Big G*

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Abstract

"Big G" typically refers to aggregate government spending on a homogeneous good. In this paper, we open up this construct by analyzing the entire universe of procurement contracts of the U.S. federal 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 and sectoral spending is only moderately persistent. Fourth, idiosyncratic variation dominates fluctuations in spending. 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 occurs, and the multiplier tends to be larger compared to a one-sector benchmark, aligning the model with the empirical evidence.

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

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1 Introduction

What is "Big G"? In the national accounts, G represents government spending—the part of GDP that comprises government expenditures. This convention possibly helps explain why 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, we frequently refer to it as Big G, and the literature assumes policymakers 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 for the fiscal transmission mechanism but focus exclusively on heterogeneity on the household side (McKay and Reis, 2016; Auclert, Rognlie, and Straub, 2018; Hagedorn, Manovskii, and Mitman, 2019).

The 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 federal government spending by characterizing its underlying heterogeneity. In light of these facts, we then reassess the fiscal transmission mechanism through the lens of a stylized two-sector New Keynesian model. We find that accounting for the heterogeneity of G has first-order effects on the transmission mechanism, aligning the model prediction with the 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 procurement contracts by the federal government since 2001. For each year, the database records several million government procurement transactions. While the data does not cover all components of G, it is unique in detail and scope: it covers 40 percent of total federal spending, and 16 percent of general government spending.[1] None of our facts are driven by the procurements of the Department of Defense (DOD), and we show that the most important facts also extend to state and local spending, which account for another 60 percent of general government expenditures. In contrast to the existing literature, we focus on the heterogeneity of government contracts and document key differences of government spending across firms and sectors, differences relative to private spending, and differences in the degree of price rigidity.[2]

[1] The largest components of federal spending outside of our analysis are government wages and R&D.

[2] There is important earlier work using procurement data by the Department of Defense (DOD) in order to estimate fiscal multipliers or the effects of government spending shocks (Fisher and Peters, 2010; Nakamura and Steinsson, 2014; Dupor and Guerrero, 2017; Demyanyk, Loutskina, and Murphy, 2019; Auerbach, Gorodnichenko, and Murphy, 2020). The data set has also been used in other contexts, e.g. in order to assess the impact of bureaucratic competence and procurement outcomes (Decarolis et al., 2020). Appendix A.2 discusses some of the earlier work in more detail.

The first of our five facts is that government spending is granular in the sense of Gabaix (2011). It is concentrated among a few firms and sectors. For instance, the largest 20 percent of suppliers in terms of average annual contract value supply 99 percent of total federal government spending and they are concentrated in a few sectors: firms in the largest three two-digit NAICS industries are counter-party for more than 60 percent of all government contracts. Concentration in defense and non-defense spending is similar: For example, the top 1 percent of firms capture 77 percent of government contracts in defense and 71 percent in non-defense. Granularity is equally pervasive at the state and local levels where the top 30 six-digit NAICS sectors receive 78 percent, compared to 82 percent for spending federal contracts.

The second fact is the existence of a sectoral bias in government spending: the allocation of government spending across sectors differs substantially from that of private spending. For instance, the sector with the largest share in total government spending (manufacturing) receives 30 percent of government spending, but accounts for only 13 percent of GDP. Conversely, the sector with the largest share in GDP (health care and social assistance) accounts for 12 percent of GDP but less than 2 percent of government contract spending. Again, this fact characterizes not only federal spending but state and local government spending as well. It is also not limited to defense spending, but holds for non-defense spending as well. In earlier work, Ramey and Shapiro (1998) stressed the importance of sectoral bias for the fiscal transmission mechanism. Until now, however, no data were available to establish the sectoral bias of government spending systematically.

Third, we show that government spending is only moderately persistent. The median contract has a duration of 31 days and 90 percent of contracts last less than one year. Appearances of firms in the data are short-lived: the median firm is in the data for less than two years, while the firm with the median value of average annual contracts is in the data for less than one year. In line with these disaggregated findings, persistence of sectoral spending processes measured by an AR(1) coefficient is moderate at a business cycle frequency. It is also subject to aggregation bias. At a monthly frequency, the estimated autoregressive parameter is 0.29 on average across sectors and 0.47 at the aggregate level, and respectively, 0.4 and 0.55 at a quarterly frequency. These aggregation effects point to a dynamic aggregation bias caused by heterogenous dynamics across sectors (Imbs et al., 2005) as well as time aggregation effects. Both defense and non-defense contracts behave very similarly in aspects of duration and persistence.

Fourth, shocks at the firm and the sectoral level, that is, idiosyncratic shocks, dominate the fluctuations in government spending over time. To establish this fact, we construct the granular residual of government spending following the approach of Gabaix (2011) and find that it explains 75 percent of monthly variation in aggregate government spending growth. An alternative approach based on a decomposition of spending growth following Foerster, Sarte, and Watson (2011) yields similar results. Lastly, we find that innovations to shock processes estimated at the sectoral level have both large negative and large positive correlations for many sector pairs. Inclusion of aggregate, time fixed effects explains very little of the innovation in the data.

Fifth, government spending tends to be concentrated in sectors with a relatively high degree of price stickiness. The monthly frequency of price changes in the top 3 2-digit NAICS sectors is 11 percent while it is on average 22 percent for the remaining sectors in the economy. These frequencies are estimated on the basis of the micro data underlying the producer price index at the Bureau of Labor Statistics, but we find that the duration of contracts is consistent with these estimates. The same patterns hold for defense and non-defense contract spending. Last, we observe that the majority of contracts—over 85 percent—are "fixed price" in nature.

The facts we establish may be in line with folk wisdom and thus not appear surprising, but what has been lacking so far is a systematic and quantitative assessment. What is more, accounting for the heterogeneity of G along our five facts has first-order effects on the fiscal transmission mechanism. In order to show this, we put forward a two-sector New Keynesian model with government spending à la Woodford (2011). The model is deliberately stylized in order to account for the five facts in a transparent way while departing from the conventional one-sector model as little as possible. Importantly, rather than postulating a driving process for G, as is commonly done, we model government spending at the sectoral level—in line with fact 4.

We establish a number of results, both in closed-form based on limiting cases and quantitatively based on model simulations. In theory, if government spending goes up in a sector where prices are fully flexible while they are sticky in the other, crowding out of private expenditure can be infinite such that the government spending multiplier turns negative. In the data, however, government spending is biased toward the sticky-price sector (fact 5) and a fiscal shock in the relatively small and sticky-price sector toward which government spending is biased (facts 1 and fact 2) induces a multiplier effect 3-4 times larger than a shock in the other sector. We obtain this result while assuming a moderately persistent shock process, calibrated to match fact 3. Moreover, we find that multiplier is larger the more flexible prices are in the sector on which private expenditure is concentrated. Hence, it is not overall price stickiness that drives the multiplier; instead the multiplier increases in the relative stickiness in the sector in which government spending goes up. This result is in line with the finding that in multi-sector economies the relative extent of frictions is key for aggregate dynamics (Barsky, House, and Kimball (2007); Barsky et al. (2016), Gilchrist et al. (2017)).

To understand this result, recall that monetary policy is key for the fiscal transmission mechanism in the New Keynesian model (Woodford, 2011; Christiano, Eichenbaum, and Rebelo, 2011; Farhi and Werning, 2016). Because government spending is inflationary, it induces the central bank to raise rates and private expenditure is crowded out due to intertemporal substitution. A number of recent contributions show that household heterogeneity and credit frictions limit intertemporal substitution such that the New Keynesian model resembles the "old Keynesian" model more closely (Galí, López-Salido, and Vallés, 2007; McKay, Nakamura, and Steinsson, 2016; Kaplan, Moll, and Violante, 2018).

Sectoral bias in government spending combined with sectoral heterogeneity in pricing frictions has a similar effect. In a nutshell, if the government spends in relatively sticky-price sectors compared to the private sector, monetary policy will need to respond less to fiscal stimulus in order to keep inflation stable. This effect becomes stronger, the larger the sectoral bias for sectoral bias implies that private expenditure is concentrated in the relatively flexible price sector.

Importantly, a muted impact of fiscal shocks on inflation and interest rates is also consistent with empirical observations from fiscal VARs (Mountford and Uhlig, 2009; Corsetti, Meier, and Müller, 2012; Ramey, 2016). Likewise, a muted response of inflation also means that the fiscal multiplier at the zero lower bound is not much larger compared to the baseline case due to a muted real rate response, in line with recent evidence by Ramey and Zubairy (2018). In sum, once we modify the model to account for the heterogeneity that characterizes spending data at the micro level, the model performance also improves at the macro level.

Our paper is also 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 as 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 sectoral level rather than at the regional 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; Pasten, Schoenle, and Weber, 2019a,b; Baqaee and Farhi, 2020; Ozdagli and Weber, 2017). Bouakez, Rachedi, and Emiliano (2018), in particular, study theoretically the transmission of fiscal policy shocks in a rich model featuring heterogeneity in sector size and input-output structure. Lastly, Woodford (2020) also investigates sectoral fiscal policy, notably in the presence of demand failures, but his focus is on transfers rather than on government spending.

2 Data

In the first part of this paper, we undertake a detailed analysis of the USASpending.gov database—sketching out the heterogeneity behind some of the traditional Big G macroeconomic characteristics, such as heterogeneity in price ridigity, consumption patterns or the size of firms and sectors. To be perfectly clear about the external validity of our analysis with respect to total government spending, we start out by describing how our data fit into the portion of GDP that is accounted for by the overall government sector, "Big G." We then detail and define several fundamental concepts before we move on to analyzing the data.

2.1 Background on USASpending

Historically, the database we use was created in response to the Federal Funding Accountability and Transparency Act (FFATA), which was signed into law on September 26, 2006. FFATA requires federal contract, grant, loan, and other financial assistance awards of more than $25,000 to be publicly accessible on a searchable website, in an effort to provide transparency to the American people on how the government spends their tax dollars. In accordance with FFATA, federal agencies are required to collect and report data on federal procurement. Agencies must report award data 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 once 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 that the federal agencies report to systems like the FPDS-NG, the site also uses information collected from the recipients of the awards themselves. Though FFATA was not signed into law until 2006, data are available back to 2001 through an external organization.

2.2 A Bird's Eye View on the Data

Since total government spending is a complex object, we provide a schematic diagram of total government spending in Figure 1. This figure allows us to illustrate clearly how our federal spending data fit in. As one can see, total government spending is made up of *government consumption expenditures and gross investment*. The first component, government consumption expenditures, consists of spending by government to produce and provide services to the public, such as national defense and public school education. The second component, gross investment, consists of spending by government for fixed assets that directly benefit the public, like highways, or that assist government agencies in their production activities, such as purchases of military hardware. General government consumption expenditures and gross investment include both federal spending (about 40 percent) and state and local spending (about 60 percent).

As Figure 1 further illustrates, government consumption expenditures (CE) are equal to gross output of the general government, less own-account investment (which is included in gross government investment) and sales to other sectors (recorded in the private sector). Gross output of the general government is made up of two components: value added (compensation of general government employees and consumption of fixed capital) and government purchases of intermediate goods and services. Gross government investment (GI) is a measure of the additions to, and replacements of, the stock of government-owned fixed assets. It consists of investment by both general government and government enterprises in structures (e.g., highways and schools), equipment (e.g., military hardware), and intellectual property products (software and R&D). It also includes own-account investment.

Federal government procurement contracts—where our focus lies—include, at the federal level, both purchases of intermediate goods and services, as well as investment in structures, equipment, and software. We highlight both components in red in Figure 1. Our data do not include state or local government spending, but using detailed BEA input-output tables for the year 2002 we subsequently verify that several of our key facts characterize state and local data as well. Additionally, our contracts data do not include compensation of government employees (note, they may include compensation for contractors) or consumption of fixed capital. Also, most (though not all) government investment in R&D comes through grants, so it is also not included in the contracts data. All in all, our procurement contracts should be approximately equal to:

$$\begin{aligned} \text{Contract Spending} &= \text{CE} + \text{GI} - (\text{Value Added} + \text{R\&D Investment}) \\ &= \text{Intermediate Goods \& Services Purchased} + \text{Non-R\&D Investment} \end{aligned}$$

Figure 2 shows that contract spending lines up very well against the relevant portion of government spending from the National Income and Product Accounts (NIPA). Solid lines in the figure represent our data while dashed lines represent the relevant NIPA data. Moreover, the fit is as good if we look only at the defense subsets (medium-light blue lines) or non-defense (lightest blue lines) subsets. On average, our federal contracts data represent about 16 percent of total government spending and 40 percent of total federal government spending.

2.3 Federal government contracts

As explained above, our data focus on a subset of total federal spending—spending on goods and services via government contracts. The Federal Acquisition Regulation (FAR) defines these

"Contract actions" as "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 threshold, or modifications to these actions regardless of dollar value." The micro-purchase threshold is in general $3,500. As the definition suggests, the goods and services that the government consumes through contracts span a wide range, from janitorial services for federal buildings and 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—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. In awarding contracts, federal agencies must abide by the guiding principles set forth in the 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. The appendix provides further details on some of these aspects such as the types of contracts awarded, the types of pricing contracts chosen and the extent of competition.

2.4 Details and Scope of the Data Set

The data set defined by these contracts includes the universe of federal government contracts from fiscal years 2001 through 2018.[3] On average, 3.2 million individual contract 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 over 1,000 six-digit NAICS sectors. The median contract value is $3,640, while the mean contract value is $206,023, suggesting the distribution is heavily right skewed. The majority of contracts (82 percent) represent positive obligations from the government to firms, but there are also de-obligations with a negative value, which occur when a modification to an initial contract is performed (see Section 3.3 for details).

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 executed (see Figure A.1 in Appendix A.3 for a schematic representation of the data at the micro level). 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

[3]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 obtain all prime award contracts for fiscal years 2001 through 2007.

number.

In our analysis, we outline a number of facts about what we refer to as individual contracts; firm-level statistics, which we aggregate by the recipient parent firm; and sector-level statistics, which we aggregate by NAICS sectors. Note that most (90% of all) contracts are single-transaction contracts. If there are multiple transactions, we use the unit of the contract as unit of analysis. The value of each contract is given by the "federal action obligation" pertaining to a contract—the government's liability for a contract. Each contract is associated with a start and end date for the period of performance (barring any subsequent modifications), which we use to calculate "duration." Finally, a contract will contain a "modification number" if it includes an action that makes a change to an initial contract.

3 Facts on Government Spending

Government spending is conventionally viewed as a homogeneous good, a relatively constant fraction of GDP that is determined by an ethereal government entity, "G." In this section, we describe five facts about government spending that illustrate that government spending is in fact heterogeneous in nature. Granularity in government spending is fundamental to these facts and 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: government spending is granular. Granularity is fundamental because it permeates our main facts. We use different methods to establish granularity of government spending. A common definition of granularity proposes 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 exhibits fat tails, then some firms or sectors are disproportionately large and granular at any level of disaggregation.

Government spending is granular according to these two definitions. First, it is concentrated among a few firms and sectors where we compute their ranking according to average annual contract value. Second, a log-normal distribution approximates the government spending distribution well at the transaction level.

Fact 1 *Government spending is granular:*

1. *The top 1 percent of firms receive 80 percent of all contract obligations, the top 1 percent*

of six-digit sectors receive 40 percent, and the top 3 of two-digit sectors receive 70 percent (where we define rank in terms of firm or sector sales).

2. *Concentration in defense and non-defense is similar: the top 1 percent of firms capture 77 percent of government contracts in defense and 71 percent in non-defense, and the top 1 percent of six-digit sectors 48 and 49 percent in defense and non-defense, respectively. The top 3 of two digit sectors receive 73 and 66 percent in defense and non-defense, respectively.*

3. *Granularity is similar at the state and local level: the top three six-digit sectors (top 1 percent) receive 20 percent of state and local government spending, the top 30 sectors (top 10 percent) 78 percent (compared to 30 and 82 percent for federal contracts).*

4. *Nearly 100 percent of the cross-sectional variation in contract spending is within firms or sectors, rather than across, both in the full sample, in the defense sample, and in the non-defense sample.*

5. *The size distribution of contracts has fat tails — in particular, it is approximately log-normal — both in the full sample, in the defense sample, and in the non-defense sample.*

3.1.1 Spending Is Concentrated Among a Few Firms and Sectors

The first sense in which government spending is granular is that it is highly concentrated among a few firms and sectors. The 10 largest suppliers of goods and services to the government (or top 0.01 percent) account for about one-third of total government spending, and the top 0.1 percent of firms account for just under one-half of total government spending. Figure 3 illustrates this unequal distribution in the left panel. To put this into perspective, we note that on average some 140,000 firms exist in our sample each year.

A similar spending concentration exists among sectors. The right panel of Figure 3 shows that over 60 percent of contract obligations are directed toward the top three (of 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 percent (of roughly 1200) six-digit sectors account for about 40 percent of government spending, while the top 10 percent of six-digit sectors account for over 80 percent of government spending. Figure 3 also shows that the concentration of spending among firms and sectors has been fairly stable over time.

Our federal contracts data allow us to show that spending in non-defense does not markedly differ from defense spending along multiple key dimensions, starting with granularity of contracts. The patterns discussed for the full sample are reflected in both the defense and non-defense sub-samples, with government contract spending highly concentrated among a small percentage of firms and sectors. The top one percent of firms capture 77 percent of the value of defense contracts and 71 percent of the value of non-defense contracts, and for both defense and non-defense, roughly half of contract value is concentrated among the top 1 percent of six-digit sectors. At the two-digit sector level, 73 percent of defense contract value is concentrated among the top three sectors and 64 percent of non-defense contract value is concentrated among the top three sectors. The top 2 sectors, 33—manufacturing, 54—professional, scientific, and technical services, are the same for both defense and non-defense. For defense spending, the complementary sector is sector 23—construction, and for non-defense spending, the complementary sector is sector 56—administrative and waste management. Table 1 presents these, and other, summary statistics.

While our analysis is focused on federal contracts, BEA input-output tables allow us to show that state and local government spending is similarly highly granular at detailed sectoral levels. According to the BEA data, the top three of 341 six-digit sectors receive 20 percent of state and local government spending, compared to 30 percent for federal spending, and the top 30 of 341 sectors receive 78 percent of state and local government spending and 82 percent of federal spending.

3.1.2 Large Contracts and Firms Drive Cross-sectional Variance

Another way to get at the granular nature of government spending is through a variance decomposition of government contracts into variation that occurs within firms, and variation that occurs across firms and similarly for sectors. A first such decomposition starts at the contract level as the smallest unit of observation, a 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 spending amount on individual contract i at firm f at date t, $\bar{g}_{f,t}$ is the firm average at date t, and $\bar{g}_t$ is the overall average at date t. Figure 4 shows this decomposition for all contracts in the left panel, for the top 20 percent of contracts (which represent 97 percent of the total value of contracts) in the middle panel, and for the bottom 80 percent of contracts in the right panel. When we look at the within-firm versus across-firm breakdown for all firms, almost 100 percent 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 same results hold not only for the full sample, but also if we consider only defense or non-defense contracts. Figure A.12 in the appendix illustrates this result.

The empirical variance at the most granular level is large and dominates this 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 also indicates the log of the average contract amount overall. The fat right tail of individual contracts is apparent, and is 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 percent of contracts fully determine this within result. When we restrict our attention to the bottom 80 percent of contracts, the fat tails are absent, and both within- and across-firm variation is present. Again, the same results hold not only for the full sample, but also if we consider only defense or non-defense contracts. Figure A.13 in the appendix illustrates this result.

Granularity across firms also has implications for the variance decomposition within and across sectors. Instead of looking at the variance in 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 at date t which is at a monthly frequency, $\bar{g}_{s,t}$ is the sector average at date t, and $\bar{g}_t$ is the overall average at date t. We find that "within sector" variation dominates the decomposition. A larger variation exists across firms within a sector than across sectors within the economy. Again, the same results hold not only for the full sample, but also if we consider only defense or non-defense contracts. Figures A.7 and A.14 in the appendix illustrate this result.

Just as in the firm-level exercise, the fat right tail in the data again drives this result. Figure A.8 in the Online Appendix shows that the density of firm size has a fat right tail in the case of the full data set (left panel) and the top 20 percent of firms (middle panel) but a fat left tail in the case of the bottom 80 percent 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. Again, the same results hold not only for the full sample, but also if we consider only defense or non-defense contracts. Figure A.15 in the appendix illustrates this result.

3.1.3 The Size Distribution of Contracts Has Fat Tails

Government spending is also granular in a statistical sense: The distribution of government contracts is fat-tailed and, in particular, well approximated by a log-normal distribution. A simple way to illustrate this point is to look at a Q-Q (quantile-quantile) plot, in which we plot the actual quantiles of the log transaction values against a set of quantiles from a simulated log-normal distribution with the same mean and variance. If both sets of quantiles come from the same distribution, the plotted points should line up along the 45-degree line.

Indeed, this is the case in the data both in the full sample, in the defense sample, and in the non-defense sample. As Figure 6 shows the scatter points roughly follow the 45-degree line across the entire distribution. Figure 7 shows the actual density of transaction values and the density of a simulated variable that is log-normally distributed with the same mean and variance, confirming that the log-normal distribution appears to be a good fit in the tails. Figures A.16 and A.17 in the Appendix illustrate that a log-normal distribution also approximates both the distribution of defense and non-defense contracts well. While a log-normal distribution is the best fitting fat-tailed distribution for the full sample of government contracts, we show in Appendix A.4.2 that a Pareto distribution, as in Gabaix (2011), also provides a good approximation to the right tail of the distribution.

3.2 Sectoral Bias

The second fact we present establishes that the government spending basket is special: The composition of government spending across sectors is distinct from the composition of private spending across sectors. Such differences exist for both total federal government spending as well as for state and local government spending. Defense and non-defense spending exhibit a similar difference. As a consequence of these spending biases, the identities of the most important firms and sectors as suppliers to the government differ substantially from the identities of the most important firms and sectors supplying to the rest of the economy.

Fact 2 *Government spending is sectorally biased:*

1. *The sector with the largest share in total government spending (NAICS 33 — manufacturing) receives 30 percent of government spending, but accounts for only 13 percent of GDP. The sector with the largest share in GDP (NAICS 62—health care and social assistance) accounts for 12 percent of GDP but less than 2 percent of government contract spending. The top 3 two-digit sectors receive 70 percent of government spending, but account for only 18 percent of GDP.*

2. *Spending in both defense and non-defense is similarly biased: the sector with the largest share in federal defense spending (NAICS 33) receives 40 percent of government defense spending, but accounts for only 13 percent of GDP. The sector with the largest share in federal non-defense spending (NAICS 54 — Professional, Scientific, and Technical*

Services) accounts for 37 percent of GDP, but only 4 percent of government spending.

