, the simplified acquisition threshold is $300,000 for contracts awarded and performed or purchases made inside the U.S. and $1 million for contracts awarded and performed or purchases made outside the U.S.

Figure 22: Extent Competed



(a) Share by Count, Full Dataset

(b) Share by Value, Full Dataset

(c) Share by Count, Top 10 Firms

(d) Share by Value, Top 10 Firms

Note. This figure shows the breakdown of extent competed by count and by value. The top two panels show the breakdown for all firms, while the bottom two panels reflect only the top 10 firms in terms of average receipts of government obligations.

B.3 Scope of the Data

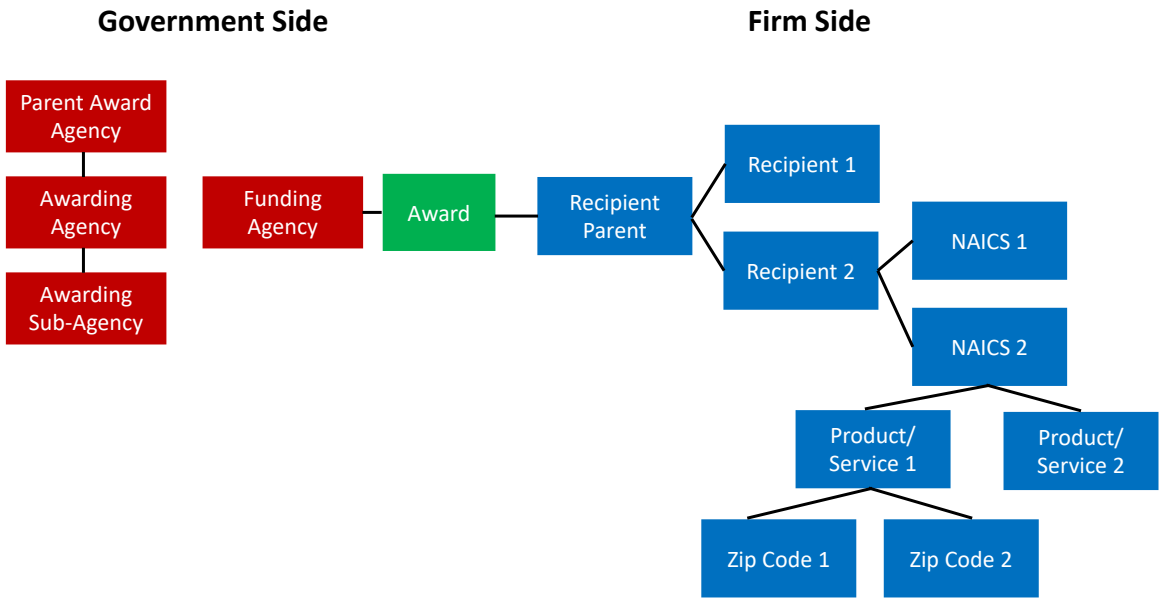


Figure 23: Tracing of Award from Origin to Recipient

C Five Facts

C.1 Sectoral Bias: Differential Granularity

Table 7: Top Firms: Government Consumption vs Compustat Sales

Firm Name	% of Contract Obligations	Sales as % of GDP
Top Recipients of Government Contracts		
LOCKHEED MARTIN CORPORATION	7.7077	0.279
THE BOEING COMPANY	4.2861	0.4779
GENERAL DYNAMICS CORPORATION	3.1632	0.1765
RAYTHEON COMPANY	2.7007	0.1524
NORTHROP GRUMMAN CORPORATION	2.697	0.186
BAE SYSTEMS PLC	1.4554	0.1589
UNITED TECHNOLOGIES CORPORATION	1.3462	0.3364
L-3 COMMUNICATIONS HOLDINGS INC.	1.1116	0.7591
BECHTEL GROUP INC.	1.0312	0.2234
SAIC INC.	0.9198	1.006
Top Firms Based on Compustat Sales		
WALMART INC	NA	2.6046
TOYOTA MOTOR CORPORATION	4e-04	1.4159
VOLKSWAGEN AG	4e-04	1.1872
GENERAL MOTORS CORP	0.0032	1.1611
DAIMLER AG	0.0344	1.1063
FORD MOTOR CO	0	1.0742
GENERAL ELECTRIC COMPANY	0.6133	1.006
AXA	8e-04	0.9008
ALLIANZ SE	0.0023	0.8619
MCKESSON CORPORATION	0.7458	0.7591

Note: Share of contract obligations is calculated as the firm's average annual share of government obligations. Sales share of GDP takes the average ratio of firm sales from Compustat to GDP.

C.2 AR(1)

We estimate the following:

$$g_{s,t} = \alpha_s + \rho_s g_{s,t-1} + \varepsilon_{s,t-1}$$

Where $g_{s,t}$ is the log of obligations to two-digit sector s in year t. We calculate the residuals, $\varepsilon_{s,t}$, and the variance-covariance matrix, $\frac{1}{T}\varepsilon'\varepsilon$. In the first specification, we omit time fixed effects, but we include them in the second specification. We also run a version of the specification including only the top half of sectors (12 of 24, by average obligations over the sample period).

The tables below show the coefficients, ρ, the variance terms, σ^2, the price stickiness parameters, Θ. We also plot the density of the covariances between sectors and the density of the correlation coefficients.

No Time Fixed Effects

Sector	ρ	σ^2	Θ
11	0.2455	0.0409	0.458
21	-0.099	0.34	0.2877
22	0.6888	0.0161	0.3997
23	0.743	0.0252	0.2552
31	0.6197	0.0184	0.216
32	0.7248	0.0408	0.1714
33	0.7403	0.0126	0.1207
42	0.8281	0.0778	0.3039
44	1.1864	0.0186	0.2288
45	0.4784	0.392	0.1851
48	0.8046	0.0194	0.3487
49	0.8021	0.0472	0.1697
51	0.8936	0.0056	0.1345
52	0.7435	0.0192	0.1935
53	0.8682	0.127	0.1927
54	0.7318	0.0034	0.0697
55	-0.1546	NA	NA
56	0.7204	0.0046	0.1389
61	-0.1682	0.0506	0.0552
62	0.8741	0.0169	0.0741
71	0.518	0.0736	0.0498
72	0.5605	0.0171	0.2388
81	0.6156	0.0118	0.0464
92	0.8107	0.109	NA

Time Fixed Effects

Sector	ρ	σ^2	Θ
11	0.336	0.0437	0.458
21	-0.189	0.282	0.2877
22	0.7948	0.0154	0.3997
23	0.8705	0.0154	0.2552
31	0.8271	0.0128	0.216
32	0.8891	0.0416	0.1714
33	0.9456	0.0127	0.1207
42	0.8408	0.0505	0.3039
44	1.0143	0.0134	0.2288
45	0.3845	0.31	0.1851
48	1.0409	0.0174	0.3487
49	0.9648	0.0522	0.1697
51	1.1683	0.0036	0.1345
52	0.8573	0.0168	0.1935
53	0.7678	0.0798	0.1927
54	0.9714	0.0054	0.0697
55	-0.178	NA	NA
56	0.9474	0.0129	0.1389
61	0.0941	0.0606	0.0552
62	1.0657	0.0133	0.0741
71	0.477	0.0994	0.0498
72	0.7107	0.0279	0.2388
81	0.8557	0.0168	0.0464
92	0.6595	0.0854	NA

