Abstract

“Big G” typically refers to aggregate government spending on a homogeneous good, often understood as a single policy instrument that can be adjusted to fine-tune the business cycle. We confront this notion with five facts—established for the universe of U.S. federal purchases. First, federal purchases account for the largest part of the short-run variation in $G$, including variation due to identified fiscal shocks. Second, the origin of their variation is granular. Third, purchases are subject to procurement and bidding. Fourth, federal spending is concentrated in long-term contracts. Fifth, the composition of federal purchases is biased towards specific sectors, in which private-sector prices are sticky. We develop a stylized two-sector extension of the New Keynesian model consistent with these five facts and find the origin of shocks to government purchases is key for their aggregate effects, consistent with VAR evidence.

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

JEL Classification: E62, E32
1 Introduction

What is “Big G”? In the national accounts, $G$ represents government spending—the part of GDP that comprises government consumption of goods and services plus investment. This convention possibly helps explain why research on fiscal policy typically entertains a somewhat abstract notion of government spending as spending on a homogeneous good, isomorphic to GDP. In empirical and theoretical work, we frequently refer to it as $G$ and the literature assumes policymakers can adjust it freely and quickly over time. The recent “renaissance of fiscal research” surveyed by Ramey (2019) has changed little in this regard. A number of recent papers 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 et al., 2018; Hagedorn et al., 2019).

The starting point of our paper is the observation that government spending 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. We formalize this insight by establishing five facts about government spending based on the universe of procurement contracts by the federal government. These federal purchases account for the largest part of the short-run variation of general government spending, including the variation due to identified fiscal shocks. In addition, we establish the granular nature of federal purchases, the extent to which federal procurement is subject to solicitation and competition, and that contracts tend to be long in duration. These facts matter because they defy the notion that $G$ is simply another policy instrument that can be fine-tuned to manage the business cycle in a timely fashion.

Federal contract spending is also special along another dimension. Our last fact establishes sectoral bias in government spending: Its allocation across sectors differs systematically from that of private expenditure. On top of that, it is concentrated in sectors in which private-sector prices are particularly sticky. To understand the implications of these findings, we revisit the fiscal transmission mechanism in a stylized two-sector model that is consistent with all five facts (but omits modeling the microfoundations of the procurement process). The model analysis shows that how government spending impacts the economy fundamentally depends on in which sector it originates, again underscoring our main point: no single big G exists, only many “little gs”. And while this aspect makes fiscal stabilization challenging, it also creates opportunities
for targeted interventions.

Our analysis of federal purchases relies on a database that has only recently become accessible: USASpending.gov. The database provides detailed information on the universe of procurement contracts by the federal government since 2001. For each year, the database records several million government procurement transactions. And while it does not cover all components of government spending, it is unique in detail and scope: it covers 40 percent of federal government spending, and 16 percent of general government spending, that is, $G$, which, in turn, accounts on average for 18.7 percent of GDP. The largest expenditure categories missing from this data set are the government wage bill and government spending at the state and local level.

Our analysis is informed by a business cycle perspective: We focus on the time variation of government spending in the short run, in particular taking into account heterogeneity in the behavior of firms and sectors. Accordingly, the first of our five facts establishes that federal purchases account for about half of the variation of government spending at quarterly frequency—even though their average share of $G$ is only one sixth. Moreover, variation of federal purchases is largely exogenous to the business cycle: While federal purchases respond significantly to identified government spending shocks—in contrast to the other components of government spending—they only account for a small fraction of the large-scale fiscal stimulus packages during our sample period.

Our second fact pierces the origins of the variation of federal purchases. Contrary to what conventional models of the business cycle assume, variation emerges from only a few influential sectors and firms, making them granular in the sense of Gabaix (2011). Consistent with this granular origin, time-fixed effects add little explanatory power in panel regressions of federal purchases. Hence, the variation of government spending originates at the micro rather than at the macro level. As a result of such granular nature, federal purchases may have limited scalability, constraining fiscal stabilization policy as it is traditionally conceived.

The third fact that we establish is that the government makes very few “off-the-shelf” purchases. Instead, purchases are made through a two-stage procurement process: a solicitation period, in which the government solicits bids and proposals for work; followed by a selection process in which the government awards the contract to a bidder. Overall, this process takes time (between 0 days and 5 years), substantiating the notion of substantial implementation lags in government spending, and tends to be competitive—patterns we characterize in detail using
the micro data.

Fact four is about the duration of federal purchases. A large part of the value of federal purchases is tied up in long-term contracts, further limiting the scope for discretionary spending. In addition to long contract durations, the median tenure of firms that interact with government as contractors is also long. These observations provide a microfoundation for the persistence of government spending that characterizes aggregate time-series data and has been identified as a major determinant of the aggregate effects of fiscal spending shocks (Baxter and King, 1993).

While the first four facts concern the dynamics of federal purchases, the fifth fact highlights a cross-sectional property: Federal purchases are biased towards specific firms and sectors. We thus confirm and extend earlier findings by Ramey and Shapiro (1998) along several dimensions: at business cycle frequency, for both defense and non-defense contracts, across a more recent time period, and at the firm level. In addition, we make a new, related observation. Federal purchases tend to be concentrated in sectors in which prices for private transactions are relatively sticky: The average frequency of price changes in these sectors is about half of the frequency in the remaining sectors.

These descriptive facts are important for understanding fiscal transmission and the implementation of fiscal policy. Facts 1 through 4 illustrate key challenges when it comes to fiscal stabilization via big $G$. Fact 5, instead, presents policy makers with an opportunity. This insight emerges as we put forward a stylized two-sector New Keynesian model of the fiscal transmission mechanism that is fully consistent with our five facts. In particular, we allow government spending to vary exogenously across firms. Still, aggregate dynamics depend on its sectoral distribution because sectors differ due to a) sectoral bias and b) private-sector pricing frictions. Procurement prices, instead, turn out to be irrelevant for the allocation because their effect on households’ tax bills is exactly offset by their effect on firm profits which, in turn, are rebated to households.

We show that—unlike in a one-sector model—crowding out of private expenditure can be infinite and the government spending multiplier can be negative if fiscal shocks originate in the sector in which prices for private transactions are relatively flexible. Conversely, a fiscal shock in the sector in which prices are sticky may generate relatively large multiplier effects. Intuitively, if the government spends in relatively sticky sectors, monetary policy needs to tighten less in order to keep inflation stable. Hence, less crowding out occurs, rendering the multiplier larger. These findings are in line with earlier work, which has stressed the interaction of monetary and
fiscal policy (Woodford, 2011; Christiano et al., 2011; Farhi and Werning, 2016). In addition, we show how sectoral bias impacts crowding out in response to sectoral shocks.

Lastly, we confront the predictions of the model with the data along the time-series dimension. Specifically, we aggregate federal purchases in a set of sectors in which prices are relatively sticky and which comprise a large share of federal purchases relative to their weight in private spending. We include this time series in a VAR model together with a time-series of the remaining federal purchases. The model also features times series data of inflation, the (shadow) interest rate, and an index of GDP, and is estimated on monthly data from 2001 to 2019. We identify shocks to both spending aggregates recursively and compare their aggregate effects. In line with the model predictions, we find that federal purchases in the relatively flexible sectors do not lead to an increase in economic activity. Instead, inflation and interest rates increase. The opposite adjustment pattern obtains in response to shocks in the sticky sectors.

Related work that also uses data from USAspending to analyze public procurement exists (Warren, 2014; Decarolis et al., 2020; Kang and Miller, 2022). What sets our paper apart is the business cycle perspective and the scope of our analysis, which exploits the entire data set. In this regard, our paper also contributes to but differs from earlier studies of the fiscal transmission mechanism, which rely on the subset of the data that captures purchases by the Department of Defense (Fisher and Peters, 2010; Nakamura and Steinsson, 2014; Dupor and Guerrero, 2017; Demyanyk et al., 2019; Auerbach et al., 2020). Hebous and Zimmermann (2021) use the data to study the effect of federal purchases on firm investment.

In terms of theory, a number of recent papers explore the implications of micro-level primitives for the fiscal transmission mechanism (Bouakez et al., 2021, 2022; Flynn et al., 2022). This literature makes explicit the network structure of the economy from which we abstract so as to focus on the granular nature of federal purchases. We share, however, modeling features with recent work that accounts for heterogeneity on the production side across sectors and firms, tracing out the implications for business cycle fluctuations (for instance, Acemoglu et al., 2012; Pasten et al., 2018, 2020; Baqee and Farhi, 2020; La’O and Tahbaz-Salehi, 2020; Bigio and La’o, 2020; Ozdagli and Weber, 2017). The sectoral heterogeneity in our model dampens intertemporal substitution, as in models with household heterogeneity and credit frictions (Galí et al., 2007; McKay et al., 2016; Kaplan et al., 2018). Finally, related work exists on regional fiscal policies and their spillovers (Galí and Monacelli, 2008; Acconcia et al., 2014; Blanchard et al., 2017; Hettig and Müller, 2018; Chodorow-Reich, 2019).
2 Data

We first provide a brief description of USAspending.gov, our data source for federal procurement contracts. We describe its background, details and scope, while also noting its limitations. We also describe the pricing data we use for fact 5.

2.1 Data Sources

USAspending.gov covers the universe of federal procurement contracts. It was created in response to the Federal Funding Accountability and Transparency Act (FFATA), which was signed into law on September 26, 2006. The 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 accordance with FFATA, federal agencies are required to collect and report data on federal procurement. The USAspending.gov database, which the Treasury Department hosts, compiles the data from these various reporting systems and collects information from the recipients of the awards themselves. Though FFATA was not signed into law until 2006, data are available going back to 2001 through an external organization. Limited contract data are available before 2001 through the National Archives, but are not comprehensive enough for our purpose.\(^1\) To facilitate future research using the USAspending.gov data, we provide cleaned subsets of the data and sample code online at https://projects.rcc.uchicago.edu/weberm/gov_contracts/.

Complementary to the federal procurement data, we also utilize data on the frequency of producer price changes at the two- and six-digit NAICS sectoral levels, derived from the micro data that underlie the construction of the Producer Price Index (PPI) by the Bureau of Labor Statistics (BLS). We rely on sectoral frequency data directly taken from Pasten et al. (2020). The PPI data record transaction prices in the private sector, but not the government sector. We revert to this point when discussing the facts about pricing.

2.2 Details and Scope of the Data Set

Our primary data set includes all federal government contracts from fiscal years 2001 through 2021. The Federal Acquisition Regulation (FAR) defines these “contract actions” as “any oral

\(^1\)See https://www.archives.gov/research/electronic-records/reference-report/federal-contracts. These data comprise only contracts issued by the Department of Defense.
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 goods and services that the government consumes span a wide range, from janitorial services for federal buildings to IT support services to airplanes and rockets. Contracts can be short-term—e.g., a one-month contract 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 Stanford University for the operation and management of the SLAC National Accelerator Laboratory.

On average, 3.2 million individual contract records exist each year—with almost 5 million annual contracts toward the end of the sample period. Recipients comprise an average of over 160,000 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, by count) represent positive obligations from the government to firms, but de-obligations with a negative value also exist, occurring when certain types of modifications to an initial contract are performed. Each observation in the data traces a contract action from its origin (the parent agency) to the recipient firm and the sector and zip code within which the award is executed (see Figure A.1 in the Online Appendix for a schematic representation of the data). In addition to the value of the contract, the data contain information about the contract’s duration, modifications of existing contracts, the mode of competition, and the pricing structure. We rely on the contract micro data to compute statistics at different levels of aggregation, from the contract-level, for statistics on contract duration, to the firm- and sector levels.

In terms of scope, federal procurement contracts include both purchases of intermediate goods and services, as well as investment in structures, equipment, and software. The data do not include compensation of federal government employees (though they may include compensation for contractors) or consumption of fixed capital, which make up 26 and 21 percent of federal government spending, respectively. Since most federal government investment in Research and Development (R&D)—about 11 percent of federal government spending—comes through grants, it is also not included in the contracts data. Overall, our contract data account for 40 percent of federal government spending, and 16 percent of total government spending, commonly denoted by G in our macro models. Relative to GDP, the data therefore account for 3 percent of activity.
We illustrate schematically the scope and limitations of the coverage for our data in the Online Appendix, see Figure A.2. Going forward, we refer to the federal procurement contracts covered by our data as “federal purchases.”

3 Five Facts on Government Spending

In this section, we establish five facts about the nature of federal purchases. We first document that federal purchases account for the largest part of the variation in $G$ and that this variation reflects shocks rather than systematic stabilization policy. The next three facts go some way towards rationalizing the first fact, and are related to the granularity of federal purchases, the nature of public procurement, and the duration of the contracts that underlie these purchases.

Our last fact establishes that federal purchases are biased towards sectors in which prices charged to the private sector are relatively sticky. Common across these facts is the observation that the government does not purchase a homogeneous good—contrary to what the traditional notion of $G$ suggests. In Online Appendix C, we consider a further breakdown of the data into purchases by the department of defense (roughly one half) and the remaining purchases: The five facts hold for both subsets.

3.1 Exogenous Variation

Our first fact concerns the origin of the business-cycle fluctuations in government spending: Federal purchases explain a majority of the variation in total government spending—$G$—even though they do not represent the majority of $G$ in levels.

**Fact 1** Exogenous variation.

1. Federal purchases explain the majority of the variation in $G$.
2. Identified government spending shocks materialize almost exclusively as federal purchases.
3. Federal purchases are a negligible part of the discretionary fiscal stimulus under the American Recovery and Reinvestment Act of 2009 and the COVID relief packages.

That fact that federal purchases explain the majority of the variation in $G$ emerges from two decompositions in which we set in relation fluctuations in total government spending to fluctuations of its underlying components: federal purchases, wages, and the remaining residual items. In both exercises, we use a proxy for the USASpending contracts data that we construct from the National Income and Product Accounts (NIPAs). The proxy variable comprises federal
Table 1: Contribution to Variation of $G$

<table>
<thead>
<tr>
<th>Component</th>
<th>Shapley (Partial $R^2$)</th>
<th>Contribution to $\sigma^2_{\Delta G}$</th>
<th>Weight (% of $G$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal purchases</td>
<td>48%</td>
<td>39%</td>
<td>16%</td>
</tr>
<tr>
<td>Government Wages</td>
<td>23%</td>
<td>19%</td>
<td>49%</td>
</tr>
<tr>
<td>Residual</td>
<td>29%</td>
<td>25%</td>
<td>34%</td>
</tr>
</tbody>
</table>

Notes. This table shows decompositions of the quarterly growth rate of $G$. Column 1 shows the Shapley values, or partial $R^2$s, which indicate the percent of the overall $R^2$ accounted for by the given component. Column 2 shows the contribution of each component to the overall variance of $\Delta G$ (one-month log-changes). The “residual” category comprises non-wage, non-contract purchases.

$purchases of intermediate goods and services, and gross investment in structures, equipment, and software$. The proxy is highly correlated with our contract data—the correlation coefficient is 0.96—but has the advantage that it allows us to perform decompositions of $G$ consistently within the NIPAs (e.g., with the same treatment for seasonal adjustment). In the first exercise, we estimate a regression of one-quarter log changes in aggregate $G$ on the one-quarter log changes of $G$’s underlying components. The first column of Table 1 shows the Shapley value, or partial $R^2$, for each component of $G$. As a whole, federal purchases explain 48 percent of the variation in the growth rate of aggregate $G$, despite accounting for only 16 percent of $G$ in levels, as shown in the last column of Table 1. Wages account for about 25 percent of the variation, and the residual component accounts for around 29 percent—both less than their respective shares in levels of 49 and 34 percent, respectively.

In an additional exercise, we calculate the contribution of each sub-component to the variance of one-quarter growth rates of $G$. Reported in the second column of Table 1, this decomposition yields similar results, with federal purchases explaining a large share of variance relative to both its weight and to the other components. These results are consistent with the observation that the variance of federal purchases—17.4 percent at a quarterly frequency—is much higher than of the other components (wages: 0.64 percent, residual: 1.8 percent). Two explanations are likely at play: First, fluctuations in the federal government’s demand for goods and services naturally arise in a much “lumpier” fashion than demand for government workers. For example, the need for military spending may change drastically, whereas the need for government analysts is quite stable. Second, the labor market and the goods market differ in nature. Protective labor laws make it difficult for the federal government to adjust spending

\footnote{See Online Appendix A.2 for details on this proxy variable and its high correlation with the contract data.}

\footnote{When we just consider the non-wage portion of $G$, federal purchases explain over 80 percent of the variation.}
Figure 1: Response of $G$ Components to Established Fiscal Shocks

(a) Military news

(b) Blanchard-Perotti shock measure

Notes. This figure shows impulse responses of the components of $G$ to fiscal shocks as measured by Ramey and Zubairy (2018). Estimation relies on same local projection (and controls) as in Ramey and Zubairy (2018). Points marked with an * are statistically significantly different from zero at a 5% level.

through the labor margin, especially downwards.

Second, identified government spending shocks materialize almost exclusively as federal purchases, again measured by the NIPA proxy. In contrast, the other components of $G$ respond very little to government spending shocks. To make this point, we estimate impulse responses of the different components of $G$ to the defense-news measure and the Blanchard-Perotti measure of fiscal shocks, compiled by Ramey and Zubairy (2018). Following Ramey and Zubairy (2018), Figure 1 shows the response of each government spending component at time $t + h$ to the fiscal shock at time $t$, over a horizon of 20 quarters. We depict point estimates that are statistically significantly different from zero at the five percent level with a star. Federal purchases exhibit the strongest response to both shocks, while wages and the the residual components barely react.\textsuperscript{4} Hence, federal purchases not only account for the bulk of variation in $G$, they also account almost exclusively for the variation that is caused by established government spending shocks that are at the heart of the analysis of the fiscal transmission mechanism in much of the literature.

Third, and quite contrary to the above, federal purchases do not feature prominently in the two largest fiscal stimulus packages during our sample period—the American Recovery

\textsuperscript{4}As we show in the Online Appendix, both the military news shock series and the Blanchard-Perotti measure of fiscal shocks move mostly the defense rather than the non-defense component of federal purchases, see Figure A.13.
and Reinvestment Act (ARRA) of 2009 and the COVID relief packages. These pieces of legislation represented sizeable discretionary fiscal stimulus, that is, systematic policy responses to economic crises, totaling about $800 billion and $4.2 trillion, respectively. Yet, these stimulus packages were largely comprised of transfers—direct aid to individuals, loans to businesses, tax relief, etc, which are not part of G, that is, exhaustive spending on goods and services by the government. For ARRA, roughly half of funds were spent on tax relief/incentives and direct aid to individuals.\(^5\) For the COVID relief package, the share of relief funds spent in these classes was over two thirds. Instead, federal purchases represented only a very small fraction of these stimulus packages: only five percent in the case of ARRA (between 2009 and 2013) and just over 1 percent for the COVID relief packages.\(^6\)

In sum, our first fact establishes that federal purchases account for the largest part of the variation in G, highlighting the importance of studying this relatively small but relevant component in levels of G. At the same time, this variation appears largely exogenous to the business cycle, rather than a systematic response to the cycle. The following facts partially rationalize this fact.

### 3.2 Granularity

Our second result arises when we study in more detail the origins of variation in federal purchases: Not only are federal purchases disproportionately important for the variation in total spending (Fact 1), the variation in federal purchases themselves also emerges from only a few influential sectors and firms.