3. *Spending at the state and local level is similarly biased: the sector with the largest share in state and local government spending (NAICS 54) receives 15 percent of state and local government spending, but less than 5 percent of GDP in the economy.*

4. *The top 0.01 percent of recipient firms (10 firms) of federal government spending account for 17 percent of average annual government spending, but only 2 percent of average annual sales.*[4]

We illustrate these facts graphically in the two panels of Figure 8. The vertical axis in the both panels measures the share of a (six-digit) sector k, in government spending, $\frac{G_k}{G}$. The horizontal axis measures the share of the same sector in GDP, $\frac{GDP_k}{GDP}$. GDP is computed using the BEA "Make" and "Use" tables as total industry output net of output sold as intermediates to other sectors and net exports. The left panel focuses on federal (red dots) as well as state and local spending shares (blue dots). The right panels focuses on federal defense (blue star) versus federal non-defense (green triangle) spending. If government spending and private spending had the same composition, then we would expect government spending and GDP shares to align perfectly along a 45-degree line.

However, government spending and private spending shares differ substantially, that is, $\frac{G_k}{G} \neq \frac{GDP_k}{GDP}$. First, some sectors that are big suppliers to the federal government are almost negligible for GDP. Sector 541300—Architectural, Engineering, and Related Services, for example, accounts for 16 percent of total federal government spending but less than 1 percent of GDP. Second, the same holds true for state and local spending: Sector 517000—Telecommunications, for example, accounts for over 6 percent of state and local government spending but less than 3 percent of GDP. Third, defense and non-defense spending exhibit a similar pattern of differential granularity: Sectors 336411—Aircraft Manufacturing and 622000—Hospitals, for example, account for 8 and 11 percent of federal defense and non-defense spending, respectively, but less than 1 percent and 5 percent of GDP.

The converse also holds true, as shown in Appendix Table A.4. The bias in government spending runs both ways. Manufacturing (NAICS 33), for example, accounts for over 30 percent of government contract spending, but only 13 percent of GDP. Conversely, in the same year, health care and social assistance (NAICS 62) accounted for over 12 percent of GDP, but less than 2 percent of government spending. Tables A.4 and A.5 also show that similar patterns hold for state and local government, federal defense, and federal non-defense spending. The Retail Trade Industry (NAICS 44), for example, accounts for 10 percent of GDP but less than

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

1 percent of state and local government spending. The Finance and Insurance Sector accounts for more than 8 percent of GDP but less than 3 percent of defense spending and less than 2 percent of non-defense spending.

Finally, sectoral bias appears at the firm level as well—Table A.6 compares the top 35 firms in terms of average annual contract spending to the top 35 non-oil firms from Compustat 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. Taken together, our evidence indicates that government spending varies across sectors and its composition does not mimic that of GDP.

3.3 Moderate Persistence

We now turn to the variation in spending over time. The third fact we establish is that government spending is only moderately persistent. First, contracts and firms in the data tend to be relatively short lived. Second, contracts are frequently modified. Third, in line with these findings, persistence of sectoral spending processes is moderate at a business cycle frequency, and subject to aggregation bias. There is no marked difference between defense and non-defense contracts.

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

1. *The median contract has a duration of 31 days. Over 90 percent of contracts last less than one year. Contracts are frequently modified: more than half of all contracts are subject to some modification.*

2. *The firm with the median value of average annual obligations is in the data set for less than one year.*

3. *The median persistence of two-digit AR(1) sectoral government spending processes is 0.29 at a monthly, and 0.4 at a quarterly frequency. Persistence is the same for just the top 3 sectors.*

4. *Omitting the largest 1% of contracts cuts persistence measured by an AR(1) coefficient in half, while aggregation in the cross-section increases monthly and quarterly AR(1) persistence to 0.47 and 0.55.*

5. *The same findings hold for defense and non-defense spending: The median defense contract lasts 26 days, the median non-defense contract 33 days. 90 percent of defense and nondefense contracts last less than 1 year. The monthly and quarterly persistence estimates are 0.25 and 0.35 for defense, and 0.26 and 0.28 for non-defense.*

To arrive at the first result, we start by calculating the duration of a contract as the difference between the period of performance start date of the contract and the current end date of the contract. Durations of 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 contracts depends entirely on the nature of the relationship and the provided product or service. Overall, however, contracts tend to have short life spans. Over the entire sample, the median contract has a duration of only 31 days.[5] In each year, about 90 percent of contracts have durations of less than one year as Figure 9 shows.[6]

Persistence of government spending can be measured by other metrics than the duration of contracts. We next provide details about persistence of government spending and its heterogeneity in two complementary ways of measuring persistence, focusing on the persistence of firms in the data as well as the persistence of sectoral AR(1) processes.

First, we find that persistence of firms, at the fundamental unit of production, is short in the dataset – in line with the short duration of contracts. For the entire sample, most firms are in the data set for only short periods of time, where "in the data set" in given year means that a firm receives a new contract in that year. In fact, the median number of years a firm is in the data set is less than 2 years, and the firm with the median value of average annual obligations is in the dataset for less than 1 year. We illustrate these results in Figure A.10 in the Online Appendix.

However, there is substantial heterogeneity of persistence in the data according to firms' size: Among large firms, such as the top 0.1 percent of firms, firms are more likely to be in the data for longer portions of the sample. A handful of such firms exist, and very few of their contracts last very long. The contracts with the longest duration are mostly related to facilities management and investment around the government. They span sectors from information technology, professional, scientific, and technical services; administrative and support and waste

[5]For this analysis we keep contracts with durations between 1 and 5500 days (15 years). These contracts represent more than 95 percent of the total value of obligations.

[6]In addition to being relatively short-lived, contracts are frequently modified. An observation in the data will have a modification number if it represents a contract with more than one transaction that makes a change to an initial award. Twenty different types of modifications exist, some of which reflect no change to the initial value of the contract, such as a change of address, and some of which reflect either additional obligations or de-obligations, such as an order for additional work. Figure 10 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. Our general approach to dealing with such errors is the following: in cases in which two potentially offsetting contracts are within 0.5 percent 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. Applying the net amount to the earlier or later action date makes no difference.

management and remediation services; as well as manufacturing. Section A.4.5 in the Online Appendix provides more detail on the identity of these firms and sectors.

Second, persistence at the sectoral level is low at a business cycle frequency if viewed through the lens of AR(1) processes. To arrive at this finding, we estimate an AR(1) process of government spending at the two-digit sectoral level, both at a monthly and a quarterly frequency. As Table 2 shows, the estimated persistence coefficient is 0.29, on average, across sectors at a monthly frequency and 0.4, on average, at a quarterly frequency. Consistent with the existence of a few large firms that are in the sample for a longer time, persistence drops to 0.16 at a monthly frequency and 0.19 at a quarterly frequency if we exclude the top 1 percent of firms, also shown in Table 2. In both cases, the higher persistence at lower frequency reflects time aggregation bias which, however, is a complicated object (see for example Working (1960), Rossana and Seater (1995), Hassler (2014)), which can be seen, for example, in some of the other panels of Table 2. Clearly, the sensitivity of the estimates to the exclusion of large firms again highlights the pervasive importance of granularity for understanding key characteristics of government spending.

If we pool all data and estimate an aggregate AR(1) process, we find that persistence goes up to 0.47 at the monthly frequency and 0.55 at the quarterly frequency. Table 2 shows this result. This finding reflects aggregation bias as in Pesaran and Smith (1995) or Imbs et al. (2005) due to underlying heterogeneous dynamics in government spending processes.

Finally, if we consider defense and non-defense spending separately, we find very similar results: the median defense contract lasts 26 days, and the median non-defense contract 33 days. Moreover, 90 percent of both defense and non-defense contracts last less than 1 year. When we estimate the persistence parameters of an AR(1), the monthly and quarterly persistence estimates are 0.25 and 0.35 for defense, and 0.26 and 0.28 for non-defense.

3.4 Idiosyncratic Shocks Drive Aggregate Variation over Time

The fourth fact we establish is that shocks at the firm and sectoral level – in short: idiosyncratic rather than aggregate shocks – drive the variation in spending over time. We show that the granularity of firms and sectors is the origin for variations in the growth rate of aggregate government spending, consistent with our previous fact # 1 on granularity: A few firms or sectors drive the dynamics of aggregate government spending.

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

1. *The granular residual explains more than 75 percent of aggregate government spending growth. If we construct a granular residual based on firms in the top 3 two-digit NAICS*

sectors only, we find that it explains about 70 percent of aggregate government spending growth.

2. *A similar result applies to defense and non-defense spending: The granular residual explains almost 80 percent of aggregate spending growth in defense, and roughly 75 percent in non-defense.*

3.4.1 Granular Origin of Government Spending Fluctuations

Building on our first fact, we use the notion of granularity to show that idiosyncratic variation is crucial to account for the growth of aggregate government spending. We follow Gabaix (2011) and Foerster, Sarte, and Watson (2011) to establish this fact. We complement these approaches with a closer look at sectoral AR(1) processes which more readily lend themselves to our calibration in the subsequent model section.[7]

Granular Residual Approach First, as in Gabaix (2011), we calculate the granular residual, Γ_t, to show that shocks to the top suppliers of government spending drive the 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 government spending at the firm level is given by:

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

The granular residual is then given by:

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

where G_t is aggregate government spending 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 suggests that idiosyncratic shocks, captured by the granular residual, account for a large part of the aggregate movement of

[7] To make more tangible what is behind the details of this section, we present Tables A.1-A.3 in the Online Appendix. These tables list the largest five contracts in each of the three largest two-digit NAICS sectors in 2012. These contracts stand directly behind whatever we subsequently conclude about the importance of firm-specific and sector-specific drivers of variation.

government spending. Specifically, we estimate:

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

We estimate this specification for $K = 100$, $Q = 100$, and $Q = 1,000$ firms, and on one and two lags of the granular residual term. We see in Table 3 that the granular residual explains about 75 percent of the monthly variation in aggregate government spending across specifications. If we consider only defense or non-defense data, we find that the granular residual explains a similar 78 and 75 percent of aggregate government spending growth in each subset, as Appendix Tables A.13 and A.14 show. Overall, 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 Spending Growth Second, as in Foerster, Sarte, and Watson (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, Sarte, and Watson (2011), we decompose aggregate government spending growth, Z_t, as follows:

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

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

Figure 11 plots the individual components of equation (2) over time. In Foerster, Sarte, and Watson (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 magnitude similar to that of the aggregate growth rate, indicating that both idiosyncratic shocks and covariance across sectors are important drivers of aggregate growth. We also find that the granular residual is important in both defense and non-defense spending though it appears to be larger and more volatile in defense spending. Figure A.21 in the Online Appendix illustrates this finding.

Furthermore, we show the importance of idiosyncratic innovations to the government spending process by revisiting our sectoral AR(1) processes from the previous fact. As we show in Online Appendix Section A.4.3, aggregate time fixed effects explain little of sectoral government spending dynamics when included into the estimation. Instead, idiosyncratic innovations drive changes in sectoral spending, which can have large positive and negative correlations across sectors.

3.5 Government Spending Is Concentrated in Sticky Sectors

The section documents a further new fact about government spending and pricing frictions: Government spending tends to be concentrated in sticky-price sectors—that is, sectors in which price changes are relatively less frequent.

We document this result in two complementary ways. First, we use micro data underlying the producer price data from the Bureau of Labor Statistics (BLS) to construct monthly frequencies of price adjustments for the sectors from which the government purchases. But, if we interpret the frequency of price changes from the BLS also as a measure of price stickiness relevant for government purchases, then a caveat applies: The frequency of price adjustment for private and government consumption may not be identical. Therefore, we also study the price rigidity of government contracts directly. Using inverse average durations from our data as a measure of frequency of price changes, we find very similar frequencies of price changes for government contracts as in the BLS data. The fact that fixed-price contracts are dominant at the micro level of the individual contracts is consistent with this finding. Our main result holds for both defense and non-defense spending.

Fact 5 *Government spending is concentrated in sticky sectors:*

1. *The monthly frequency of price changes in the top 3 two digit sectors to the government is 10 percent while it is 22 percent, on average, for the remaining sectors.*

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

3. *The monthly frequency of price changes in the top 3 two digit supplying defense (non-defense) sectors to the government is 13 (10) percent while it is 20 (21) percent, on average, for the remaining sectors. Overall, defense and non-defense pricing frictions show very similar distributions.*

Our main result for this fifth fact is that government spending is concentrated in sticky-price sectors. Figure 12a 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 spending. The figure shows that the government spends the vast majority of dollars in sectors with low frequencies of price adjustment.

We find that the frequency of price changes in the largest two sectors is 9 percent, while it is 20 percent on average. The same patterns hold for defense and non-defense contract spending. The frequency of price changes in the largest two defense sectors is 9 percent, while it is 22 percent, on average, for the remaining sectors. The frequency of price changes in the largest two non-defense sectors is 10 percent, while it is 21 percent, on average, for the remaining sectors. Overall, the defense and non-defense distributions look qualitatively very similar: larger sectors tend to have lower frequencies of price changes. Figure A.22 in the Online Appendix illustrates the results for defense and non-defense spending.

An important caveat for the interpretation of our analysis concerns the assumption that the frequency of price adjustment from the BLS and the frequency of price changes of government spending only are the same. We show that there is indeed no obvious difference using the contract data. To do so, we use inverse average durations from our data as a measure of frequency of price changes. We find very similar frequencies of price changes for government contracts as in the BLS data. Figure 12b illustrates this result. The frequency of price changes implied by the average contract duration equals 21.5 percent while the average frequency from the BLS equals 19.7 percent.

Finally, our findings are consistent with the types of contracts firms use to set their prices. We find this consistency in the distribution by both count and value of pricing types for government contracts. By count, the majority of contracts are firm fixed-price contracts—the pricing type that places all of the risk on the contractor. Fixed-price contracts with economic adjustment follow. The total share of contracts that are fixed price is over 85 percent. 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 percent. This finding justifies using a sticky-price setting to model the effect of government spending. Table A.8 in the Online Appendix summarizes our findings in this regard.

4 A New Keynesian Model with Sectoral Government Spending

We now put forward a two-sector New Keynesian model which allows us to assess how the heterogenetiy of government spending impacts the fiscal transmission mechanism. The model is deliberately stylized, departing as little as possible from the one-sector textbook model. Sectors potentially differ along three dimensions: first, the shares of private and public spending and hence, their size; second, the degree of price rigidity; third, the incidence of shocks. Rather than postulating a process for "big G," we model government spending in each sector as distinct variables. In what follows we outline the set-up in general terms and derive a number of theoretical results. We then simulate the model to illustrate the quantitative relevance of the five facts established above.

4.1 Set-up

We focus on the 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 chooses consumption and labor in order to solve an infinite horizon problem subject to a period budget constraint:

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

subject to

$$W_{1t}L_{1t} + W_{2t}L_{2t} + \Pi_t + I_{t-1}B_{t-1} \quad = \quad B_t + P_{1t}C_{1t} + P_{2t}C_{2t} + P_{1t}G_{1t} + P_{2t}G_{2t}.$$

Here, C_{kt} and G_{kt} denote private and public consumption of sector-k goods, with $k = \{1, 2\}$, respectively. G_{kt} is determined exogeneously and financed by lump-sum taxes for which we substituted in the household budget constraint. Government spending provides utility according to the function $f(G_{1t}, G_{2t})$, but independently of private consumption and leisure. P_{kt} is the price of sector-k goods. 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} and we rule out Ponzi schemes.

The optimal allocation of consumption expenditures across sectors requires:

$$C_{1t} = \omega \left(\frac{P_{1t}}{P_{Ct}} \right)^{-1} C_t \text{ and } C_{2t} = (1-\omega) \left(\frac{P_{2t}}{P_{Ct}} \right)^{-1} C_t, \tag{3}$$

where $P_{Ct} = P_{1t}^{\omega} P_{2t}^{1-\omega}$ is the consumer price index. The consumption bundles in each sector, in turn, are 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:

$$C_{1t} \equiv \left[n^{-1/\theta} \int_0^n C_{j1t}^{1-\frac{1}{\theta}} dj \right]^{\frac{\theta}{\theta-1}}, \quad C_{2t} \equiv \left[(1-n)^{-1/\theta} \int_n^1 C_{j2t}^{1-\frac{1}{\theta}} dj \right]^{\frac{\theta}{\theta-1}}, \tag{4}$$

and analogously for government consumption G_{1t} and G_{2t}. Cost minimization implies the demand for differentiated goods:

$$C_{j1t} = \frac{1}{n} \left(\frac{P_{j1t}}{P_{1t}} \right)^{-\theta} C_{1t}, \quad C_{j2t} = \frac{1}{1-n} \left(\frac{P_{j2t}}{P_{2t}} \right)^{-\theta} Y_{2t}, \tag{5}$$

and analogously for government consumption G_{j1t} and G_{j2t}. Lastly, the sectoral price indices are given by

$$P_{1t} = \left[\frac{1}{n} \int_0^n P_{j1t}^{1-\theta} dj \right]^{\frac{1}{1-\theta}}, \quad P_{2t} = \left[\frac{1}{1-n} \int_n^1 P_{j1t}^{1-\theta} dj \right]^{\frac{1}{1-\theta}}. \tag{6}$$

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

$$\frac{W_{kt}}{P_{Ct}} = \xi_k L_{kt}^{\varphi} C_t \text{ for } k = \{1, 2\}, \tag{7}$$

$$1 = \mathbb{E}_t \left[\beta \left(\frac{C_{t+1}}{C_t} \right)^{-1} I_t \frac{P_{Ct}}{P_{Ct+1}} \right]. \tag{8}$$

Differentiated goods are produced according to: $Y_{jkt} = L_{jkt}$. 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:

$$\max_{P_{jkt}} \mathbb{E}_t \sum_{s=0}^{\infty} Q_{t,t+s} \alpha_k^s \left[P_{jkt} Y_{jkt+s} - \mathcal{C}_{t+s}(Y_{t+s|t}) \right], \tag{9}$$

subject to the constraint that production is adjusted in order to meet demand at posted prices:

$$Y_{jkt} = C_{jkt} + G_{jkt}.$$

Here consumption demand for good j, C_{jkt}, depends on prices according to (5), and equivalently for government spending. In expression (9), $Q_{t,t+s}$ is the stochastic discount factor and $\mathcal{C}_{t+k}(\cdot)$ are costs of production. The first-order condition is:

$$\sum_{s=0}^{\infty} Q_{t,t+s} \alpha_k^s Y_{jkt+s} \left[P_{kt}^* - \mathcal{M} \Psi_{kt+s} \right] = 0, \tag{10}$$

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

$$P_{kt} = \left[(1-\alpha_k) P^{*1-\theta}_{kt} + \alpha_k P^{1-\theta}_{kt-1} \right]^{\frac{1}{1-\theta}}. \tag{11}$$

We define sectoral output as follows:

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

and write nominal GDP

$$P_{Yt} Y_t \equiv P_{1t} Y_{1t} + P_{2t} Y_{2t}. \tag{12}$$

Here $P_{Yt} \equiv P_1^n P_2^{1-n}$ is the GDP deflator. Analogously, we define aggregate government spending ("Big G") as:

$$P_{Gt} G_t \equiv P_{1t} G_{1t} + P_{2t} G_{2t}. \tag{13}$$

Assuming that 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):

$$\Pi_{Y_t} = \frac{P_{Y_t}}{P_{Y_{t-1}}} = 0. \tag{14}$$

In the spirit of Svensson (2003), we assume that monetary policy adjusts short-term interest rates to meet the inflation target at all times.

4.2 Approximate Equilibrium Conditions

We now consider an approximation of the equilibrium conditions around a steady state in which relative prices are unity and inflation is zero (see Appendix A.1.1 for details). The size of sectors in steady state is may differ, reflecting granularity and sectoral bias. To see this, 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 $1-\zeta = G/Y$. In this case, the steady-state sizes of sectors 1 and 2 are given by the weighted average of each sector's share in private and public spending, respectively:

$$n = \omega\zeta + \gamma(1-\zeta) \tag{15}$$

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

We state the equilibrium conditions in terms of deviations from the steady state with lowercase letters denoting percentage deviations from the steady state. Market clearing in each sector implies:

$$ny_{1,t} = -\omega\zeta(1-\omega)\tau_t + \omega\zeta c_t + (1-\zeta)\gamma g_{1,t} \tag{17}$$

$$(1-n)y_{2,t} = (1-\omega)\zeta\omega\tau_t + (1-\omega)\zeta c_t + (1-\zeta)(1-\gamma)g_{2,t}. \tag{18}$$

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:

$$\alpha_1\pi_{1,t} = \alpha_1\beta E_t\pi_{1,t+1} + (1-\alpha_1)(1-\beta\alpha_1)\psi_{1t} \tag{19}$$

$$\alpha_2\pi_{2,t} = \alpha_2\beta E_t\pi_{2,t+1} + (1-\alpha_2)(1-\beta\alpha_2)\psi_{2t}, \tag{20}$$

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:

$$\psi_{1t} = c_t + \varphi y_{1,t} - (1-\omega)\tau_t \tag{21}$$

$$\psi_{2t} = c_t + \varphi y_{2,t} + \omega\tau_t. \tag{22}$$

An approximation of the Euler equation yields:

$$c_t = E_t c_{t+1} - (i_t - E_t\pi_{c_{t+1}}) \tag{23}$$

$$\pi_{c_t} = \omega\pi_{1,t} + (1-\omega)\pi_{2,t}, \tag{24}$$

where the second equation is consumer price inflation. Equations (12) and (13) and the definition of the deflators for GDP and government spending imply the following equations for real GDP and real aggregate government spending:

$$y_t = ny_{1,t} + (1-n)y_{2,t} \tag{25}$$

$$g_t = \gamma g_{1,t} + (1-\gamma)g_{2,t}. \tag{26}$$

Regarding monetary policy, the inflation target (14) requires:

$$\pi_{y_t} = 0. \tag{27}$$

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

$$g_{1,t} = \rho_1 g_{1,t-1} + \varepsilon_{1,t} \tag{28}$$

$$g_{2,t} = \rho_2 g_{2,t-1} + \varepsilon_{2,t}, \tag{29}$$

where $\varepsilon_{k,t}$ are sector-specific spending shocks and parameters $\rho_k \in [0,1)$ capture the persistence of the spending processes.