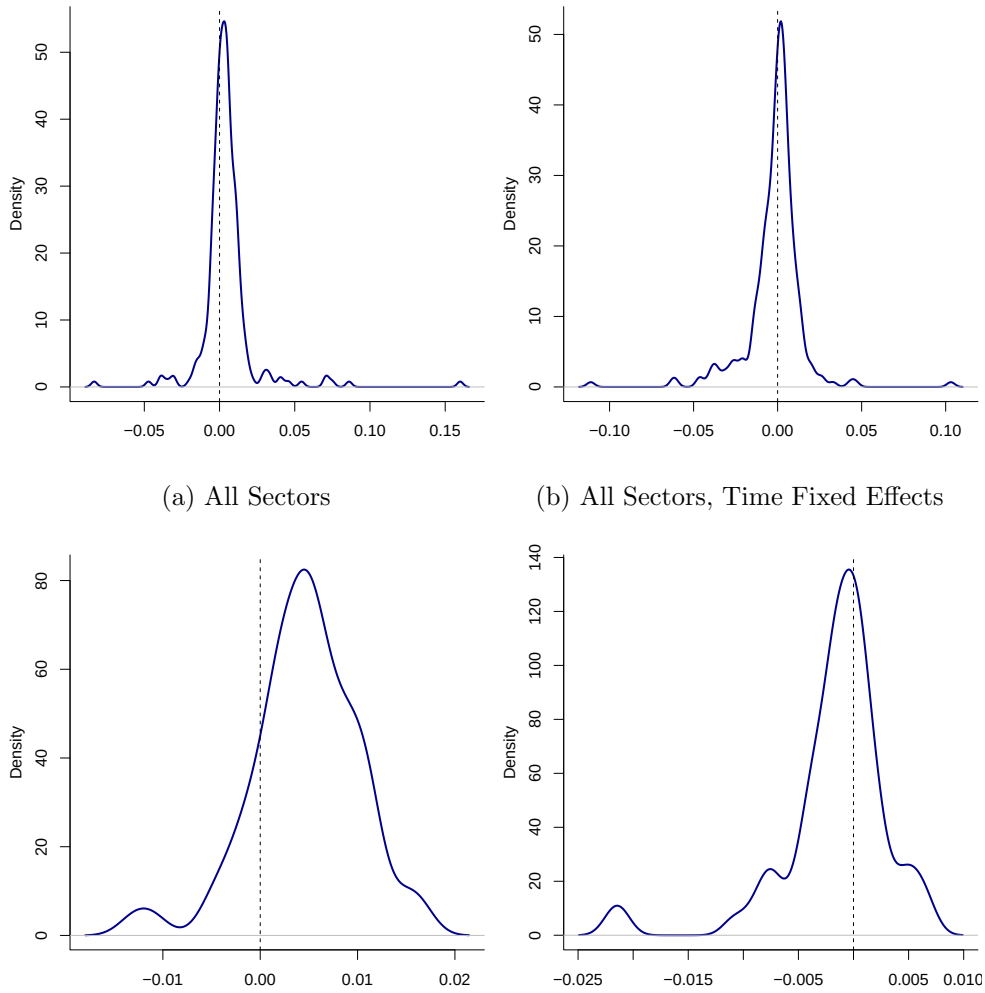
No Time Fixed Effects (REAL)

Sector	ρ	σ^2	Θ
11	0.5767	0.0561	0.458
21	0.1249	0.412	0.2877
22	0.6948	0.0216	0.3997
23	0.6842	0.0311	0.2552
31	0.6099	0.0209	0.216
32	0.5778	0.042	0.1714
33	0.6008	0.0124	0.1207
42	0.8632	0.0769	0.3039
44	1.2074	0.0155	0.2288
45	0.5713	0.451	0.1851
48	0.7221	0.0161	0.3487
49	0.7245	0.0474	0.1697
51	0.8018	0.0077	0.1345
52	0.677	0.0213	0.1935
53	0.9123	0.128	0.1927
54	0.5333	0.0053	0.0697
55	-0.0993	NA	NA
56	0.4827	0.0069	0.1389
61	0.0833	0.0757	0.0552
62	0.8236	0.0204	0.0741
71	0.5745	0.07	0.0498
72	0.3661	0.0191	0.2388
81	0.2761	0.0159	0.0464
92	0.8936	0.115	NA

Time Fixed Effects (REAL)

Sector	ρ	σ^2	Θ
11	0.4437	0.0435	0.458
21	-0.003	0.337	0.2877
22	0.4784	0.0145	0.3997
23	0.7753	0.0169	0.2552
31	0.609	0.0129	0.216
32	0.8681	0.0468	0.1714
33	0.9784	0.0148	0.1207
42	0.8769	0.0477	0.3039
44	0.9642	0.0143	0.2288
45	0.4802	0.335	0.1851
48	1.1787	0.0189	0.3487
49	1.0061	0.0553	0.1697
51	1.4046	0.008	0.1345
52	0.8733	0.019	0.1935
53	0.8012	0.0776	0.1927
54	0.9856	0.0086	0.0697
55	-0.142	NA	NA
56	0.7891	0.0162	0.1389
61	0.0965	0.0557	0.0552
62	1.1793	0.0146	0.0741
71	0.3987	0.0896	0.0498
72	0.5414	0.0267	0.2388
81	0.337	0.0149	0.0464
92	0.7257	0.0864	NA

Figure 24: Density of Error Term Covariances (Nominal)