**Fact 2 Granularity.**

1. The variation of federal purchases at business cycle frequency is granular: it is due to a few influential sectors and firms.
2. Time fixed effects account for a small fraction of the aggregate variation in federal purchases.

To establish the granular nature of federal purchases, we run regressions of the aggregate growth in federal spending on the granular residual following Gabaix (2011). These regressions measure

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\(^5\)Oh and Reis (2012) document for a sample of OECD countries that the increase of government expenditures between 2007 and 2009 was mostly in transfers. The effect of transfers is studied by Oh and Reis (2012), Bayer et al. (2020), and Woodford (2022), among others.

\(^6\)Source: ARRA contracts are identified using The Federal Procurement Data System - Next Generation (FPDS-NG), which publishes a report listing government procurement contracts that were associated with the Recovery Act from 2009 through September 2019. Details on COVID-19 spending come from USASpending.gov.
how much variation in the growth of aggregate federal purchases comes from a few influential firms of sectors rather than a common aggregate movement. We start by calculating the granular residual, $\Gamma_t$ for federal purchases. We denote total purchases from sector or firm $i$ in month $t$ by $g_{i,t}$, and the 4-quarter growth rate of these purchases by $z_{i,t} = \ln(g_{i,t}) - \ln(g_{i,t-4})$. The granular residual is defined as follows:

$$\Gamma_t = \sum_{i=1}^{K} \frac{g_{i,t-4}}{G_{t-4}} (z_{i,t} - \bar{z}_t),$$

(3.1)

where $G_t$ are aggregate purchases in quarter $t$, and $\bar{z}_t = Q^{-1} \sum_{i=1}^{Q} z_{i,t}$ is the average growth rate of purchases from the top $Q$ sectors or firms. In other words, the granular residual is the weighted difference in growth rates for the top $K$ sectors or firms relative to the average growth rate for the top $Q$ sectors or firms, where $Q \geq K$. We calculate the granular residual over the top $K = 10$ six-digit NAICS sectors or firms (defined in terms of overall purchases over the full sample period), and take averages over the top $Q = 1000$ sectors or firms.

The granular residual provides a measure of the importance of idiosyncratic variation in the growth rate of purchases. To see this point, consider the case in which variation in government spending grows at a uniform rate in all sectors or firms. In this case, $z_{it} = z_{jt} = \bar{z}_t$ and the granular residual would be 0. Instead, absent perfect correlation, idiosyncratic deviations from any common increase in government spending will be reflected in a non-zero residual.

To quantify the statistical and economic significance of granularity in accounting for the variation of federal purchases, we follow Gabaix (2011) and run a regression of the aggregate growth rate, $Z_t = \ln(G_t) - \ln(G_{t-4})$, on the granular residual and its lags. Specifically, we estimate:

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

(3.2)

The granular residual has a highly statistically significant relationship with aggregate government spending growth and explains a large fraction of its variation. We show results in the top panel of Table 2. Columns (1) and (2) for sectors and columns (3) and (4) for firms show the granular residual explains 28 (19) to 54 (35) percent of the variation of the growth rate of federal purchases, measured in terms of $R^2$. These results echo the estimates of Gabaix

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7 Using the approach of Foerster et al. (2011), we obtain similar results, see Online Appendix Section B.1. For evidence on the variation of contracts within firms, see Online Appendix B.5. The distribution of contracts, firms, and sectors can be well approximated by a log-normal distribution, see Online Appendix B.6.

8 We use 4-quarter growth rates to deal with the highly seasonal nature of the data.
Table 2: Granularity in Variation of Federal Purchases

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sectors</td>
<td>Sectors</td>
<td>Firms</td>
<td>Firms</td>
</tr>
<tr>
<td>(a) Explanatory Power of Granular Residual for Aggregate Purchases</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Gamma_t$</td>
<td>1.005***</td>
<td>0.896***</td>
<td>0.959***</td>
<td>0.971***</td>
</tr>
<tr>
<td></td>
<td>(0.199)</td>
<td>(0.169)</td>
<td>(0.246)</td>
<td>(0.229)</td>
</tr>
<tr>
<td>$\Gamma_{t-1}$</td>
<td>-0.749***</td>
<td>-0.585*</td>
<td>-0.567***</td>
<td>-0.380</td>
</tr>
<tr>
<td></td>
<td>(0.173)</td>
<td>(0.237)</td>
<td>(0.13)</td>
<td>(0.228)</td>
</tr>
<tr>
<td>$\Gamma_{t-2}$</td>
<td>-0.466**</td>
<td>-0.572***</td>
<td>-0.367**</td>
<td>-0.572***</td>
</tr>
<tr>
<td></td>
<td>(0.166)</td>
<td>(0.013)</td>
<td>(0.013)</td>
<td>(0.013)</td>
</tr>
<tr>
<td>Observations</td>
<td>67</td>
<td>65</td>
<td>67</td>
<td>65</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.282</td>
<td>0.539</td>
<td>0.190</td>
<td>0.346</td>
</tr>
</tbody>
</table>

| (b) Importance of Aggregate Factors for Purchases at Sector/Firm level | | | | |
| Lagged Spending       | 0.538***| 0.490***| 0.567***| 0.572***|
|                      | (0.021) | (0.023) | (0.013) | (0.013) |
| Sector FEs           | Yes     | Yes     | No      | No      |
| Firm FEs             | No      | No      | Yes     | Yes     |
| Time FEs             | No      | Yes     | No      | Yes     |
| Observations         | 1583    | 1583    | 4427    | 4427    |
| $R^2$                | 0.957   | 0.961   | 0.564   | 0.585   |

Notes. In Panel (a), we run a regression at a quarterly frequency of the 4-quarter change in aggregate growth, $Z_t = \ln(G_t) - \ln(G_{t-4})$, on the granular residual and its lags. The granular residual is given by $\Gamma_t = \sum_{i=1}^{K} \frac{g_{i,t} - \bar{z}_t}{\bar{z}_{t-1}} (z_{i,t} - \bar{z}_t)$, where $K = 10$. $G_t$ is aggregate government purchases in period $t$ and $\bar{z}_t$ is the average growth rate over the top $Q = 1000$ NAICS 6 sectors or firms. In Panel (b), we show the results of estimating the following regression at a quarterly frequency: $g_{i,t} = \alpha_0 + \rho g_{i,t-4} + \alpha_i + \varepsilon_{i,t}$, where $g_{i,t}$ denotes sectoral or firm-level purchases. Columns (2) and (4) also include time fixed effects, $\alpha_t$, in addition to sector or firm fixed effects.

As a complementary perspective on the granular nature of federal purchases, we next show that granular rather than aggregate variation explains the government spending process, with the associated shocks often strongly positively or negatively correlated. To do so, we proceed under the assumption that the processes for purchases can be approximated by a first-order
autoregressive processes:

\[ g_{i,t+1} = \alpha_0 + \alpha_i + \alpha_t + \rho g_{i,t} + \epsilon_{i,t+1}, \]  

(3.3)

where \( g_{i,t} \) denotes the log of purchases from the two-digit sector or firm \( i \) at time \( t \). Parameters \( \alpha_i \) and \( \alpha_t \) are sectoral/ firm and time fixed effects, respectively. Our main interest lies in the statistical importance of common, aggregate factors captured by \( \alpha_t \).

Our findings, reported in the bottom panel of Table 2, are twofold: First, estimating the specification at a quarterly frequency and at the sector level, we find the inclusion of time fixed effects, \( \alpha_t \), only marginally raises the \( R^2 \) from 95.7 percent to 96.1 percent (columns (1) and (2)). If, instead of sectors, we estimate model (3.3) using purchases from the top 100 firms, we get a similar result: the inclusion of time fixed effects only raises the \( R^2 \) from 56.4 percent to 58.5 percent (columns (3) and (4)). Hence, aggregate variation does not explain much of the time variation of purchases at the firm and sector level; instead, firm- and sector-specific variation is far more important. Second, we find large positive and negative correlations characterize innovations for many sector or large-firm pairs. While centered around 0 by construction, a lot of the correlation resides between -0.5 and 0.5 (shown in Figure A.5 in the Online Appendix), consistent with substantial granular variation.

Hence, only few aggregate shocks to government spending at business cycle frequency exist—contrary to what conventional models assume. Yet, we cannot formally reject the notion that aggregate \( G_t \) is determined by a political process and then allocated top-down across various firms or industries. After all, the allocation could follow non-uniform random processes consistent with the importance of the granular residual. For example, any extra spending could randomly go to a single firm or sector. However, as we show in the context of Fact 4 below, a few sectors and firms, with long tenure in the data, maintain an approximately constant share of federal purchases over time. In light of this additional fact, Fact 2 is more consistent with a “constituent” model of government spending growth: Variation in spending arises bottom up, rather than top-down.

### 3.3 Procurement and Bidding

Our next fact concerns the process through which the government purchases goods. Conventional New Keynesian business-cycle models frequently make a simple assumption: The government
goes out and buys goods at “sticky” prices, with firms perfectly elastically supplying all quantities demanded. His assumption is at odds with the facts about the public procurement process, which we characterize in our third fact:

**Fact 3** *No off-the-shelf purchases.*

1. Federal purchases are preceded by a lengthy solicitation period.
2. The largest fraction of federal purchases take place through full and open competition.

Federal purchases are made through a two-stage process: a solicitation period, in which the government solicits proposals for work, followed by a selection period. Earlier work has highlighted various aspects of this process, focusing mostly on determinants of the quality of the procurement outcome, such as public sector capacity, management structures, or political connections (Bandiera et al., 2009; Chakravarty and MacLeod, 2009; Gagnepain et al., 2013; Coviello et al., 2018; Campos et al., 2021). Based on our comprehensive data set, we instead seek to document the nature of the public procurement process.

When the federal government wishes to purchase a good or service, it begins by issuing a solicitation. Federal Acquisition Regulations require that contract actions are publicized in order to increase competition, broaden participation, and to assist small- and minority-owned businesses in obtaining (sub-)contracts. Contracting officers must publicize solicitations on the website SAM.gov, where organizations can then submit bids or proposals and compete for receipt of the contract. The duration of the solicitation period varies from acquisition to acquisition. Contracting officers are required to allow a minimum of 30 to 45 days of response time, but exceptions exist depending on the circumstances (e.g., urgency). We do not have information about the length of the solicitation process in our main data set. However, looking at a sample of about 10,000 active solicitations posted on SAM.gov, provides a sense of the distribution of the length of the solicitation period: the average (median) number of days between the solicitation
Table 3: Competition and Bidding Summary Statistics (2001-2018)

<table>
<thead>
<tr>
<th>Extent Competed</th>
<th>Share of Contracts (Wtd)</th>
<th>Mean (Wtd.)</th>
<th>Median (Wtd.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fully Competed</td>
<td>0.66 (0.54)</td>
<td>8.4 (5.0)</td>
<td>3 (3)</td>
</tr>
<tr>
<td>Partially Competed</td>
<td>0.09 (0.09)</td>
<td>6.4 (6.8)</td>
<td>3 (3)</td>
</tr>
<tr>
<td>Not Competed</td>
<td>0.25 (0.36)</td>
<td>1.1 (1.3)</td>
<td>1 (1)</td>
</tr>
</tbody>
</table>

Notes. This table shows summary statistics of contracts characterized by their degree of competition and bidding. For this exercise, we exclude contracts where the number of offers received is coded as 999 (< 2 percent of the value of the contracts with no usable numerical record). Values in parentheses are weighted by contract value.

publication date and the response deadline is 55 days (19 days), and ranges from 0 days to over 5 years. Importantly, this solicitation process occurs for all types of government purchases, from “coffee cake mix” purchased for a Federal prison to “ballistic laser training systems” to be utilized by the U.S. Coast Guard.

The solicitation procedure is designed to increase competition in the selection process—the second stage of the procurement process. We can characterize this stage in detail using our data, because contracts are categorized into one of nine different “extent competed” categories. Table 3 shows that roughly two-thirds of contracts by count and just over half of contract dollar value are awarded competitively. We define “fully competed” contracts as those classified under full and open competition, competitive delivery orders, and competed under simplified acquisition procedures (SAP)—a designation given to contracts under a certain dollar threshold.

About ten percent of contracts by count and value are “partially competed,” a category that contains contracts that are classified as “full and open competition after exclusion of sources,” whereas two thirds of contracts by value are fully competed. At the same time, full and open competition does not necessarily imply a large number of bidders. The weighted and unweighted median number of bidders in contracts awarded through full and open competition is 3. The mean (weighted mean) number of bidders is higher at 8.4 (5.0), an observation which Kang and Miller (2022) rationalize in a principal-agent model in which the procurement agency can extract informational rents from sellers.

In some circumstances, procurement contracts can be designated “not available for competition,” meaning that the contracting agency does not require a full and openly competitive bidding process. This is permissible, for instance, when supplies are only available from one or
a limited number of responsible sources. As a whole, about 25 percent of contracts by count (36 percent by value) are non-competitive. This share doubles when it comes to contracts going to the top ten firms. Considerable heterogeneity across sectors in the share of competed contracts also exists. The share of dollars allocated through bidding ranges from 13 percent at the low end in NAICS 336411—Aircraft Manufacturing—to 76 percent at the high end in NAICS 517110—Wired Telecommunications Carriers.

These facts have two important implications: First, while not logically ruling out New-Keynesian short-run perfectly elastic supply at sticky prices, they suggest “sticky” prices in the New Keynesian sense do not dominate public procurement. Second, they also point to the challenge that policy makers face if they seek to adjust the level of government spending to cyclical fluctuations in a timely manner, providing a fresh perspective on the “implementation lag,” which features prominently in the traditional debate about fiscal policy.

### 3.4 Durations

The modern literature on fiscal policy emphasizes the persistence of shifts in government spending as a key determinant of their effects. Government spending that is purely transitory impacts the economy differently than permanent shifts in spending (Baxter and King, 1993). The persistence of the spending process, however, is not a parameter that policy makers can easily control: A large part of the value of government spending is tied up in long-term contracts, limiting the scope for discretionary adjustments. Our next fact concerns the duration of the contracts underlying federal purchases and the tenure of firms in the data as recipients of those contracts.

**Fact 4** Long durations of contracts and firm tenure.

1. The value-weighted median of the duration of contracts is 1,279 days; the 10th and 90th percentiles are 92 and 4,411 days, respectively.
2. For firms, the value-weighted median tenure in the data is 18 years; the 10th and 90th percentiles are 6 and 19 years.

The USASpending data is recorded at the transaction level: a contract comprises one or

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12 This skew toward non-competitive procurement for the top firms is not surprising given this top group comprises defense contractors like Lockheed Martin and General Dynamics—large firms that build specialized equipment for the military and are often the sole source for a given product.

13 Our data do not allow us to directly follow prices for the same goods in a consistent fashion as the Bureau of Labor Statistics (2011) does on the basis of PPI data. The main reason lies in the absence of quantity data so (changes in) nominal contract values cannot be attributed to (changes in) prices or quantities.
more transactions. We calculate the duration of a contract as the time between the start-date of the first associated transaction and the end-date of the final transaction.\textsuperscript{14} The majority of the contracts in our sample—87 percent—are made up of a single transaction, however these single-transaction contracts represent only 17 percent of total contracted dollars. The remaining 83 percent of contracted dollars are contained in multi-transaction contracts, which tend to be larger and longer in duration.

When we calculate statistics about the duration of contracts weighted by value, we find that contracted dollars are largely concentrated in contracts that are long in duration. The median of the value-weighted duration of contracts is 1,279 days (about 3.5 years), and the 10th and 90th percentiles are 92 and 4,411 days, respectively. Similarly, the government’s relationships with individual firms—or firms’ tenure in the data—are also relatively long-lived. To be considered “in the data” in a given year, we require that a firm must be associated with a new contract transaction in that year. We then refer to “firm tenure” as the number of years that a firm is “in the data.” The value-weighted median firm tenure in the data is 18 years, with 10th and 90th percentiles of 6 and 19 years. We also observe that the top firms and sectors consistently capture a large share of federal purchases over time, see Figures A.9 and A.10 in the Online Appendix. As discussed in Section 3.2 above, long firm tenure and stable spending shares suggest that changes in federal purchases are not perfectly randomly allocated, consistent with a bottom-up view of $G$.

Because the majority of contracts by count are smaller, single-transaction contracts, a different picture emerges if we compute the corresponding statistics without weighting by contract value. The unweighted median contract has a duration of only 25 days, and the vast majority of contracts have durations that are shorter than one year: the 10th percentile of the duration of contracts is 1 day and the 90th percentile is 333 days. Panel (a) of Figure 2 displays the weighted and unweighted distributions. Similarly, firm tenure in the data also appears much shorter when we consider the unweighted statistics: the unweighted median tenure of a firm in the data is 2 years, and the 10th and 90th percentiles are 1 and 9 years, respectively. Panel (b) of Figure 2 shows the weighted and unweighted distributions of firm tenure.

We want to stress the small subset of multi-transaction contracts almost exclusively drives the long median duration of weighted contract length. Even when weighted by value, single-transaction-contracts tend to have much shorter durations, with a median of only 115 days.

\textsuperscript{14}We consider only contracts with duration between 0 and 7,300 days (20 years)—a subsample that contains 99 percent of the contract value in our data.
Notes. The figures above show the unweighted and weighted empirical CDFs of contract duration (left) and firm duration (right). In the weighted figures, weights are given by the total value of the contract in the left panel and the total value of obligations the firm receives in the right panel. Vertical dashed lines in the left panel represent the one- and two-year marks.

Yet, while single transaction contracts represent 87 percent of contracts by count, they only represent 17 percent of value. Hence, the bulk of purchases that come in the form of large multi-transaction contracts, is characterized by long duration.

The importance of weighting by contract values for median durations highlights once more the granular nature of federal purchases. A few large contracts and firms are disproportionately large exactly because they have long durations over which they can accumulate more spending. On average, this relation between duration and size introduces a positive relationship between these variables that amplifies the dispersion in the distribution by giving more weight to the right tail. The correlation between contract size and duration is 0.5 when using total contract dollar values as weights. However, if we use total contract values normalized by the number of contract days as weights, the correlation between size and duration vanishes to -0.01. Figure A.11 in the Online Appendix illustrates this finding graphically. Overall, large persistent contracts occurring in specific sectors partially (but not fully) explain why some sectors are large suppliers to the government via contracts: Average contract size explains about 70 percent of the variation in sectoral shares. We provide further distributional details in Section B.8 of the Online Appendix.

The granular influence of these large contracts and firms—while dominating the average relationship—camouflages substantial underlying heterogeneity in the relationship between contract/firm size and duration/tenure. Not all large contracts are also long in duration: Only
40 percent of large contracts (above the 90th percentile in value) are also long in duration (above the 90th percentile in duration); 5 percent of large contracts are actually short in duration (below the 10th percentile); and the remainder have durations somewhere in between. Similarly, the majority of small contracts (below the 10th percentile) are neither short in duration (9 percent) nor long (< 1 percent), but actually have durations in an intermediate range. A similar pattern holds for firm tenure: only 44 percent of large firms (above the 90th percentile in lifetime contract obligations) are also characterized by long duration in the data (above the 90th percentile), and 3 percent are characterized by a short duration in the data (only 1 year). The opposite does not hold, however: small firms (less than or equal to the 10th percentile in lifetime contract obligations) are almost always characterized by a short lifespan in the data (87 percent are only in the data for 1 year).