4.3 Closed-form 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 $\alpha_2 \in [0,1]$.

To solve the model, we first derive the solution for the terms of trade, which are the only endogenous state variable in the model. Intuitively, since prices are (potentially) sticky in sector 2, the adjustment to even purely transitory shocks takes time and the dynamics of the terms of trade govern the adjustment process. Inflation targeting implies $\pi_{y_t} = n\pi_{1,t} + (1-n)\pi_{2,t} = 0$. This equation allows us to rewrite the Phillips curve in sector 2 (equation (20)) as:

$$n(\tau_t - \tau_{t-1}) = n\beta(E_t(\tau_{t+1} - \tau_t)) - \kappa_2 \psi_{2t}. \tag{30}$$

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

$$\psi_{2t} = \left(1 + \frac{\zeta\varphi(1-\omega)}{1-n}\right) c_t + \left(1 + \frac{\zeta\varphi(1-\omega)}{1-n}\right) \omega\tau_t + (1-\zeta)(1-\gamma)\frac{\varphi}{1-n} g_{2,t}. \tag{31}$$

We use the market clearing condition in equation (18) to substitute for output in equation (22). To substitute for consumption, we exploit the fact 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:

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

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 effect accounts for the negative impact of government spending on consumption in expression (32) for given terms of trade.

Using equation (32) in equation (31) and substituting in equation (30) we obtain a second-order difference equation in the terms of trade:

$$\{(1+\beta)+\kappa A_2\}\tau_t-\tau_{t-1}-\beta E_t\tau_{t+1} \quad = \quad \kappa\frac{A_2}{A_1}\frac{\varphi}{n}(1-\zeta)\gamma g_{1t}-\frac{\kappa\varphi}{1-n}(1-\zeta)(1-\gamma)g_{2,t}, \tag{33}$$

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 sector's share in private consumption as well as with its size. We solve equation (33) 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 monetary policy targets producer price inflation ($\pi_{y_t}=0$), the solution for the terms of trade is given by:*

$$\tau_t=\Lambda_0\tau_{t-1}+\Lambda_1(1-\zeta)\gamma g_{1,t}-\Lambda_2(1-\zeta)(1-\gamma)g_{2,t}, \tag{34}$$

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

Proof. See Appendix A.1.3 ■

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 (32) for the terms of trade using equation (34) 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 that prices in sector 1 are fully flexible ($\alpha_1=0$) and monetary policy targets producer price inflation ($\pi_{y_t}=0$),*
(1) *the solution for consumption is given by*

$$c_t=\Theta_0\tau_{t-1}-\Theta_1(1-\zeta)\gamma g_{1,t}-\Theta_2(1-\zeta)(1-\gamma)g_{2,t} \tag{35}$$

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 A.1.3 ■

Expression (35) shows that, all else equal, higher terms of trade imply 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 (35) that government spending crowd out private consumption: 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.[8] As a result, there is upward pressure on prices, 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 sector-specific demand.

This logic also accounts for why $\Theta_2 \to 0$ as $\kappa \to 0$. $\kappa \to 0$ implies that prices are approximately fixed. Hence, government spending in sector 2 does not induce price pressures. 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. Intuitively, consumption drops more in response to an increase in government spending in sector 1, because the higher flexibility of prices implies stronger price pressures and calls for a more aggressive response of monetary authority 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 that 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

[8] Except if utility is linear in labor ($\varphi = 0$). In this case, marginal costs are independent of the level of production and $\Theta_1 = \Theta_2 = 0$.

matches the increase in government spending in absolute value such that marginal costs, and hence inflation, remain constant. This happens for a relatively modest reduction in 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 that prices in sector 1 are fully flexible ($\alpha_1 = 0$) and monetary policy targets producer price inflation ($\pi_{y_t} = 0$), the solution for output is given by*

$$y_t = \Gamma_0 \tau_{t-1} + \Gamma_1 (1-\zeta)\gamma g_{1,t} + \Gamma_2 (1-\zeta)(1-\gamma) g_{2,t} \tag{36}$$

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

$$\Gamma_1 = 1 - \zeta\Theta_1 \text{ and } \Gamma_2 = 1 - \zeta\Theta_2. \tag{37}$$

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

In expression (36), 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.[9] Also, equation (37) shows that the sum of the direct effect of higher spending on output and the indirect effect on private consumption, which is negative, determines the overall multiplier.

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

4.4 Model simulations: baseline

In this section, we run model simulations in order to illustrate how the heterogeneity in government spending impacts the fiscal transmission mechanism. For the numerical simulations we assume that a period in the model corresponds to one month and set $\beta = 0.997$. Next, we set $\varphi = 4$, in line with estimates for the Frisch elasticity of labor supply (Chetty et al., 2011). Lastly, we assume that government spending accounts for 20 percent of GDP and set

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

$\zeta = 0.8$.[10] Eventually, we will assume that government spending is concentrated in sector 2 which we specify so as to represent key features of the top 3 2-digit NAICS sectors.

Still, in order to set the stage, we first show results for a symmetric model. In this case we abstract from granularity and sectoral bias and set $\gamma = \omega = 0.5$. As a result, the two sectors are of equal size: $n = 0.5$. Moreover, in this case, to obtain a benchmark, we assume that the frequency of price adjustments is the same in both sectors and, for reasons that become clear below, at the higher end of the values discussed above. Specifically, we set $\alpha_1 = \alpha_2 = 0.89$. For this model specification we first compute an aggregate shock to government spending which raises government spending simultaneously and proportionally to the steady-state level in both sectors. Here, and in what follows, we normalize the size of the shock so that government spending increases initially be one percent of steady-state output. Importantly, since we consider an aggregate spending shock in a perfectly symmetric model, the adjustment dynamics are identical to those in a one-sector model. In line with fact 3 we assume a moderate duration of the shock and set the autocorrelation coefficient to 0.3. We will do so in all the experiments that follow because, as our discussion of fact 3 made clear, government spending displays a moderate degree of persistence in most sectors.

Figure 13 shows the adjustment to the shock in the left column. In each panel we display the impulse response of a different variable: aggregate government spending in the top row, followed by output, consumption, and the interest rate. The solid line with circles represents the responses to the aggregate shock. We observe that output increases somewhat on impact, by about 0.25 percent, consumption drops considerably and the interest rate increases. Recall that we assume that monetary policy implements a strict inflation target. As a result, we obtain the flexible-price allocation, that is, the response of output represents the response of potential output. In the face of temporarily higher demand for goods by the governments, households find it optimal to increase labor supply and reduce consumption even in a frictionless environment (Woodford, 2011).

Against this background, we now assess the impact of the heterogeneity of government spending along various dimensions. We start with fact 4: "idiosyncratic shocks drive aggregate variation over time". We do so by studying the adjustment to government spending shocks that originate at the sectoral level. Results are also shown in the left column of Figure 13. The solid line represents the adjustment to a government spending shock in sector 1, the dashed line the responses to a shock in sector 2. In both instances, the responses of aggregate spending shown in the top panel is identical to that in case of an aggregate shock. This is by way or normalization.

[10] We calibrate the model to capture the key features of the contract data which cover only 16 percent of general government spending. Still, the evidence presented above suggests that these data are representative for general government spending.

The responses of the other variables, however, are also identical. This illustrates—perhaps unsurprisingly—that whether shocks originate at the sectoral or at the aggregate level does not matter to the extent that sectors are otherwise perfectly homogenous.

Yet once we account for fact 5, that is, the fact that government spending is concentrated in sticky sectors, a different picture emerges. In the second to left column of Figure 13 we show simulation results for a scenario where sectors are still symmetric in steady state, but differ in the degree of price rigidity. Specifically, we assume that α_2 is 0.89 as before, but that prices are more flexible in sector 1, namely, we set $\alpha_1 = 0.78$. We contrast once again the effects of an aggregate shocks to those of sectoral shocks. The first thing to note is that the effect of the aggregate spending shock is unchanged relative to the symmetric model: by targeting inflation the central bank can still implement the flexible-price allocation.

Yet, once we turn to sector-specific shocks we observe larger differences: output declines in response to shock originating in sector 1, but rises strongly in response to a shock in sector 2. The mechanism driving this result has been discussed above. An increase of sector 1 spending creates strong price pressures. The central bank responds by raising the interest rate (bottom panel). Consumption declines strongly (third row) and, in fact, by more than the increase of government spending—as a result output drops. We have discussed the possibility of a negative government spending multiplier in response to a government spending shock in the flexible price sector above. Here, we simply observe that the multiplier is negative even though $n = 0.5$ and the degree of price stickiness is not particularly low. Against this background, we investigate more systematically how the relative degree of price stickiness shapes aggregate dynamics. The left panel of Figure 14 displays output multipliers for alternative values of α_1, measured along the horizontal axis. Throughout, we keep the pricing friction in sector 2 unchanged ($\alpha_2 = 0.89$). Perhaps unsurprisingly, raising the pricing friction in sector 1 also raises the multiplier in response to a sector 1 shock (given by the solid line). However, it lowers the multiplier in response to a sector 2 shock (given by the dashed line). When we raise α_1 above the level of our baseline calibration (0.78), we increase the overall price stickiness in the economy and yet the multiplier in response to a sector 2 shock declines. The mechanism that underlies this result is straightforward to understand: as sector 1 becomes more sticky, monetary policy has to compress consumption by more in order to stabilize inflation.

We consider the effect of granularity on the fiscal transmission next. For this purpose we assume that sector 1 is larger than sector 2 and set $n = 82$. We do so because eventually we will assume that sector 2 represents the top 3 2-digit sectors in terms of government spending and they account for 18 percent of GDP (see fact 2.1). For now, however, we assume that there is no sectoral bias in government spending and instead assume that both, private consumption and government spending are concentrated in sector 1 ($\omega = \gamma = 0.82$). The third column of Figure

13 shows the results. It is organized in the same way as the previous columns. A key difference relative to the scenario without equally-sized sectors (shown in the second column) is that the output response to both shocks is larger than before. To understand this result, recall that the extent of crowding out is determined by monetary policy's desire to keep inflation stable. In case $n = 0.84$ private consumption is concentrated in the relatively flexible sector. Hence, a more moderate reduction of consumption is sufficient to achieve price stability. The right panel of Figure 14 illustrates systematically how varying n from zero to one alters the impact effect of fiscal shocks on output. It appears noteworthy that the response of output is negative for both sector 1 and for aggregate shocks unless sector 1 accounts for more than two-thirds of the economy.

Last, we also account for sectoral bias and set sector-1 government spending in steady state to $\gamma = 0.3$ because the top 3 2-digit NAICS sectors account for 70 percent of government spending and they are meant to be represented by sector 2 (see fact 1.1). We adjust $\omega = 0.95$ in order to maintain $n = 0.82$ as before. The results are shown in the rightmost column Figure 13. We observe that sectoral bias raises the output effect somewhat further. Again, the reason is easy to understand: with sectoral bias a larger fraction of private consumption is concentrated in the sector where prices are relatively flexible.

It is also worthwhile to emphasize that government spending is not only concentrated in sector 2. According to fact 4.1, a granular residual based on firms in the top 3 2-digit NAICS sectors account for the largest part of fluctuations in G. Against this background it seems reasonable to compare the effects of the sector-2 shock to recent time series evidence. In this regard it is noteworthy that several studies find the response of inflation and interest rates to government spending shocks very much muted, or even negative (Mountford and Uhlig, 2009; Corsetti, Meier, and Müller, 2012; Ramey, 2016). As our model simulations show, accounting for the heterogeneity in G goes some way towards accounting for these findings. In particular, as the bottom row of Figure 13 shows, the interest rate response to fiscal shocks tends to becomes weaker as we move from the left to the right column, thus progressively accounting for more and more dimensions of heterogeneity.

4.5 Model simulations: robustness

Until now we have maintained the assumption that monetary policy follows a strict inflation target. And our discussion of the results has invoked inflation targeting by the central bank as an essential aspect of the transmission mechanism. For this reason we verify that our main results also holds once we assume that monetary policy follows a simply interest rate feedback rule. Specifically, we assume that the policy rate is adjusted to inflation with a response coefficient of

1.5. Relative to strict inflation targeting this implies a somewhat more accommodative monetary stance in the face of government spending shocks. Still as we show in the left column of Figure 15, the adjustment dynamics are similar to what have obtained for the baseline model (shown in the right column of Figure 13), although the difference in the effects across shocks is now less pronounced.

Nevertheless, monetary policy and, in particular, its interaction with the degree of price stickiness, is key for the fiscal transmission mechanism, especially when the zero lower bound on interest rates binds. In this case, higher government spending does not trigger an increase in interest rates: private consumption is crowded in and the fiscal multiplier is larger than in normal times—a result well known from one-sector models (Eggertsson, 2011; Christiano, Eichenbaum, and Rebelo, 2011). We therefore also investigate the role of monetary policy and the ZLB in our two-sector model. We assume that a shock to the time-discount factor increases households' desire to save and, as a result, pushes the economy at the ZLB. We then contrast the effect of government spending shocks in sectors 1 and 2.[11] We show the results in the second column of Figure 15 for the case of a Taylor rule (the results look very similar to the case of inflation targeting). Note that the interest rate, shown in the bottom panel, is not responding during the first three months because the ZLB binds.[12] As a result, private consumption is now increasing on impact in response to the shocks and the multiplier slightly exceeds unity just as in the one-sector model.

The novel result is that the ranking of the multipliers across sectors flips at the ZLB. The spending shock in sector 1 now has a larger effect on output than a shock in sector 2: the impact multiplier is about 1.1 in the case of a sector 1 shock, the sector with more flexible prices, and just slightly above one in the case of a sector 2 shock. The multiplier is larger in case of a sector-1 shock, because higher government spending in this sector has a stronger inflationary impact. In normal times, the inflationary pressure would trigger a stronger monetary contraction, which does not take place at the ZLB. The stronger inflationary impulse therefore translates into a stronger drop in the real interest rate and, eventually, a stronger crowding in of private consumption. Conversely, the ZLB provides little amplification in the case of sector-2 shock because here prices are more sticky. As discussed above, one may think of sector-2 shocks as a proxy for aggregate shocks in light of fact 4.1. This, in turn, suggests that the fiscal multiplier at the zero lower bound is not much larger compared to the baseline case, in line with recent evidence by Ramey and Zubairy (2018).

[11] We solve the model while allowing for an occasionally binding ZLB constraint using the OccBin toolkit of Guerrieri and Iacoviello (2015).

[12] The fiscal impulse is small enough and does not change the duration for which the ZLB binds even though, in principle, the exit from the ZLB is endogenous and may be quicker if the fiscal stimulus is large (Erceg and Lindé, 2014).

In theory the persistence of fiscal of shocks is an important parameter for the fiscal transmission mechanism by its implied wealth effect (Baxter and King, 1993). For this reason we also run model simulations for $\rho_k = 0.85$ and show results in the third column of Figure 15. We obtain a similar picture as for the baseline, except that the adjustment is more drawn out; moreover, the differences across shocks gets amplified and, as expected, interest rates respond less to more persistent shocks. We note, however, that our model does not feature capital in production. In the analysis of Baxter and King (1993) it is because the wealth effect alters labor supply and hence capital accumulation that shock persistence has a first order effect on the fiscal transmission mechanism.[13]

In a last experiment we assess whether calibrating the government sector to DoD-contract data makes a difference (relative to the baseline which uses all contract data). Specifically, in this case we set $\gamma = 0.27$ and $n = 0.77$, $\alpha_1 = 0.72$, and $\alpha_2 = 0.84$. Note that these values differ because if we focus on DoD-contract the top 3 2-digit NAICS sectors differ from our baseline setup (see fact 2). Yet the adjustment to fiscal shocks, shown in column of Figure 15 is similar to those for the baseline case (right column of Figure 13.

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, complemented by an analysis of state and local spending based on BEA input-output tables where available, allows us to establish five basic facts 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. **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 calibrate a simple two-sector New Keynesian model that captures the five facts in a stylized fashion.

The fiscal transmission mechanism in the micro-founded two-sector model differs considerably, depending on which sector the shock originates in. Importantly, while private expenditure

[13] In a more recent analysis, Boehm (2020) finds that short-lived government investment shocks generate a smaller fiscal multiplier than government consumption shocks.

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, by a factor of four. We leave a more systematic quantitative exploration for future work.

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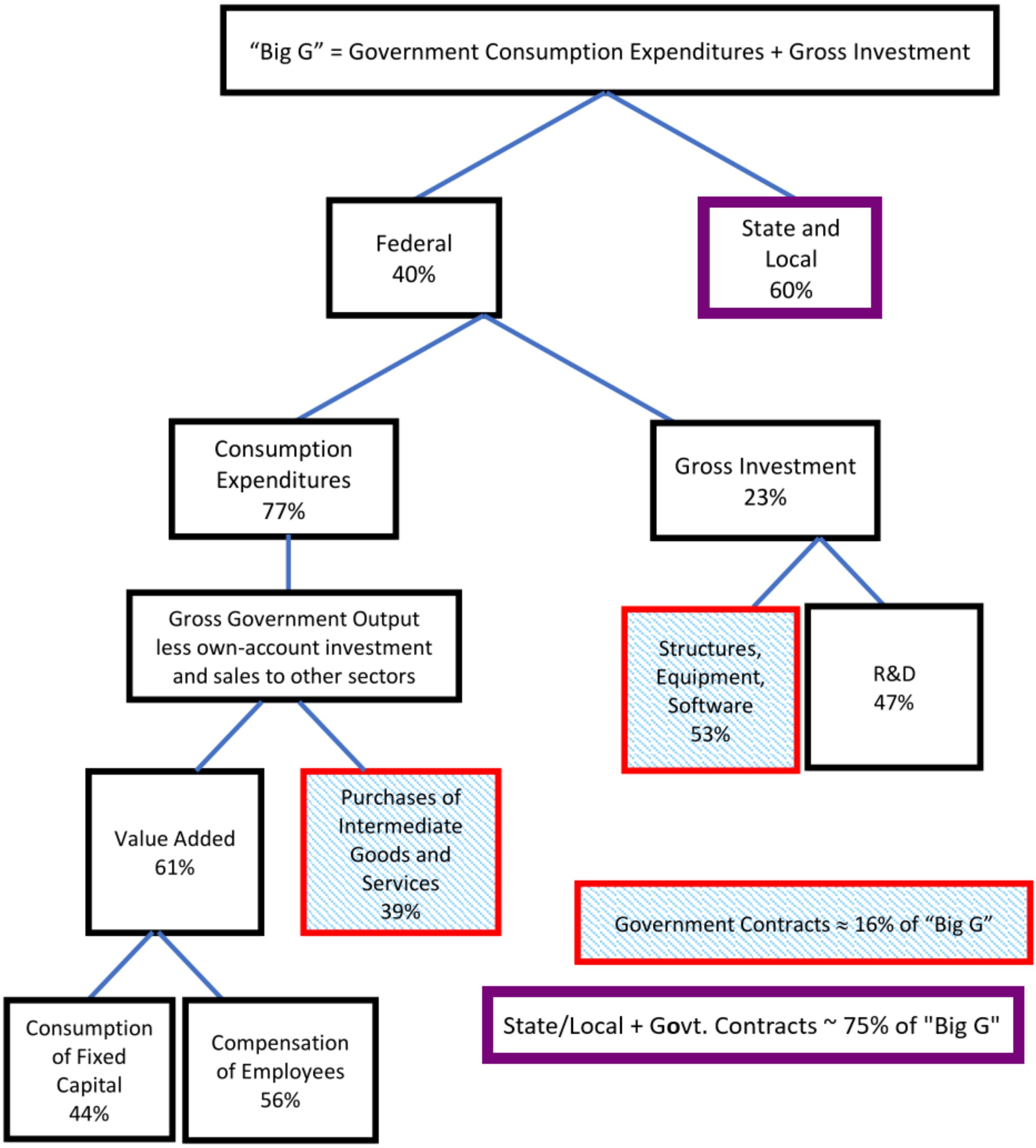
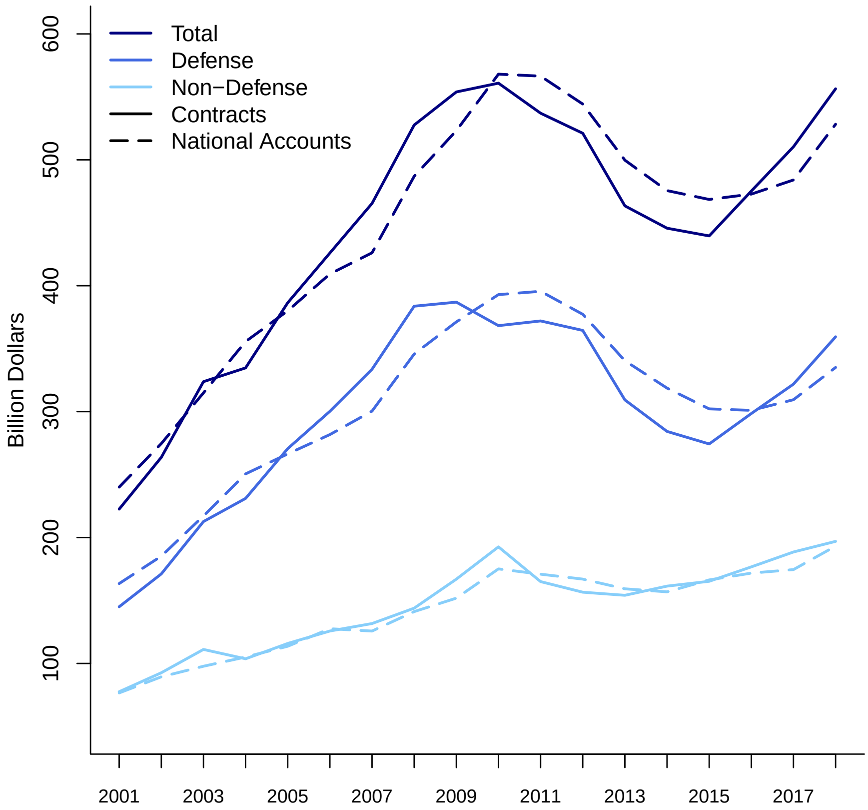
6 Figures and Tables

Figure 1: Categories of Big G



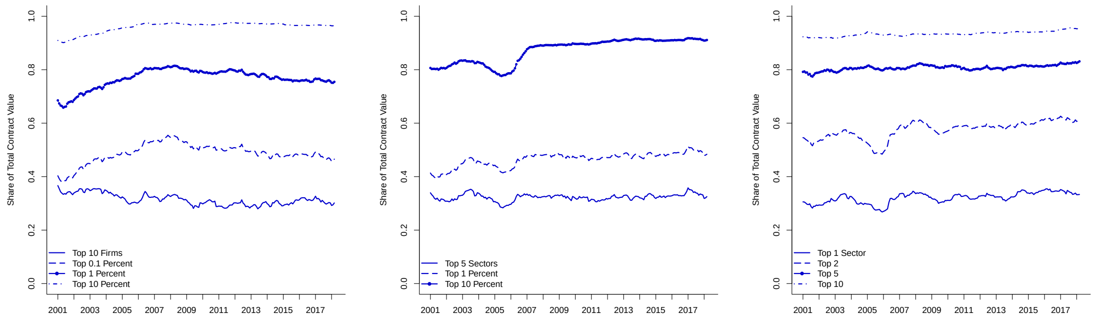
Note. This figures classifies the categories of Big G. The contract data in USAspending.gov represent the categories “Purchases of intermediate goods and services” as well as “Structures, equipment, and Software”. We use data from the BEA 2002 Make and Use Tables to characterize government spending at the state and local level (Facts 1 and 2).