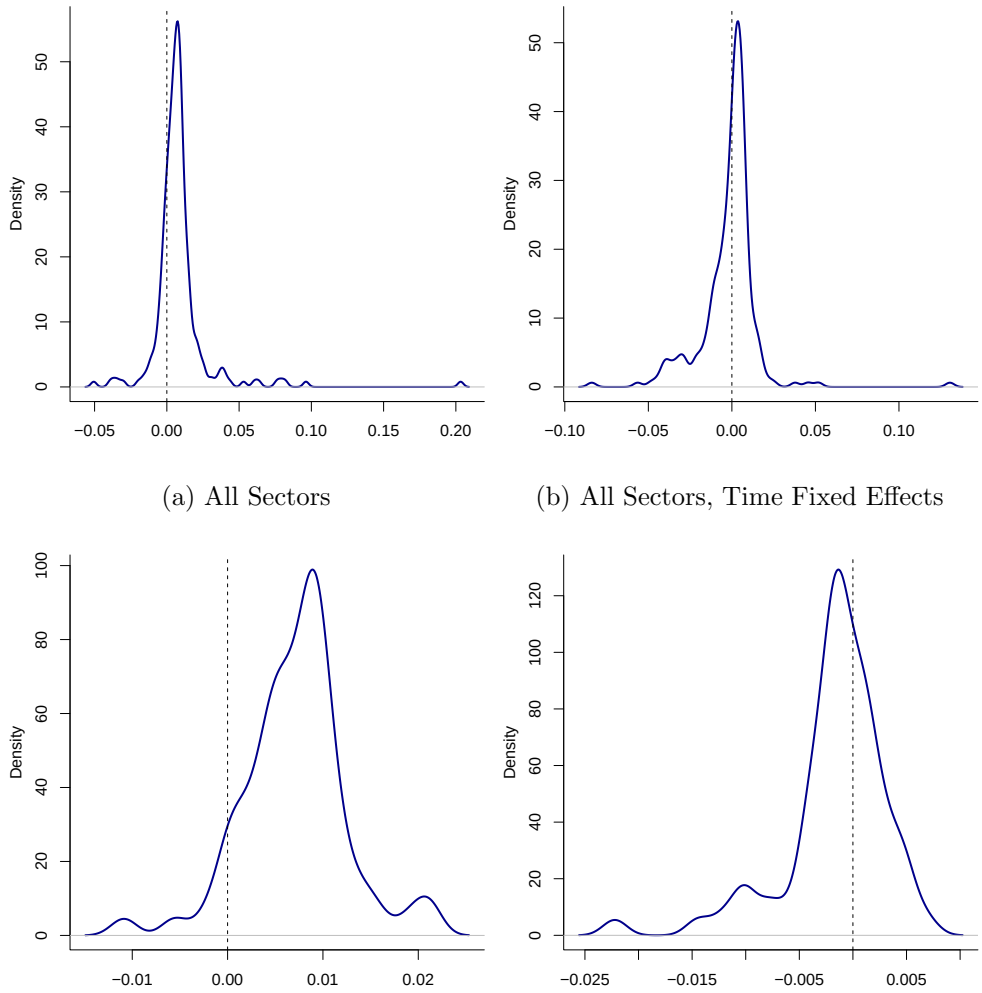
(a) All Sectors

(b) All Sectors, Time Fixed Effects

(c) Top Sectors

(d) Top Sectors, Time Fixed Effects

Figure 25: Density of Error Term Covariances (Real)



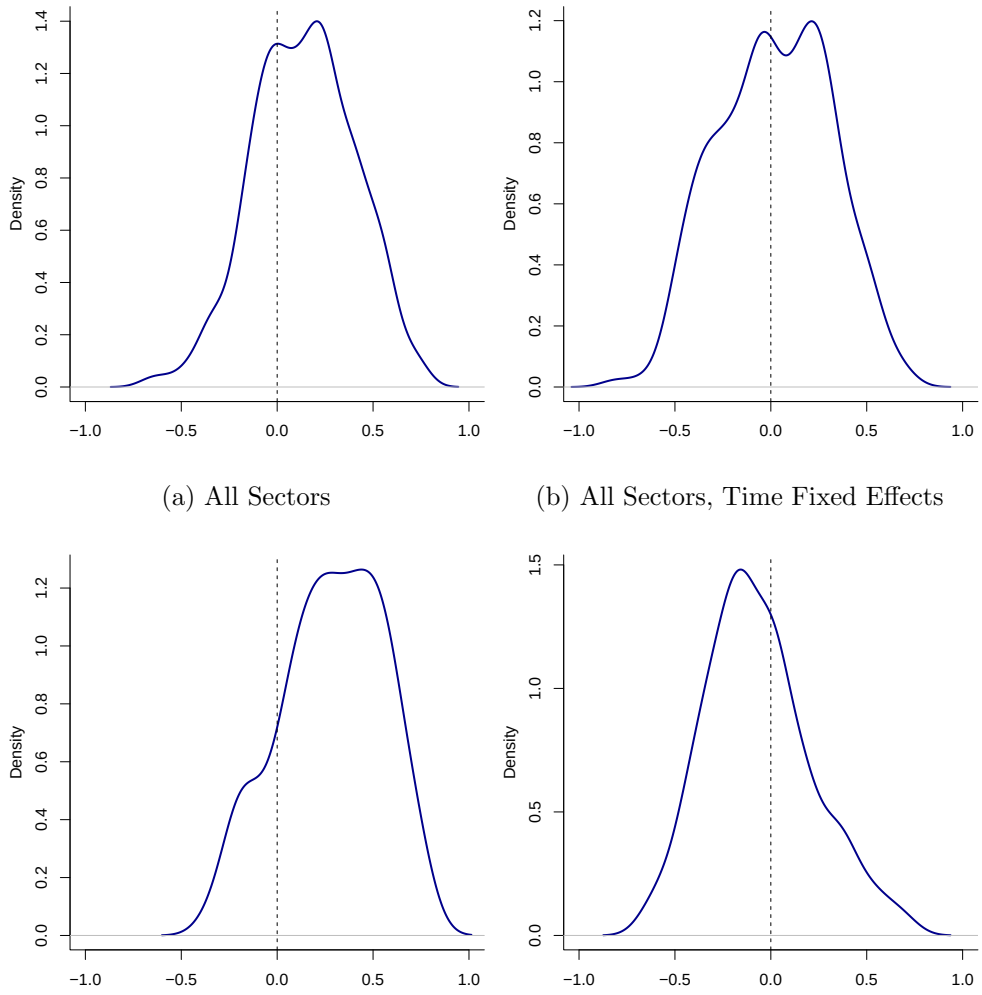
(a) All Sectors

(b) All Sectors, Time Fixed Effects

(c) Top Sectors

(d) Top Sectors, Time Fixed Effects

Figure 26: Density of Error Term Correlation Coefficients (Nominal)



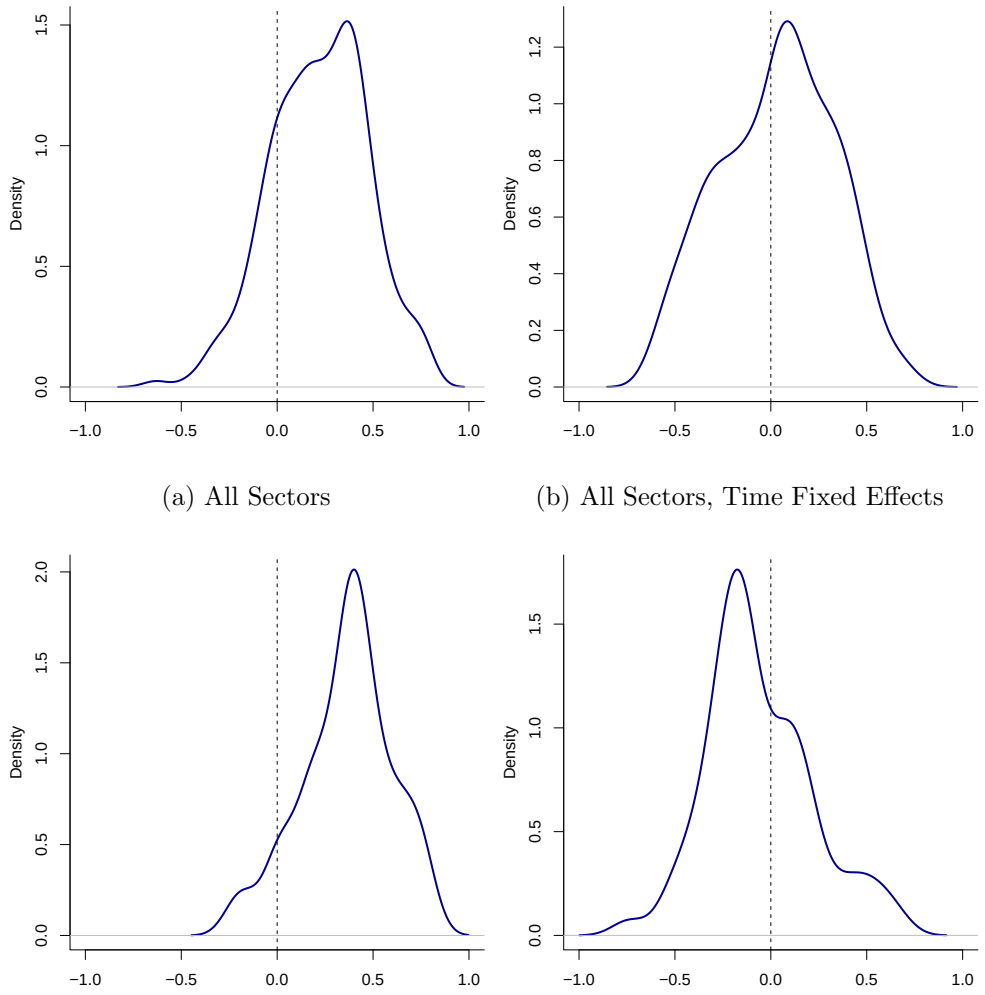
(a) All Sectors

(b) All Sectors, Time Fixed Effects

(c) Top Sectors

(d) Top Sectors, Time Fixed Effects

Figure 27: Density of Error Term Correlation Coefficients (Real)