The fact that the majority of federal purchases occurs through long-term contracts limits the scope for discretionary spending plans. However, one dimension along which the government may command some flexibility in making its purchases is through contract modifications. In the data, if a contract is modified after the initial award, subsequent transactions are recorded with a “modification number.” More than twenty types of modifications exist, some of which reflect no change to the value of the contract (e.g., a change of address) but some of which reflect additional obligations or de-obligations (e.g., an order for additional work or exercising an option that was established in the initial award). The three most common modifications by count cover “other administrative actions”, “funding only actions”, and “supplemental agreements for work within scope.” By value, the three most common modifications are “funding only actions”, “exercise an option,” and “supplemental agreements for work within scope.” In particular, exercising an option—a proxy for the notion of a “shovel-ready” spending plan—amounts for 10 percent of federal purchases. In general, spending associated with modifications is unsurprisingly substantial. Its share is in fact higher than the spending share from initial, non-modification contracts: 55 percent of contract dollars are obligated through contract modifications, illustrating that the ability to make adjustments is heavily utilized.

3.5 Sectoral bias

While the first four facts concern the dynamics governing federal contract spending, our final fact highlights a cross-sectional property: a systematic bias in the distribution of federal purchases

\footnote{We use no weights in this calculation.}
Notes. Panel (a) shows the distribution of federal purchase shares across 350 sectors (y-axis) plotted against the distribution of sectoral GDP in the economy (x-axis). Values represent averages over the 2001-2018 sample period. Sectoral GDP is calculated as total industry output net of output sold as intermediates to other sectors and net exports. Data sources: BEA Input Output Accounts: Make Table and Use Table. Panel (b) shows average federal purchase share over 2001-2018 versus private spending shares for 1,117 firms that we can match with Compustat. Private sales shares are calculated as firm sales (from Compustat) over total business sales in the United States (from the U.S. Census Bureau). We match firms in the contracts data to firms in Compustat using the concordance from Hebous and Zimmermann (2021).

across firms and sectors relative to private spending exists. Moreover, this bias is important with regard to a key aspect: Federal purchases tend to be concentrated in sectors in which private-sector prices are relatively sticky.

**Fact 5** Sectoral bias.

1. The distribution of federal purchases across firms and sectors differs systematically from the distribution of private spending.

2. On average, federal purchases are concentrated in sectors in which private-sector prices are relatively sticky.

The first observation confirms earlier work by Ramey and Shapiro (1998), who provide evidence for a sectoral bias in military buildups for selected historical episodes—World War II, the Korean War, the Vietnam War, and the Carter-Reagan buildup, the 1950s construction of the U.S. highway system, and the rise of federal medical spending. Our analysis confirms the relevance of their findings along several further dimensions: at business cycle frequency (rather than for specific long swings in the data), for the universe of federal contracts including non-defense contracts (which make up half of federal contracts by count), an extension to the
Table 4: Sectoral Bias for Top Firms and Sectors

<table>
<thead>
<tr>
<th>Firm/NAICS 6 Sector/NAICS 2 Sector</th>
<th>Government Share</th>
<th>Private Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lockheed Martin Corp</td>
<td>7.6 %</td>
<td>0.3 %</td>
</tr>
<tr>
<td>Northrop Grumman Corp</td>
<td>1.3 %</td>
<td>0.2 %</td>
</tr>
<tr>
<td>Leidos Holdings Inc</td>
<td>1.15 %</td>
<td>0.1 %</td>
</tr>
<tr>
<td>541300–Architectural, engineering, related services</td>
<td>16.2%</td>
<td>0.6 %</td>
</tr>
<tr>
<td>622000–Hospitals</td>
<td>9.1 %</td>
<td>4.2 %</td>
</tr>
<tr>
<td>518200–Data processing, hosting, related services</td>
<td>6.4 %</td>
<td>0.2 %</td>
</tr>
<tr>
<td>33–Manufacturing</td>
<td>30.1 %</td>
<td>12.7%</td>
</tr>
<tr>
<td>54–Professional, Scientific, Technical Services</td>
<td>27.9 %</td>
<td>4.0 %</td>
</tr>
<tr>
<td>56–Administrative and Waste Management</td>
<td>8.9 %</td>
<td>1.4 %</td>
</tr>
</tbody>
</table>

Notes. This table shows spending shares for top federal spending firms and sectors. NAICS 6 (2) Sector classification in middle (bottom) panel. Corresponding private share measured by total business sales for output sold as final goods for sectors (net of output sold as intermediates to other sectors and net exports). The distribution of federal purchases across sectors is quite distinct from that of private spending. The top two 2-digit NAICS sectors (33—Manufacturing, and 54—Professional, Scientific, and Technical Services) receive 60 percent of federal purchases, but account for only 17 percent of private spending. We illustrate this point graphically at the 6-digit NAICS sector and firm level in Figure 3. In panel (a), the vertical axis measures the share of a six-digit sector $k$ in federal purchases (shown in logs), $G_k^{GF}$, and the horizontal axis the (log) share of the same sector in GDP, $G_k^{GDP}$. GDP$_k$ is computed using the BEA “Make” and “Use” tables as total industry output net of output sold as intermediates to other sectors (including itself) and net exports. This measure represents the portion of sector $k$’s output that is sold as final goods—a proxy for the private spending share of sector $k$. If government spending and private spending had the same composition, then we would expect government spending shares and GDP shares to align perfectly along a 45-degree line. However, government and private spending shares differ substantially, that is, $G_k^{GF} \neq G_k^{GDP}$. Some sectors that are big suppliers to the federal government are almost negligible for GDP. Panel (b) of Figure 3 shows a similar pattern holds at the firm level, where we compare the shares of individual firms in government purchases to their shares in total U.S. business sales. Generally, these top government suppliers also have a higher number of employees, more R&D expenditures, assets, gross profits, and invested capital relative to the median firms in Compustat, as Table A.7 in the Online Appendix summarizes. As an illustrative example, Table 4 reports the spending shares of government and private spending for the top last 25 years, and at the firm level.
firms and sectors. It also shows that the top firms and sectors represent a much larger portion of government purchases than purchases in the private sector.\footnote{In line with these findings, federal purchases are also much more concentrated in a few firms compared with concentration in private purchases, with less of a difference at the industry level. For example, the top 10 sellers to the government capture 29.3% of federal purchases, whereas the top sellers to the private sector only capture 10.4% of private purchases. Table A.8 in the Online Appendix presents some summary statistics.}

Our second cross-sectional observation is that federal purchases happen to be concentrated, on average, in sectors with relatively sticky prices for private purchases. The average frequency of price changes in the sectors in which the government purchases are concentrated is half the frequency of the remaining sectors. Our analysis builds on data for the frequency of monthly price changes computed by Pasten et al. (2020). This frequency data is based on prices for sales to the private sector. While it might also be of general interest to analyze price setting of firms when they sell to the government, our data do not allow for such an analysis, because we only observe nominal contract values, so cannot discern price or quantity movements.\footnote{We provide additional details and examples in Online Appendix B.4.}

Still, when we relate the incidence of federal purchases to the prices charged for private purchases in the same sectors, a robust finding emerges: government spending is heavily concentrated in sectors with relatively sticky prices for private purchases.

Figure 4 illustrate this fact at the two-digit and six-digit levels, in panels (a) and (b), respectively. The size of the circles in each figure corresponds to the average sector share of

Notes. This figure shows the average annual share of federal purchases in each two- and six-digit sector, plotted against the frequency of price changes for private purchases in these sectors, based on BLS and USASpending.gov data. The size of the circles emphasizes the average sectoral share of annual aggregate spending (also shown on the x-axis).
annual federal purchases (the circles merely highlight visually the numerical information on the x-axis.) The government spends the vast majority of dollars in sectors with low frequencies of price adjustment by the private sector: Figure 4 panel (a) shows the frequency of price changes for private sector purchases is 11 percent in the largest three two-digit NAICS sectors in which the government purchases (the same sectors shown in the bottom of Table 4). The average frequency of price changes is double that—22 percent—for all remaining sectors. Figure 4 panel (b) illustrates a similar pattern at a more dis-aggregated level. Of course, as the Figure suggests, the bias in federal purchases is only on average concentrated in sectors in which the private sectors face relatively sticky prices. Some sectors, for example service sectors such as “Arts, Entertainment, and Recreation” fetch a low share of federal purchases relative to private spending (0.03 vs 1.2 percent), but also feature a very low frequency of price changes (5 percent).

In sum, federal purchases are biased towards specific sectors and these sectors stand out in terms of the stickiness of private sector prices. In order to evaluate the implications of this fact for the fiscal transmission mechanism we resort to a stylized model of the business cycle.

4 Implications for fiscal policy transmission

We use a version of the New Keynesian model to investigate how the granular and heterogeneous nature of government spending shapes the fiscal transmission mechanism. The model is largely standard and, hence, we relegate a formal exposition to Online Appendix D. Still, we extend the baseline New Keynesian model in accordance with the five facts established above. To account for Fact 1, we follow much of the earlier work and study the effect of an exogenous variation in government spending. Two aspects of the model are new. First, consistent with Facts 2, 3, and 4, we model government spending bottom up, allowing for variation in government spending to arise at the level of firms and sectors—in contrast to much of the earlier work, which studies aggregate government spending (e.g., Woodford, 2011). We do not, however, micro-found public procurement, but rather study how its features play out in the aggregate.

Second, in accordance with Fact 5, the model distinguishes between two sectors that differ in terms of their (a) importance for private and public spending (sectoral bias) and (b) pricing frictions. We assume that labor is perfectly immobile across sectors. Private spending is modeled as consumption, and we do not model investment. Parameters $\omega \in (0, 1)$ and $\gamma \in (0, 1)$ capture the steady-state share of private and government spending in sector 1, and the remaining share
goes to sector 2. Letting $\zeta \in (0,1)$ denote the share of private spending in GDP, the size of sector 1 and 2 is given by $n = \zeta \omega + (1 - \zeta)\gamma$ and $1 - n$, respectively. The “Calvo” parameters $\alpha_1$ and $\alpha_2$ capture the degree of rigidity of private-sector prices in the two sectors. Importantly, the prices of government purchases are not determined in the model since they are irrelevant for the allocation under Ricardian equivalence. Once we consider alternative model specifications, the gap between procurement and private-sector prices has real effects through the government budget (see Online Appendix F).

We solve the model based on a first-order approximation of the equilibrium conditions around a zero-inflation steady state. We first assume that monetary policy pursues a strict inflation target to derive a number of closed-form results in Section 4.1. Afterwards, we run numerical simulations based on a Taylor rule. To study the role of monetary policy in more detail, we consider a simplified version of the model in Online Appendix E; moreover, we explore model extensions featuring rule-of-thumb households and behavioral agents as in Gali et al. (2007) and Gabaix (2020), respectively, in Online Appendix F. Qualitatively, all results we establish below hold in these model extensions.

4.1 The aggregate effect of sectoral shocks

We now establish how shocks to government spending impact aggregate output. We focus on sectoral shocks, which, in turn, may represent granular shocks at the firm level. Still, what matters in our setup is the average variation of government spending within a sector over time, given by $g_{1,t}$ and $g_{2,t}$. We use distinct AR(1)-processes to simulate this variation for each sector, but with the same persistence parameter $\rho$. Moreover, to obtain closed-form results, we assume for now flexible prices in sector 1, $\alpha_1 = 0$, while allowing for nominal price rigidity in sector 2, $\alpha_2 \in (0,1]$. In our two-sector model, aggregate private demand and output respond sluggishly to even purely transitory shocks. The adjustment dynamics are governed by the evolution of prices in sector 1, $p_{1,t}$, relative to those in sector 2, $p_{2,t}$, which we refer to as the terms of trade, $\tau_t \equiv p_{1,t} - p_{2,t}$ and for which we solve first.

Proposition 1 (Solution for terms of trade) Assuming that prices in sector 1 are fully flexible ($\alpha_1 = 0$) and monetary policy targets consumer price inflation ($\pi_t = 0$), the solution for the terms of trade is given by:

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

(4.1)
where \( \Lambda_0 \in (0, 1) \) and \( \Lambda_1, \Lambda_2 \geq 0 \).

We provide proofs for all propositions and expressions in terms of the underlying model parameters in Online Appendix D.4. Proposition 1 simply states that, all else equal, government spending in sector 1 increases the terms of trade and conversely for spending in sector 2. The next proposition establishes our main result.

**Proposition 2 (Crowding out of consumption)** *Assuming that prices in sector 1 are fully flexible and monetary policy targets consumer price inflation, we obtain the solution for consumption:

\[
c_t = \Theta_0 \tau_{t-1} - \Theta_1 (1 - \zeta) \gamma g_{1,t} - \Theta_2 (1 - \zeta)(1 - \gamma) g_{2,t},
\]

where \( \Theta_0 \in (0, 1) \) and \( \Theta_1 \in [0, \infty) \) and \( \Theta_2 \in [0, \zeta^{-1}] \), with \( \partial \Theta_1 / \partial \alpha_2 > 0 \) and \( \partial \Theta_2 / \partial \alpha_2 < 0 \), and the ratio \( \Theta_1 / \Theta_2 \) increasing in \( \omega - \gamma \).

Higher terms of trade imply higher consumption \( (\Theta_0 > 0) \) because they put downward pressure on marginal costs in sector 1. For markups to remain constant in this flex-price sector, consumption needs to go up in order to put upward pressure on the real wage. Our main result, however, is that the consumption response to a government spending shock differs depending on the sector of origin of the fiscal impulse. It is captured by coefficients \( \Theta_1 \) and \( \Theta_2 \), while the terms \( (1 - \zeta) \gamma \) and \( (1 - \zeta)(1 - \gamma) \) in expression (4.2) normalize the size of the shock to one unit of steady-state output. \( \Theta_1 \) and \( \Theta_2 \) are both non-negative: Sectoral government spending crowds out consumption.\(^{18}\) The strength of the crowding out depends on (a) sectors’ relative pricing frictions and (b) the composition of private and government demand in steady state. We discuss these features in turn.

Consider the differential pricing friction first. An increase in government spending in either of the two sectors raises production and employment as well as marginal costs in the sector. As a result, upward pressure on prices occurs, which induces monetary policy to raise interest rates and incentivizes households to reduce their consumption. Hence, a sectoral shock spills over to the other sector and its macro impact is potentially large because monetary policy can only steer aggregate—rather than sectoral—demand. In fact, the extent of crowding out is potentially unlimited if the shock originates in the flex-price sector 1, \( \Theta_1 \in [0, \infty) \), see also Online

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\(^{18}\)In model extensions, we find that the extent of crowding out is reduced or even crowding-in exists, but the sources of heterogeneity in the response to sectoral shocks that operate in our baseline model continue to matter, see Online Appendix F.
Appendix E. Further, as price stickiness in sector 2 increases, monetary policy needs to respond more aggressively in order to offset the inflationary pressure resulting from a sector-1 shock. As a result, more crowding out occurs, as price stickiness (in sector 2) increases: $\partial \Theta_1 / \partial \alpha_2 > 0$. However, $\partial \Theta_2 / \partial \alpha_2 < 0$: if sector-2 prices are stickier and hence less responsive to sector-2 shocks, monetary policy reacts less to engineer a contraction of consumption to stabilize inflation.\(^{19}\)

Second, we consider the role of the sectoral composition of private and government demand in steady state, captured by $\omega$ and $\gamma$. To develop intuition, we assume all prices are flexible ($\alpha_2 = 0$) so that monetary policy plays no role for the consumption response. Instead, the consumption response now depends exclusively on the response of hours worked (the only factor in production). Consider, for the sake of the argument, a positive government spending shock in sector 1. The shock pushes labor demand up in that sector; crucially, $\omega$ and $\gamma$ determine by how much. All else equal, the higher is $\gamma$, the larger is sector 1 because the share of government spending in sector 1 is larger as $n = \omega \zeta + \gamma (1 - \zeta)$. A government shock of a given magnitude is then smaller relative to the size of the sector and, hence, the sector’s labor market: Therefore, less pressure on wages arises, the larger is $\gamma$, and, hours respond less to the shock, resulting in more crowding out. Raising $\omega$ has the same effect. But at the same time, it implies that consumption is more exposed to a sector 1 shock. As a result, we find relatively more crowding out in response to a sector 1 shock occurs, as sectoral bias increases: $\Theta_1 / \Theta_2$ increases in $\omega - \gamma$. If prices are sticky in sector 2 ($\alpha_2 > 0$), a higher $\omega$ has the additional effect that the resulting surge in prices in sector 1 increases aggregate prices by more, so monetary policy responds more strongly, resulting in further crowding out.

Finally, we can now establish the effect of government spending on output, that is, the multiplier. We do so in the next proposition.

**Proposition 3 (Output multipliers)** Assuming that prices in sector 1 are fully flexible and monetary policy targets consumer price inflation, the solution for output is given by

\[
y_t = \Gamma_0 \sigma_{t-1} + \Gamma_1 (1 - \zeta) \gamma g_{1,t} + \Gamma_2 (1 - \zeta)(1 - \gamma) g_{2,t}
\]

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

\[
\Gamma_1 = 1 - \zeta \Theta_1 \quad \text{and} \quad \Gamma_2 = 1 - \zeta \Theta_2.
\]

\(^{19}\)Our results also generalize beyond the case of inflation targeting, as we show for a simplified version of the model which features a Taylor-type monetary policy rule. In particular, we are able to establish that alternative monetary policy rules which react to inflation do not alter the ratio $\Theta_1 / \Theta_2$ but merely scale the responses to the shocks proportionally, see Online Appendix E.
Moreover, $\Gamma_0 \in (0, 1)$, $\Gamma_1 \in [1 - 1/\omega, 1]$ and $\Gamma_2 \in [0, 1]$.

The coefficients $\Gamma_1$ and $\Gamma_2$ in Proposition 3 directly capture the impact multiplier of government spending on output, that is, the change in output caused by a change in government spending equal to one unit of steady-state output. Also, equation (4.4) shows the multiplier is equal to the sum of the direct effect of higher spending on output and the indirect effect on private consumption. Given the results in Proposition 2, it follows that $\Gamma_1$ may actually be negative: that is, government spending may actually lower output—the fiscal multiplier can be negative, in contrast to the one-sector New Keynesian model. $^{20}$ $\Gamma_2$, instead, is bounded by zero from below. Moreover, multipliers may not exceed unity, just as in the baseline one-sector New Keynesian model unless the zero lower bound on interest rates binds (Woodford, 2011).

4.2 Quantitative relevance

This section illustrates the quantitative relevance of our results through model simulations. For this purpose, we calibrate the model at a monthly frequency and set the time discount factor $\beta$ to 0.997. The inverse of the Frisch elasticity is $\varphi = 4$ (see, e.g., Chetty et al., 2011). We assume government spending accounts for 20 percent of output in steady state and explore the effects of changes in government spending which originate mostly—as Fact 1 establishes—from variation in federal purchases. Facts 2 and 3 show that these purchases are both granular and heterogeneous. We capture these aspects of the data in a stylized manner by focusing on sectoral shocks. We set $\rho = 0.85$, consistent with Fact 4. Lastly, in line with Fact 5, we calibrate sector 2 to represent five sectors that have relatively sticky consumer prices and together comprise a large share of federal purchases relative to their share of value added. These are: Manufacturing (32 and 33), Administrative and Support and Waste Management and Remediation Services (56); Arts, Entertainment, and Recreation (71); and Other Services (81). $^{21}$ Together they account for 44 percent of federal purchases but only for 24 percent of private expenditures (sectoral bias), see Table A.1 in the Online Appendix. In terms of model parameters, these numbers translate into sector 1 parameters of $\gamma = 0.56$ and $\omega = 0.76$ which implies $n = 0.72$. Given our sector classification, we compute the average price duration across sectors and obtain values $\alpha_1 = 0.78$ and $\alpha_2 = 0.90$, meaning that private-sector prices are considerably more sticky in sector 2, with implied average price durations of 4.5 and 10 months, respectively. For monetary policy we

$^{20}$ Baxter and King (1993) also obtain a negative multiplier in case taxes are distortionary. Instead, we assume throughout that taxes are lump sum.