Figure 2: Contracts vs. National Accounts Comparison



Note. This figure shows actual contract spending from USASpending (solid lines) and the corresponding components of government spending in the national accounts—federal purchases of intermediate goods and services and federal non-R&D investment (dashed lines), both in the full sample, as well as defense and non-defense only.

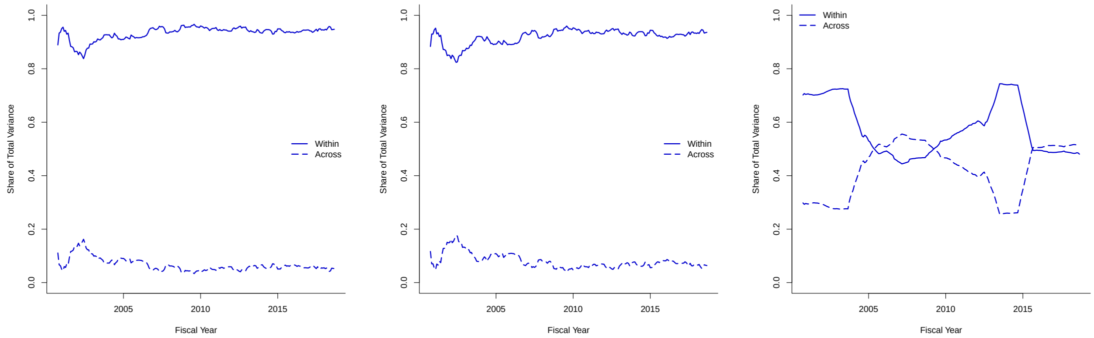
Figure 3: Share of Obligations by Top Firms and Sectors



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

Note. This figure shows the 12-month moving average of the monthly share of contract obligations awarded to the top firms (the left panel), six-digit NAICS sectors (the middle panel), and two-digit NAICS sectors (the right panel).

Figure 4: Variance Decomposition: Within and Across Firms



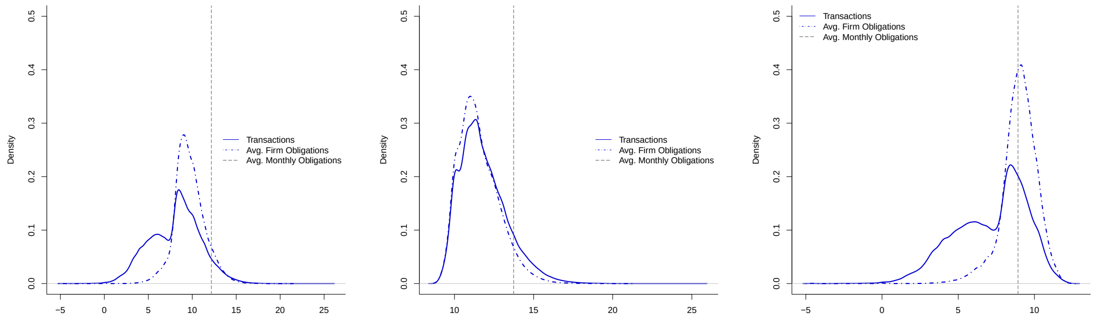
(a) Full Data Set (b) Top 20 Percent (c) Bottom 80 Percent

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 data set, panel (b) restricts the sample to the top 20 percent of contracts, and panel (c) shows only the bottom 80 percent of contracts.

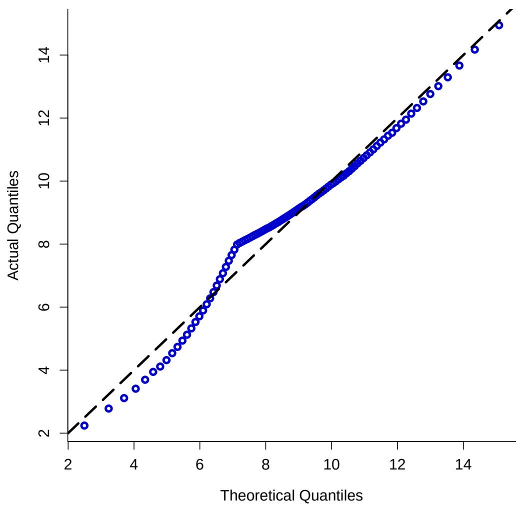
Figure 5: Density of Variance Decomposition Components



(a) Full Data Set (b) Top 20 Percent (c) Bottom 80 Percent

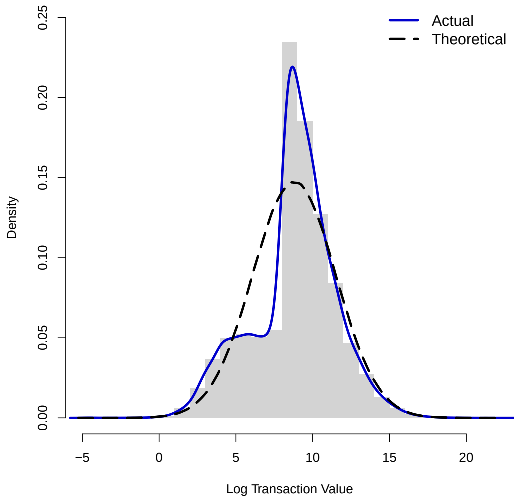
Note. This figure shows the density of each of the three components that underlie the variance decomposition in Figure 4. The solid-blue line shows the density of the individual contract transactions—$g_{if,t}$; the dash-dotted line shows the density of average firm obligations—$\bar{g}_{f,t}$; and the dashed-black horizontal line shows the average annual obligations—$\bar{g}_t$. Panel (a) shows these densities for the full data set, panel (b) restricts the sample to the top 20 percent of contract transactions, and panel (c) shows only the bottom 80 percent of contracts.

Figure 6: Q-Q Plot



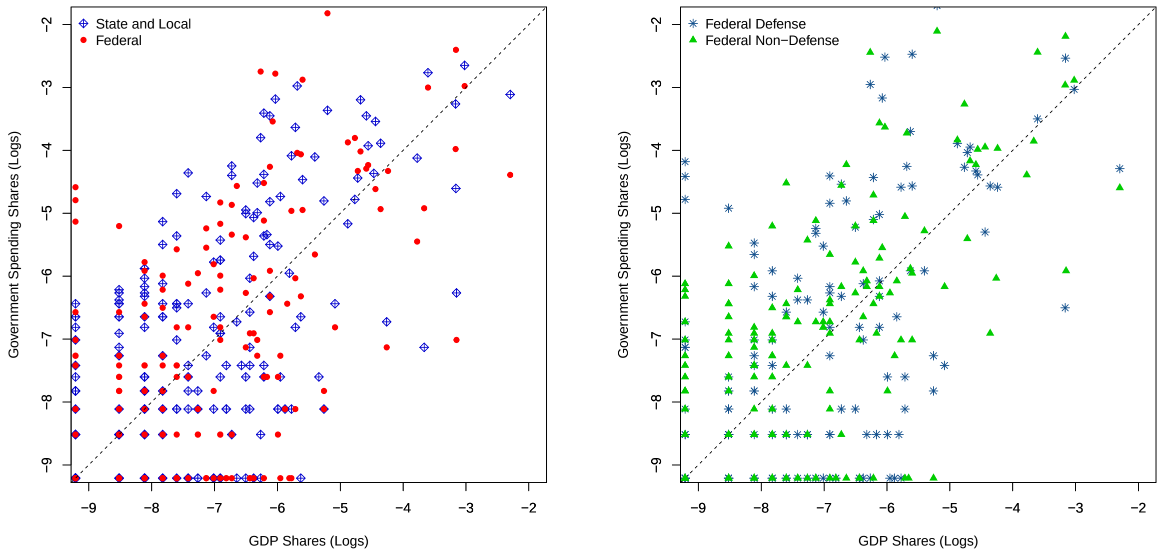
Note. This figure is a Q-Q plot with actual quantiles of log transactions on the y-axis and theoretical quantiles from a log-normal distribution with the same mean and standard deviation plotted on the x-axis.

Figure 7: Transaction Value Histogram



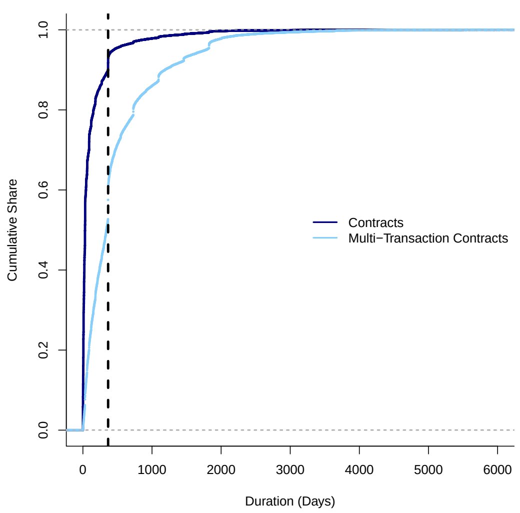
Note. This figure shows a histogram of log transaction obligations and the density of those log obligations. We also plot the density of a theoretical log-normal distribution with the same mean and variance.

Figure 8: Sectoral Bias in Government Spending



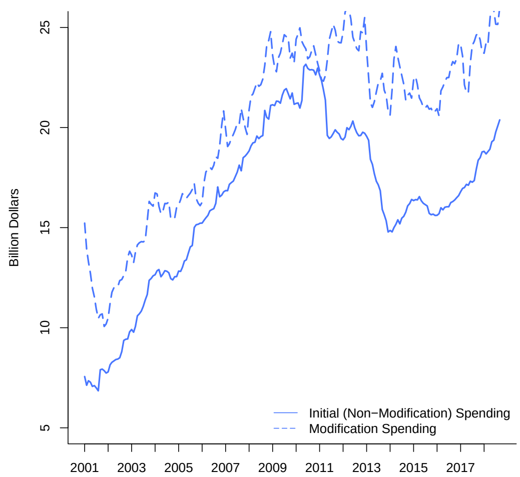
Notes. These figures plot the distribution of government spending across 350 sectors (measured along the y-axis) against the distribution of sectoral GDP in the economy (x-axis), average values for 2001–2018. Sectoral GDP is calculated as total industry output net of output sold as intermediates to other sectors and net exports. The left panel distinguishes between federal government spending and state-level and local government spending, the right panel between spending by the department of defense and federal non-defense spending. Data sources: BEA Input Output Accounts: *Make Table* and *Use Table*.

Figure 9: ECDF of Contract Durations



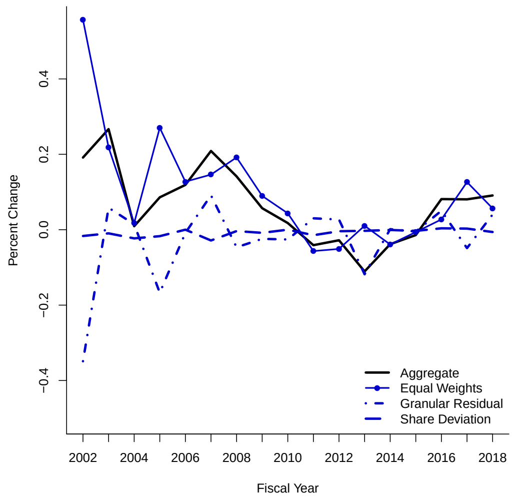
Note. This figure shows the empirical cumulative distribution function of the duration—the number of days between the start and end date—of contracts and multi-transaction contracts. The dashed black line marks 365 days. Contracts with negative durations or durations more than 5500 days (15 years) are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

Figure 10: 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).

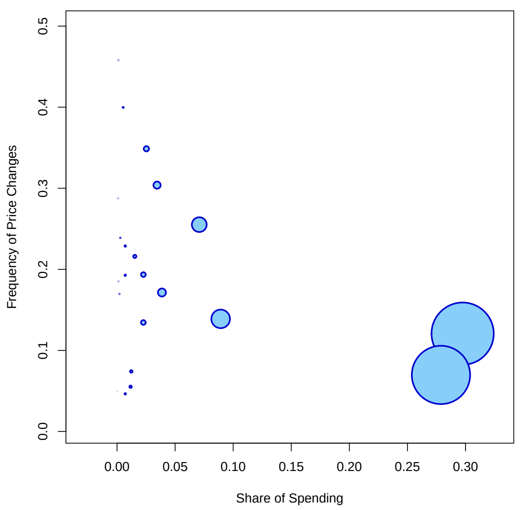
Figure 11: Decomposition of Sectoral Spending Growth



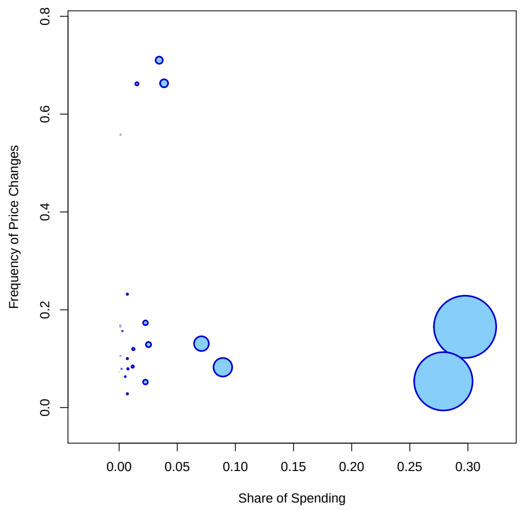
Note. This figure plots the individual components of government consumption growth, decomposed as in Foerster, Sarte, and Watson (2011) as follows:

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

Figure 12: Frequency of Price Adjustment



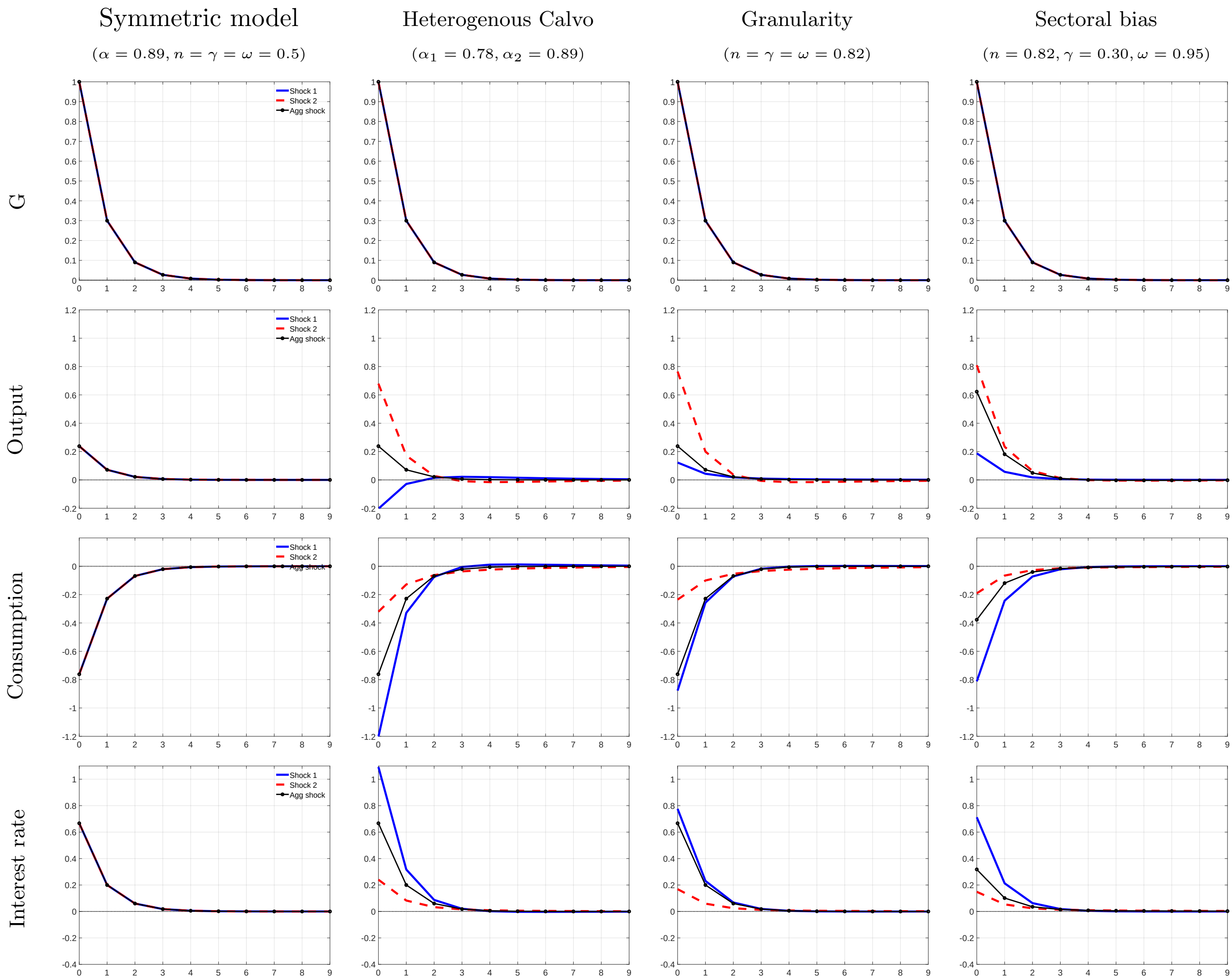
(a) BLS Frequency



(b) Inverse Duration

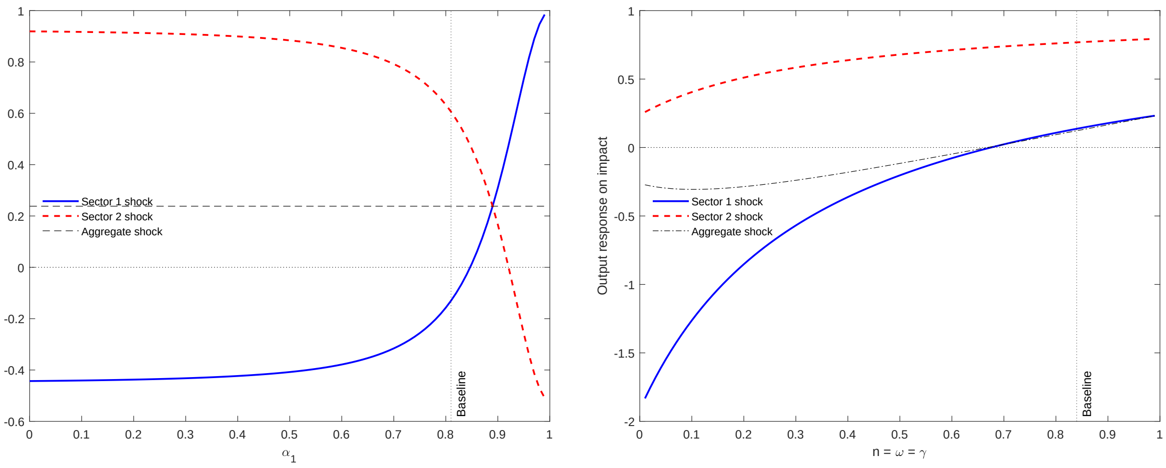
Note. This figure shows the average annual share of government spending in each two-digit sector (x-axis) plotted against the frequency of price changes in those sectors, based on BLS data. The size of the bubble corresponds with the average sectoral share of annual aggregate spending.

Figure 13: Dynamic Effects of Government Spending shocks



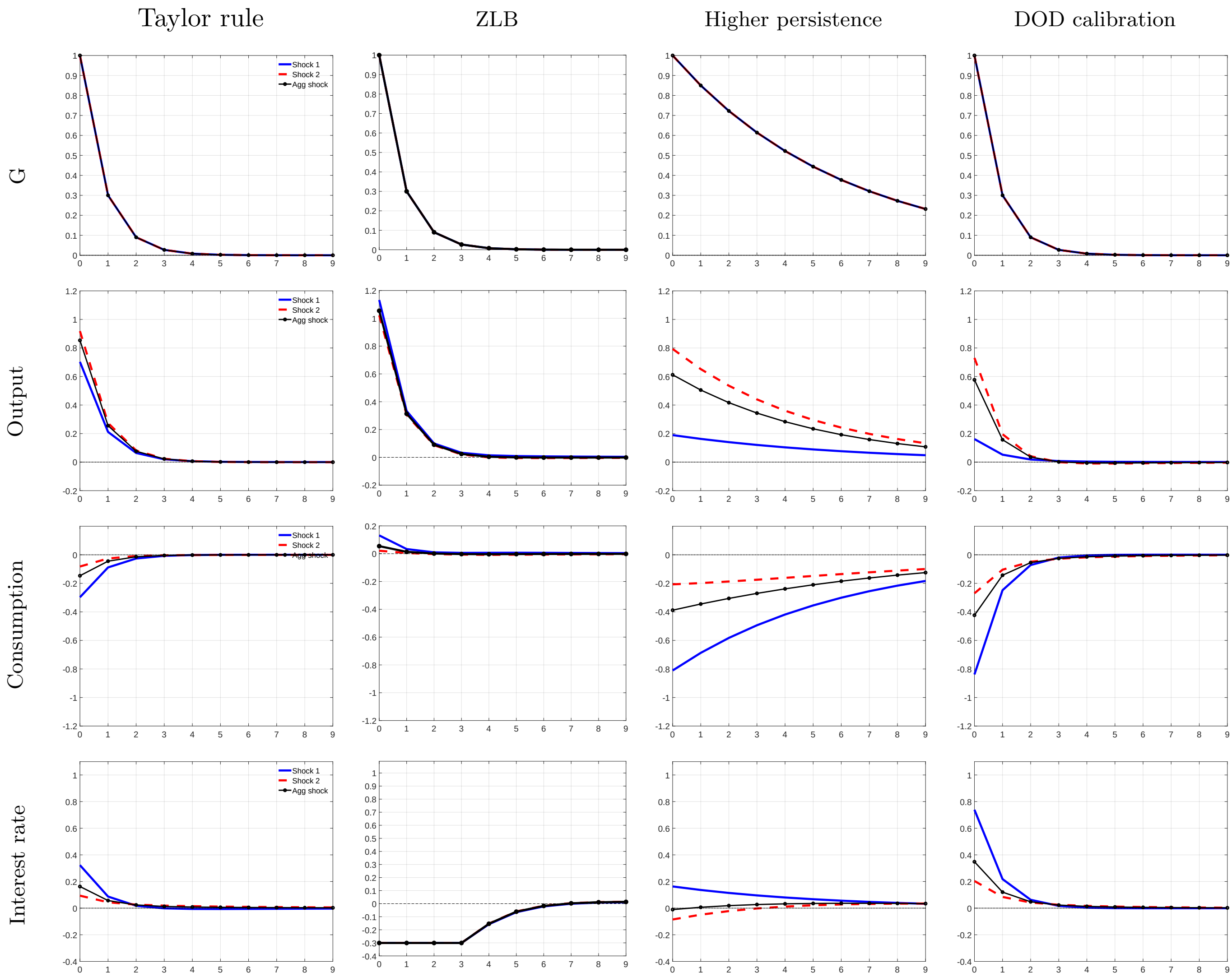
Notes: all shocks are normalized so that the shock amounts to one percent of steady-state output in each instance; horizontal axis measures time in months, vertical axis measures deviation from steady state in percentage points of steady-state output for government spending, output and consumption and percentage points for the interest rate. Solid line represents government spending shock in sector 1, dashed line in sector 2, solid line with circles represents aggregate shock. Each column corresponds to an alternative model specification.