(a) All Sectors

(b) All Sectors, Time Fixed Effects

(c) Top Sectors

(d) Top Sectors, Time Fixed Effects

No Time Fixed Effects: In the first specification, we exclude time fixed effects. The shocks that are the most highly correlated are sectors 45 and 21 (retail trade and mining). The other sectors in the right tail of the distribution (covariance > 0.05) are (21,42), (21,45), (21,53), (21,92), (45,42), (92,45). In the far left tail, the sectors with the most negative covariance are 45 and 61 (retail trade and educational services). The sectors with the highest correlation coefficients are 56 (administrative and waste management) and 72 (accommodation and food services). The sectors with the most negative correlation coefficient are 61 (educational services) and 45 retail trade.

Including Time Fixed Effects: In the second specification, we include a set of time fixed effects. Purging the estimates of common time shocks changes the distribution of the covariance terms slightly, primarily reducing the mass in the right tail. The sectors with the maximum and minimum covariances are the same as in the specification without time fixed effects — (max: 45 and 21, min: 45 and 61). The other sectors that remain in the right tail (covariance > 0.05) are (45,21) and (92,21). The sectors in either tail of the correlation coefficient distribution are

the same as above. The sectors with the highest correlation coefficients are 56 (administrative and waste management) and 72 (accommodation and food services). The sectors with the most negative correlation coefficient are 61 (educational services) and 45 retail trade.

Estimation for Top Sectors:
We do the same exercise as above, but restrict our sample to the top 12 of 24 two-digit sectors. The results for these top sectors are below for both real and nominal spending.

No Time Fixed Effects

Sector	ρ	σ^2	Θ
23	0.743	0.0252	0.2552
31	0.6197	0.0184	0.216
32	0.7248	0.0408	0.1714
33	0.7403	0.0126	0.1207
42	0.8281	0.0778	0.3039
48	0.8046	0.0194	0.3487
51	0.8936	0.0056	0.1345
52	0.7435	0.0192	0.1935
54	0.7318	0.0034	0.0697
56	0.7204	0.0046	0.1389
61	-0.1682	0.0506	0.0552
62	0.8741	0.0169	0.0741

Time Fixed Effects

Sector	ρ	σ^2	Θ
23	0.6771	0.0143	0.2552
31	0.5894	0.0061	0.216
32	0.7365	0.0296	0.1714
33	0.7118	0.007	0.1207
42	0.7824	0.066	0.3039
48	0.8515	0.0102	0.3487
51	0.8952	0.0039	0.1345
52	0.7436	0.0127	0.1935
54	0.7011	0.0021	0.0697
56	0.6609	0.0106	0.1389
61	0.0193	0.0432	0.0552
62	0.8945	0.0102	0.0741

No Time Fixed Effects (REAL)

Sector	ρ	σ^2	Θ
23	0.6842	0.0311	0.2552
31	0.6099	0.0209	0.216
32	0.5778	0.042	0.1714
33	0.6008	0.0124	0.1207
42	0.8632	0.0769	0.3039
48	0.7221	0.0161	0.3487
51	0.8018	0.0077	0.1345
52	0.677	0.0213	0.1935
54	0.5333	0.0053	0.0697
56	0.4827	0.0069	0.1389
61	0.0833	0.0757	0.0552
62	0.8236	0.0204	0.0741

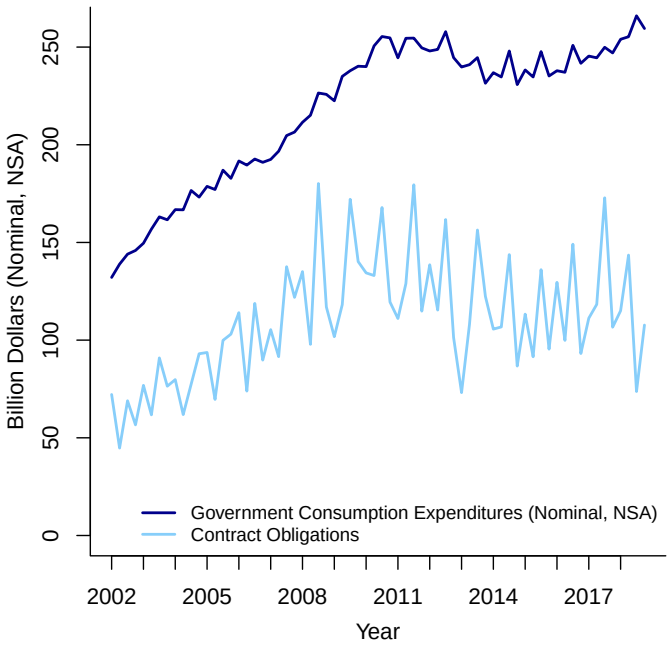
Time Fixed Effects (REAL)

Sector	ρ	σ^2	Θ
23	0.6819	0.0135	0.2552
31	0.6815	0.0066	0.216
32	0.6996	0.0297	0.1714
33	0.7297	0.0075	0.1207
42	0.8612	0.0617	0.3039
48	0.9412	0.0108	0.3487
51	1.0209	0.0054	0.1345
52	0.7519	0.0127	0.1935
54	0.6987	0.0023	0.0697
56	0.5898	0.011	0.1389
61	0.2258	0.0504	0.0552
62	0.9801	0.0104	0.0741

C.3 Seasonality

We showed in figure 2a, that at an annual basis, government consumption in the form of contract obligations roughly follows federal government consumption expenditures as presented in the National Accounts. At a quarterly frequency, however figure 28 shows that government contract obligations appear to be much more volatile than consumption expenditures in the national accounts.[33]

Figure 28: Contract Obligations vs. Government Consumption Expenditures, Quarterly



In order to understand whether there is a meaningful seasonal aspect to the government contracts data, we look at several statistics about the contract spending, aggregated by the month of the year in which the contract was initiated. The left panel of figure 29 shows that there is a large spike in the total amount of obligations in the month of September—the last month of the fiscal year. The middle panel of figure 29 shows that this increase in total obligations is driven in part by an increase in the average size of contracts during the month of September, thought the monthly variation is much less stark. The right panel of the figure shows that there is also an increase in the number of contracts given out in September, also contributing to the increase in total money spent. In addition to the September spikes, we see smaller spikes in both total obligations and average contract size in the final months of each of the other quarter (March, June, and December). The monthly variation appears to be driven more by non-modification spending than by modifications. These end-of-fiscal-year spikes may make a lot of sense in the context of the federal budget process. When government agencies are making requests for