$^{21}$ Our simulation results are not sensitive to the specific sector choice as long as they align with Fact 5.
Figure 5: Effects of Government Spending Shocks

Notes. This figure shows impulse responses to a shock equal to one percent of steady-state output in each scenario; horizontal axis: time in months, vertical axis: deviation from steady state. Blue solid lines correspond to the baseline calibration. Red dashed lines correspond to the symmetric counterfactual.

assume a simple interest rate feedback rule, $i_t = 1.5\pi_t$, rather than strict inflation targeting (as in the previous section). In this way, we illustrate that our main insights also obtain for alternative specifications of monetary policy.

Our simulation results contrast the effect of a shock to government spending in sector 1 to the effect of a shock originating in sector 2. Each shock is normalized so that spending increases by 1 percent of steady-state output. Figure 5 shows the associated impulse responses following
the two shocks in the left and right column, respectively. From top to bottom, we show the impulse responses of CPI inflation, the interest rate, and output. In each panel, the blue solid line shows the deviation from steady state (vertical axis) in percentage points/percent. Time is measured in months along the horizontal axis.

The red dashed line shows the responses for a counterfactual in which we assume a perfectly symmetric economy with $\omega = \gamma = n = 0.5$ and equal pricing frictions for both sectors, corresponding to the weighted average of our baseline ($\alpha_1 = \alpha_2 = 0.84$). In the symmetric model, the effects of the shock do not depend on the sector in which the shock originates. Government spending increases inflation by pushing up marginal costs, that is, wages, which in turn induces monetary policy to tighten. The interest rate goes up and sizeable crowding out of consumption occurs (not shown). Output increases by about 0.4 percent on impact.

A different picture emerges when we consider our baseline model, which accounts for sectoral heterogeneity (blue solid lines). The effects of the shock now depend on the sector in which the shock originates. As discussed above, the difference in responses depends on the price stickiness of both sectors and the sectoral composition of private and government demand in steady state. In response to a sector-1 shock, inflation goes up, even more so than in the symmetric case, because sector 1 has relatively flexible prices and it has large weight on aggregate inflation. Instead, in response to a sector-2 shock, inflation is much more muted (top-right panel). A direct implication is that the policy response differs strongly (middle row). The inflationary effect of a sector-1 shock causes a monetary tightening, whereas the sector-2 shock hardly triggers any policy reaction at all. As the Taylor principle is satisfied, the real interest rate moves strongly for a sector-1 shock, crowding out private consumption in response to a sector 1 shock, but not in response to a sector 2 shock. The differential crowding out of consumption rationalizes the output response in the bottom panels: output increases by about 0.25 percent in response to a sector 1 shock, but by about 0.75 in response to a sector 2 shock. A similar picture emerges when hand-to-mouth households are introduced following Galí et al. (2007), although in this case consumption is crowded-in in response to a sector-2 shock, see Online Appendix F.1. Moreover, we note that the fiscal multiplier changes non-monotonically in the “Calvo gap.” That is, for a given degree of average price stickiness, the multiplier depends on the relative stickiness across sectors, both on impact and in present value terms, defined as in Uhlig (2010), see Online

Note the ordering of the output effects may flip if monetary policy is constrained by the effective lower bound. In this case the stronger response of inflation in response to a sector 1 shock does not trigger a monetary tightening. Hence, real interest rates decline, crowding in private consumption (unreported).
Appendix D.5 (which also illustrate how multipliers depend on sectoral bias). Lastly, we note that our model has interesting implications for how sectoral markups respond to government spending shocks, an issue we discuss in Online Appendix D.6.

5 Some Time-Series Evidence

We now turn to time-series data in order to validate the model’s prediction that sectoral heterogeneity is key for the aggregate effects of sectoral shocks to federal purchases. For this purpose, we rely on a VAR model which, while simple, mimics our model-based analysis closely. In particular, we construct measures of shocks to federal purchases at the sector level and contrast their effects on the aggregate economy. Specifically, we aggregate purchases in the same five sectors to which we calibrate sector 2 in Section 4.2 (“sticky-sector purchases”) as well as aggregate purchases in the remaining sectors, in which consumer prices are relatively more flexible (“flexible-sector purchases”). We then include the log of both time series in real terms in a monthly VAR model. It features 12 lags, a constant, and a linear time trend and includes observations for the period 2001:01 to 2019:12. In order to control for economic activity at the monthly frequency we include the unemployment rate in the model. We also include CPI inflation, the shadow interest rate as a measure for the monetary policy stance, and an index for real GDP, in logs.

In the spirit of Blanchard and Perotti (2002), we identify shocks to federal purchases recursively, with federal purchases in the two sectors ordered first and second in the VAR. In this way, we rule out a response of federal purchases to the other variables in the VAR within the month. This restriction appears mild, not least in view of Fact 1. Figure 6 shows the estimated impulse responses to purchase shocks in the flexible-price (left) and the sticky-price sector (right), respectively. In each panel, the solid line represents the point estimate, whereas the shaded areas indicate 68 and 90 percent confidence bands, obtained by bootstrap sampling.

23 We perform a seasonal adjustment after aggregating using the X13 filter and deflate the series with the Consumer Price Index (CPI) because a deflator for government spending is not available at monthly frequency.

24 Unless noted otherwise, our data source is the FRED database maintained at the St. Louis Fed. We measure inflation based on the Consumer Price Index (CPI), year-on-year. Our index of GDP is based on the Brave-Butters-Kelley measure of monthly real GDP growth compiled by the Federal Reserve Bank of Chicago. The shadow rate is from Wu and Xia (2016).

25 Because we use monthly data, the assumption that spending does not respond contemporaneously to the other variables included in the VAR is less restrictive than in the original work of Blanchard and Perotti (2002). The ordering of the two series for federal purchases relative to each other also matters in principle, but we find it makes little difference in practice. In what follows, we show results for the case of ordering the sticky-sector purchases first.
Figure 6: VAR Evidence

A. Flexible-sector shock

B. Sticky-sector shock

Notes. Impulse responses to federal purchase shocks in sticky and relatively flexible sectors. Solid line represents point estimate, shaded areas indicate 68 and 90 percent confidence bands. Time is measured in months along horizontal axis. The vertical axis measures deviation from pre-shock levels in percent. The size of the shock is one percent.

The horizontal axis measures time in months, the vertical axis measures the deviation from the pre-shock level in percent. We show in each row the responses of variables corresponding to
those shown in Figure 5. The response of purchases to each shock exhibits a fair amount of persistence and the time series of purchases in one sector responds only mildly to the shock in the other sector, see Online Appendix B.9.

Turning to the responses of inflation, the (shadow) interest rate and output (the Brave-Butters-Kelley index), we detect a clear pattern consistent with the model simulations. A shock to federal purchases in the flexible-price sector raises inflation (after about 6 months) and triggers a monetary contraction, that is, a rise in the shadow interest rate. At the same time, output does not increase: in fact it even declines slightly. A different pattern emerges in response to a shock in the sticky sector. Here, inflation and the interest rate do not rise—they even decline somewhat—while output starts to increase after about 9 months. Hence, the simple time-series evidence aligns well with the predictions of the model shown in Figure 5 above. It also puts a fresh perspective on earlier work which has documented puzzling responses of prices and the interest rate to aggregate government spending shocks (Mountford and Uhlig, 2009; Corsetti et al., 2012; Ramey, 2016).

In sum, the VAR estimates underscore the importance of accounting for the sectoral origin of government spending shocks: Whether purchases are raised in the sticky or relatively flexible sector makes all the difference in terms of their aggregate effects. While our focus is on the role of price stickiness, it is unlikely the only or—for that matter—the most import differentiator when it comes to the effects of federal purchases.\(^{26}\)

6 Conclusion

In this paper, we take a business cycle perspective and provide an anatomy of the universe of U.S. federal procurement spending since 2001. These federal purchases account for about one sixth of overall government spending, but for about one half of its variation over time. We establish this and four more facts on the nature of government spending. The bottom line is: G is granular and heterogeneous. It not a single policy instrument that can be easily adjusted to fine tune the business cycle—contrary to what most models of the business cycle assume. Instead, G is composed of many little gs. This fact presents policy makers with an opportunity because the aggregate effects of altering the level of purchases ultimately depend on the firms and/or sectors in which the fiscal adjustment takes place. This aspect is key for the design of

\(^{26}\)We provide time-series data for federal purchases aggregated to the sectoral level at https://projects.rcc.uchicago.edu/weberm/gov_contracts/ to facilitate further research.
optimal fiscal policy and should be investigated formally in future research.

References


Oh, H. and R. Reis (2012). Targeted transfers and the fiscal response to the great recession. *Journal of Monetary Economics* 59(S), S50–S64.
A Data Appendix

A.1 Scope of the Government Contracts Data

Figure A.1 schematically represents the micro structure of the contracts data.

Figure A.1: Tracing of Award from Origin to Recipient
Figure A.2 shows a schematic of which portions of total government spending (government consumption expenditures and gross investment) are represented in the contracts data.

**Figure A.2: Contract Portion of Total Government Spending**
A.2 Contract Proxy Variable

The data analysis presented in Section 3.1 rely on a “proxy” for the contracts data that we construct from the National Income and Product Accounts (NIPAs). The advantages of looking at the contract proxy are twofold: first, by constructing the contract series from the NIPAs, we can be sure that it has been treated (smoothed and seasonally adjusted) in the same manner as the other components of $G$, therefore we do not introduce additional noise. Second, in doing decompositions of $G$, we can be sure that the components sum perfectly to the aggregate. To instill some confidence in this “proxy” variable, Figure A.3 shows that it is highly correlated with the contracts data from USASpending (correlation coefficient of 0.96).

![Figure A.3: Comparison of Contract Series](image)

The left panel shows a comparison of the three contract series: (i) the raw data, (ii) the seasonally adjusted contracts data, and (iii) the proxy for contract spending constructed from the National Income and Product Accounts. The right panel shows the strong correlation between the seasonally adjusted contract data and the NIPA proxy.
B Additional Empirical Results

B.1 Decomposition of Government Spending Growth

As in Foerster et al. (2011), we decompose changes in aggregate government spending growth into components arising from aggregate and idiosyncratic (sector-specific) shocks. Specially, we decompose aggregate government spending growth, \( Z_t \):

\[
Z_t = \sum_{i=1}^{N} \omega_{i,t} z_{i,t} = \frac{1}{N} \sum_{i=1}^{N} z_{i,t} + \frac{1}{N} \left( \bar{\omega}_i - \frac{1}{N} \right) z_{i,t} + \sum_{i=1}^{N} (\omega_{i,t} - \bar{\omega}_i) z_{i,t}
\]  

(B.1.1)

where \( i \) denotes two-digit NAICS sectors, \( \omega_{i,t} \) is sector \( i \)'s share of spending in year \( t \), and \( \bar{\omega}_i \) is the average share of sector \( i \) in government spending for all years. The term \( \frac{1}{N} \sum_{i=1}^{N} z_{i,t} \) weights each sector equally. If \( z_{i,t} \) is uncorrelated, this component has a variance proportional to \( N^{-1} \). The second term, the granular residual term, \( \sum_{i=1}^{N} (\omega_{i,t} - (1/N)) z_{i,t} \) will be large if the cross-sectional variance of sectoral shares is large at date \( t \).

Figure A.4 plots the individual components of equation (B.1.1) over time. In Foerster et al. (2011), the equally-weighted component tracks the series for aggregate industrial production growth more closely than the granular residual term. In our case, both series exhibit fluctuations of a magnitude similar to that of the aggregate growth rate, indicating that both idiosyncratic shocks and covariance across sectors are important drivers of aggregate growth.

Figure A.4: Decomposition of Sectoral Spending Growth

Notes. This figure plots the individual components of government consumption growth, decomposed as in Foerster et al. (2011) as in equation (B.1.1).
### B.2 Sectoral Share of Government Consumption versus Share of GDP

#### Table A.1: Percent of Government Consumption versus Percent of GDP

<table>
<thead>
<tr>
<th>Sector Name</th>
<th>NAICS</th>
<th>Government Share (%)</th>
<th>Private Share (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturing</td>
<td>33</td>
<td>30.14</td>
<td>12.72</td>
</tr>
<tr>
<td>Professional, Scientific, and Technical Services</td>
<td>54</td>
<td>27.98</td>
<td>4.04</td>
</tr>
<tr>
<td>Administrative and Waste Management</td>
<td>56</td>
<td>8.88</td>
<td>1.14</td>
</tr>
<tr>
<td>Construction</td>
<td>23</td>
<td>7.13</td>
<td>9.84</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>32</td>
<td>4.01</td>
<td>4.57</td>
</tr>
<tr>
<td>Wholesale Trade</td>
<td>42</td>
<td>3.53</td>
<td>4.87</td>
</tr>
<tr>
<td>Transportation and Warehousing</td>
<td>48</td>
<td>2.59</td>
<td>2.15</td>
</tr>
<tr>
<td>Finance and Insurance</td>
<td>52</td>
<td>2.4</td>
<td>8.32</td>
</tr>
<tr>
<td>Information</td>
<td>51</td>
<td>2.27</td>
<td>5.31</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>31</td>
<td>1.5</td>
<td>5.93</td>
</tr>
<tr>
<td>Health Care, Social Assistance</td>
<td>62</td>
<td>1.27</td>
<td>12.32</td>
</tr>
<tr>
<td>Educational Services</td>
<td>61</td>
<td>1.1</td>
<td>1.52</td>
</tr>
<tr>
<td>Other Services, ex. Government</td>
<td>81</td>
<td>0.7</td>
<td>3.87</td>
</tr>
<tr>
<td>Real Estate, Rental, Leasing</td>
<td>53</td>
<td>0.68</td>
<td>4.79</td>
</tr>
<tr>
<td>Retail Trade</td>
<td>44</td>
<td>0.66</td>
<td>10.06</td>
</tr>
<tr>
<td>Utilities</td>
<td>22</td>
<td>0.51</td>
<td>1.45</td>
</tr>
<tr>
<td>Accommodation and Food Services</td>
<td>72</td>
<td>0.28</td>
<td>4.7</td>
</tr>
<tr>
<td>Transportation and Warehousing</td>
<td>49</td>
<td>0.21</td>
<td>0.21</td>
</tr>
<tr>
<td>Agriculture, Forestry, Fishing, Hunting</td>
<td>11</td>
<td>0.11</td>
<td>0.5</td>
</tr>
<tr>
<td>Mining</td>
<td>21</td>
<td>0.09</td>
<td>0.47</td>
</tr>
<tr>
<td>Arts, Entertainment, Recreation</td>
<td>71</td>
<td>0.03</td>
<td>1.22</td>
</tr>
</tbody>
</table>

Notes. This table shows the percent of federal 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 federal government consumption across sectors varies from the allocation of private consumption across sectors.
B.3 Estimated Residuals of the Spending Process

Figure A.5 shows the distributions of correlations across sector pairs (left panel) and the top 100 firms (right panel), obtained from estimating the regressions that underlie the auto-regressive processes in Table 2.

Figure A.5: Density of Error Term Correlation Coefficients

(a) Sectors

(b) Top 100 Firms

Notes. This figure shows the distribution of correlation across sector pairs (left) and the top 100 firms (right) that result from examining the sectoral process: \( g_{i,t+1} = \alpha_0 + \alpha_i + \alpha_t + \rho g_{i,t} + \varepsilon_{i,t+1} \), where \( g_{i,t} \) is the log of government consumption of output from two-digit sector or firm \( i \) in quarter \( t \). The figure shows the distribution of the correlation coefficients of the residuals for all sector or firm pairs.
B.4 Pricing in the Contracts Data

From the USASpending data, it is difficult to ascertain much about the prices at which the government buys goods and services for the simple reason that we observe only nominal contract values, with no information about quantities.

Repeat Prices

Given the challenges of the data, we do several exercises in which we attempt to proxy for “sticky prices” to illustrate how prevalent they may be in the data. In the first exercise, as a proxy for sticky prices, we count how often the same firm receives a contract transaction that has an identical nominal value. In the second, more flexible case, we condition only on the firm and sector—that is, we count the number of times a firm receives a contract for the same sector and the same nominal value. In the third, less flexible case, we also condition on the contract’s description—that is, we count the number of times a firm receives a contract for the same sector with the same description and for the same nominal value.

Table A.2 shows some summary statistics. In the more flexible case, 41 percent of (positive value) transactions\(^1\) are contained in the group of repeated transactions. (If a transaction is repeated 10 times, we count that as 10 in both the numerator and denominator when computing this share.) These repeated transactions are all low in value, however, representing only 7 percent of total dollars obligated in our sample. The average (median) number of times a contract is repeated is 5.38 (2), and the average (median) gap between the first and last of these repeated transactions is 1.67 (1) year.

When we condition further on the description of the award, so we only count transactions with identical descriptions and identical nominal values, the share of repeated transactions is much smaller. Here, only 17 percent of transactions are repeated, and those 17 percent represent only 3 percent of contracted dollars. Of all transactions with repeated descriptions, the subset that also has repeated value is just over 30 percent. The average (median) number of repeats is similar at 5.2 (2), but the gap between repeated transactions shrinks to less than a year on average (meaning the repeated transactions occur within the same calendar year).

\(^1\)We drop de-obligations and 0 value transactions.
Table A.2: Repeated Nominal Transactions

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Flexible</th>
<th>Matching Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Share Repeated</td>
<td>0.41</td>
<td>0.17</td>
</tr>
<tr>
<td>Share Dollars</td>
<td>0.07</td>
<td>0.03</td>
</tr>
<tr>
<td>Avg Count</td>
<td>5.38</td>
<td>5.2</td>
</tr>
<tr>
<td>Median Count</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Avg Year Gap</td>
<td>1.67</td>
<td>0.68</td>
</tr>
<tr>
<td>Median Year Gap</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Notes. In the summary statistics above, we consider only transactions with positive, non-zero values. The “flexible” column reports all transactions given to the same firm in the same sector that have matching nominal values. The “Matching Descriptions” column also requires that the contract have an identical description.

Four Examples

Snow Removal Services. The first set of example contracts are those designated for snow removal services at the Mary E. Switzer Federal Building in Washington DC. Between June 2009 and May 2021, there are 15 contracts pertaining to snow removal services at the Switzer building. The contracts are awarded to three different companies over this 12 year period. As Table A.3 shows, even though these contracts are all for the same type of service, they are by no means “standardized” over this 12-year period. The nominal values range from $525 to $46,000; sometimes there are multiple contracts within the same year, while in other cases there is one contract for the entire fiscal year of services; some descriptions are just for snow removal, and some contain descriptions for “related services.”