Figure 14: Impact Multipliers for alternative parameter values



Note. Impact response of output (measured along vertical axis in percent of steady state output) to government spending shock originating in sector 1 (solid line) vs sector 2 (dashed line) as well as aggregate spending shock. Shocks normalized to be equal to 1 percentage point of steady state output. Left panel shows impact multipliers for alternative values of α_1, measured along the horizontal axis. $\alpha = 0.89$ and other parameter values as in symmetric baseline. Right panel shows impact multipliers for various degrees of granularity. In this case we set $\alpha_1 = 0.78$ and $\alpha_2 = 0.89$.

Figure 15: Dynamic Effects of Government Spending shocks—Robustness



Notes: all shocks are normalized so that the shock amounts to one percent of steady-state output in each instance; horizontal axis measures time in months, vertical axis measures deviation from steady state in percentage points of steady-state output for government spending, output and consumption and percentage points for the interest rate. Solid line represents government spending shock in sector 1, dashed line in sector 2, solid line with circles represents aggregate shock. Each column corresponds to an alternative model specification for which the baseline scenario displayed in the right column of Figure 13 serves as the point of departure.

Table 1: Summary Statistics: DOD vs. Non-DOD

	All	Defense	Non-Defense
Contract Size (Mean)	193454	242286	134462
Contract Size (Median)	3630	4325	2626
Contract Size (Std Dev)	15622793	18233058	11717756
Duration (Mean)	127	117	139
Duration (Median)	31	27	33
Duration (Std Dev)	284	271	299
Transactions per Contract (Mean)	1.34	1.34	1.34
Transactions per Contract (Median)	1	1	1
Transactions per Contract (Std Dev)	2.9	3.46	2.02
Share Fixed Price Contracts	0.73	0.78	0.68
Share Top 1 Pct of Firms	0.77	0.77	0.71
Share Top 1 Pct NAICS 6 Sectors	0.47	0.49	0.48

Note. This table shows basic summary statistics for our entire 2001-2018 pooled contract data.

Table 2: AR(1) Coefficients at Different Aggregation Levels

All Contracts

	Monthly	Quarterly
Sectoral	0.29	0.4
Omit Top 1 Pct	0.16	0.19
Aggregate	0.47	0.55

DOD Contracts

	Monthly	Quarterly
Sectoral	0.25	0.35
Omit Top 1 Pct	0.18	0.17
Aggregate	0.44	0.58

Non-DOD Contracts

	Monthly	Quarterly
Sectoral	0.26	0.28
Omit Top 1 Pct	0.14	0.09
Aggregate	0.44	0.37

Note. These tables show the persistence coefficients from estimates of an AR(1) process at different levels of time aggregation. The Sectoral estimates are weighted averages, and the aggregate estimate done over the pooled sample.

Table 3: Explanatory Power of the Granular Residual

	(1) ΔG	(2) ΔG	(3) ΔG	(4) ΔG
$\Gamma_t^{Q=1000}$	1.611***		1.509***	
	(0.0620)		(0.0609)	
$\Gamma_t^{Q=100}$		1.572***		1.475***
		(0.0618)		(0.0592)
$\Gamma_{t-1}^{Q=1000}$			-0.323***	
			(0.0611)	
$\Gamma_{t-2}^{Q=1000}$			-0.224***	
			(0.0613)	
$\Gamma_{t-1}^{Q=100}$				-0.350***
				(0.0594)
$\Gamma_{t-2}^{Q=100}$				-0.222***
				(0.0596)
Constant	0.524***	0.590***	0.349***	0.376***
	(0.0229)	(0.0253)	(0.0376)	(0.0417)
Observations	214	214	213	213
R^2	0.761	0.753	0.795	0.795

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4: 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	30.93	6.29	0.12	0.14	0.3	0.28
2	59.89	13.3	0.09	0.2	0.27	0.31
3	69.14	16.22	0.1	0.22	0.29	0.28
4	76.48	20.39	0.13	0.2	0.24	0.36
5	80.51	24.72	0.14	0.21	0.23	0.39
6	84.13	30.66	0.17	0.19	0.3	0.35
8	89.12	40.5	0.19	0.15	0.32	0.29
12	95.53	55.3	0.17	0.18	0.34	0.34

Note. Avg. Freq. In refers to the average frequency of price changes in sectors within the given % of government spending. Avg. Freq. Out is the average frequency of price changes for all other sectors. The same interpretation is true for ρ, the persistence parameter of estimated AR(1) processes.

Online Appendix:
Big G

Lydia Cox, Gernot J. Müller, Ernesto Pasten, Raphael Schoenle, and Michael Weber

Not for Publication

A.1.1 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 the 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. (3) and (5) 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

$$Y_1 = C_1 + G_1, \quad Y_2 = C_2 + G_2 \tag{A.1}$$

Adding these gives

$$Y_1 + Y_2 = \omega C + (1-\omega)C + G_1 + G_2 = C + G_1 + G_2 = Y \tag{A.2}$$

where the last equation follows from the definition of real GDP. 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

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

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

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

The steady-state labor supply from equation (7) 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 a result we have for labor supply in the steady state

$$\frac{W}{P} = L^{\varphi} C. \tag{A.3}$$

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

$$CP + P_1 G_1 + P_2 G_2 = WL + \Pi \tag{A.4}$$

$$\Pi = P_1 Y_1 + P_2 Y_2 - WL = PY - WL \tag{A.5}$$

$$Y = L \tag{A.6}$$

$$P = \frac{\theta}{\theta - 1} W. \tag{A.7}$$

From (A.7) we have

$$\frac{W}{P} = \left(\frac{\theta - 1}{\theta}\right) \tag{A.8}$$

This in turn implies

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

A.1.2 Note on Linearization of Phillips Curve

To derive the NKPC rewrite the first order condition of the firm (10) 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 the 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

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

A.1.3 Proofs

A.1.3.1 Proposition 1

Proof of proposition 1. Substituting the solution (34) in (33) yields the conditions for the unknown coefficients:

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

Let

$$f(x) = \beta x^2 - \{1+\beta+\kappa A_2\}\,x + 1. \tag{A.9}$$

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

$$f(1) = \beta - [(1+\beta) + \kappa A_2] + 1 = -\kappa A_2 < 0 \tag{A.10}$$

Therefore the two roots of the quadratic equations lie 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. Then, we plug the results into the system and solve directly:

$$\Lambda_1 = \frac{\kappa\frac{A_2}{A_1}\frac{\varphi}{n}}{\{(1+\beta)+\kappa A_2\} - \beta(\Lambda_0+\rho)} \geq 0 \tag{A.11}$$

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

Similarly

$$\Lambda_2 = \frac{\kappa\frac{\varphi}{1-n}}{\{(1+\beta)+\kappa A_2\} - \beta(\Lambda_0+\rho)} \geq 0 \tag{A.12}$$

A.1.3.2 Proposition 2

Proof of (1), solution for consumption

Recall that c_t can be written as

$$c_t = (1-\omega)\tau_t - \left(1+\frac{\zeta\varphi\omega}{n}\right)^{-1}(1-\zeta)\gamma\frac{\varphi}{n}g_{1t} \tag{A.13}$$

Plugging in for τ_t as derived from Proposition 1

$$c_t = (1-\omega)\Lambda_0\tau_{t-1} + (1-\omega)(1-\zeta)[\Lambda_1\gamma g_{1,t} - \Lambda_2(1-\gamma)g_{2,t}] - \left(1+\frac{\zeta\varphi\omega}{n}\right)^{-1}(1-\zeta)\gamma\frac{\varphi}{n}g_{1t} \tag{A.14}$$

Combining (A.14) with the expression for b and c in (A.11) and (A.12) yields

$$c_t = (1-\omega)\Lambda_0\tau_{t-1} + \frac{1-\zeta}{\zeta}\left[\frac{\kappa(1-\omega)(\frac{A_2}{A_1}\frac{\varphi}{n}\gamma g_1 - \frac{\varphi}{1-n}(1-\gamma)g_2)}{\{(1+\beta)+\kappa A_2\} - \beta(\Lambda_0+\rho)} - \left(1+\frac{\zeta\varphi\omega}{n}\right)^{-1}\gamma\frac{\varphi}{n}g_1\right] \tag{A.15}$$

Let

$$c_t = \Theta_0\tau_{t-1} - \Theta_1(1-\zeta)\gamma g_{1t} - \Theta_2(1-\zeta)(1-\gamma)g_{2t} \tag{A.16}$$

Thus, the lag coefficient on the previous period's terms of trade τ_{t-1} is

$$\Theta_0 = (1-\omega)\Lambda_1 \tag{A.17}$$

where recall that $\Lambda_0 \in (0,1)$ is the root of equation (A.9). Thus $\Theta_0 \in (0,1)$ as well.

The rest of (A.15) can be decomposed into the coefficient of consumption wrt government spending in sector 1, Θ_1:

$$\Theta_1 = \frac{\varphi}{A_1 n} - (1-\omega)\Lambda_1 = \frac{\varphi}{A_1 n} - (1-\omega)\frac{\kappa\frac{A_2}{A_1}\frac{\varphi}{n}}{\{(1+\beta)+\kappa A_2\} - \beta(\Lambda_0+\rho)} \tag{A.18}$$

$$\Theta_1 = \frac{\varphi}{A_1 n}\frac{(1+\beta)+\omega\kappa A_2 - \beta(\Lambda_0+\rho)}{\{(1+\beta)+\kappa A_2\} - \beta(\Lambda_0+\rho)} \tag{A.19}$$

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

$$\Theta_2 = (1-\omega)\Lambda_2 = \frac{(1-\omega)\kappa\frac{\varphi}{1-n}}{\{(1+\beta)+\kappa A_2\} - \beta(\Lambda_0+\rho)} \tag{A.20}$$

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

From equations (A.19) and (A.20), it is immediate that both Θ_1 and Θ_2 are greater than or equal to 0. The lower bound 0 can be attained by setting $\varphi = 0$.

Next we show that Θ_1 is unbounded above. From (A.19), plugging in for A_1 and A_2,

$$\Theta_1 = \frac{\varphi}{\left(1+\frac{\zeta\varphi\omega}{n}\right)n}\frac{(1+\beta)+\omega\kappa A_2-\beta(\Lambda_0+\rho)}{\{(1+\beta)+\kappa A_2\}-\beta(\Lambda_0+\rho)} \tag{A.21}$$

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 (A.20), plugging in for A_2, and multiplying by ζ on both sides,

$$\zeta\Theta_2 = \frac{\zeta(1-\omega)\kappa\frac{\varphi}{1-n}}{(1+\beta)+\kappa\left(1+\frac{\zeta\varphi(1-\omega)}{1-n}\right)-\beta(\Lambda_0+\rho)} \tag{A.22}$$

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 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 (A.19) and (A.20).

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

$$[\kappa\frac{1-n+\zeta\varphi(1-\omega)}{1-n}\omega\varphi + A_1(1+(1-a-\rho)\beta)n](1-n) > \kappa\frac{n+\zeta\varphi\omega}{n}(1-\omega)\varphi n \tag{A.23}$$

Since $\Lambda_0, \rho, \beta < 1$, it's clear that $(1+(1-\Lambda_0-\rho)\beta) > 0$, with emphasis on the strictness of the inequality. Thus, inequality (A.23) holds if

$$[1-n+\zeta\varphi(1-\omega)]\omega \geq [n+\zeta\varphi\omega](1-\omega) \tag{A.24}$$

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

$$\frac{\omega}{n} \geq \frac{1-\omega}{1-n} \implies \omega > \gamma \tag{A.25}$$

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

A.1.3.3 Proposition 3

Proof of Proposition 3. From the definition of output

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

Therefore, y_t can be written as

$$
y_t = \Gamma_0\tau_{t-1} - \Gamma_1(1-\zeta)\gamma g_{1t} - \Gamma_2(1-\zeta)(1-\gamma)g_{2t}. \tag{A.26}
$$

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 (A.19) and (A.20) gives

$$
\Gamma_1 = 1 - \zeta \cdot \underbrace{\frac{\varphi}{\left(1+\frac{\zeta\varphi\omega}{n}\right)n} \frac{(1+\beta)+\omega\kappa A_2 - \beta(\Lambda_0+\rho)}{\{(1+\beta)+\kappa A_2\} - \beta(\Lambda_0+\rho)}}_{\Theta_1}. \tag{A.27}
$$

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

$$
\Gamma_2 = 1 - \zeta \underbrace{\frac{(1-\omega)\kappa\frac{\varphi}{1-n}}{(1+\beta)+\kappa\left(1+\frac{\zeta\varphi(1-\omega)}{1-n}\right) - \beta(\Lambda_0+\rho)}}_{\Theta_2} \tag{A.28}
$$

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

A.2 USASpending vs. Other Data in the Literature

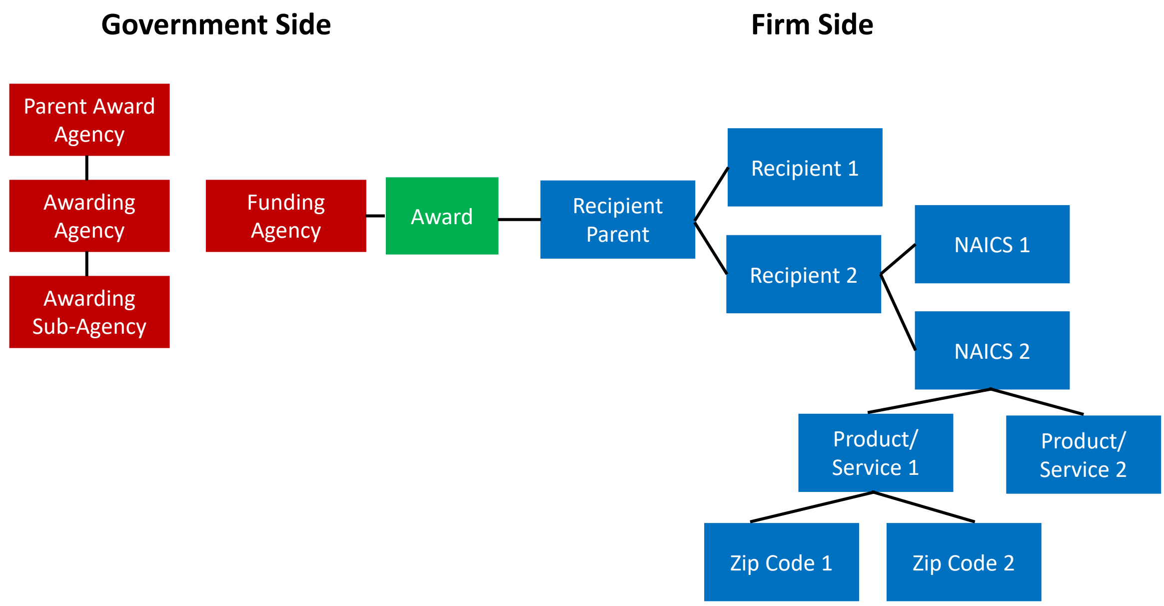
While, to our knowledge, no one has employed the USASpending database in the way we do in this paper, a number of papers make use of similar types of data on government spending. Most recently, Auerbach, Gorodnichenko, and Murphy (2020) use part of the USASpending database in a more aggregated fashion. Specifically, they use only contracts that originate at the US Department of Defense (DOD). To extend their time series backward, they supplement the USASpending data on DOD contracts with data that come 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 are from the DD Form 350, the procurement reporting form that preceded the FPDS forms that are in the USASpending database and Auerbach, Gorodnichenko, and Murphy (2020) 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, Gorodnichenko, and Murphy (2020) aggregate to the city level, Nakamura and Steinsson (2014) aggregate to the state level.[1]

Cohen, Coval, and Malloy (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 the USASpending data do, 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, Coval, and Malloy (2011) also use some data on government procurement contracts from 1992-2008,[2] aggregated at the state level.

[1] 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 100 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).

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

Figure A.1: Tracing of Award from Origin to Recipient



A.3 What are Government Contracts?

A.3.1 Types of Awards

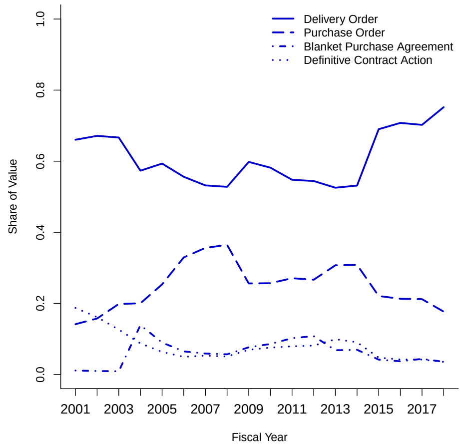
The government can use different types of awards to procure services. The majority of federal spending through contracts is done through either a definitive contract action (DCA) or a delivery order. A DCA is a legally binding agreement obligating the seller to furnish certain supplies or services and 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, 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, 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 the option of four additional years. The contract stipulated a maximum dollar amount for the base period and four option years of $69,698,540. DCAs tend to be used for larger, one-time purchases, while delivery orders are used for smaller and more frequent purchases.

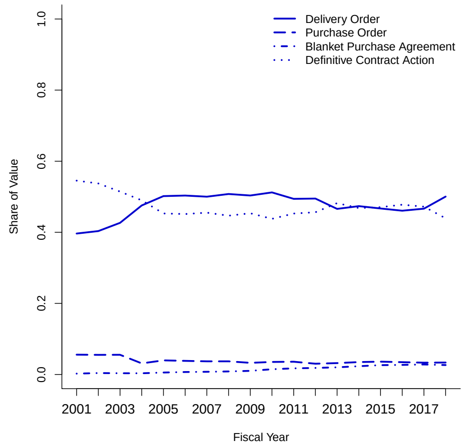
Figure A.2 shows the share of each type of award by count and value for all firms (top two panels) and the top 10 firms (bottom two panels). By count, delivery orders and purchase orders are the most common type of award. By value, however, definitive contract actions account for about half of the dollars 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. As shown in Figure A.2, 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 the Lockheed Martin Corporation and the Sikorsky Aircraft Corporation. The Lockheed Martin Corporation contract was 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.[3]

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

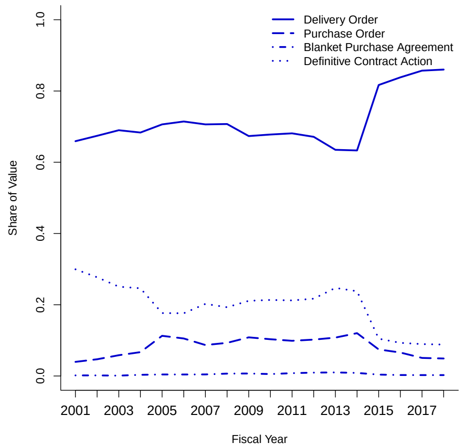
Figure A.2: Award Types



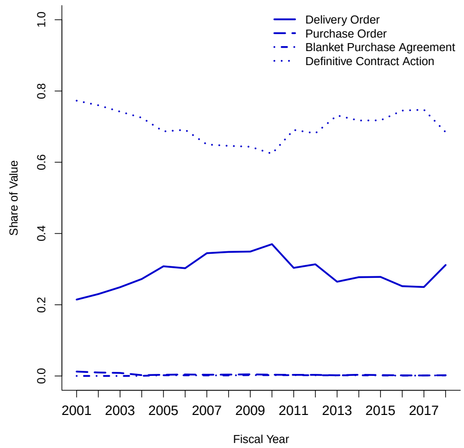
(a) Share by Count, Full Data Set



(b) Share by Value, Full Data Set



(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.

A.3.2 Types of Contract Pricing

In addition to the types of award, a wide selection of contract pricing is 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 execution costs of the contract, and the nature of the incentives offered to the contractor for its 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 frequent, 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."

A.3.3 Competition

Federal regulations generally require contracting officers to promote 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 awarded contracts were fully and openly competitive via negotiated proposals. 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.

A number of cases, however, exist, in which full and open competition is not required. Some contracts are deemed "not available for competition," in which case agencies are authorized by statute to solicit bids from only one source. 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. The Lockheed Martin contract for guided multiple launch rocket systems is an example of the latter.

Finally, for smaller awards—those below a certain dollar threshold—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.