[33]Note that in order to make this comparison, we need to look at non seasonally adjusted data from the NIPAs. The BEA only publishes the non-seasonally adjusted government consumption expenditures, not the non-seasonally adjusted version of compensation for federal employees. We showed that when we subtract the compensation variable, the government consumption expenditures lines up relatively well with our series. To the extent that one believes that federal wages are less seasonal than the other components in the consumption expenditures series, the dark blue line in the figure may be flatter than it would be if we could subtract this component out.

appropriations during the budget process, they justify these requests in part based on prior year spending.[34] If they do not spend all allotted funds in a given year, that portion of their budget could be revised down. Thus, we may be seeing agencies rushing to spend out their last remaining dollars before the clock runs out. This is consistent with evidence from Liebman and Mahoney (2017), who set out to study this exact topic and find that, indeed, procurement spending by the U.S. federal government in the last week of the year is almost five times higher than the rest-of-the-year weekly average.[35]

We may also wonder whether this pattern of spending occurs across the board, or whether it is somehow distributed unevenly. To see this, we do the same exercise, but look separately at the top 10 percent of contracts, the bottom 10 percent of contracts, and the middle 20 percent of contracts. The September peaks appear to hold throughout the distribution, though they are more pronounced in the top 10 percent than they are in the middle 20 percent. Interestingly, the bottom 10 percent of contracts experience a large *negative* shock in the month of September.

C.4 Steady state

We consider a symmetric steady state where relative prices are unity and inflation is zero. However, note that the size of sectors will generally differ in steady state. We show below conditions for the existence of a symmetric steady state across firms in which the following holds:

$$W_k = W, \quad P_{jk} = P \quad \text{for all } j, k$$

Symmetry in prices across all firms implies

$$P = P^k$$

such that from eqs. (4) and (9) we have

$$\begin{aligned} C_1 &= \omega C, C_2 = (1-\omega)C, \\ nY_{j1} &= Y_1, (1-n)Y_{j2} = Y_2. \end{aligned}$$

Note that while sectors differ in size, the level of steady-state production is the same across firms. For sectoral output we have

$$Y_1 = C_1 + G_1, \quad Y_2 = C_2 + G_2 \tag{39}$$

Adding these gives

$$Y_1 + Y_2 = \omega C + (1-\omega)C + G_1 + G_2 = C + G_1 + G_2 = Y \tag{40}$$

where the last equation follows from the definition of real GDP, eq. (**??**) above. In the symmetric steady state we have

$$G = G_1 + G_2$$

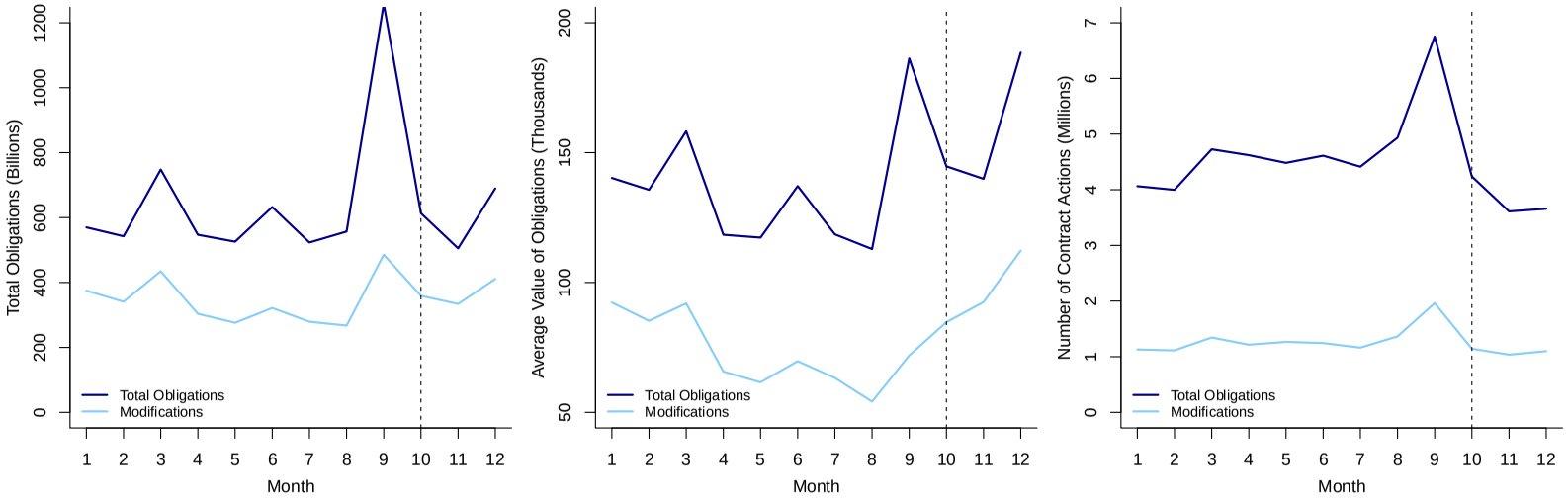
such that we can define the sectoral shares of public spending as follows

$$\gamma \equiv \frac{G_1}{G} \text{ and } 1 - \gamma = \frac{G_2}{G}.$$

[34] https://www.whitehouse.gov/wp-content/uploads/2018/06/a11.pdf

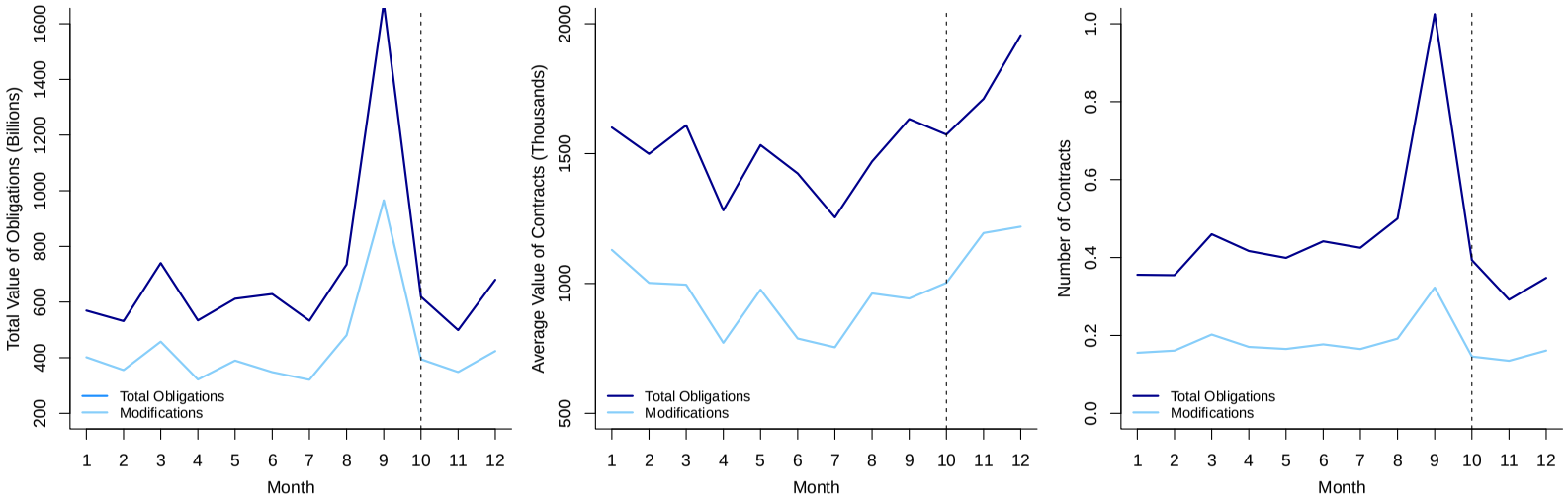
[35] The authors use the same data, from USASpending.gov, in their analysis.