E2-D Hawkeye Aircraft. Table A.4 shows examples of contracts that the government entered into with Northrop Grumman for production and purchase of the E-2D Hawkeye—a plane used by the U.S. Navy. As shown by the contract descriptions, the process is much more complicated than the government purchasing some number of E-2 planes from Northrop Grumman. Except for in one case—a transaction associated with the contract starting on 2-15-2018, we see no information about the number of units purchased. (In that case, there is one transaction that is for the production of 24 E-2 planes.)
<table>
<thead>
<tr>
<th>Start</th>
<th>End</th>
<th>Contracting Firm</th>
<th>Amount</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6-29-2009</td>
<td>6-30-2009</td>
<td>East West Inc.</td>
<td>5,533</td>
<td>Provide snow removal services at the Switzer Bldg, Wash, DC.</td>
</tr>
<tr>
<td>6-30-2009</td>
<td>6-30-2009</td>
<td>East West Inc.</td>
<td>5,433</td>
<td>Snow removal services provided to the Switzer Building, Wash, DC.</td>
</tr>
<tr>
<td>3-9-2010</td>
<td>6-30-2010</td>
<td>East West Inc.</td>
<td>46,814</td>
<td>Reimbursable services used under the basic contract for snow removal services at the Mary E. Switzer Building, Under Contract GS11P05YTD0269</td>
</tr>
<tr>
<td>3-30-2010</td>
<td>6-30-2010</td>
<td>East West Inc.</td>
<td>9,320.7</td>
<td>Snow removal at the Mary Switzer Building under contract GS11P05YTD0269</td>
</tr>
<tr>
<td>11-23-2010</td>
<td>3-31-2011</td>
<td>East West Inc.</td>
<td>21,656</td>
<td>Snow removal services at Switzer Building</td>
</tr>
<tr>
<td>12-23-2011</td>
<td>3-23-2012</td>
<td>East West Inc.</td>
<td>9,925</td>
<td>Snow and ice removal at Switzer</td>
</tr>
<tr>
<td>6-13-2014</td>
<td>7-25-2014</td>
<td>Tri-State Building Service, Inc.</td>
<td>5,829.7</td>
<td>Snow removal for Mary Switzer Federal Building Event 7-02/16/2015 IGF::OT::IGF for other functions.</td>
</tr>
<tr>
<td>4-20-2016</td>
<td>4-28-2016</td>
<td>Tri-State Building Service, Inc.</td>
<td>30,496.8</td>
<td>Snow removal services at Mary E Switzer Building.</td>
</tr>
<tr>
<td>12-19-2016</td>
<td>4-30-2017</td>
<td>Tri-State Building Service, Inc.</td>
<td>5,604.95</td>
<td>Snow/Ice removal and other related services at the Mary E. Switzer Building.</td>
</tr>
<tr>
<td>11-15-2018</td>
<td>4-30-2019</td>
<td>Melgar Facility Maintenance LLC</td>
<td>36,840</td>
<td>Snow and ice removal services at the Mary E. Switzer Building.</td>
</tr>
<tr>
<td>11-16-2020</td>
<td>4-30-2021</td>
<td>Melgar Facility Maintenance LLC</td>
<td>18,800</td>
<td></td>
</tr>
<tr>
<td>Start</td>
<td>End</td>
<td>Contracting Firm</td>
<td>Amount</td>
<td>Description</td>
</tr>
<tr>
<td>------------</td>
<td>------------</td>
<td>------------------------</td>
<td>---------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>10-1-1999</td>
<td>12-31-2006</td>
<td>Northrop Grumman Corp</td>
<td>674,822,987.00</td>
<td>Contract to be awarded for contractor support services for USCG Hawkeye, CGVTS, and COMDAC</td>
</tr>
<tr>
<td>9-7-2001</td>
<td>9-6-2016</td>
<td>Northrop Grumman Corp</td>
<td>27,337,754.00</td>
<td>Advanced aquisition funding for E-2D Advanced Hawkeye Aircraft (LRIP 1)</td>
</tr>
<tr>
<td>3-28-2003</td>
<td>9-30-2009</td>
<td>Northrop Grumman Corp</td>
<td>231,800,034.00</td>
<td>New Contract for CGVTS/Hawkeye support and development.</td>
</tr>
<tr>
<td>5-22-2007</td>
<td>9-16-2008</td>
<td>Northrop Grumman Corp</td>
<td>3,825,350.11</td>
<td>E-2D advanced Hawkeye Aircraft (LRIP 3)</td>
</tr>
<tr>
<td>12-26-2007</td>
<td>3-23-2020</td>
<td>Northrop Grumman Corp</td>
<td>965,574,587.10</td>
<td>Task order no. NND11GH26T engineering support for integration of the attrax instruments onto the NASA global Hawk Aircraft...</td>
</tr>
<tr>
<td>9-14-2008</td>
<td>9-29-2009</td>
<td>Northrop Grumman Corp</td>
<td>2,712,774.11</td>
<td>Spare consumables and spare re-</td>
</tr>
<tr>
<td>3-15-2010</td>
<td>4-30-2019</td>
<td>Northrop Grumman Corp</td>
<td>1,627,964,603.00</td>
<td>E-2C Hawkeye Logistics and Engineering</td>
</tr>
<tr>
<td>1-20-2011</td>
<td>3-31-2012</td>
<td>Northrop Grumman Corp</td>
<td>433,546.36</td>
<td>E-2 Advanced Hawkeye Aircraft (FRP-1)</td>
</tr>
<tr>
<td>4-5-2011</td>
<td>6-30-2016</td>
<td>Northrop Grumman Corp</td>
<td>27,850,000.00</td>
<td>Contractor support to procure, package, handle, store, transport, and deliver units under test in support of the E-2D advanced Hawkeye Program...</td>
</tr>
<tr>
<td>2-1-2012</td>
<td>3-19-2020</td>
<td>Northrop Grumman Corp</td>
<td>828,394,056.00</td>
<td>Basic ordering agreement order for over and above labor and materials for the E-2D Hawkeye aerial refueling capability development.</td>
</tr>
<tr>
<td>4-27-2012</td>
<td>10-30-2015</td>
<td>Northrop Grumman Corp</td>
<td>15,343,569.00</td>
<td>Basic ordering agreement order for over and above labor and materials for the E-2D Hawkeye production.</td>
</tr>
<tr>
<td>5-13-2013</td>
<td>6-30-2024</td>
<td>Northrop Grumman Corp</td>
<td>5,276,401,410.16</td>
<td>Basic ordering agreement order for over and above labor and materials for the E-2D Hawkeye production.</td>
</tr>
<tr>
<td>11-9-2015</td>
<td>9-30-2021</td>
<td>Northrop Grumman Corp</td>
<td>1,150,000.00</td>
<td>Basic ordering agreement order for over and above labor and materials for the E-2D Hawkeye production.</td>
</tr>
<tr>
<td>5-27-2016</td>
<td>9-30-2022</td>
<td>Northrop Grumman Corp</td>
<td>851,921.51</td>
<td>Basic ordering agreement order for over and above labor and materials for the E-2D Hawkeye production.</td>
</tr>
<tr>
<td>10-27-2016</td>
<td>9-30-2022</td>
<td>Northrop Grumman Corp</td>
<td>556,681.63</td>
<td>Basic ordering agreement order for over and above labor and materials for the E-2D Hawkeye production.</td>
</tr>
<tr>
<td>2-15-2018</td>
<td>9-30-2027</td>
<td>Northrop Grumman Corp</td>
<td>4,785,417,284.00</td>
<td>E-2 Advanced Hawkeye Aircraft (FRP-7)</td>
</tr>
<tr>
<td>6-30-2020</td>
<td>10-31-2014</td>
<td>Northrop Grumman Corp</td>
<td>62,269,255.78</td>
<td>PSE in support of the E-2 Advanced Hawkeye.</td>
</tr>
</tbody>
</table>
Coffee and Cleaning Services. There are a few examples of repeated purchases of fairly homogeneous goods and services, for example, the purchase of “Nesquik and Coffee Mate” and “1 day per week cleaning services” at Fort Stewart in Georgia. Table A.5 shows the contracts for Nesquik and Coffee Mate, purchased from Nestle USA. The government appears to have made this purchase on a quarterly basis (with one exception in August 2010), and the prices range between $2.3 and $3.2 million for these quarterly shipments. We have no information about quantities, so the fluctuation in prices may be due to quantity or price changes, or both. Similarly, Table A.6 shows the contracts for cleaning services at FSGA (we assume this is Fort Stewart, Georgia). This contract was renewed almost every month, and again, the nominal values are varied.

Table A.5: Contracts for Nesquik and Coffee Mate

<table>
<thead>
<tr>
<th>Start</th>
<th>End</th>
<th>Contracting Firm</th>
<th>Amount</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-1-2010</td>
<td>9-30-2010</td>
<td>Nestle USA, Inc</td>
<td>2,617,626</td>
<td>Resale—Nesquik and Coffee Mate</td>
</tr>
<tr>
<td>8-1-2010</td>
<td>8-31-2010</td>
<td>Nestle USA, Inc</td>
<td>2,319,045</td>
<td>Resale—Nesquik and Coffee Mate</td>
</tr>
<tr>
<td>10-1-2010</td>
<td>12-31-2010</td>
<td>Nestle USA, Inc</td>
<td>2,915,687</td>
<td>Resale—Nesquik and Coffee Mate</td>
</tr>
<tr>
<td>1-1-2011</td>
<td>3-31-2011</td>
<td>Nestle USA, Inc</td>
<td>2,886,085</td>
<td>Resale—Nesquik and Coffee Mate</td>
</tr>
<tr>
<td>4-1-2011</td>
<td>6-30-2011</td>
<td>Nestle USA, Inc</td>
<td>2,984,326</td>
<td>Resale—Nesquik and Coffee Mate</td>
</tr>
<tr>
<td>7-1-2011</td>
<td>9-30-2011</td>
<td>Nestle USA, Inc</td>
<td>2,679,614</td>
<td>Resale—Nesquik and Coffee Mate</td>
</tr>
<tr>
<td>10-1-2011</td>
<td>12-31-2011</td>
<td>Nestle USA, Inc</td>
<td>3,216,759</td>
<td>Resale—Nesquik and Coffee Mate</td>
</tr>
<tr>
<td>1-1-2012</td>
<td>3-31-2012</td>
<td>Nestle USA, Inc</td>
<td>3,168,333</td>
<td>Resale—Nesquik and Coffee Mate</td>
</tr>
<tr>
<td>4-1-2012</td>
<td>6-30-2012</td>
<td>Nestle USA, Inc</td>
<td>2,947,472</td>
<td>Resale—Nesquik and Coffee Mate</td>
</tr>
<tr>
<td>7-1-2012</td>
<td>9-30-2012</td>
<td>Nestle USA, Inc</td>
<td>3,001,697</td>
<td>Resale—Nesquik and Coffee Mate</td>
</tr>
</tbody>
</table>

Table A.6: Cleaning Services at Fort Stewart

<table>
<thead>
<tr>
<th>Start</th>
<th>End</th>
<th>Contracting Firm</th>
<th>Amount</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-1-2018</td>
<td>9-30-2018</td>
<td>Goodwill Industries</td>
<td>891,019</td>
<td>1 Day Per Week Cleaning-FSGA</td>
</tr>
<tr>
<td>9-28-2018</td>
<td>10-31-2018</td>
<td>Goodwill Industries</td>
<td>290,183</td>
<td>1 Day Per Week Cleaning-FSGA</td>
</tr>
<tr>
<td>11-2-2018</td>
<td>11-30-2018</td>
<td>Goodwill Industries</td>
<td>287,965</td>
<td>1 Day Per Week Cleaning-FSGA</td>
</tr>
<tr>
<td>11-29-2018</td>
<td>12-31-2018</td>
<td>Goodwill Industries</td>
<td>284,141</td>
<td>1 Day Per Week Cleaning-FSGA</td>
</tr>
<tr>
<td>12-13-2018</td>
<td>1-31-2019</td>
<td>Goodwill Industries</td>
<td>283,320</td>
<td>1 Day Per Week Cleaning-FSGA</td>
</tr>
<tr>
<td>1-29-2019</td>
<td>2-28-2019</td>
<td>Goodwill Industries</td>
<td>247,099</td>
<td>1 Day Per Week Cleaning-FSGA</td>
</tr>
<tr>
<td>3-29-2019</td>
<td>4-30-2019</td>
<td>Goodwill Industries</td>
<td>324,491</td>
<td>1 Day Per Week Cleaning-FSGA</td>
</tr>
<tr>
<td>4-29-2019</td>
<td>5-31-2019</td>
<td>Goodwill Industries</td>
<td>340,980</td>
<td>1 Day Per Week Cleaning-FSGA</td>
</tr>
<tr>
<td>6-27-2019</td>
<td>7-31-2019</td>
<td>Goodwill Industries</td>
<td>329,676</td>
<td>1 Day Per Week Cleaning-FSGA</td>
</tr>
<tr>
<td>7-31-2019</td>
<td>8-31-2019</td>
<td>Goodwill Industries</td>
<td>319,916</td>
<td>1 Day Per Week Cleaning-FSGA</td>
</tr>
</tbody>
</table>
This subsection presents two variance decompositions of federal purchases into variation within and across firms, and within and across sectors. Notably, the first decomposition shows that even within firms there is a fat right tail in the distribution of contract size.

Figure A.6: Variance Decomposition: Within and Across Firms

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

\[
\sum_{f} \sum_{c \in f} (g_{c,f,t} - \bar{g}_t)^2 = \sum_{f} \sum_{c \in f} (g_{c,f,t} - \bar{g}_{f,t})^2 + \sum_{f} \sum_{c \in f} (\bar{g}_{f,t} - \bar{g}_t)^2,
\]

where \(c\) 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 firms, and panel (c) shows only the bottom 80 percent of firms.
Notes. This figure shows a decomposition of the variance of government spending into “within-sector” and “across-sector” variation. Specifically, total variation is given by:

\[
\sum_{s} \sum_{f \in s} (g_{fs,t} - \bar{g}_t)^2 = \sum_{s} \sum_{f \in s} (g_{fs,t} - \bar{g}_{s,t})^2 + \sum_{s} \sum_{f \in s} (\bar{g}_{s,t} - \bar{g}_t)^2,
\]

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.
B.6 Federal Purchases Well-Approximated by a Log-Normal Distribution

Figure A.8: Q-Q Plot: Actual vs. Log-Normal

Notes. 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. Data represent a single annual cross section from the year 2012, but patterns are robust in any year of the sample.

B.7 Concentration of Federal Purchases Among Few Firms and Sectors

Figure A.9 shows the share of federal purchases accounted for by the top firms, six-digit NAICS sectors, and two-digit NAICS sectors.

Figure A.9: Share of Obligations by Top Firms and Sectors

Notes. 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 right panel).
Figure A.10 shows that the individual firms and sectors in which federal purchases are concentrated has remained relatively stable over time, with the same three to four firms/sectors remaining the top recipients over our sample period.

Figure A.10: Share of Obligations by Top Firms and Sectors

(a) Firms

(b) Sectors

Notes. This figure shows the share of contract obligations given to four of the top firms in the left panel, and four of the top sectors (NAICS 2) in the right panel. The firms and sectors shown are the top four firms/sectors at the beginning of our sample, and remain in the data for the full sample period, within the top five firms/sectors in nearly every year.

Table A.8 shows how concentration of suppliers of federal purchases compares to concentration of suppliers to the private sector. At the two-digit sector level, the suppliers to the federal government are slightly more concentrated than suppliers to the private sector, with the top two-digit sector accounting for 36 percent of federal purchases and the top two-digit sector supplying an average of 29 percent of intermediate goods across all sectors in the aggregate economy. At the six-digit sector level, the federal government’s suppliers appear more concentrated than the aggregate economy, with the top 5 supplying sectors accounting for almost a third of government purchases—double the share accounted by the top 5 suppliers of intermediate inputs to the aggregate economy.

Table A.7 shows that the top recipient firms of federal purchases tend to have relatively high employment, R&D expenditures, current assets, gross profits, and invested capital.
### Table A.7: Characteristics of Top Recipient Firms

<table>
<thead>
<tr>
<th>Firm</th>
<th>Employment (Thousands)</th>
<th>R&amp;D ($M)</th>
<th>Assets ($M)</th>
<th>Profits ($M)</th>
<th>Invested Capital ($M)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lockheed Martin Corp</td>
<td>123</td>
<td>979</td>
<td>13437</td>
<td>5654</td>
<td>12645</td>
</tr>
<tr>
<td>Boeing Co</td>
<td>159</td>
<td>3166</td>
<td>52176</td>
<td>12717</td>
<td>18387</td>
</tr>
<tr>
<td>General Dynamics Corp</td>
<td>88</td>
<td>408</td>
<td>13746</td>
<td>5399</td>
<td>15522</td>
</tr>
<tr>
<td>Northrop Grumman Corp</td>
<td>96</td>
<td>630</td>
<td>9111</td>
<td>6278</td>
<td>18867</td>
</tr>
<tr>
<td>Leidos Holdings Inc</td>
<td>36</td>
<td>52</td>
<td>3000</td>
<td>1399</td>
<td>4695</td>
</tr>
<tr>
<td>McKesson Corp</td>
<td>49</td>
<td>260</td>
<td>26154</td>
<td>7577</td>
<td>10934</td>
</tr>
<tr>
<td>Booz Allen Hamilton Holding Corp</td>
<td>25</td>
<td>–</td>
<td>1640</td>
<td>1464</td>
<td>2373</td>
</tr>
<tr>
<td>Raytheon Co.</td>
<td>71</td>
<td>586</td>
<td>9146</td>
<td>5373</td>
<td>15023</td>
</tr>
<tr>
<td>KBR Inc</td>
<td>34</td>
<td>1</td>
<td>2791</td>
<td>542</td>
<td>2310</td>
</tr>
<tr>
<td>Huntington Ingalls Industries Inc</td>
<td>39</td>
<td>23</td>
<td>2142</td>
<td>1527</td>
<td>3014</td>
</tr>
<tr>
<td><strong>Compustat Median</strong></td>
<td><strong>0.27</strong></td>
<td><strong>4</strong></td>
<td><strong>47</strong></td>
<td><strong>24</strong></td>
<td><strong>98</strong></td>
</tr>
</tbody>
</table>

Notes. This table shows statistics gathered from Compustat for the top recipient firms of federal purchases, relative to the median for all firms in Compustat. Numbers reflect an average over the period 2001-2021.

### Table A.8: Concentration in the Aggregate Economy

<table>
<thead>
<tr>
<th>Firms:</th>
<th>Share of Government Purchases</th>
<th>Share of Private Sales/GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top 10</td>
<td>29.3%</td>
<td>10.4 %</td>
</tr>
<tr>
<td>Top 1 Percent</td>
<td>81.2%</td>
<td>37.8 %</td>
</tr>
<tr>
<td>Top 10 Percent</td>
<td>98.1%</td>
<td>84.9 %</td>
</tr>
<tr>
<td><strong>Sectors (NAICS 2):</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top 3</td>
<td>58.1%</td>
<td>35.1%</td>
</tr>
<tr>
<td>Top 5</td>
<td>78.1%</td>
<td>53.3%</td>
</tr>
<tr>
<td><strong>Sectors (NAICS 6):</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top 5</td>
<td>28.4%</td>
<td>27.7%</td>
</tr>
<tr>
<td>Top 10</td>
<td>41.4%</td>
<td>42.7%</td>
</tr>
</tbody>
</table>

Note. This table shows the share of federal vs private sector purchases accounted for by the respective top firms and sectors. Private sector purchases come from Compustat (firms), the BEA National Income and Product Accounts (NAICS 2) and the BEA Input Output Tables (NAICS 6).