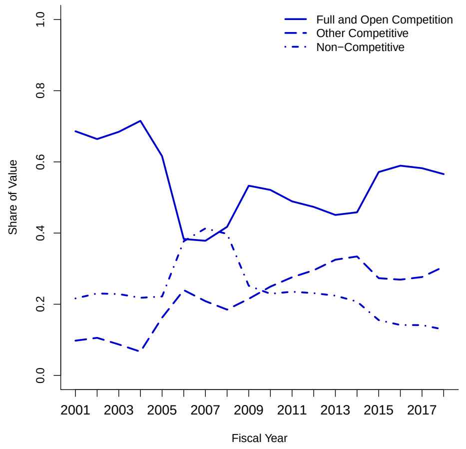
A.3.4 Extent Competed

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 a combination of competitive procedures 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 the purchase of commonly purchased supplies or services 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.[4] 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.

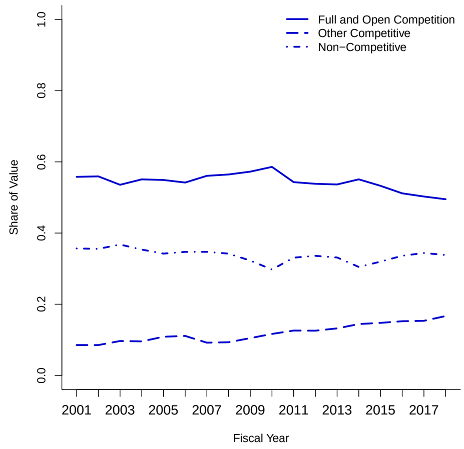
Figure A.3 shows that both for all firms and for the top 10 firms, about half of transactions are awarded under "full and open competition" (which includes "competitive delivery orders"). This is true both by count and by value of transaction. By value, slightly more of the contracts awarded to the top 10 firms are non-competitive, and, in particular, 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 A.3, 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 discussed in Section A.3 were all deemed to be under full and open competition, helping to explain the increase.

[4]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 US and $1 million for contracts awarded and performed or purchases made outside the US

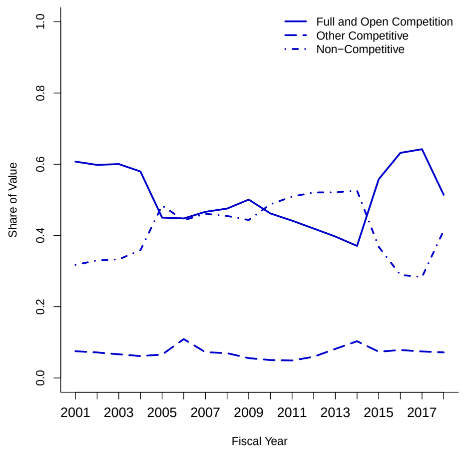
Figure A.3: Extent Competed



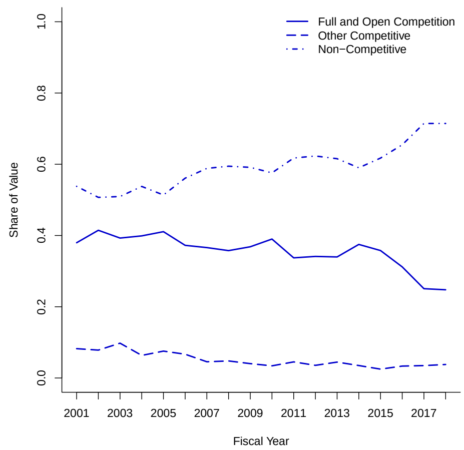
(a) Share by Count, Full Data Set



(b) Share by Value, Full Data Set



(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. “Full and Open Competition” includes competitive delivery orders. “Other Competitive” includes transactions classified as “Competed under SAP,” “Follow on to Competed Action,” and “Full and Open Competition After Exclusion of Sources.” Non-Competitive includes transactions classified as “Non-Competitive Delivery Orders,” “Not Available for Competition,” “Not Competed,” and “Not Competed Under SAP.”

A.4 Additional Results

This section reports additional results that we reference in the main body of the paper.

A.4.1 Largest Contracts in Top Sectors

To provide a bit more intuition as to what is "behind" the shocks that we estimate, we show the five largest contracts awarded to the three largest sectors in terms of its share of government contracts. These arrivals are behind the shock (though not the same, of course). Table A.1 shows the three largest transactions in NAICS 33 (manufacturing). Perhaps unsurprisingly, since this is the manufacturing sector, the top contracts are all defense-related. Tables A.2 and A.3 show the top contracts for NAICS 23 and NAICS 56, which are a bit broader in scope.

Table A.1: Ten Largest Transactions in NAICS33, Fiscal Year 2012

Action Date	**Recipient**	**Amount**	**Description**
3/8/2012	The Boeing Company	\$3.37 B	RSAF F-15 Fleet Modernization Program
6/6/2012	United Technologies Corporation	\$2.83 B	Multi Service Contract for H60 Helicopters
1/31/2012	General Dynamics	\$2.71 B	Construction of SSN 784
5/31/2012	Huntington Ingalls Industries, Inc.	\$2.16 B	Award of LHA 7 Detail Design and Construction
6/22/2012	The Boeing Company	\$1.83 B	F-15 S/SA Conversion & Provisioning
11/23/2011	Bell Boeing Joint Project Office	\$1.68 B	Lot 16 MV Full Funding
9/21/2012	The Boeing Company	\$1.60 B	Definitize P-8A LRIP III Aircraft
12/9/2011	Lockheed Martin Corporation	\$1.59 B	Authorize efforts associated w/LRIP 5 Production
6/6/2012	The Boeing Company	\$1.24 B	Definitization of India Aircraft

Table A.2: Five Largest Transactions in NAICS23, Fiscal Year 2012

Action Date	**Recipient**	**Amount**	**Description**
9/28/2012	PCCP Constructors	\$625.9 M	Permanent Canal Closures and Pumps
11/18/2011	Kiewit-Turner	\$580.2 M	Price adj. for replacement med ctr (Aurora, CO).
9/24/2012	B.L. Harbert Holdings LLC	\$302.4 M	New Embassy Compound, Jakarta, Indonesia
3/29/2012	Balfour Beatty/DPR/Big-D	\$221.0 M	Utah Data Center (Camp Williams, UT).
1/13/2012	Hensel Phelps Constfuction CO	\$191.6 M	Social Security Adinistration Nat'l Support Center

Table A.3: Five Largest Transactions in NAICS56, Fiscal Year 2012

Action Date	Recipient	Amount	Description
7/31/2012	Lawrence Livermore Nat'l Security	\$7.86 B	Mgmt/Oprtn, Lawrence Livermore Nat'l Lab
3/15/2012	S&K Aerospace LLC	\$1.24 B	PROS IV (Tri-Service Technical Support)
6/18/2012	United Space Alliance, LLC	\$470.0 M	Space Program Operations Contract
3/27/2012	Mission Essential Personnel, LLC	\$400.0 M	Linguist Interpretation and Translation Services
9/30/2012	Hewlett-Packard Company	\$330.9 M	Other ADP and Telecommunications Services

A.4.2 Granularity: Power Law Distribution

Government spending is granular in the sense that the distribution of government contracts is fat tailed. In the main text we show that the full distribution is well approximated by a log-normal distribution. Here, we show that a power law with shape parameter $\zeta < 2$ also 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:

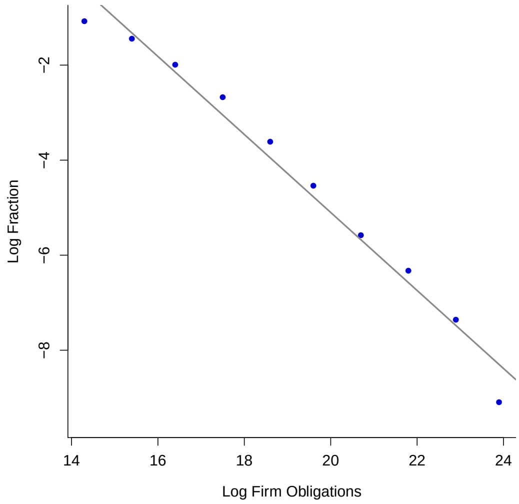
$$\ln(f(x)) = -(\zeta + 1)\ln(x) + C$$

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.

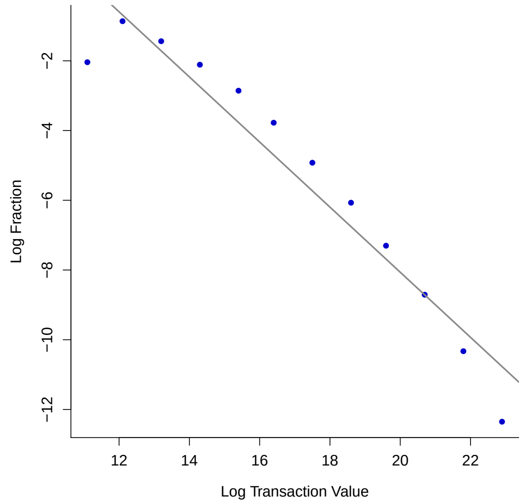
The left panel of Figure A.4 documents a linear relationship between the log size of firm obligations and the log frequency when we use the top 20 percent of suppliers that supply 99 percent of government consumption. The right panel of the figure shows that the same relationship also holds at the contract level (for the top 20 percent of contracts, which account for 97 percent 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 A.5 shows the histogram of (the log of) contract obligations and the simulated probability density function using the estimated parameters. When we compare the likelihood of the data under a Pareto distribution and a log-normal distribution, the log-normal provides the better fit, which is why we use it in the main text.

Figure A.4: Log Frequency vs. Log Contracts



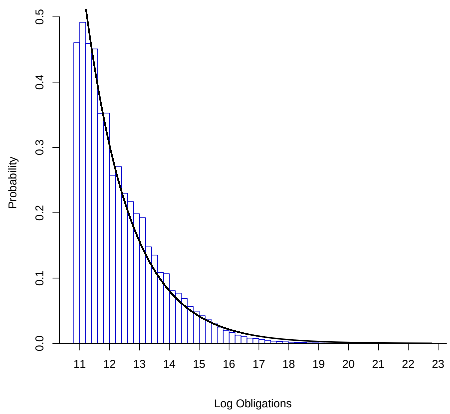
(a) Top 20 Percent of Firms



(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 A.5: 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 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 $\theta = \ln(x_m)$.

A.4.3 Shock Structure of the Spending Process

Here, we examine the shock structure of the sectoral government spending process. Idiosyncratic variation dominates this process, and these shocks are often strongly positively or negatively correlated. To see this, we examine the shock structure of the following processes:

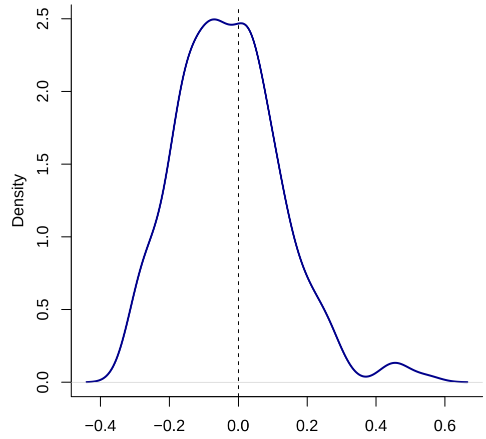
$$g_{s,t+1} = \alpha_0 + \alpha_s + \alpha_t + \rho_s g_{s,t} + \varepsilon_{s,t+1} \tag{A.29}$$

where $g_{s,t}$ is the log of government consumption from two-digit sector s at time 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 percent to only 98.34 percent. 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 that idiosyncratic innovations can have large positive and negative correlations for many sector pairs. Figure A.6 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.

Our previous cross-sectional variance decomposition ("Fact 1") suggests that across-sector variation is relatively unimportant. We note that our previous cross-sectional result is perfectly consistent with the dynamic fact. *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.

Figure A.6: Density of Error Term Correlation Coefficients



Note. This figure shows the distribution of correlation across sector pairs that result from examining the sectoral process: $g_{s,t+1} = \alpha_0 + \alpha_s + \alpha_t + \rho_s g_{s,t} + \varepsilon_{s,t+1}$, where $g_{s,t}$ is the log of government consumption of output from two-digit sector s in month t. The figure shows the distribution of the correlation coefficients of the residuals for all sector pairs.

A.4.4 The Role of Monetary Policy

Until now we have maintained the assumption that monetary policy follows a strict inflation target. Formally, $\pi_{y_t} = 0$, simplifies the algebra considerably and allows 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. However, the assumption that the monetary authority hits the inflation target fully 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.[5]

Figure **??** shows the results for the Taylor rule. 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 targeting rule. As before, the solid lines represent the adjustment to a shock in sector 1, while the dashed lines show the adjustment to a shock in sector 2. Overall, monetary policy under the Taylor rule is more accommodating than under the targeting rule: the policy rate increases by less and the overall effect on output (upper-right panel) is somewhat stronger than in the baseline case, reflecting a weaker crowding out of private consumption. Overall, results are qualitatively similar to the baseline scenario of inflation targeting.

[5]Formally, equation $i_t = 1.5\pi_{y_t}$ replaces equation (27) as an equilibrium condition.

A.4.5 Who Gets the Longest Contracts?

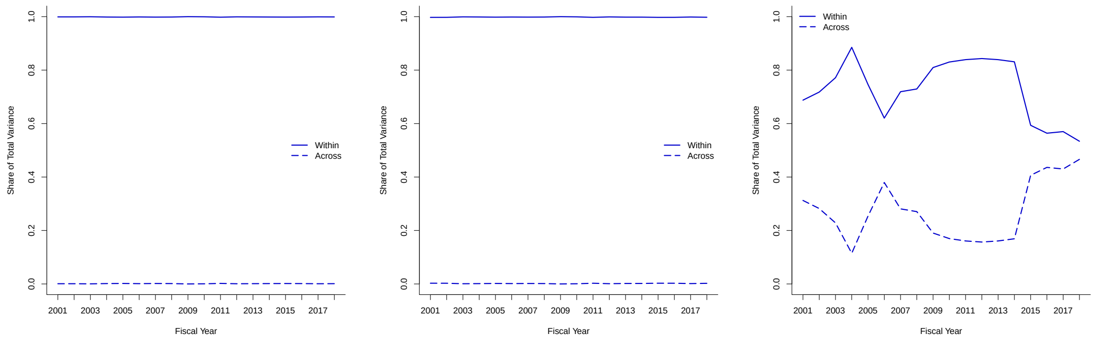
The transactions/contracts with the longest durations go to just a handful of recipients. It appears that many of these longer-term contracts have to do with facilities maintenance and investment around the government. The recipients of the 30 transactions with the longest durations include:

- Johnson Controls Inc. (14) – the recipient with the longest-duration contracts, by far, is an HVAC company that provides services to federal buildings across the government
- United Technologies (2) – primarily an aircraft manufacturing company
- URS Corporation (2) – Now AECOM, an engineering, design and construction firm. Provides services like hazardous waste treatment and disposal, engineering services,'and facilities support services
- Gentex (2) – a company that develops electronic products for the automotive, aerospace, and fire protection industries. Supplies things like specialized clothing, aircraft manufacturing and other miscellaneous manufacturing
- Ameresco Inc (2) – an energy efficiency and energy infrastructure company that has contracts with a number of agenices for energy efficieny and performance and energy infrastructure projects
- State of Texas (2) – has received contracts from a multitude of agencies for a wide range of services like food services, fossil fuel electric power generation, data processing, janitorial services, etc.

The sectoral composition of long- and short-duration transactions differs as well.

- Of long transactions – those with durations that exceed three years – 70 percent of the transactions are in NAICS 51 (Information) and NAICS 54 (Professional, Scientific, and Technical Services). NAICS 33 (Manufacturing) and NAICS 56 (Administrative and Support and Waste Management and Remediation Services) round out the top four recipient sectors for long transactions
- Of "short" transactions – those with durations below three years – 70 percent of transactions are in NAICS 33 (Manufacturing) and NAICS 42 (Wholesale Trade). NAICS 54 (Professional, Scientific, and Technical Services) and NAICS 23 (Construction) round out the top four recipient sectors for short transactions.

Figure A.7: Variance Decomposition: Within and Across Sectors



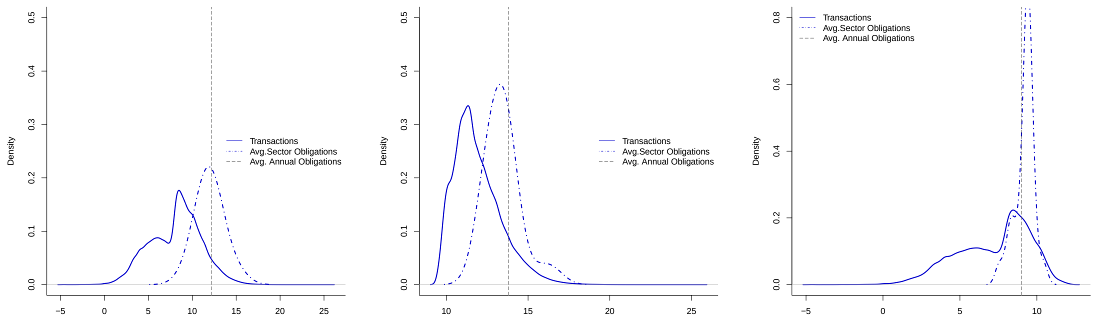
(a) Full Data Set (b) Top 20 Percent (c) Bottom 80 Percent

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 two-digit NAICS sector. We plot each of the two RHS components as a share of the LHS. Panel (a) shows this decomposition for the full data set, panel (b) restricts the sample to the top 20 percent of firms, and panel (c) shows only the bottom 80 percent of firms.

Figure A.8: Density of Variance Decomposition Components



(a) Full Data Set (b) Top 20 Percent (c) Bottom 80 Percent

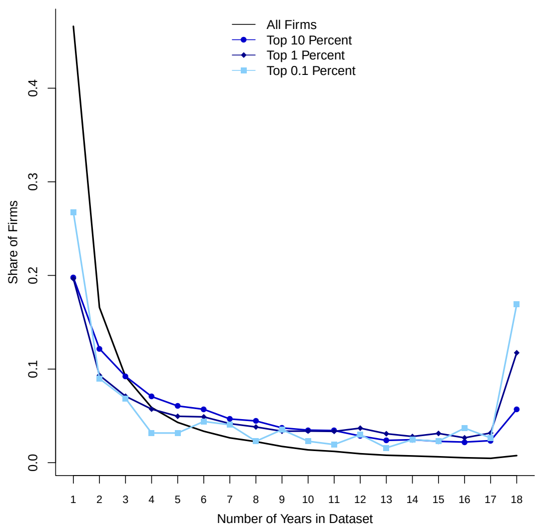
Note. This figure shows the density of each of the three components that underlie the variance decomposition above. The blue line shows the density of the firm obligations—$g_{fs,t}$; the red line shows the density of average sector obligations—$\bar{g}_{s,t}$; and the black line shows the density of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

Figure A.9: Example of Offsetting Transactions

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 A.10: Government-Supplier Relationships



Note. This figure shows the share of firms that show up in the data set (receive a new contract) for 1,2,...,18 years. The solid black line shows that high turnover occurs among all firms—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 more likely to be long-term in nature.

Table A.4: Percent of Government Consumption versus Percent of GDP

Sector Name	**NAICS**	**% Federal**	**% State**	**% GDP**
Manufacturing	33	30.14	4.74	12.72
Professional, Scientific, and Technical Services	54	27.98	15.27	4.04
Administrative and Waste Management	56	8.88	11.27	1.14
Construction	23	7.13	5.1	9.84
Manufacturing	32	4.01	17	4.57
Wholesale Trade	42	3.53	4.46	4.87
Transportation and Warehousing	48	2.59	3.88	2.15
Finance and Insurance	52	2.4	2.87	8.32
Information	51	2.27	9.24	5.31
Manufacturing	31	1.5	3.55	5.93
Health Care, Social Assistance	62	1.27	0.84	12.32
Educational Services	61	1.1	1.8	1.52
Other Services, ex. Government	81	0.7	4.43	3.87
Real Estate, Rental, Leasing	53	0.68	4.7	4.79
Retail Trade	44	0.66	0.06	10.06
Utilities	22	0.51	4.67	1.45
Accommodation and Food Services	72	0.28	3.14	4.7
Transportation and Warehousing	49	0.21	1.83	0.21
Agriculture, Forestry, Fishing, Hunting	11	0.11	0.34	0.5
Retail Trade	45	0.11	0.06	NA
Mining	21	0.09	0.14	0.47
Arts, Entertainment, Recreation	71	0.03	0.63	1.22

Note. This table shows the percent of government contracts obligated to each 2-digit NAICS sector compared to that sector's percent of GDP calculated from the BEA Input Output tables. It is clear that contracts are not distributed in accordance with sector value added. In other words, the allocation of government consumption across sectors varies from the allocation of private consumption across sectors.

Table A.5: Percent of DOD and Non-DOD Consumption versus Percent of GDP

Sector Name	**NAICS**	**% DOD**	**% Non-DOD**	**% GDP**
Manufacturing	33	39.74	10.35	12.72
Professional, Scientific, and Technical Services	54	23.56	37	4.04
Administrative and Waste Management	56	5.38	16.05	1.14
Construction	23	7.36	6.64	9.84
Manufacturing	32	3.8	4.43	4.57
Wholesale Trade	42	3.57	3.45	4.87
Transportation and Warehousing	48	3.08	1.56	2.15
Finance and Insurance	52	2.82	1.52	8.32
Information	51	1.92	3.01	5.31
Manufacturing	31	1.36	1.8	5.93
Health Care, Social Assistance	62	0.69	2.46	12.32
Educational Services	61	0.55	2.22	1.52
Other Services, ex. Government	81	0.74	0.6	3.87
Real Estate, Rental, Leasing	53	0.18	1.69	4.79
Retail Trade	44	0.47	1.05	10.06
Utilities	22	0.41	0.71	1.45
Accommodation and Food Services	72	0.33	0.19	4.7
Transportation and Warehousing	49	0.19	0.26	0.21
Agriculture, Forestry, Fishing, Hunting	11	0.02	0.3	0.5
Retail Trade	45	0.06	0.21	NA
Mining	21	0.1	0.05	0.47
Arts, Entertainment, Recreation	71	0.02	0.04	1.22

Note. This table shows the percent of DOD and Non-DOD contracts obligated to each 2-digit NAICS sector compared to that sector's percent of GDP, calculated from the BEA Input Output tables. It is clear that contracts are not distributed in accordance with sector value added. In other words, the allocation of government consumption across sectors varies from the allocation of private consumption across sectors.

Table A.6: 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

Note. This table shows the firms that receive the highest average annual government contract obligations compared to the top (non-oil) publicly traded firms by sales from Compustat. There is very little overlap between the two, showing that the firms that supply government consumption are different from the firms that supply private consumption.