Figure 29: Government Contract Obligations by Month of the Year



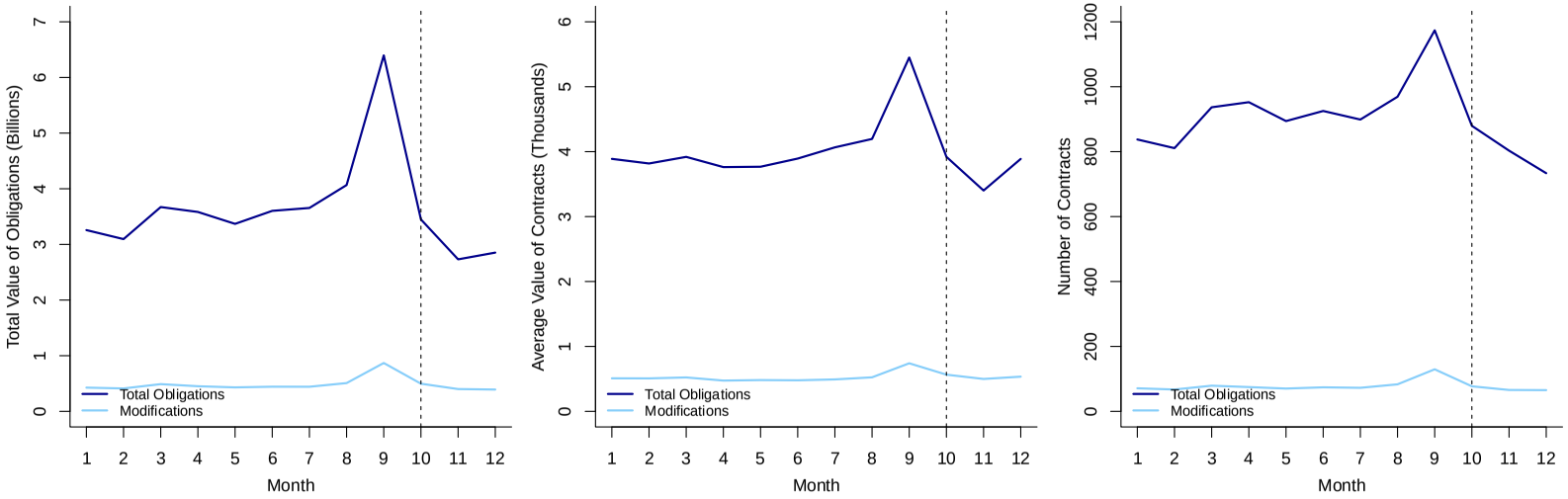
(a) Total Value of Contracts (b) Average Value of Contracts (c) Number of Contracts

Figure 30: Government Contract Obligations by Month of the Year, Top 10 Percent



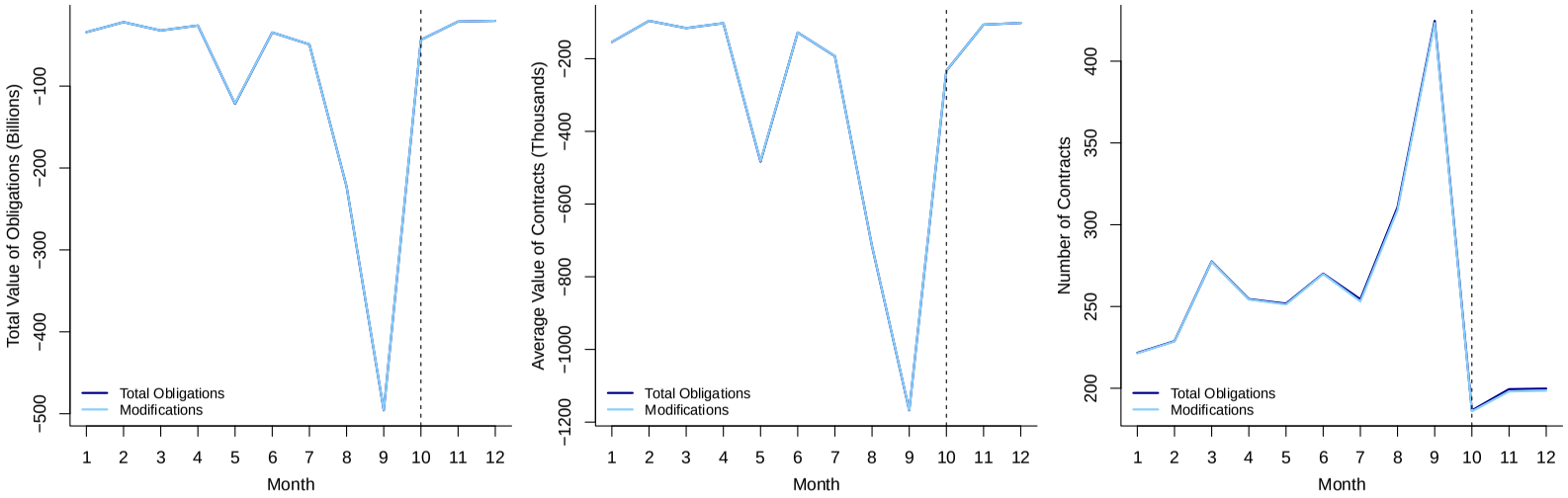
(a) Total Value of Contracts (b) Average Value of Contracts (c) Number of Contracts

Figure 31: Government Contract Obligations by Month of the Year, Middle 20 Percent



(a) Total Value of Contracts (b) Average Value of Contracts (c) Number of Contracts

Figure 32: Government Contract Obligations by Month of the Year, Bottom 10 Percent



(a) Total Value of Contracts (b) Average Value of Contracts (c) Number of Contracts

Regarding the size of the sectors note that $n = Y_1/Y$ and $1-n = Y_2/Y$. This implies for labor $L_1 = nL$ and $L_2 = (1-n)L$. Last define the share of private and public consumption in GDP as follows

$$\zeta = \frac{C}{Y} \text{ and } 1-\zeta = \frac{G}{Y}$$

We thus write the following restriction

$$\begin{aligned} n &= \frac{Y_1}{Y} = \frac{\omega C + \gamma G}{Y} = \omega\zeta + \gamma(1-\zeta) \\ 1-n &= \frac{Y_2}{Y} = \frac{(1-\omega)C + (1-\gamma)G}{Y} = (1-\omega)\zeta + (1-\gamma)(1-\zeta) \end{aligned}$$