### B.8 Small vs. Large Contracts

As noted in Section 3.4, there is a quasi-mechanical relationship between contract size and contract duration: long contracts are, by nature, larger, because there is more time over which dollars can accrue. This mechanical relationship can be seen in Figure A.11, which shows the average duration of contracts in each size-decile, represented by the blue square points. The relationship is clearly upward sloping. The red circles in Figure A.11 show the relationship between contract dollars per day and contract duration. Here, the positive

---

2The weighted correlation between contract size and duration is 0.5.
correlation disappears—contracts that are larger per unit of time are not necessarily longer.\textsuperscript{3}

Figure A.11: Binned Scatter of Contract Size vs. Duration

Next, we provide further summary statistics about small- and large-contracts in terms of duration and sectoral composition. We define small contracts as those with values below the 10th percentile and large contracts as those with values above the 90th percentile. Table A.9 shows the share of contracts in each sector that are contained in short versus long-duration contracts, as well as the percent contained in large contracts. There is substantial heterogeneity here, with some sectors completely dominated by short contracts (i.e., NAICS 52), and some with larger shares in short contracts (i.e., NAICS 42). As shown in Table A.10, small and large contracts are both heavily concentrated in NAICS 33 (manufacturing). Small contracts are more heavily concentrated in NAICS 42 (wholesale trade), while large contracts are more heavily concentrated in NAICS 54 (Professional, Scientific, and Technical Services). Small contracts account for less than one percent of total federal purchases, while large contracts account for almost 99 percent. The mean and median durations of small contracts (20.2 and 10 days) are shorter than the mean and median duration of large contracts (266 and 113 days), but there are small contracts with very long durations—the maximum duration contract in each group is similar (7293 vs 7301 days).

\textsuperscript{3}The correlation coefficient between dollars per day and duration is -0.01.
### Table A.9: Short and Long Duration Contracts by Sector

<table>
<thead>
<tr>
<th>NAICS 2</th>
<th>Sector Share of Total</th>
<th>% in Short Contracts</th>
<th>% in Long Contracts</th>
<th>% in Large Contracts</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>0.1</td>
<td>4.3</td>
<td>47.6</td>
<td>82.2</td>
</tr>
<tr>
<td>21</td>
<td>0.1</td>
<td>3.2</td>
<td>72.8</td>
<td>95.8</td>
</tr>
<tr>
<td>22</td>
<td>0.4</td>
<td>4.4</td>
<td>79.7</td>
<td>97.4</td>
</tr>
<tr>
<td>23</td>
<td>7.3</td>
<td>0.4</td>
<td>86.6</td>
<td>98.6</td>
</tr>
<tr>
<td>31</td>
<td>1.7</td>
<td>1.4</td>
<td>22.6</td>
<td>92.1</td>
</tr>
<tr>
<td>32</td>
<td>4.4</td>
<td>2.5</td>
<td>53.9</td>
<td>94.4</td>
</tr>
<tr>
<td>33</td>
<td>30.2</td>
<td>0.6</td>
<td>85.3</td>
<td>96.0</td>
</tr>
<tr>
<td>42</td>
<td>3.3</td>
<td>10.8</td>
<td>23.9</td>
<td>80.7</td>
</tr>
<tr>
<td>44</td>
<td>0.6</td>
<td>2.3</td>
<td>57.1</td>
<td>88.7</td>
</tr>
<tr>
<td>45</td>
<td>0.1</td>
<td>7.5</td>
<td>37.0</td>
<td>74.0</td>
</tr>
<tr>
<td>48</td>
<td>2.6</td>
<td>7.1</td>
<td>74.5</td>
<td>98.9</td>
</tr>
<tr>
<td>49</td>
<td>0.2</td>
<td>11.5</td>
<td>80.1</td>
<td>96.8</td>
</tr>
<tr>
<td>51</td>
<td>2.4</td>
<td>0.7</td>
<td>89.0</td>
<td>96.7</td>
</tr>
<tr>
<td>52</td>
<td>2.6</td>
<td>0.8</td>
<td>97.4</td>
<td>99.8</td>
</tr>
<tr>
<td>53</td>
<td>0.6</td>
<td>13.7</td>
<td>53.4</td>
<td>82.0</td>
</tr>
<tr>
<td>54</td>
<td>28.3</td>
<td>0.6</td>
<td>94.2</td>
<td>99.2</td>
</tr>
<tr>
<td>55</td>
<td>0.0</td>
<td>2.0</td>
<td>82.4</td>
<td>89.2</td>
</tr>
<tr>
<td>56</td>
<td>8.4</td>
<td>0.4</td>
<td>92.7</td>
<td>98.6</td>
</tr>
<tr>
<td>61</td>
<td>1.1</td>
<td>0.6</td>
<td>88.7</td>
<td>96.9</td>
</tr>
<tr>
<td>62</td>
<td>1.6</td>
<td>3.7</td>
<td>65.3</td>
<td>96.7</td>
</tr>
<tr>
<td>71</td>
<td>0.0</td>
<td>3.2</td>
<td>62.9</td>
<td>84.8</td>
</tr>
<tr>
<td>72</td>
<td>0.3</td>
<td>1.7</td>
<td>64.5</td>
<td>89.8</td>
</tr>
<tr>
<td>81</td>
<td>0.7</td>
<td>1.0</td>
<td>83.2</td>
<td>92.6</td>
</tr>
<tr>
<td>92</td>
<td>0.4</td>
<td>4.7</td>
<td>70.3</td>
<td>97.8</td>
</tr>
<tr>
<td>99</td>
<td>0.0</td>
<td>42.0</td>
<td>56.8</td>
<td>99.8</td>
</tr>
</tbody>
</table>

Notes. This table shows the share of contract dollars in each sector that are contained in short contracts (bottom 10 percent of duration), long contracts (top percent of duration) and large contracts (top percent of contract size).
Table A.10: Small vs Large Contracts: Distribution Across Sectors and Duration

<table>
<thead>
<tr>
<th>Sector</th>
<th>Small Contracts</th>
<th>Large Contracts</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>0</td>
<td>0.1</td>
</tr>
<tr>
<td>21</td>
<td>0</td>
<td>0.1</td>
</tr>
<tr>
<td>22</td>
<td>0</td>
<td>0.4</td>
</tr>
<tr>
<td>23</td>
<td>0</td>
<td>7.5</td>
</tr>
<tr>
<td>31</td>
<td>3.6</td>
<td>1.6</td>
</tr>
<tr>
<td>32</td>
<td>14</td>
<td>4.3</td>
</tr>
<tr>
<td>33</td>
<td>37.5</td>
<td>29.9</td>
</tr>
<tr>
<td>42</td>
<td>23.1</td>
<td>2.7</td>
</tr>
<tr>
<td>44</td>
<td>8.7</td>
<td>0.6</td>
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<td>45</td>
<td>8.9</td>
<td>0.1</td>
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<td>48</td>
<td>0</td>
<td>2.7</td>
</tr>
<tr>
<td>49</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>51</td>
<td>0</td>
<td>2.4</td>
</tr>
<tr>
<td>52</td>
<td>0</td>
<td>2.7</td>
</tr>
<tr>
<td>53</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>54</td>
<td>0.7</td>
<td>29.1</td>
</tr>
<tr>
<td>55</td>
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<td>0</td>
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<tr>
<td>56</td>
<td>0.1</td>
<td>8.5</td>
</tr>
<tr>
<td>61</td>
<td>0</td>
<td>1.1</td>
</tr>
<tr>
<td>62</td>
<td>0.1</td>
<td>1.6</td>
</tr>
<tr>
<td>71</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>72</td>
<td>0</td>
<td>0.3</td>
</tr>
<tr>
<td>81</td>
<td>0</td>
<td>0.7</td>
</tr>
<tr>
<td>92</td>
<td>0</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Share of Dollars  
Mean Duration 19.8  368.1  
Median Duration 10  199  
Max Duration 7075  7301

Notes. This table shows the share of small (bottom quintile) versus large (top quintile) contracts in each 2-digit NAICS sector. The last four rows show the share of contract dollars contained in small and large contracts as well as the mean, median, and max duration of contracts in each group.
B.9 Additional Time Series Evidence

Figure A.12 shows the impulse responses to a shock in sticky sector spending (top row), flex-sector spending (middle row), and unemployment (third row).

Figure A.12: VAR Evidence

A. Flexible-sector purchases

B. Sticky-sector purchases

Notes. Impulse responses to federal purchases shocks in sticky and relatively flexible sectors. Solid line represents point estimate, shaded areas indicate 68 and 90 percent confidence bands. Time measured in months along horizontal axis. Vertical axis measures deviation from pre-shock level in percent. Size of the shock is one percent.
C Five Facts: Defense and Non-Defense

In this section, we show that the five facts outlined in the main text hold for both the Defense and Non-Defense subsets of federal purchases. Defense purchases account for just over half of federal contracts by count and around two-thirds of contracts by value.

C.1 Exogenous Variation

Table A.11 shows the Shapley value, or partial $R^2$ for each component of $G$, with government purchases broken down into defense purchases and non-defense purchases. Defense and non-defense purchases account for 35 and 12 percent of the variation in the growth rate of aggregate $G$, despite accounting for only 11 and 4 percent of $G$ in levels.

<table>
<thead>
<tr>
<th>Component</th>
<th>Shapley (Partial $R^2$)</th>
<th>Weight (% of G)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal Defense purchases</td>
<td>35%</td>
<td>11%</td>
</tr>
<tr>
<td>Federal Non-Defense purchases</td>
<td>12%</td>
<td>4%</td>
</tr>
<tr>
<td>Government Wages</td>
<td>23%</td>
<td>49%</td>
</tr>
<tr>
<td>Residual</td>
<td>29%</td>
<td>34%</td>
</tr>
</tbody>
</table>

Notes. Accounting for quarterly growth rate of $G$. Column 1 shows the Shapley values, or partial $R^2$, which indicate the percent of the overall $R^2$ accounted for by the given component. Column 2 shows the contribution of each component to the overall variance of $\Delta G$ (one-month log-changes).

Figure A.13 shows the response of the defense and non-defense purchases to the defense-news shock of Ramey and Zubairy (2018) and the Blanchard-Perotti measure of fiscal shocks.
Figure A.13: Response of $G$ Components to Established Fiscal Shocks

(a) Military news

(b) Blanchard-Perotti shock measure

Notes. Impulse responses of the components of $G$ to fiscal shocks as measured by Ramey and Zubairy (2018). Estimation relies on same local projection (and controls) as in their paper. Points marked with an * are statistically significantly different from 0 at a 95% confidence level.
C.2 Granularity

The following two tables show that Fact 2 applies both for federal defense as well as non-defense purchases.

### Table A.12: Granularity of Federal Defense Purchases

<table>
<thead>
<tr>
<th></th>
<th>(1) Sectors</th>
<th>(2) Sectors</th>
<th>(3) Firms</th>
<th>(4) Firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Gamma_t )</td>
<td>0.894 (*)</td>
<td>0.962 (*)</td>
<td>0.834 (*)</td>
<td>0.965 (*)</td>
</tr>
<tr>
<td>( \Gamma_{t-1} )</td>
<td>( -0.629 (*) )</td>
<td>( -0.272 )</td>
<td>( -0.155 )</td>
<td>( -0.290 )</td>
</tr>
<tr>
<td>( \Gamma_{t-2} )</td>
<td>( -0.155 )</td>
<td>( -0.272 )</td>
<td>( -0.155 )</td>
<td>( -0.290 )</td>
</tr>
<tr>
<td>Observations</td>
<td>67</td>
<td>65</td>
<td>67</td>
<td>65</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.247</td>
<td>0.477</td>
<td>0.210</td>
<td>0.364</td>
</tr>
</tbody>
</table>

(a) Explanatory Power of Granular Residual for Aggregate Purchases

(b) Importance of Aggregate Factors for Purchases at Sector/Firm level

<table>
<thead>
<tr>
<th>Lagged Spending</th>
<th>(1) 0.606 (*)</th>
<th>(2) 0.574 (*)</th>
<th>(3) 0.628 (*)</th>
<th>(4) 0.630 (*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \alpha_0 )</td>
<td>0.020</td>
<td>0.022</td>
<td>0.011</td>
<td>0.011</td>
</tr>
<tr>
<td>Sector FEIs</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Firm FEIs</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Time FEIs</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Observations</td>
<td>1545</td>
<td>1545</td>
<td>6362</td>
<td>6362</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.951</td>
<td>0.956</td>
<td>0.638</td>
<td>0.653</td>
</tr>
</tbody>
</table>

Standard errors in parentheses

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

Note. In Panel (a), we run a regression at a quarterly frequency of the 4-quarter change in aggregate growth, \( Z_t = \ln(G_t) - \ln(G_{t-4}) \), on the granular residual and its lags. The granular residual is given by \( \Gamma_t = \sum_{i=1}^{K} g_{i,t-4}(\bar{z}_{i,t} - \bar{z}_t) \), where \( K = 10 \). \( G_t \) is aggregate defense consumption in period \( t \) and \( \bar{z}_t \) is the average growth rate over the top \( Q = 1000 \) NAICS 6 sectors or firms. In Panel (b), we show the results of estimating the following, at a quarterly frequency: \( g_{i,t} = \alpha_0 + \rho g_{i,t-4} + \alpha_i + \varepsilon_{i,t} \), where \( g_{i,t} \) denotes sectoral or firm-level purchases. Columns (2) and (4) also include time fixed effects, \( \alpha_t \) in addition to sector or firm fixed effects.
Table A.13: Granularity of Federal Non-Defense Purchases

<table>
<thead>
<tr>
<th></th>
<th>(1) Sectors</th>
<th>(2) Sectors</th>
<th>(3) Firms</th>
<th>(4) Firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \Gamma_t )</td>
<td>0.863*** (0.150)</td>
<td>0.852*** (0.156)</td>
<td>2.439*** (0.602)</td>
<td>0.604*** (2.402)</td>
</tr>
<tr>
<td>( \Gamma_{t-1} )</td>
<td></td>
<td></td>
<td>-1.044 (0.599)</td>
<td></td>
</tr>
<tr>
<td>( \Gamma_{t-2} )</td>
<td></td>
<td></td>
<td>-0.047 (0.603)</td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>67</td>
<td>65</td>
<td>67</td>
<td>65</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.337</td>
<td>0.340</td>
<td>0.201</td>
<td>0.242</td>
</tr>
</tbody>
</table>

(a) Explanatory Power of Granular Residual for Aggregate Purchases

(b) Importance of Aggregate Factors for Purchases at Sector/Firm level

<table>
<thead>
<tr>
<th>Lagged Spending</th>
<th>0.550*** (0.021)</th>
<th>0.461*** (0.023)</th>
<th>0.622*** (0.010)</th>
<th>0.629*** (0.010)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sector FEs</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Firm FEs</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Time FEs</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Observations</td>
<td>1581</td>
<td>1581</td>
<td>6246</td>
<td>6246</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.937</td>
<td>0.945</td>
<td>0.559</td>
<td>0.576</td>
</tr>
</tbody>
</table>

Standard errors in parentheses

\* \( p < 0.05 \), \** \( p < 0.01 \), \*** \( p < 0.001 \)

Note. In Panel (a), we run a regression at a quarterly frequency of the 4-quarter change in aggregate growth, \( Z_t = \ln(G_t) - \ln(G_{t-4}) \), on the granular residual and its lags. The granular residual is given by \( \Gamma_t = \sum_{i=1}^{K} g_{i,t-4} (z_{i,t} - \bar{z}_t) \), where \( K = 10 \). \( G_t \) is aggregate non-defense consumption in period \( t \) and \( \bar{z}_t \) is the average growth rate over the top \( Q = 1000 \) NAICS 6 sectors or firms. In Panel (b), we show the results of estimating the following, at a quarterly frequency: \( g_{i,t} = \alpha_0 + \rho g_{i,t-4} + \alpha_t + \varepsilon_{i,t} \), where \( g_{i,t} \) denotes sectoral or firm-level purchases. Columns (2) and (4) also include time fixed effects, \( \alpha_t \), in addition to sector or firm fixed effects.
Figure A.14 shows the distributions of correlations across sector pairs (left panel) and the top 100 firms (right panel) for defense contracts (top panel) and non-defense contracts (bottom panel), obtained from estimating the regressions that underlie the auto-regressive processes in Table 2.

Figure A.14: Density of Error Term Correlation Coefficients (Defense and Non-Defense)

(a) Sectors (Defense)  
(b) Top 100 Firms (Defense)

(c) Sectors (Non-Defense)  
(d) Top 100 Firms (Non-Defense)

Notes. This figure shows the distribution of correlation across sector pairs (left) and the top 100 firms (right) that result from examining the sectoral process: \( g_{i,t+1} = \alpha_0 + \alpha_i + \alpha_t + \rho g_{i,t} + \varepsilon_{i,t+1} \), where \( g_{i,t} \) is the log of government consumption of output from two-digit sector or firm \( i \) in quarter \( t \). The figure shows the distribution of the correlation coefficients of the residuals for all sector or firm pairs.
C.3 Procurement and Bidding

Table A.14: Competition and Bidding Summary Statistics (2001-2021)

<table>
<thead>
<tr>
<th>Extent Competed</th>
<th>Share of Contracts (Wtd)</th>
<th>Mean (Wtd.)</th>
<th>Median (Wtd.)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Defense Contracts</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fully Competed</td>
<td>0.75 (0.44)</td>
<td>9.4 (5)</td>
<td>3 (3)</td>
</tr>
<tr>
<td>Partially Competed</td>
<td>0.1 (0.1)</td>
<td>6.1 (6.4)</td>
<td>3 (3)</td>
</tr>
<tr>
<td>Not Competed</td>
<td>0.15 (0.46)</td>
<td>1.1 (1)</td>
<td>1 (1)</td>
</tr>
<tr>
<td><strong>Non-Defense Contracts</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fully Competed</td>
<td>0.55 (0.75)</td>
<td>5.3 (5.4)</td>
<td>2 (2)</td>
</tr>
<tr>
<td>Partially Competed</td>
<td>0.06 (0.09)</td>
<td>9.8 (9)</td>
<td>3 (4)</td>
</tr>
<tr>
<td>Not Competed</td>
<td>0.39 (0.17)</td>
<td>1.1 (2.4)</td>
<td>1 (1)</td>
</tr>
</tbody>
</table>

Notes. This table shows summary statistics of defense (top) and non-defense (bottom) contracts characterized by the extent that they were competed. For this exercise, we exclude contracts where the number of offers received is coded as 999 (less than 2 percent of the value of the contracts). Values in parentheses are weighted by contract value.
C.4 Durations

Figure A.15: Distribution of Contract and Firm Duration

(a) Defense Contract Duration

(b) Non-Defense Contract Duration

(c) Defense Firm Tenure

(d) Non-Defense Firm Tenure

Notes. The figures above show the unweighted and weighted empirical CDFs of contract duration (top panel) and firm duration (bottom panel) for defense (left) and non-defense (right) contracts. In the weighted figures, weights are given by the total value of the contract in the left panel and the total value of obligations the firm receives in the right panel. Vertical dashed lines in the top panels represent the one- and two-year marks.
C.5 Sectoral Bias

Figure A.16: Frequency of Price Adjustment: Defense and Non-Defense

(a) Defense Spending

(b) Non-Defense Spending

Notes. The figures above show the average annual share of government defense (left) and non-defense (right) spending in each two-digit sector, plotted against the frequency of price changes for private consumption in these sectors, based on BLS data and USASpending.gov data. The size of the circles emphasizes the average sectoral share of annual aggregate spending (also shown on the x-axis).
C.6 Additional Results

C.6.1 Variance Decompositions

Figures A.17 and A.18 show decompositions of the variance of federal purchases into “within” firm/sector and “across” firm/sector variation.