Table A.7: Distribution of Contract Durations (Days)

	Contracts	Multi-Transaction Contracts
Mean	123	483
10th Percentile	3	37
Median	31	359
90th Percentile	364	1187

Note. This table shows the distribution of the duration of individual transactions, contracts (bundles of transactions that pertain to the same award), and multi-transaction contracts, which are the subset of contracts that are made up of more than one transaction. Contracts with negative durations or durations of greater than 5500 days (15 years) are excluded.

Table A.8: 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

Note. This table shows the shares by count and value of contracts by pricing type for all firms and for the top 10 firms. As a whole, most contracts are "Fixed Price", but the distribution differs slightly for the top 10 firms where a larger share are "Cost Fixed Fee."

Table A.9: Estimated AR(1) at the Sectoral Level

(Monthly) No Time Fixed Effects

Sector	ρ	σ^2	Θ
11	0.4168	0.441	0.458
21	0.1961	0.667	0.2877
22	0.383	0.203	0.3997
23	0.2306	0.434	0.2552
31	0.2068	0.152	0.216
32	0.252	0.678	0.1714
33	0.4604	0.167	0.1207
42	0.6646	0.2	0.3039
44	0.4738	0.283	0.2288
45	0.5794	0.512	0.1851
48	0.6652	0.237	0.3487
49	0.508	0.515	0.1697
51	0.4148	0.211	0.1345
52	0.3081	1.14	0.1935
53	0.0959	0.89	0.1927
54	0.4474	0.153	0.0697
55	0.0486	1.82	NA
56	0.4058	0.169	0.1389
61	0.2701	0.255	0.0552
62	0.5137	0.446	0.0741
71	0.3192	0.322	0.0498
72	0.446	0.274	0.2388
81	0.329	0.149	0.0464
92	0.3568	0.443	NA
Average	0.4236	0.2457	0.1367

(Monthly) Time Fixed Effects

Sector	ρ	σ^2	Θ
11	0.2751	0.324	0.458
21	0.1734	0.57	0.2877
22	0.4478	0.124	0.3997
23	0.0406	0.235	0.2552
31	-0.0261	0.0965	0.216
32	0.1877	0.509	0.1714
33	0.3004	0.12	0.1207
42	0.577	0.131	0.3039
44	0.4638	0.203	0.2288
45	0.5347	0.406	0.1851
48	0.6341	0.173	0.3487
49	0.4562	0.368	0.1697
51	0.2738	0.0847	0.1345
52	0.3163	0.961	0.1935
53	0.142	0.765	0.1927
54	0.2434	0.056	0.0697
55	0.0667	1.72	NA
56	0.3896	0.0934	0.1389
61	0.2563	0.192	0.0552
62	0.546	0.306	0.0741
71	0.3233	0.27	0.0498
72	0.4571	0.178	0.2388
81	0.2007	0.104	0.0464
92	0.4379	0.405	NA
Average	0.2864	0.1562	0.1367

Note. The tables above show the coefficients, ρ, the variance terms σ^2, and the price-stickiness terms for each two-digit NAICS sector. ρ and σ^2 are estimated using equation A.29 at a monthly frequency for government contract obligations, without time fixed effects in the left table and with time fixed effects in the right table.

Table A.10: Estimated AR(1) at the Sectoral Level

(Quarterly) No Time Fixed Effects

Sector	ρ	σ^2	Θ
11	-0.0204	0.387	0.458
21	-0.0307	0.595	0.2877
22	0.1966	0.112	0.3997
23	-0.0298	0.37	0.2552
31	0.4364	0.07	0.216
32	0.6218	0.175	0.1714
33	0.6509	0.0772	0.1207
42	0.7988	0.0966	0.3039
44	0.5985	0.162	0.2288
45	0.4496	0.615	0.1851
48	0.654	0.175	0.3487
49	0.6746	0.255	0.1697
51	0.5141	0.111	0.1345
52	0.4103	0.759	0.1935
53	0.7821	0.186	0.1927
54	0.3261	0.107	0.0697
55	-0.029	2	NA
56	0.3917	0.0822	0.1389
61	-0.08	0.206	0.0552
62	0.5196	0.292	0.0741
71	0.4375	0.191	0.0498
72	0.3039	0.183	0.2388
81	0.344	0.0675	0.0464
92	0.3523	0.277	NA
Average	0.4548	0.1416	0.1367

(Quarterly) Time Fixed Effects

Sector	ρ	σ^2	Θ
11	-0.111	0.261	0.458
21	-0.0574	0.518	0.2877
22	0.2529	0.067	0.3997
23	-0.1163	0.198	0.2552
31	0.3364	0.0282	0.216
32	0.5399	0.19	0.1714
33	0.5926	0.0545	0.1207
42	0.6701	0.0837	0.3039
44	0.585	0.107	0.2288
45	0.4445	0.471	0.1851
48	0.6714	0.151	0.3487
49	0.673	0.167	0.1697
51	0.3972	0.0523	0.1345
52	0.449	0.722	0.1935
53	0.6954	0.204	0.1927
54	0.2675	0.0472	0.0697
55	-0.0126	1.79	NA
56	0.3538	0.0624	0.1389
61	0.0947	0.183	0.0552
62	0.5425	0.233	0.0741
71	0.5407	0.162	0.0498
72	0.3813	0.128	0.2388
81	0.2154	0.0422	0.0464
92	0.4278	0.27	NA
Average	0.4007	0.0968	0.1367

Note. The tables above show the coefficients, ρ, the variance terms σ^2, and the price-stickiness terms for each two-digit NAICS sector. ρ and σ^2 are estimated using equation A.29 at a quarterly frequency for government contract obligations, without time fixed effects in the left table and with time fixed effects in the right table.

A.5 Additionals Facts: DOD versus non-DOD

In this section, we present our primary set of facts broken down into Department of Defense (DOD) and non-DOD contracts. We begin with some summary statistics on DOD spending complementing Table 1. First, Table A.11 shows that the top 8 recipients of contract obligations overall are the same as the top 8 recipients of DOD contracts. There are roughly 80 different awarding agencies throughout the sample period. The DOD awards the largest share of obligations. Table A.12 shows the top 15 awarding agencies and their share of obligations awarded. Some of the smaller awarding agencies not included in the table are the National Transportation Safety Board (NTSB), the International Trade Commission (USITC), the National Endowment for the Arts (NEA), the Library of Congress (LOC), and the American Battle Monuments Commission (ABMC).

Table A.11: Top 8 Recipients of All Contracts and DOD Contracts

ALL	DOD	DOD Share
LOCKHEED MARTIN CORPORATION	LOCKHEED MARTIN CORPORATION	0.83
THE BOEING COMPANY	THE BOEING COMPANY	0.93
GENERAL DYNAMICS CORPORATION	GENERAL DYNAMICS CORPORATION	0.91
RAYTHEON COMPANY	RAYTHEON COMPANY	0.94
NORTHROP GRUMMAN CORPORATION	NORTHROP GRUMMAN CORPORATION	0.91
BAE SYSTEMS PLC	BAE SYSTEMS PLC	0.97
UNITED TECHNOLOGIES CORPORATION	UNITED TECHNOLOGIES CORPORATION	0.95
L-3 COMMUNICATIONS HOLDINGS INC.	L-3 COMMUNICATIONS HOLDINGS INC.	0.92

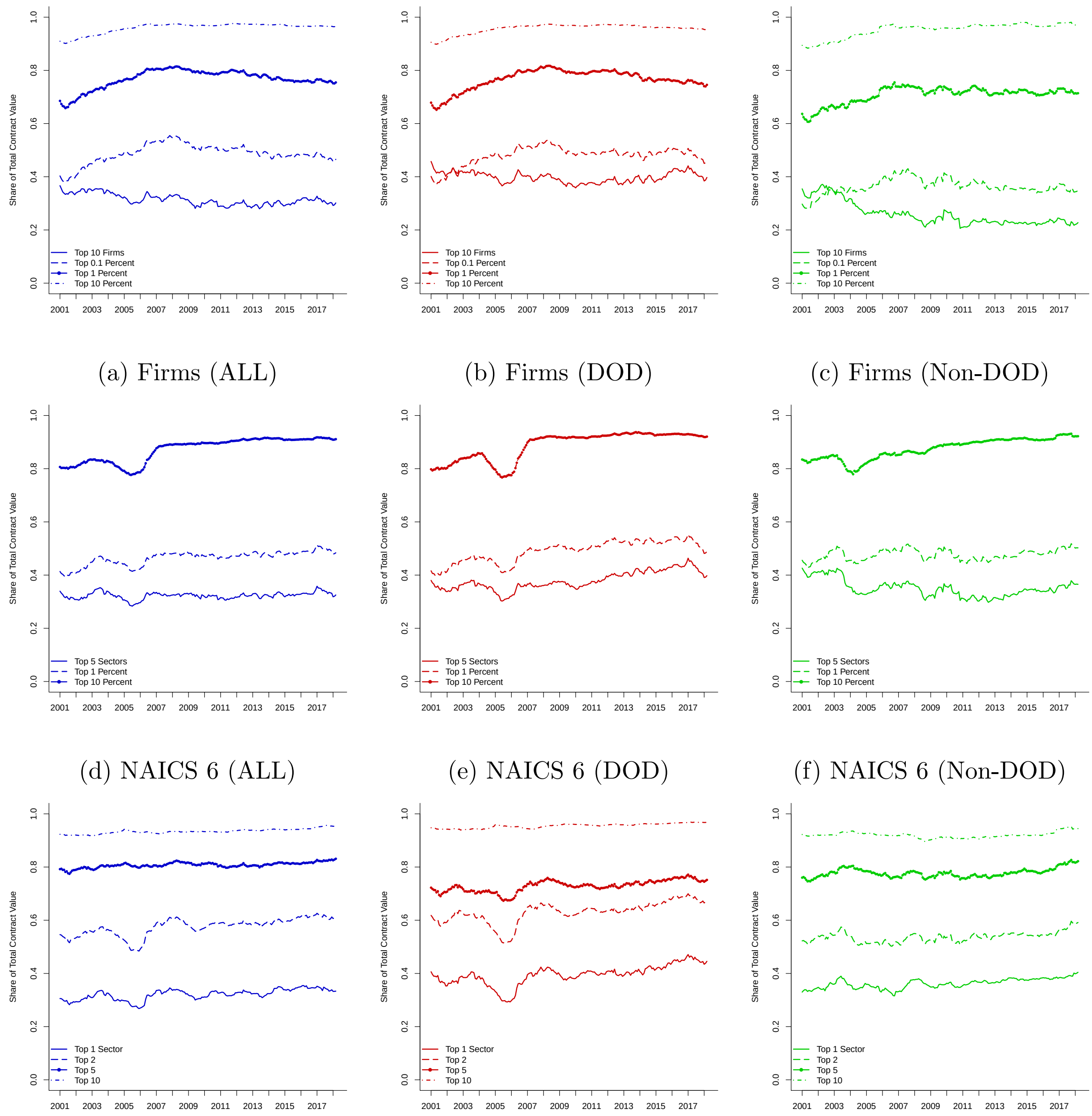
Note. This table shows that the top eight recipients of all government contracts are the same as the top eight recipients of the subset of contracts awarded by the Department of Defense.

Table A.12: Top 15 Awarding Agencies of Federal Contracts

Awarding Agency	Share of Obligations
DEPARTMENT OF DEFENSE (DOD)	0.667
DEPARTMENT OF ENERGY (DOE)	0.059
DEPARTMENT OF HEALTH AND HUMAN SERVICES (HHS)	0.037
DEPARTMENT OF VETERANS AFFAIRS (VA)	0.034
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)	0.031
GENERAL SERVICES ADMINISTRATION (GSA)	0.031
DEPARTMENT OF HOMELAND SECURITY (DHS)	0.026
DEPARTMENT OF STATE (DOS)	0.015
DEPARTMENT OF JUSTICE (DOJ)	0.014
DEPARTMENT OF THE TREASURY (TREAS)	0.014
DEPARTMENT OF AGRICULTURE (USDA)	0.012
DEPARTMENT OF TRANSPORTATION (DOT)	0.011
DEPARTMENT OF THE INTERIOR (DOI)	0.009
AGENCY FOR INTERNATIONAL DEVELOPMENT (USAID)	0.009
DEPARTMENT OF COMMERCE (DOC)	0.006

Note. This table shows the top 15 government agencies that award contracts. The Department of Defense clearly dominates, awarding two-thirds of contract obligations.

Figure A.11: Share of Obligations by Top Firms and Sectors



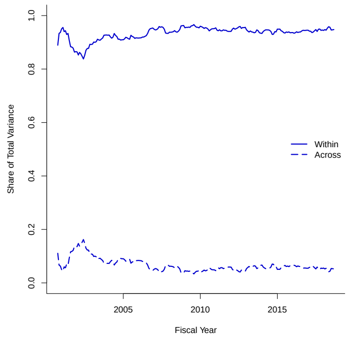
(a) Firms (ALL) (b) Firms (DOD) (c) Firms (Non-DOD)

(d) NAICS 6 (ALL) (e) NAICS 6 (DOD) (f) NAICS 6 (Non-DOD)

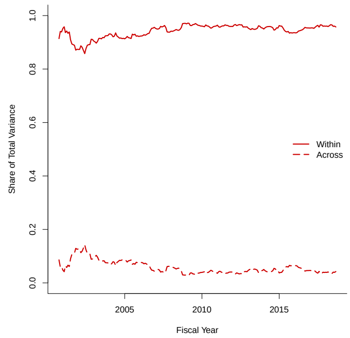
(g) NAICS 2 (ALL) (h) NAICS 2 (DOD) (i) NAICS 2 (Non-DOD)

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).

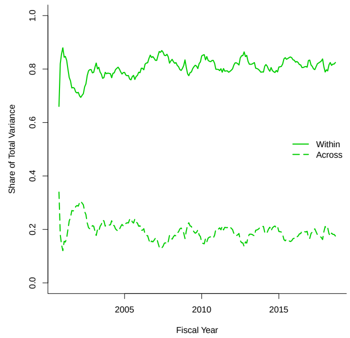
Figure A.12: Variance Decomposition: Within and Across Firms



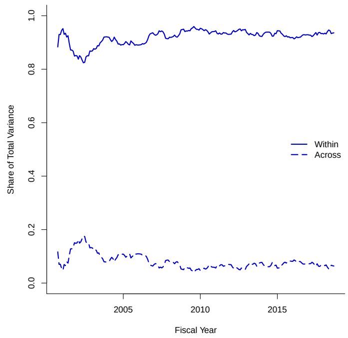
(a) Full Data Set (ALL)



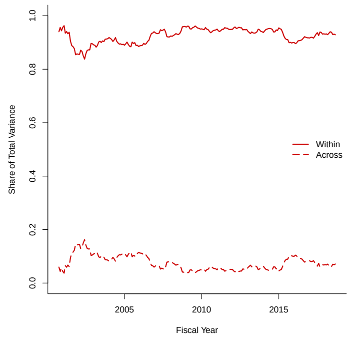
(b) Full Data Set (DOD)



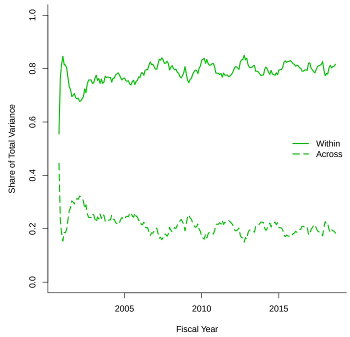
(c) Full Data Set (Non-DOD)



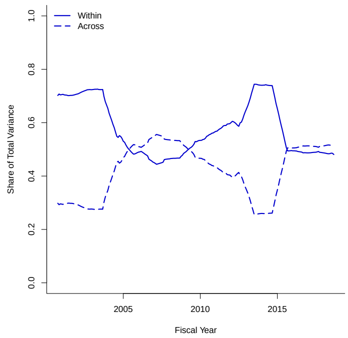
(d) Top 20% (ALL)



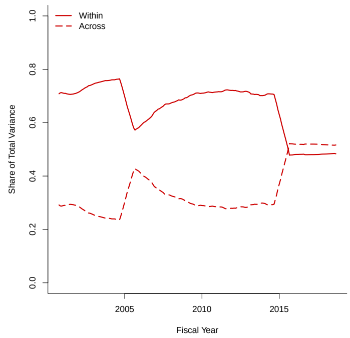
(e) Top 20% (DOD)



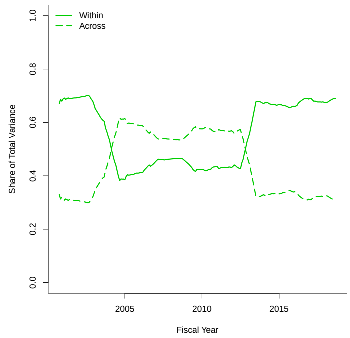
(f) Top 20% (Non-DOD)



(g) Bottom 80% (ALL)



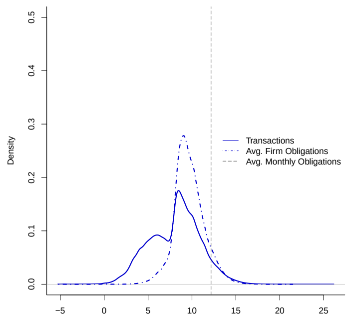
(h) Bottom 80% (DOD)



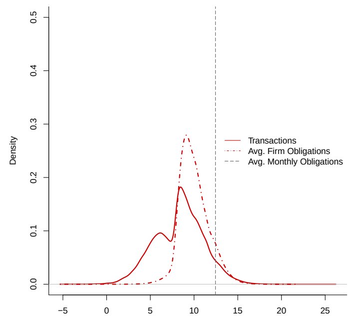
(i) Bottom 80% (Non-DOD)

Note. This figure shows a decomposition of the variance of government spending into "within-firm" and "across-firm" variation: $\sum_f \sum_{i\in f}(g_{if,t} - \bar{g}_t)^2 = \underbrace{\sum_f \sum_{i\in f}(g_{if,t} - \bar{g}_{f,t})^2}_{\text{(a) Within Firm}} + \underbrace{\sum_f \sum_{i\in f}(\bar{g}_{f,t} - \bar{g}_t)^2}_{\text{(b) Across Firm}}$, where i is an individual contract transaction and f is a firm. We plot each of the RHS components as a share of the LHS.

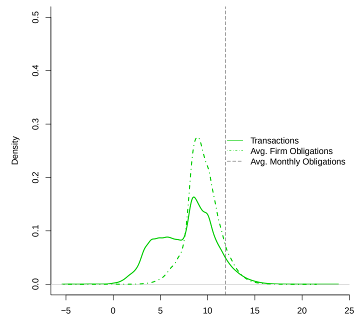
Figure A.13: Density of Variance Decomposition Components



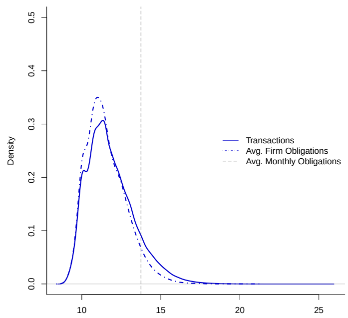
(a) Full Data Set (ALL)



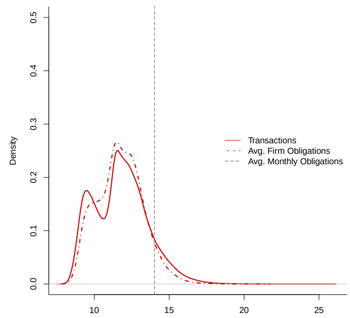
(b) Full Data Set (DOD)



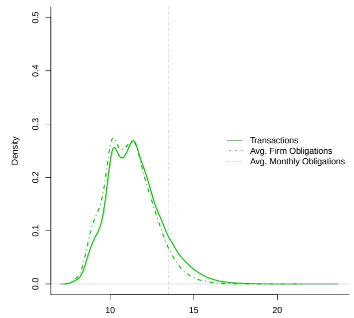
(c) Full Data Set (Non-DOD)



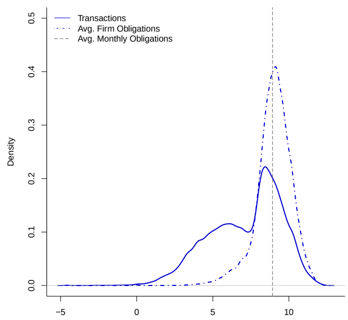
(d) Top 20% (ALL)



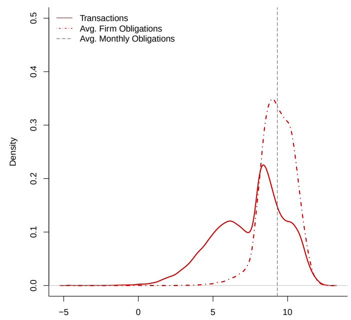
(e) Top 20% (DOD)



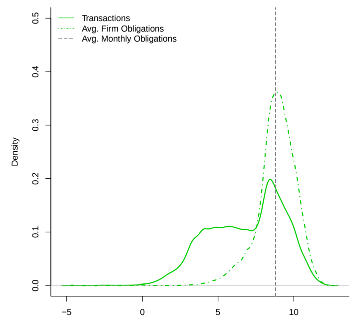
(f) Top 20% (Non-DOD)



(g) Bottom 80% (ALL)



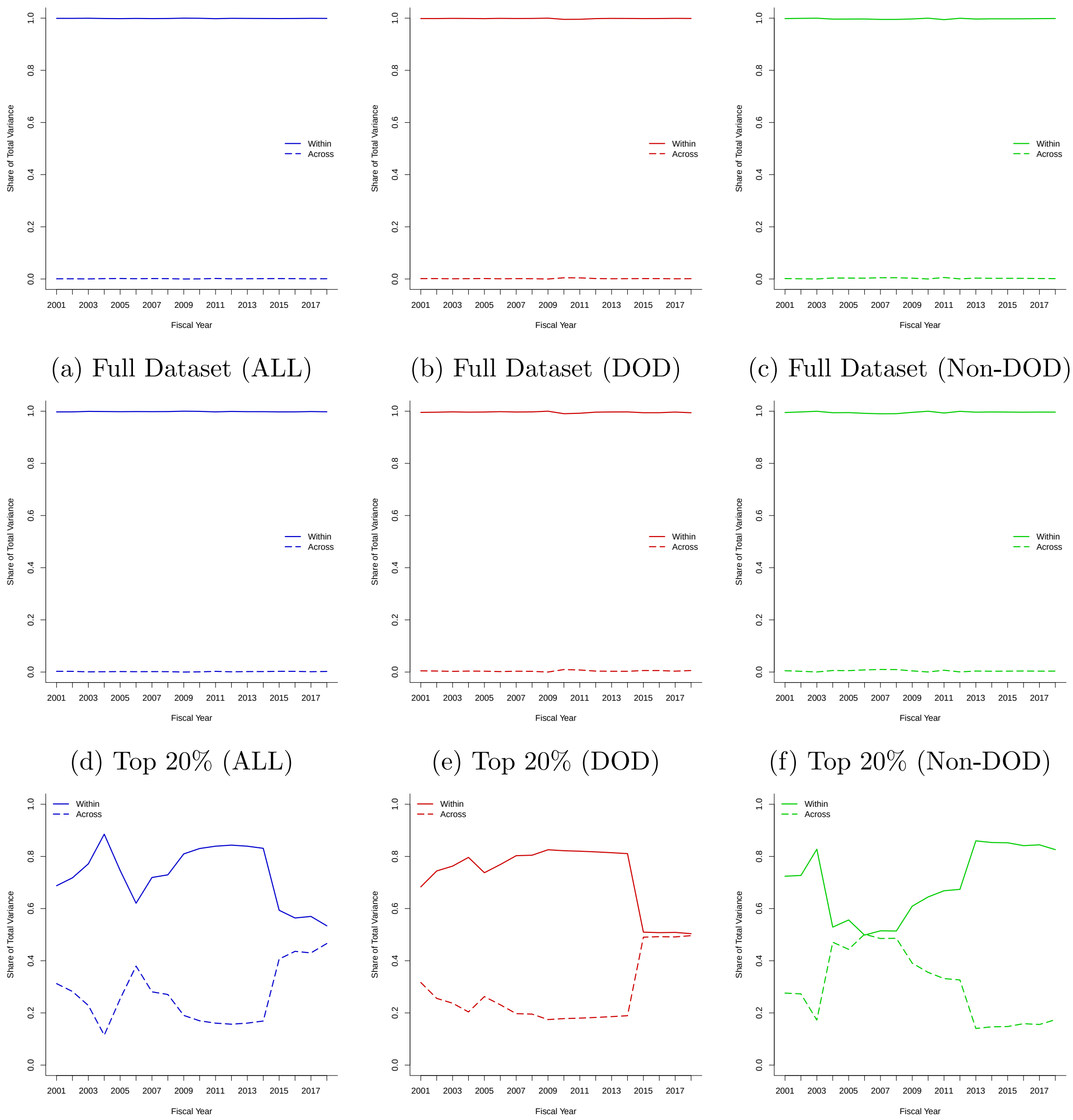
(h) Bottom 80% (DOD)



(i) Bottom 80% (Non-DOD)

Note. This figure shows the density of each of the three components that underlie the variance decomposition in Figure 4. The solid line shows the density of the individual contract transactions—$g_{if,t}$; the dot-dash line shows the density of average firm obligations—$\bar{g}_{f,t}$; and the dashed line shows the density of average annual obligations—$\bar{g}_t$.