Steady-state labor supply from equation (5) is

$$\frac{W_k}{P} = \xi_1 (nL)^{\varphi} C = \xi_2 ((1-n)L)^{\varphi} C$$

For the symmetric steady state to exist it is sufficient that $\xi_1 = n^{-\varphi}$ and $\xi_2 = (1-n)^{-\varphi}$. As result we have for labor supply in steady state

$$\frac{W}{P} = L^{\varphi} C. \tag{41}$$

Households' budget constraint, firms' profits, production function, and optimal prices in steady state are, respectively,

$$CP + P_1 G_1 + P_2 G_2 = WL + \Pi \tag{42}$$

$$\Pi = P_1 Y_1 + P_2 Y_2 - WL = PY - WL \tag{43}$$

$$Y = L \tag{44}$$

$$P = \frac{\theta}{\theta - 1} W. \tag{45}$$

From (45) we have

$$\frac{W}{P} = \left(\frac{\theta - 1}{\theta} \right) \tag{46}$$

This in turn implies

$$\frac{\Pi}{P} = \frac{1}{\theta} Y.$$

C.5 Note on linearization of Phillips curve

To derive the NKPC rewrite the first order condition of the firm (11) in the main text as follows

$$\sum_{\tau=0}^{\infty} Q_{t,t+\tau} \alpha_k^{\tau} \frac{P_{kt}^* Y_{jkt+\tau}}{P_{kt}} = \mathcal{M} \sum_{\tau=0}^{\infty} Q_{t,t+\tau} \alpha_k^{\tau} Y_{jkt+\tau} \frac{\Psi_{kt+\tau}}{P_{kt+\tau}} \frac{P_{kt+\tau}}{P_{kt}}$$

Note that here we divide both sides with the sectoral price level. Linearizing around the symmetric steady state gives

$$\sum_{\tau=0}^{\infty}(\beta\alpha_k)^\tau\left[p_{kt}^*-p_{kt}+y_{jkt+\tau}\right]=\sum_{\tau=0}^{\infty}(\beta\alpha_k)^\tau\left[y_{jkt+\tau}+\psi_{kt+\tau}+p_{kt+\tau}-p_{kt}\right]$$

here $\psi_{kt+\tau}$ is the deviation of real marginal costs from steady state (where marginal costs are deflated with P_{kt}). Rewriting

$$\frac{1}{1-\alpha_k\beta}\left[p_{kt}^*-p_{kt}\right]=\sum_{\tau=0}^{\infty}(\beta\alpha_k)^\tau\left[\psi_{kt+\tau}+\sum_{l=0}^{\tau-1}\pi_{k,t+1+l}\right]$$

Using $\sum_{\tau=0}^{\infty}(\beta\alpha_k)^\tau\sum_{l=0}^{\tau-1}\pi_{k,t+1+l}=\frac{\alpha_k\beta}{1-\alpha_k\beta}\sum_{\tau=0}^{\infty}(\beta\alpha_k)^\tau\pi_{kt+1+\tau}$ we can rewrite the previous equation as follows

$$\left[p_{kt}^*-p_{kt}\right]=(1-\alpha_k\beta)\sum_{\tau=0}^{\infty}(\beta\alpha_k)^\tau\psi_{kt+\tau}+\alpha_k\beta\sum_{\tau=0}^{\infty}\pi_{kt+1+\tau}$$

Writing this in difference form

$$\left[p_{kt}^*-p_{kt}\right]=\beta\alpha_k\left[p_{kt+1}^*-p_{kt+1}\right]+(1-\beta\alpha_k)\psi_{kt}+\alpha_k\beta\pi_{kt+1}$$

From the definition of the price level in sector k we have: $p_{kt}^*-p_{kt}=\frac{\alpha_k}{1-\alpha_k}\pi_{kt}$ Hence, we obtain

$$\pi_{kt}=\beta E_t\pi_{kt+1}+\frac{(1-\alpha_k)(1-\beta\alpha_k)}{\alpha_k}\psi_{kt}$$

C.6 Proofs

C.6.1 Proposition 1

Proof of proposition 1. Substituting the solution (35) in (34) yields the conditions for the unknown coefficients:

$$\begin{aligned}\beta\Lambda_0^2-\left\{(1+\beta)+\kappa\left[A_2\right]\right\}\Lambda_0+1 &= 0\\ \left\{(1+\beta)+\kappa A_2\right\}\Lambda_1 &= \beta\Lambda_0\Lambda_1+\beta\Lambda_1\rho+\kappa\frac{A_2}{A_1}\frac{\varphi}{n}\\ \left\{(1+\beta)+\kappa A_2\right\}\Lambda_2 &= \beta\Lambda_0\Lambda_2+\beta\Lambda_2\rho+\kappa\frac{\varphi}{1-n}\end{aligned}$$

Let

$$f(x)=\beta x^2-\left\{1+\beta+\kappa A_2\right\}x+1. \tag{47}$$

This is a quadratic equation, with evaluation $f(\Lambda_0)\to\infty$ if $\Lambda_0\to\infty$ or $\Lambda_0\to-\infty$. Plugging in $\Lambda_0=0$, we obtain that $f(0)=1$. Plugging in $\Lambda_0=1$, we obtain that

$$f(1)=\beta-\left[(1+\beta)+\kappa A_2\right]+1=-\kappa A_2<0 \tag{48}$$

Therefore the two roots of the quadratic equations lies within $(0,1)$ and $(1,\infty)$. The unique and stable root is $\Lambda_0\in(0,1)$. Since we know that the root we seek is the smaller of the two, the

desired Λ_0 is decreasing in $\kappa\left(1+\frac{\zeta\varphi(1-\omega)}{1-n}\right)$.

Next we need to solve for Λ_1 and Λ_2 such that Then, we plug into the system as solve directly:

$$\Lambda_1 = \frac{\kappa\frac{A_2}{A_1}\frac{\varphi}{n}}{\{(1+\beta)+\kappa A_2\}-\beta(\Lambda_0+\rho)} \geq 0 \tag{49}$$

The denominator of Λ_1 is positive since $\beta(\Lambda_0+\rho) < 2\beta < 1+\beta$.

Similarly

$$\Lambda_2 = \frac{\kappa\frac{\varphi}{1-n}}{\{(1+\beta)+\kappa A_2\}-\beta(\Lambda_0+\rho)} \geq 0 \tag{50}$$

C.6.2 Proposition 2

Proof of (1), solution for consumption

Recall that c_t can be written as

$$c_t = (1-\omega)\tau_t - \left(1+\frac{\zeta\varphi\omega}{n}\right)^{-1}(1-\zeta)\gamma\frac{\varphi}{n}g_{1t} \tag{51}$$

Plugging in for τ_t as derived from Proposition 1

$$c_t = (1-\omega)\Lambda_0\tau_{t-1} + (1-\omega)(1-\zeta)[\Lambda_1\gamma g_{1,t} - \Lambda_2(1-\gamma)g_{2,t}] - \left(1+\frac{\zeta\varphi\omega}{n}\right)^{-1}(1-\zeta)\gamma\frac{\varphi}{n}g_{1t} \tag{52}$$

Combining (52) with the expression for b and c in (49) and (50) yields

$$c_t = (1-\omega)\Lambda_0\tau_{t-1} + \frac{1-\zeta}{\zeta}\left[\frac{\kappa(1-\omega)(\frac{A_2}{A_1}\frac{\varphi}{n}\gamma g_1 - \frac{\varphi}{1-n}(1-\gamma)g_2)}{\{(1+\beta)+\kappa A_2\}-\beta(\Lambda_0+\rho)} - \left(1+\frac{\zeta\varphi\omega}{n}\right)^{-1}\gamma\frac{\varphi}{n}g_1\right] \tag{53}$$

Let

$$c_t = \Theta_0\tau_{t-1} - \Theta_1(1-\zeta)\gamma g_{1t} - \Theta_2(1-\zeta)(1-\gamma)g_{2t} \tag{54}$$

Thus, the lag coefficient on previous period terms of trade τ_{t-1} is

$$\Theta_0 = (1-\omega)\Lambda_1 \tag{55}$$

where recall that $\Lambda_0 \in (0,1)$ is the root of equation (47). Thus $\Theta_0 \in (0,1)$ as well.