Figure A.17: Variance Decomposition: Within and Across Firms (Defense and Non-Defense)

(a) Full Data (Defense)  (b) Top 20% (Defense)  (c) Bottom 80% (Defense)

(d) Full Data (Non-Defense)  (e) Top 20% (Non-Defense)  (f) Bottom 80% (Non-Defense)

Notes. This figure shows a decomposition of the variance of federal purchases into “within-firm” and “across-firm” variation. Specifically, total variation is given by:

\[ \sum \sum (g_{c,f,t} - \bar{g}_c)^2 = \sum \sum (g_{c,f,t} - \bar{g}_{f,t})^2 + \sum \sum (\bar{g}_{f,t} - \bar{g})^2, \]

where \( c \) 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 firms, and panel (c) shows only the bottom 80 percent of firms.
Figure A.18: Variance Decomposition: Within and Across Sectors (Defense and Non-Defense)

Notes. This figure shows a decomposition of the variance of federal purchases into “within-sector” and “across-sector” variation. Specifically, total variation is given by:

$$\sum_s \sum_f (g_{fs,t} - \bar{g}_t)^2 = \sum_s \sum_f (g_{fs,t} - \bar{g}_{s,t})^2 + \sum_s \sum_f (\bar{g}_{s,t} - \bar{g}_t)^2,$$

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.
### C.6.2 Sectoral Share of Government Consumption vs Share of GDP

Table A.15: Percent of DOD and Non-DOD Consumption versus Percent of GDP

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

Notes. 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 federal purchases across sectors varies from the allocation of private consumption across sectors.
C.6.3 Federal Purchases Well-Approximated by a Log-Normal Distribution

Figure A.19: Q-Q Plot: Actual vs. Log-Normal

(a) DOD Contracts  (b) DOD Firms  (c) DOD Sectors

(d) Non-DOD Contracts  (e) Non-DOD Firms  (f) Non-DOD Sectors

Notes. 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. The top (bottom) row shows the plots for defense (non-defense) contracts, firms, and sectors from left to right. 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. Data represent a single annual cross section from the year 2012, but patterns are robust in any year of the sample.
C.6.4 Concentration of Purchases Among Few Firms and Sectors

Figure A.20: Share of Obligations by Top Firms and Sectors

(a) Firms (DOD)  (b) NAICS 6 (DOD)  (c) NAICS 2 (DOD)
(d) Firms (Non-DOD)  (e) NAICS 6 (Non-DOD)  (f) NAICS 2 (Non-DOD)

Notes. 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). The top row shows the breakdown for defense purchases and the bottom row for non-defense purchases.
D Baseline model

In this section we describe the two-sector version of the New Keynesian model. The model is largely standard but it differs from earlier work in the way government spending is modelled: a) we allow for variation at the firm level and b) we do not make any assumptions on how government purchases are prices. In this way, we make the model consistent with the facts we establish in the main text.

We first describe the model setup, discuss aggregation and the steady state, and present a linearized version of the equilibrium conditions. Section D.4 presents the proofs for the results in Section 4.1 of the main text.

D.1 Setup

In what follows, we outline the behavior of households, firms, and the government. A representative household chooses consumption and labor in order to solve an infinite horizon problem subject to a period budget constraint:

\[
\max_{\{C_{1,t}, C_{2,t}, L_{1,t}, L_{2,t}\}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left( \ln \left( \frac{C_{1,t}^{1-\omega} C_{2,t}^{\omega}}{\omega (1-\omega)} \right) - \xi_1 \frac{L_{1,t}^{1+\varphi}}{1+\varphi} - \xi_2 \frac{L_{2,t}^{1+\varphi}}{1+\varphi} \right), \quad (D.1.1)
\]

s.t. \[ W_{1,t} L_{1,t} + W_{2,t} L_{2,t} + \Gamma_t + I_{t-1} B_{t-1} = B_t + P_{1,t} C_{1,t} + P_{2,t} C_{2,t} + T_t. \]

Here \( \beta \in (0, 1) \) is the time-discount factor, \( \omega \in (0, 1) \) measures sector 1’s weight in steady-state consumption, and \( \varphi \geq 0 \) is the inverse Frisch elasticity of labor supply. \( C_{k,t} \) denotes private consumption of sector-k goods, with \( k = \{1, 2\} \), respectively. \( L_{k,t} \) and \( W_{k,t} \) are labor employed and wages paid in sector \( k \). The labor market is sectorally segmented. We set \( \xi_k \) to ensure symmetric firms in steady state (sectors can differ). Households own firms and receive profits, \( \Gamma_t \), as dividends. Bonds, \( B_{t-1} \), pay a nominal gross interest rate of \( I_{t-1} \) and Ponzi schemes are ruled out. \( P_{k,t} \) is the sectoral price level relevant for the household. \( T_t \) are lump-sum taxes.

The optimal allocation of consumption expenditures across sectors requires \( C_{1,t} = \omega \left( \frac{P_{1,t}^C}{P_{1,t}^C P_{2,t}^C} \right) C_t \) and \( C_{2,t} = (1-\omega) \left( \frac{P_{1,t}^C}{P_{2,t}^C} \right) C_t \), where \( P_{1,t}^C = P_{1,t}^C P_{2,t}^{1-\omega} \) is the consumer price index (CPI). The consumption bundles in each sector, in turn, are defined as aggregates of differentiated goods, indexed by \( j \in [0, n] \) for sector 1 and \( j \in (n, 1] \) for sector 2:

\[
C_{1,t} = \left\{ n^{-\frac{1}{p}} \int_0^n \left[ \frac{C_t(j)^{\frac{p-1}{p}} dJ}{\pi} \right] \right\}^\frac{p}{p-1}, \quad C_{2,t} = \left\{ (1-n)^{-\frac{1}{p}} \int_n^1 \left[ \frac{C_t(j)^{\frac{p-1}{p}} dJ}{\pi} \right] \right\}^\frac{p}{p-1}. \quad (D.1.2)
\]
Letting $P_t(j)$ denote the price which the household pays for good $j$, cost minimization implies the demand functions for sector-1 and sector-2 goods, respectively:

$$C_{1,t}(j) = \frac{1}{n} \left( \frac{P_{1,t}(j)}{P_{1,t}} \right)^{-\theta} C_{1,t}$$

and

$$C_{2,t}(j) = \frac{1}{1-n} \left( \frac{P_{2,t}(j)}{P_{2,t}} \right)^{-\theta} C_{2,t},$$

with $P_{1,t} = \left[ \frac{1}{n} \int_0^n [P_t(j)]^{1-\theta} dj \right]^{\frac{1}{1-\theta}}$ and $P_{2,t} = \left[ \frac{1}{1-n} \int_0^1 [P_t(j)]^{1-\theta} dj \right]^{\frac{1}{1-\theta}}$. Finally, the household first-order conditions determine labor supply and define the Euler equation:

$$W_{k,t} \frac{P_t}{C_t} = \xi_k L_{k,t} C_t$$

for $k = \{1, 2\}, \ 1 = \mathbb{E}_t \left[ \beta \left( \frac{C_{t+1}}{C_t} \right)^{-1} H_t \frac{P_t^C}{P_{t+1}^C} \right]. \quad \text{(D.1.3)}$$

Firms employ a production technology which is linear in labor: $Y_t(j) = L_t(j)$. They are constrained in their ability to set prices. With probability $\alpha_k$, which may differ across sectors, a firm may not adjust its price in the next period. The problem of firm $j$ in sector $k$ is to set a price for the household while maximizing expected profits:

$$\max_{P_t(j)} \mathbb{E}_t \sum_{s=0}^{\infty} Q_{t,t+s} \alpha_k^s [P_t(j) C_{t+s}(j) - W_{k,t+s} Y_{t+s}(j)], \quad \text{(D.1.4)}$$

where $Q_{t,t+s}$ is the stochastic discount factor. We assume that firms adjust production to satisfy consumption demand at posted prices and as well government spending, $G_t(j)$, at all times:

$$Y_t(j) = C_t(j) + G_t(j). \quad \text{(D.1.5)}$$

We now turn to the government which runs monetary policy and determines spending and taxes. For monetary policy we assume that it adjusts short term interest rates to stabilize consumer price inflation, $\Pi_t = \frac{P_t^C}{P_{t-1}^C} = 0$, see Svensson (2003). Regarding government spending, we take a bottom-up perspective and assume that government spending is determined exogenously at the firm level, consistent with the granular nature of government spending. Spending at the sector level, in turn, is—for any distribution of spending across firms within a sector—given by:

$$G_{1,t} = \int_0^n G_t(j) dj \quad \text{and} \quad G_{2,t} = \int_1^n G_t(j) dj. \quad \text{(D.1.6)}$$

The model can be deliberately agnostic about the variation in firm-level government spending and concentrates on sectoral variation because of two assumptions. First, labor is perfectly

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4 The CPI inflation target facilitates the algebra and allows us to better isolate the channel this paper focuses on. In addition, it also corresponds to the measure of inflation most central banks focus on. In our model simulations we also report results for interest-rate rules (rather than strict inflation targeting).
mobile within but immobile across sectors. Changing government spending at the firm level thus affects the wage of all firms in the sector. Second, also the frequency of consumer-prices changes is the same for all firms in a sector. In what follows we thus focus on exogenous variations in $G_{1,t}$ and $G_{2,t}$ and do not take a stand on the variation across the firms within a sector.

In our baseline analysis, we assume balanced government budget. Letting $P_{t}^G(j)$ denote the price that a generic firm $j$ charges to the government, we thus have for lump-sum taxes:

$$T_t = \int_0^1 P_t^G(j) G_t(j) dj.$$  \hfill (D.1.7)

In our setup, the prices charged to the government are not allocative because spending is determined exogenously. In addition, because the central bank targets consumer price inflation and taxes are lump-sum, the prices charged to the government are irrelevant for the equilibrium allocation. To see this, note that aggregate profits are given by $\Gamma_t = \int_0^1 [P_t(j) C_t(j) + P_t^G(j) G_t(j) - W_t Y_t(j)] dj$. Thus, procurement prices enter firm profits and the tax bill, given by equation (D.1.7), in the same way and do not appear in the household’s budget constraint stated above. Intuitively, a firm may “overcharge” the government and earn an extra profit which is then paid out to the household via dividends. Yet these dividends are eventually funded by the same household’s tax bill. Because government prices are irrelevant for the allocation, we remain agnostic about how they are determined. In particular, we do not assume that they are necessarily subject to the stickiness which characterizes consumer prices—consistent with the notion that public procurement is subject to a bidding process.

In our analysis below, we rely on a first-order approximation of the equilibrium conditions of the model around a symmetric, zero-inflation steady state. We provide details of the linearized equilibrium conditions in the Online Appendix D.3. For this purpose we may rely on the following definition of aggregate output: $Y_t = \int_0^1 Y_t(j) dj$ which, up to first order, is consistent with the definition of the household’s consumption basket. The size of sectors in steady state will generally be different than their share in consumption because of sectoral bias. Specifically, we use $\gamma$ to denote the fraction of sector-1 government spending in steady state: $\gamma \equiv G_1/(G_1 + G_2)$. Here, and in what follows, letters without time-subscript refer to steady-state values. Small-case letters, in turn, denote the percentage deviation from steady state. We use $\zeta$ to measure the steady-state ratio of household consumption to output: $\zeta \equiv C/Y$. Then, we have $1 - \zeta = (G_1 + G_2)/Y$ and the size of sector 1 in steady state is given by $n = \omega \zeta + \gamma(1 - \zeta)$. 

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D.2 Aggregation and steady state

We first aggregate goods markets at the firm level, given by eq. (D.1.5) in the main text, in accordance with the definition of output given above:

\[ Y_t = \int_0^1 Y_t(j) dj = \int_0^1 \left[ C_t(j) + G_t(j) \right] dj = \int_0^1 C_t(j) dj + G_{1,t} + G_{2,t}, \tag{D.2.1} \]

where the last equality use the definition (D.1.6) for sectoral government spending given in the main text. Substituting for \( C_t(j) \) using the demand functions for varieties gives

\[ Y_t = C_1, t \int_0^n \left[ \left( \frac{P_t(j)}{P_{1t}} \right)^{-\theta} \right] dj + C_2, t \int_0^n \left[ \left( \frac{P_t(j)}{P_{2t}} \right)^{-\theta} \right] dj + G_{1,t} + G_{2,t}. \tag{D.2.2} \]

We define sectoral outputs accordingly

\[ Y_{1t} = C_{1,t} \int_0^n \left[ \left( \frac{P_t(j)}{P_{1t}} \right)^{-\theta} \right] dj + G_{1,t}, \tag{D.2.3} \]

\[ Y_{2t} = C_{2,t} \int_0^n \left[ \left( \frac{P_t(j)}{P_{2t}} \right)^{-\theta} \right] dj + G_{2,t}. \tag{D.2.4} \]

We consider a symmetric steady state at the firm level where relative prices are unity and inflation is zero. The size of sectors will generally differ in the steady state. Below we establish conditions for the existence of a symmetric steady state across firms in which the following holds:

\[ W_k = W, \quad P_{jk} = P \quad \text{for all} \ j, k \tag{D.2.5} \]

Symmetry in (private markets) prices across all firms implies

\[ P = P^k = P^C \tag{D.2.6} \]

such that sectoral allocation of consumption is given by

\[ C_1 = \omega C, C_2 = (1 - \omega)C. \tag{D.2.7} \]

Equation (D.2.2) implies for steady-state output

\[ Y = C_1 + C_2 + G_1 + G_2 = C + G_1 + G_2 \tag{D.2.8} \]
We define total government demand in steady state as

\[ G \equiv G_1 + G_2 \]  
(D.2.9)

and the sectoral shares of public spending as follows

\[ \gamma \equiv \frac{G_1}{G} \quad \text{and} \quad 1 - \gamma = \frac{G_2}{G}. \]  
(D.2.10)

Regarding the size of the sectors, we have \( Y_1 = C_1 + G_1 \) and \( Y_2 = C_2 + G_2 \) and define \( n = \frac{Y_1}{Y} \) and \( 1 - n = \frac{Y_2}{Y} \). Symmetry among firms within sectors implies \( L_1 = nL \) and \( L_2 = (1 - n)L \).

Last define the share of private and public consumption in GDP as follows

\[ \zeta = \frac{C}{Y} \quad \text{and} \quad 1 - \zeta = \frac{G}{Y}. \]  
(D.2.11)

We thus write the following restriction

\[
\begin{align*}
n &= \frac{Y_1}{Y} = \frac{\omega C + \gamma G}{Y} = \omega \zeta + \gamma (1 - \zeta) \\
1 - n &= \frac{Y_2}{Y} = \frac{(1 - \omega)C + (1 - \gamma)G}{Y} = (1 - \omega)\zeta + (1 - \gamma)(1 - \zeta)
\end{align*}
\]

The steady-state labor supply from equation (D.1.3) is

\[
\frac{W_k}{P} = \xi_1 (nL)\bar{\epsilon}C = \xi_2 ((1 - n)L)\bar{\epsilon}C
\]  
(D.2.12)

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

\[
\frac{W}{P} = L^{\bar{\epsilon}}C.
\]  
(D.2.13)

Substituting for taxes in the households’ budget constraint gives

\[ CP + P_1^G G_1 + P_2^G G_2 = WL + \Gamma \]  
(D.2.14)

where we keep for now the assumption that prices paid by the government are exogenous and
do not need to coincide with those paid by households. With some algebra,
\[
\Gamma = PY - WL + \left( P_G^1 - P_1 \right) G_1 + \left( P_G^2 - P_2 \right) G_2 \tag{D.2.15}
\]
which together with \( Y = L \) and the optimal pricing rule for private transactions,
\[
P = \frac{\theta}{\theta - 1} W \tag{D.2.16}
\]
implies
\[
\frac{\Gamma}{P} = \frac{1}{\theta} Y + \frac{P_G^1 - P_1}{P} G_1 + \frac{P_G^2 - P_2}{P} G_2 \tag{D.2.17}
\]
showing that the gap of prices paid by the government relative to private transactions only affect firms’ profits, which in turn cancel out with taxation in households’ budget constraints. In case the price price gap is zero in steady state we have: \( \frac{\Gamma}{P} = \frac{1}{\theta} Y \).

### D.3 Linear approximations

Because the price dispersion terms in (D.2.2) and (D.2.3) is zero up to first order, see Galí (2015), we have

\[
y_t = \omega \zeta c_{1t} + (1 - \omega) \zeta c_{2t} + \gamma (1 - \zeta) g_{1t} + (1 - \gamma)(1 - \zeta) g_{2t}
\]

\[
n y_{1t} = \omega \zeta c_{1t} + \gamma (1 - \zeta) g_{1t}
\]

\[
(1 - n) y_{1t} = (1 - \omega) \zeta c_{2t} + (1 - \gamma)(1 - \zeta) g_{2t}
\]

Linearing sectoral consumption demand and substituting gives

\[
y_t = n y_{1,t} + (1 - n) y_{2,t} \tag{D.3.1}
\]

\[
n y_{1,t} = -\omega \zeta (1 - \omega) \tau_t + \omega \zeta c_t + (1 - \zeta) g_{1,t} \tag{D.3.2}
\]

\[
(1 - n) y_{2,t} = (1 - \omega) \zeta \omega \tau_t + (1 - \omega) \zeta c_t + (1 - \zeta)(1 - \gamma) g_{2,t} \tag{D.3.3}
\]

where the terms of trade is \( \tau_t = p_{1,t} - p_{2,t} \) such that \( p_{1,t} - p_{1}^G = (1 - \omega) \tau_t \).
The New Keynesian Phillips curves in each sector are given by (see below for a derivation):

$$\alpha_1 \pi_{1,t} = \alpha_1 \beta E_t \pi_{1,t+1} + (1 - \alpha_1)(1 - \beta \alpha_1) \psi_{1t}$$  \hspace{1cm} (D.3.4)

$$\alpha_2 \pi_{2,t} = \alpha_2 \beta E_t \pi_{2,t+1} + (1 - \alpha_2)(1 - \beta \alpha_2) \psi_{2t}$$  \hspace{1cm} (D.3.5)

where $\psi_{kt}$ is the real product wage (wage deflated with the producer price in each sector). After substituting for labor in the labor supply equation we have:

$$\psi_{1t} = c_t + \varphi y_{1,t} - (1 - \omega) \tau_t$$  \hspace{1cm} (D.3.6)

$$\psi_{2t} = c_t + \varphi y_{2,t} + \omega \tau_t.$$  \hspace{1cm} (D.3.7)

An approximation of the Euler equation yields:

$$c_t = E_t c_{t+1} - (i_t - E_t \pi_{ct+1})$$  \hspace{1cm} (D.3.8)

$$\pi_t = \omega \pi_{1,t} + (1 - \omega) \pi_{2,t},$$  \hspace{1cm} (D.3.9)

where the second equation is consumer price inflation. Monetary policy, in turn, implies:

$$\pi_t = 0.$$  \hspace{1cm} (D.3.10)

We assume an exogenous AR(1) process for government spending in both sectors:

$$g_{1,t} = \rho g_{1,t-1} + \varepsilon_{1,t}$$  \hspace{1cm} (D.3.11)

$$g_{2,t} = \rho g_{2,t-1} + \varepsilon_{2,t},$$  \hspace{1cm} (D.3.12)

where $\varepsilon_{k,t}$ are sector-specific spending shocks with mean zero and parameters $\rho_k \in [0, 1)$ capture the persistence of the spending processes. We use equations (D.3.1) to (D.3.12) to pin down the equilibrium dynamics and to solve the model up to first order.