Figure A.14: Variance Decomposition: Within and Across Sectors



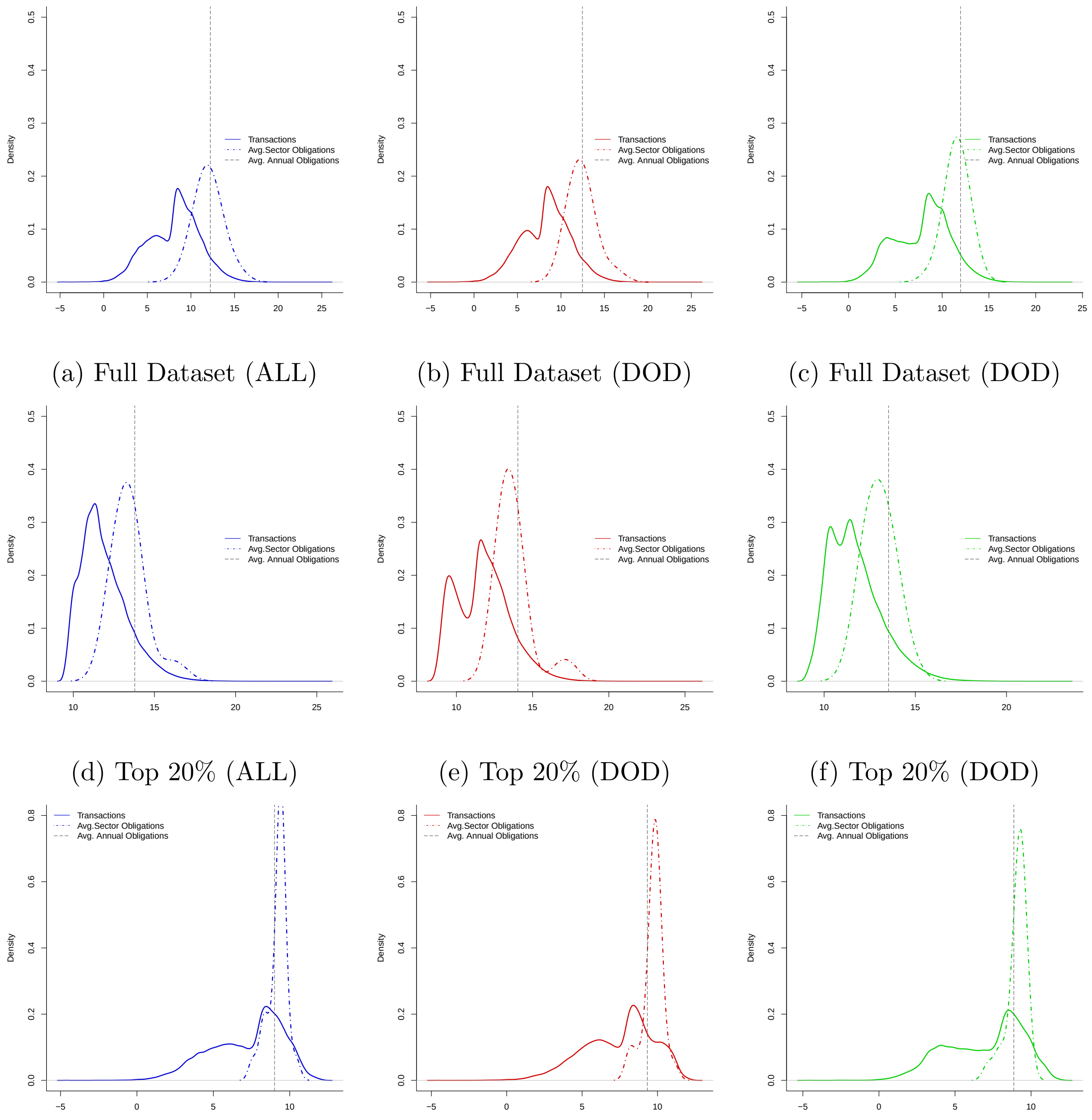
(a) Full Dataset (ALL) (b) Full Dataset (DOD) (c) Full Dataset (Non-DOD)

(d) Top 20% (ALL) (e) Top 20% (DOD) (f) Top 20% (Non-DOD)

(g) Bottom 80% (ALL) (h) Bottom 80% (DOD) (i) Bottom 80% (Non-DOD)

Note. This figure shows a decomposition of the variance of government spending into "within-firm" and "across-firm" variation: $\sum_f \sum_{i\in f}(g_{if,t}-\bar{g}_t)^2 = \underbrace{\sum_f \sum_{i\in f}(g_{if,t}-\bar{g}_{f,t})^2}_{\text{(a) Within Firm}} + \underbrace{\sum_f \sum_{i\in f}(\bar{g}_{f,t}-\bar{g}_t)^2}_{\text{(b) Across Firm}}$, where i is an individual contract transaction and f is a firm. We plot each of the RHS components as a share of the LHS.

Figure A.15: Density of Sectoral Variance Decomposition Components



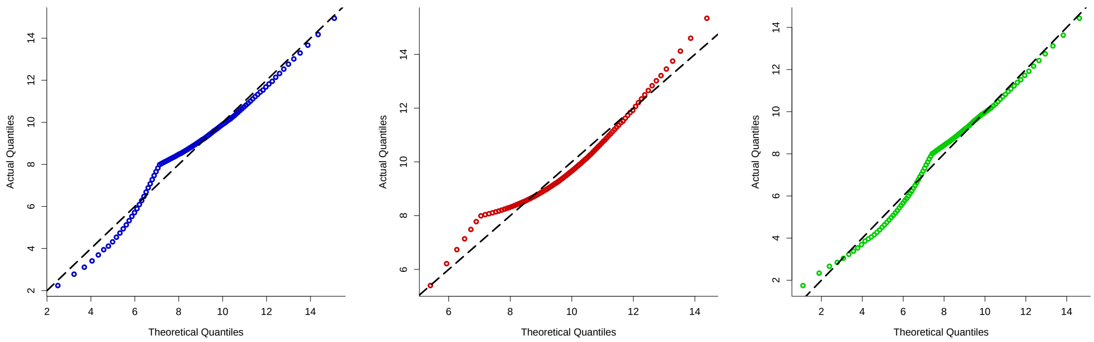
(a) Full Dataset (ALL) (b) Full Dataset (DOD) (c) Full Dataset (DOD)

(d) Top 20% (ALL) (e) Top 20% (DOD) (f) Top 20% (DOD)

(g) Bottom 80% (ALL) (h) Bottom 80% (DOD) (i) Bottom 80% (DOD)

Note. This figure shows the density of each of the three components that underly the variance decomposition in figure A.7. The solid line shows the density of the individual contract transactions—$g_{if,t}$, the dot-dash line shows the density of average firm obligations—$\bar{g}_{f,t}$, and the dashed line shows the density of average annual obligations—$\bar{g}_t$.

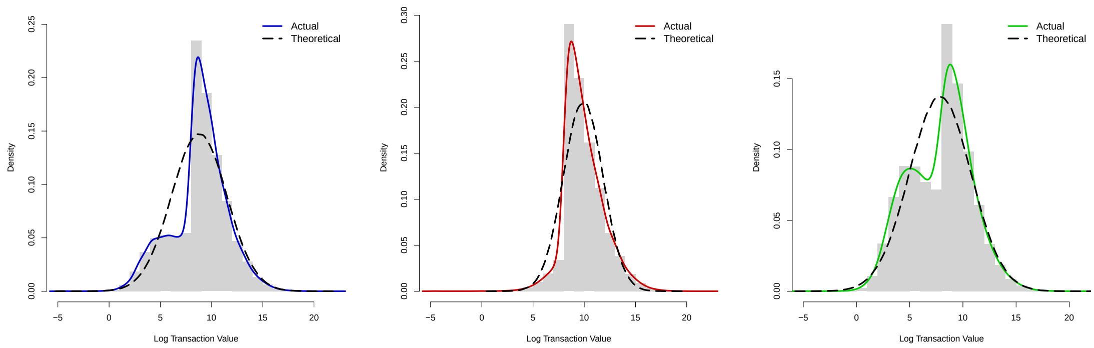
Figure A.16: Q-Q Plot: Actual vs. Log-Normal



(a) All Contracts (b) DOD Contracts (c) Non-DOD Contracts

Note. The figures above are Q-Q plots with actual quantiles of log transactions on the y-axis and theoretical quantiles from a log-normal distribution with the same mean and standard deviation plotted on the x-axis. That the points fall along the 45-degree line suggests that all three subsets of the data are well-approximated by a log-normal distribution.

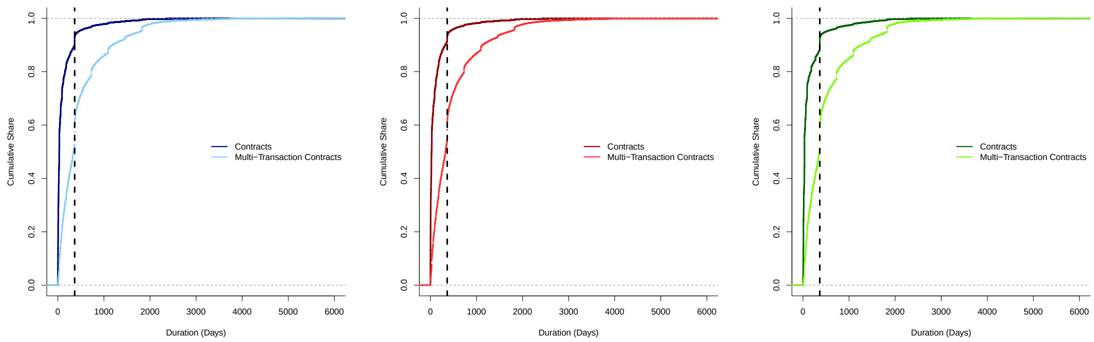
Figure A.17: Histogram of Log Transaction Value



(a) All Contracts (b) DOD Contracts (c) Non-DOD Contracts

Note. The figures above show histograms of log transaction obligations and the density of those log obligations for each subset of data. We also plot the density of a simulated log-normal distribution with the same mean and variance.

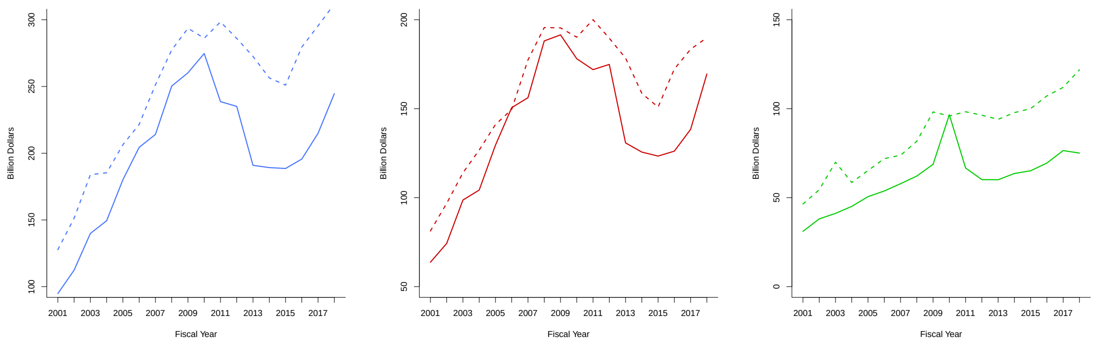
Figure A.18: Empirical CDF of Contract Durations



(a) All (b) DOD (c) Non-DOD

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. Transactions represent the observation level of the data. Contracts are bundles of transactions that pertain to the same award. Multi-Transaction Contracts are the subset of contracts that are made up of more than one transaction.

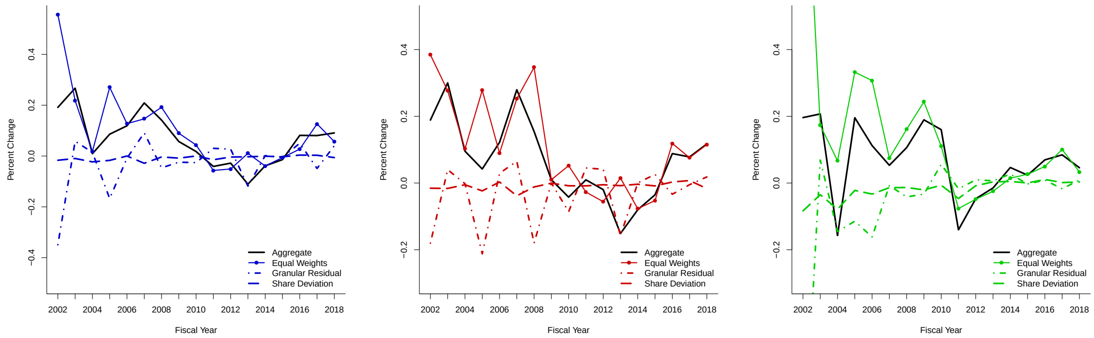
Figure A.19: Initial and Modification Spending



(a) All (b) DOD (c) Non-DOD

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 A.21: Decomposition of Sectoral Spending Growth

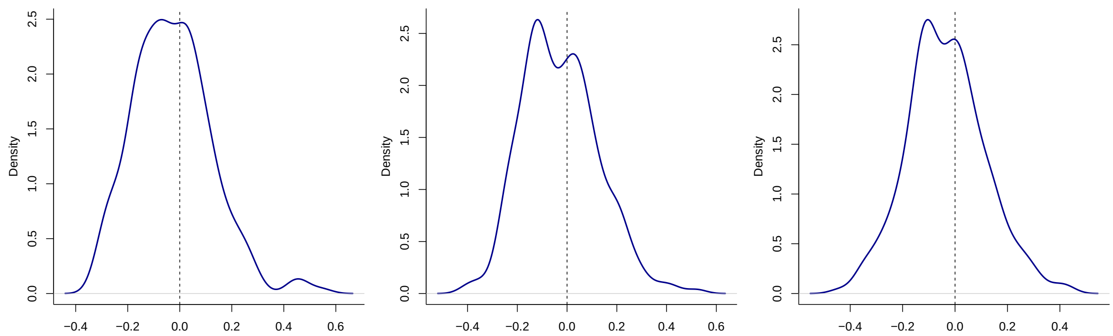


(a) All (b) DOD (c) Non-DOD

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

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

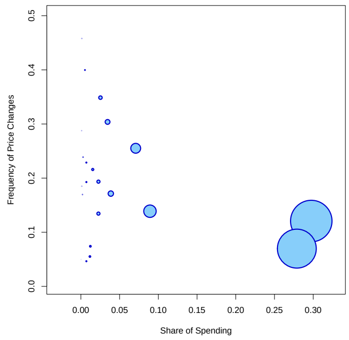
Figure A.20: Density of Error Term Correlation Coefficients



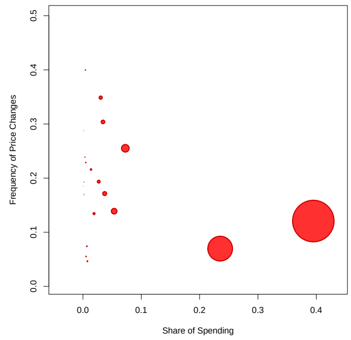
(a) All Contracts (b) DOD Contracts (c) NON-DOD Contracts

Note. This figure shows the distribution of correlation across sector pairs that result from examining the sectoral process: $g_{s,t+1} = \alpha_0 + \alpha_s + \alpha_t + \rho_s g_{s,t} + \varepsilon_{s,t+1}$, 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.

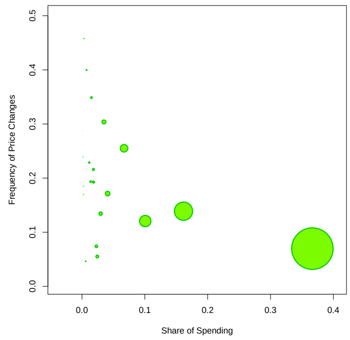
Figure A.22: Sectoral Spending and Price Rigidity



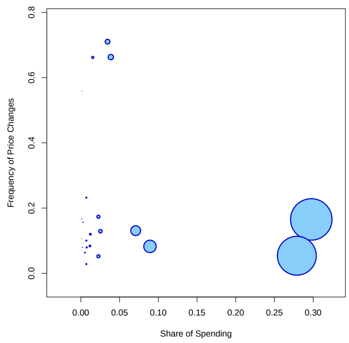
(a) All (BLS)



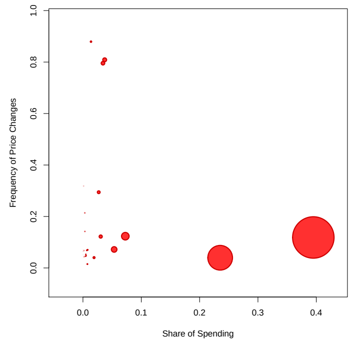
(b) DOD (BLS)



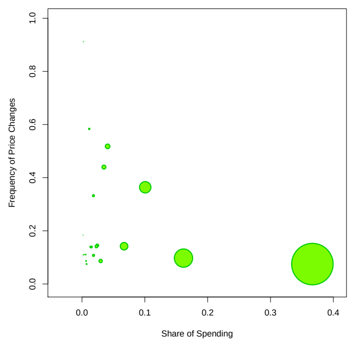
(c) Non-DOD (BLS)



(d) All (Duration)



(e) DOD (Duration)



(f) Non-DOD (Duration)

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, in the top row, and based on the inverse sectoral contract duration in the bottom row. The size of the bubble corresponds with the average sectoral share of annual aggregate spending.

Tables A.13 and A.14 show regressions of aggregate government spending on the granular residual and its lags for DOD and non-DOD contracts, respectively. Both regressions show that the granular residual explains roughly three-quarters of the variation in aggregate spending growth.

Table A.13: Explanatory Power of the Granular Residual

	(1) ΔG	(2) ΔG	(3) ΔG	(4) ΔG
$\Gamma_t^{Q=1000}$	1.453***		1.356***	
	(0.0523)		(0.0537)	
$\Gamma_t^{Q=100}$		1.423***		1.328***
		(0.0538)		(0.0536)
$\Gamma_{t-1}^{Q=1000}$			-0.252***	
			(0.0544)	
$\Gamma_{t-2}^{Q=1000}$			-0.172**	
			(0.0543)	
$\Gamma_{t-1}^{Q=100}$				-0.290***
				(0.0540)
$\Gamma_{t-2}^{Q=100}$				-0.166**
				(0.0541)
Constant	0.538***	0.611***	0.380***	0.412***
	(0.0219)	(0.0250)	(0.0389)	(0.0443)
Observations	214	214	213	213
R^2	0.785	0.768	0.808	0.798

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A.14: Explanatory Power of the Granular Residual

	(1) ΔG	(2) ΔG	(3) ΔG	(4) ΔG
$\Gamma_t^{Q=1000}$	1.392***		1.357***	
	(0.0539)		(0.0574)	
$\Gamma_t^{Q=100}$		1.350***		1.317***
		(0.0553)		(0.0583)
$\Gamma_{t-1}^{Q=1000}$			-0.0939	
			(0.0601)	
$\Gamma_{t-2}^{Q=1000}$			-0.118*	
			(0.0569)	
$\Gamma_{t-1}^{Q=100}$				-0.112
				(0.0610)
$\Gamma_{t-2}^{Q=100}$				-0.131*
				(0.0578)
Constant	0.255***	0.339***	0.232***	0.294***
	(0.0200)	(0.0220)	(0.0225)	(0.0282)
Observations	214	214	213	213
R^2	0.759	0.737	0.764	0.747

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$