The rest of (53) can be decomposed into the coefficient of consumption wrt government spending in sector 1, Θ_1 is:

$$\Theta_1 = \frac{\varphi}{A_1 n} - (1-\omega)\Lambda_1 = \frac{\varphi}{A_1 n} - (1-\omega)\frac{\kappa\frac{A_2}{A_1}\frac{\varphi}{n}}{\{(1+\beta)+\kappa A_2\}-\beta(\Lambda_0+\rho)} \tag{56}$$

$$\Theta_1 = \frac{\varphi}{A_1 n}\frac{(1+\beta)+\omega\kappa A_2-\beta(\Lambda_0+\rho)}{\{(1+\beta)+\kappa A_2\}-\beta(\Lambda_0+\rho)} \tag{57}$$

And the multiplier for consumption in sector 2, Θ_2 is:

$$\Theta_2 = (1-\omega)\Lambda_2 = \frac{(1-\omega)\kappa\frac{\varphi}{1-n}}{\{(1+\beta)+\kappa A_2\}-\beta(\Lambda_0+\rho)} \tag{58}$$

Proof of (2), the support of Θ_1 and Θ_2

From equations (57) and (58), it is immediate that both Θ_1 and Θ_2 are greater or equal to 0. The lower bound 0 can be attained by setting $\varphi = 0$.

Next we show Θ_1 is unbounded above. From (57), plugging in for A_1 and A_2,

$$\Theta_1 = \frac{\varphi}{\left(1 + \frac{\zeta\varphi\omega}{n}\right) n} \frac{(1+\beta) + \omega\kappa A_2 - \beta(\Lambda_0 + \rho)}{\{(1+\beta) + \kappa A_2\} - \beta(\Lambda_0 + \rho)} \tag{59}$$

Consider an example where $\zeta, \varphi, \kappa \neq 0$. As $n \to 0$, it must be that $\omega \to 0$ as well. Then $\varphi/(n + \zeta\varphi\omega) \to \infty$, and $\Theta_1 \to \infty$ as well. Thus the support of Θ_1 is between $[0, \infty)$.

Finally, we show that Θ_2 is bounded above by ζ^{-1}. From (58), plugging in for A_2, and multiplying by ζ on both sides,

$$\zeta\Theta_2 = \frac{\zeta(1-\omega)\kappa\frac{\varphi}{1-n}}{(1+\beta) + \kappa\left(1 + \frac{\zeta\varphi(1-\omega)}{1-n}\right) - \beta(\Lambda_0 + \rho)} \tag{60}$$

As $1 + \beta + \kappa - \beta(\Lambda_0 + \rho) > 0$, the numerator of $\zeta\Theta_2$ is always less than the denominator. Thus $\zeta\Theta_2 \leq 1$. Next, when $1 - n \to 0$, $\zeta\Theta_2 \to 1$. Therefore, the support of Θ_2 is between $[0, \zeta^{-1})$. It allows follows immediately that $\Theta_2 \to 0$ for $\kappa \to 0$.

Proof of (3), Comparative statics between Θ_1 and Θ_2

The terms Θ_1 and Θ_2 are compared in equations (57) and (58).

Again, plugging in for A_1 and A_2, $\Theta_1 > \Theta_2$ if

$$[\kappa\frac{1-n+\zeta\varphi(1-\omega)}{1-n}\omega\varphi + A_1(1 + (1-a-\rho)\beta)n](1-n) > \kappa\frac{n+\zeta\varphi\omega}{n}(1-\omega)\varphi n \tag{61}$$

Since $\Lambda_0, \rho, \beta < 1$, it's clear that $(1 + (1 - \Lambda_0 - \rho)\beta) > 0$, with emphasis of the strictness of the inequality. Thus, inequality (61) holds if

$$[1 - n + \zeta\varphi(1-\omega)]\omega \geq [n + \zeta\varphi\omega](1-\omega) \tag{62}$$

Simplifying further by dividing out $(1-w)w$ and canceling $\zeta\varphi$, we obtain that a sufficient condition such that $\Theta_1 > \Theta_2$ is

$$\frac{\omega}{n} \geq \frac{1-\omega}{1-n} \implies \omega > \gamma \tag{63}$$

which implies that sector 1 is relatively more biased on the consumption side.

C.6.3 Proposition 3

Proof of Proposition 3. From the definition of output

$$\begin{aligned} y_t &= n y_{1,t} + (1-n) y_{2,t} \\ &= \zeta c_t + (1-\zeta)\gamma g_{1,t} + (1-\zeta)(1-\gamma) g_{2,t} \\ &= \zeta[\Theta_0\tau_{t-1} - \Theta_1(1-\zeta)\gamma g_{1,t} - \Theta_2(1-\zeta)(1-\gamma)g_{2,t}] + (1-\zeta)\gamma g_{1,t} + (1-\zeta)(1-\gamma)g_{2,t} \\ &= \zeta\Theta_0\tau_{t-1} + (1-\zeta\Theta_1)(1-\zeta)\gamma g_{1t} + (1-\zeta\Theta_2)(1-\zeta)(1-\gamma)g_{2t}. \end{aligned}$$

Therefore, y_t can be written as

$$y_t = \Gamma_0 \tau_{t-1} - \Gamma_1(1-\zeta)\gamma g_{1t} - \Gamma_2(1-\zeta)(1-\gamma)g_{2t}. \tag{64}$$

As $\Gamma_0 = \zeta\Theta_0$, and since $\zeta, \Theta_0 \in (0,1)$, $\Gamma_0 \in (0,1)$ as well.

We solve for the output multipliers Γ_1 and Γ_2 of sector 1 and sector 2 government spending, respectively. Using equations (57) and (58) gives

$$\Gamma_1 = 1 - \zeta \cdot \underbrace{\frac{\varphi}{\left(1+\frac{\zeta\varphi\omega}{n}\right)n} \frac{(1+\beta)+\omega\kappa A_2 - \beta(\Lambda_0+\rho)}{\{(1+\beta)+\kappa A_2\} - \beta(\Lambda_0+\rho)}}_{\Theta_1}. \tag{65}$$

To show that the support of Γ_1 $(-\infty, 1]$, simply note that Θ_1 has support between $[0,\infty)$, and thus $\Gamma_1 = 1 - \zeta\Theta_1$ is unbounded on the left and upper bounded by 1.

Next, consider

$$\Gamma_2 = 1 - \zeta \underbrace{\frac{(1-\omega)\kappa\frac{\varphi}{1-n}}{(1+\beta)+\kappa\left(1+\frac{\zeta\varphi(1-\omega)}{1-n}\right) - \beta(\Lambda_0+\rho)}}_{\Theta_2} \tag{66}$$

Recall that Θ_2 has support between $[0, \zeta^{-1})$, and thus $\Gamma_2 = 1 - \zeta\Theta_2$ has support $(0,1]$.