**Linearization of Phillips Curves.** The first order condition of the firm’s price setting problem is given by

$$\mathbb{E}_t \sum_{s=0}^{\infty} Q_{t,t+s} \alpha_k^2 Y_{t+s}(j) [P_{kt}^* - \mathcal{M}W_{kt+s}] = 0,$$  \hspace{1cm} (D.3.13)
\( M \equiv \theta \frac{\theta}{\theta - 1} \) denotes the desired markup. To derive the NKPC, we rewrite the first order condition (D.3.13) as follows

\[
\sum_{\tau=0}^{\infty} Q_{t,t+\tau} \alpha_k^{-1} P_{kt}^* C_{t+\tau}(j) = \sum_{\tau=0}^{\infty} Q_{t,t+\tau} \alpha_k^{-1} C_{t+\tau}(j) \frac{W_{kt+t} P_{kt}}{P_{kt}} \tag{D.3.14}
\]

Note that here we divide both sides with the sectoral price level (private transactions only).

Linearizing around the symmetric steady state gives

\[
\sum_{\tau=0}^{\infty} (\beta \alpha_k)^{\tau} [p_{kt}^* - p_{kt} + c_{t+\tau}(j)] = \sum_{\tau=0}^{\infty} (\beta \alpha_k)^{\tau} [c_{t+\tau}(j) + \psi_{kt+t} + p_{kt+t} - p_{kt}] \tag{D.3.15}
\]

here \( \psi_{kt+t} \) is the real product wage (wage deflated with \( P_{kt} \)). Rewriting

\[
\frac{1}{1 - \alpha_k \beta} [p_{kt}^* - p_{kt}] = \sum_{\tau=0}^{\infty} (\beta \alpha_k)^{\tau} \left[ \psi_{kt+t} + \sum_{l=0}^{\tau-1} \pi_{k,t+1+l} \pi_{k,t+1+l} \right] \tag{D.3.16}
\]

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

\[
[p_{kt}^* - p_{kt}] = (1 - \alpha_k \beta) \sum_{\tau=0}^{\infty} (\beta \alpha_k)^{\tau} \psi_{kt+t} + \alpha_k \beta \sum_{\tau=0}^{\infty} \pi_{kt+1+\tau} \tag{D.3.17}
\]

Writing this in difference form

\[
[p_{kt}^* - p_{kt}] = \beta \alpha_k \left[ p_{kt+1}^* - p_{kt+1} \right] + (1 - \beta \alpha_k) \psi_{kt} + \alpha_k \beta \pi_{kt+1} \tag{D.3.18}
\]

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

\[
\pi_{kt} = \beta \pi_{kt+1} + \frac{(1 - \alpha_k)(1 - \beta \alpha_k)}{\alpha_k} \psi_{kt} \tag{D.3.19}
\]

**D.4 Proofs of Propositions**

**D.4.1 Proposition 1**

Inflation targeting implies \( \pi_t = \omega \pi_{1,t} + (1 - \omega) \pi_{2,t} = 0 \). This equation allows us to rewrite the Phillips curve in sector 2 (equation (D.3.5)) as:

\[
\omega(\tau_t - \tau_{t-1}) = \omega \beta (E_t(\tau_{t+1} - \tau_t)) - \kappa_2 \psi_{2t}, \tag{D.4.1}
\]
where $\kappa_2 \equiv \frac{(1-\alpha_2)(1-\beta_2)}{\alpha_2}$.

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

$$\psi_{2t} = \left(1 + \frac{\zeta \varphi (1 - \omega)}{1 - n}\right) c_t + \left(1 + \frac{\zeta \varphi (1 - \omega)}{1 - n}\right) \omega \tau_t + (1 - \zeta)(1 - \gamma) \frac{\varphi}{1 - n} g_{2t}. \quad (D.4.2)$$

We use the market clearing condition in equation (D.3.3) to substitute for output in equation (D.3.7). 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:

$$c_t = (1 - \omega) \tau_t - \left(1 + \frac{\zeta \varphi \omega}{n}\right)^{-1} (1 - \zeta) \tau_t \frac{\varphi}{n} g_{1t}. \quad (D.4.3)$$

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 (D.4.3) for given terms of trade.

Using equation (D.4.3) in equation (D.4.2) and substituting in equation (D.4.1) we obtain a second-order difference equation in the terms of trade:

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

where $\kappa \equiv \frac{\kappa_2}{\omega}$, $A_1 = 1 + \frac{\zeta \varphi \omega}{n}$ and $A_2 = 1 + \frac{\zeta \varphi (1 - \omega)}{1 - n}$. We solve this equation to obtain a solution for the terms of trade in government spending. Substituting in the solution (4.1) yields the conditions for the unknown coefficients:

$$\beta \Lambda_0^2 - \{ (1 + \beta) + \kappa [A_2] \} \Lambda_0 + 1 = 0$$

$$\{ (1 + \beta) + \kappa A_2 \} \Lambda_1 = \beta \Lambda_0 A_1 + \beta \Lambda_1 \rho + \kappa \frac{A_2}{A_1} \frac{\varphi}{n}$$

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

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Let

\[ f(x) = \beta x^2 - \{1 + \beta + \kappa A_2\} x + 1. \] (D.4.4)

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

\[ f(1) = \beta - [(1 + \beta) + \kappa A_2] + 1 = -\kappa A_2 < 0 \] (D.4.5)

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 \( \Lambda_0 \) is decreasing in \( \kappa \left(1 + \frac{\zeta \varphi (1-\omega)}{1-n}\right) \).

Next we need to solve for \( \Lambda_1 \) and \( \Lambda_2 \). Then, we plug the results into the system and solve directly:

\[ \Lambda_1 = \frac{\frac{\kappa A_2 \varphi}{\Lambda_1 n}}{\{(1 + \beta) + \kappa A_2\} - \beta(\Lambda_0 + \rho)} \geq 0 \] (D.4.6)

such that the denominator of \( \Lambda_1 \) is positive since \( \beta(\Lambda_0 + \rho) < 2\beta < 1 + \beta \).

Similarly

\[ \Lambda_2 = \frac{\kappa \varphi}{\{(1 + \beta) + \kappa A_2\} - \beta(\Lambda_0 + \rho)} \geq 0 \] (D.4.7)

**D.4.2 Proposition 2**

We now substitute in expression (D.4.3) for the terms of trade using equation (4.1) to obtain our second result. Government spending crowds out private consumption—independently of the sector in which spending occurs.

**Solution for consumption.** Recall that \( c_t \) can be written as

\[ c_t = (1 - \omega)\tau_t - \left(1 + \frac{\zeta \varphi \omega}{n}\right)^{-1} (1 - \zeta) \gamma \frac{\varphi}{n} g_{1t} \] (D.4.8)

Plugging in for \( \tau_t \) as derived from Proposition 1

\[ c_t = (1 - \omega)\Lambda_0 \tau_{t-1} + (1 - \omega)(1 - \zeta)[\Lambda_1 \gamma g_{1,t} - \Lambda_2 (1 - \gamma) g_{2,t}] - \left(1 + \frac{\zeta \varphi \omega}{n}\right)^{-1} (1 - \zeta) \gamma \frac{\varphi}{n} g_{1t} \] (D.4.9)
Combining (D.4.9) with the expression for \( b \) and \( c \) in (D.4.6) and (D.4.7) yields
\[
c_t = (1 - \omega) \Lambda_0 \tau_{t-1} + \frac{1 - \zeta}{\zeta} \left[ \frac{\kappa(1 - \omega)(\frac{A_2}{A_1} \frac{n}{\Lambda_0} \gamma g_1 - \frac{A_2}{A_1} (1 - \gamma) g_2)}{(1 + \beta) + \kappa A_2} - \beta(\Lambda_0 + \rho) \right]^{-1} \gamma \frac{\varphi}{n} g_1
\]
(D.4.10)

Let
\[
c_t = \Theta_0 \tau_{t-1} - \Theta_1 (1 - \zeta) \gamma g_{1t} - \Theta_2 (1 - \zeta) (1 - \gamma) g_{2t}
\]
(D.4.11)

Thus, the lag coefficient on the previous period’s terms of trade \( \tau_{t-1} \) is
\[
\Theta_0 = (1 - \omega) \Lambda_0
\]
(D.4.12)

where \( \Lambda_0 \in (0, 1) \) is the root of equation (D.4.4). Thus \( \Theta_0 \in (0, 1) \) as well.

In turn, \( \Theta_1 \) solves
\[
\Theta_1 = \frac{\varphi}{A_1 n} - (1 - \omega) \Lambda_1 = \frac{\varphi}{A_1 n} - (1 - \omega) \frac{\kappa A_2 \varphi}{(1 + \beta) + \kappa A_2} - \beta(\Lambda_0 + \rho)
\]
(D.4.13)

and the multiplier for consumption in sector 2, \( \Theta_2 \), is:
\[
\Theta_2 = (1 - \omega) \Lambda_2 = \frac{(1 - \omega) \frac{A_2}{A_1} \frac{n}{\Lambda_0} \gamma}{(1 + \beta) + \kappa A_2 - \beta(\Lambda_0 + \rho)}
\]
(D.4.14)

and
\[
\Theta_2 = (1 - \omega) \Lambda_2 = \frac{(1 - \omega) \frac{A_2}{A_1} \frac{n}{\Lambda_0} \gamma}{(1 + \beta) + \kappa A_2 - \beta(\Lambda_0 + \rho)}
\]
(D.4.15)

From equations (D.4.14) and (D.4.15), it is immediate that \( \Theta_1 \geq 0 \) and \( \Theta_2 \geq 0 \).

**Properties of \( \Theta_1 \) and \( \Theta_2 \).** Manipulating the solutions of \( \Theta_1 \) and \( \Theta_2 \), we obtain
\[
\Theta_1 = \frac{\varphi[(1 + \beta) + \kappa_2 A_2 - \beta(\Lambda_0 + \rho)]}{(n - \varphi) \omega [ \omega((1 + \beta) - \beta(\Lambda_0 + \rho)) + \kappa_2 A_2]}
\]
(D.4.16)

and
\[
\Theta_2 = \frac{\kappa_2 \varphi}{\kappa_2(1 - n) + \zeta \varphi + \frac{1 - n}{1 - \omega} \omega \omega((1 + \beta) - \beta(\Lambda_0 + \rho))}
\]
(D.4.17)

From these expressions it follows that \( \partial \Theta_1 / \partial \alpha_2 > 0 \) and \( \partial \Theta_2 / \partial \alpha_2 < 0 \). In addition, when \( \omega = \gamma = 0 \) or when \( \omega = \zeta = 0 \), then \( n = \omega \). Thus, if we first set \( n = \omega \) in (D.4.16) and (D.4.17), then \( \Theta_1 \to \infty \) when \( \alpha_2 \to 1 \). In turn, when \( \gamma \to 1 \) and \( \zeta \to 1 \), then \( n \to 1 \) with \( \omega \in [0, 1) \), so
Finally, we get
\[
\frac{\Theta_1}{\Theta_2} = \frac{(1 - n)\omega A_2}{n(1 - \omega)A_1} + \frac{[1 + \beta - \beta(\Lambda_0 + \rho)](1 - n)\omega}{\kappa_2 A_1 (1 - \omega) n}
\]
such that the ratio \( \frac{\Theta_1}{\Theta_2} \) is increasing in \( \omega - \gamma \).

**D.4.3 Proposition 3**

From the definition of output
\[
y_{t} = ny_{1,t} + (1 - n)y_{2,t}
\]
\[
= \zeta c_t + (1 - \zeta) \gamma g_{1,t} + (1 - \zeta) (1 - \gamma) g_{2,t}
\]
\[
= \zeta [\Theta_0 \tau_{t-1} - \Theta_1 (1 - \zeta) \gamma g_{1,t} - \Theta_2 (1 - \zeta) (1 - \gamma) g_{2,t}] + (1 - \zeta) \gamma g_{1,t} + (1 - \zeta) (1 - \gamma) g_{2,t}
\]
\[
= \zeta \Theta_0 \tau_{t-1} + (1 - \zeta \Theta_1) (1 - \zeta) \gamma g_{1,t} + (1 - \zeta \Theta_2) (1 - \zeta) (1 - \gamma) g_{2,t}.
\]

Therefore, \( y_t \) can be written as
\[
y_t = \Gamma_0 \tau_{t-1} - \Gamma_1 (1 - \zeta) \gamma g_{1,t} - \Gamma_2 (1 - \zeta) (1 - \gamma) g_{2,t}.
\]

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 \( \Gamma_1 \) and \( \Gamma_2 \) of sector 1 and sector 2 government spending, respectively. Using equations (D.4.14) and (D.4.15) gives
\[
\Gamma_1 = 1 - \zeta \cdot \frac{\varphi}{1 + \frac{\zeta \varphi \omega}{n}} \frac{(1 + \beta) + \omega \kappa A_2 - \beta(\Lambda_0 + \rho)}{\kappa_2 A_1 (1 - \omega) n}. \tag{D.4.19}
\]

To show that the support of \( \Gamma_1 \) \((-\infty, 1]\), simply note that \( \Theta_1 \) 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
\[
\Gamma_2 = 1 - \zeta \cdot \frac{(1 - \omega)\kappa \varphi}{1 + \frac{\zeta \varphi (1 - \omega)}{1 - n}} \frac{(1 + \beta) + \kappa (1 + \frac{\zeta \varphi (1 - \omega)}{1 - n}) - \beta(\Lambda_0 + \rho)}{\kappa_2 A_1 (1 - \omega) n}. \tag{D.4.20}
\]

Recall that \( \Theta_2 \) has support between \([0, \zeta^{-1})\), and thus \( \Gamma_2 = 1 - \zeta \Theta_2 \) has support \((0, 1]\).
D.5 Fiscal multipliers, Calvo gaps, and sectoral bias

This section illustrates the way that (a) pricing frictions and (b) sectoral bias impact fiscal transmission. The following results are referenced in Section 4.1 in the main text. The calibration of the model is as explained in Section 4.2 in the main text, unless noted otherwise.

We first vary the heterogeneity of pricing frictions across sectors. We start from a symmetric baseline for which we set $\alpha_1 = \alpha_2 = 0.75$ and then consider an increasingly larger “Calvo gap”: we keep the average Calvo parameter constant at 0.75 while lowering $\alpha_1$ gradually to 0.5 and simultaneously raising $\alpha_2$ to 1. Otherwise the model is assumed perfectly symmetric in order to focus on pricing frictions. The top panels of Figure A.21 plot the fiscal multiplier against the Calvo gap. In the left panel we display the impact multiplier on aggregate output, in the right panel the net present value multiplier as defined by Uhlig (2010) over a 6-month period.

Consider first the impact multiplier (upper-left panel). In this case the multiplier of a sector-2 shock (red dashed line) increases in the Calvo gap. This reflects the mechanism discussed in Section 4.1 in the main text: As sector 2 becomes more sticky, the inflationary impact of increased government spending gets smaller, needing less monetary tightening, and, eventually, generating less crowding out. The effect of sector-1 shock (blue solid line), instead, changes non-monotonically in the Calvo gap. First, the impact multiplier declines, in line with the notion that as prices become more flexible, a stronger monetary response is called for. At some point, however, the impact multiplier of a sector-1 shock starts to rise again. This reflects that, as the Calvo gap increases, the response of the terms of trade becomes stronger. In the limit, sector-2 prices are completely unresponsive while sector-1 prices are fairly flexible. The terms of trade increase in response to a sector-1 shock, which, in turn, boosts aggregate consumption as discussed above (see Proposition 2 in Section 4.1). This effect starts to dominate for large Calvo gaps, so the impact multiplier increases. The terms of trade appreciation builds up over time, inducing a hump shaped output response in response to a sector-1 shock, shown Figure A.22. This effect also shows up once we turn to the present value multiplier in the right panel.

Because output increases gradually over time with the terms of trade, for large Calvo gaps the present value multiplier of a sector-1 shock exceeds the present value multiplier of sector-2 shocks. Lastly, we also compute and display the fiscal multiplier of a shock common to both sectors (black dashed line): It, too, increases in the Calvo gap—both the impact and the present value multiplier. Thus, for a given average degree of price rigidity, an aggregate shock has stronger effect the more heterogeneous pricing frictions are across sectors, as in Carvalho (2006)
Figure A.21: Fiscal Multipliers and Calvo Gaps

A. Impact multiplier

B. Present value multiplier

Notes. Fiscal multipliers for government spending shock originating in sector 1 (solid line) vs sector 2 (dashed line). Panel A shows impact multiplier, Panel B shows net present value multiplier for 6 months horizon computed as in Uhlig (2010). Shocks are normalized to be equal to one unit of steady state output. Top panels: Model symmetric but for difference in Calvo parameter. Horizontal axis varies “Calvo gap” across sectors from zero ($\alpha_1 = \alpha_2 = 0.75$) to 0.5 ($\alpha_1 = 0.5, \alpha_2 = 1$), keeping average Calvo parameter constant at 0.75. Bottom panels: Model symmetric with Calvo parameter equal to 0.83, except for $\gamma$ which we measure along the horizontal axis.

or Nakamura and Steinsson (2010). This result that multiplier varies in the relative stickiness across sectors is in line with the finding that the relative extent of frictions is key for aggregate dynamics in multi-sector economies (Barsky et al., 2007; Gilchrist et al., 2017).

When we explore the role of sectoral bias in an otherwise symmetric model, we find that it changes the multiplier only moderately. Results are shown in the bottom panels of Figure A.21. The output effects of a sector-1 (sector-2) shock become stronger (weaker), the more government spending is biased towards sector 1 (higher values of $\gamma$). Higher government spending is less
Figure A.22: Effects of Government Spending Shocks for alternative Calvo Gaps

**Sector-1 shock**

- Symmetric Calvo ($\alpha_1 = \alpha_2 = 0.84$)
- Intermediate gap ($\alpha_1 = 0.6, \alpha_2 = 0.9$)
- Max gap ($\alpha_1 = 0.5, \alpha_2 = 1$)

**Sector-2 shock**

- Symmetric Calvo ($\alpha_1 = \alpha_2 = 0.84$)
- Intermediate gap ($\alpha_1 = 0.6, \alpha_2 = 0.9$)
- Max gap ($\alpha_1 = 0.5, \alpha_2 = 1$)

**Notes.** Shock equals one percent of steady-state output in each scenario; horizontal axis: time in months, vertical axis: deviation from steady state.
consequential for consumer prices because the stronger the sectoral bias, the more is private consumption concentrated in the other sector. And because there is less inflationary pressure, monetary policy leans less against the fiscal impulse, hence the larger output effect.

D.6 Sectoral Markups

The markup response is another dimension along which our two-sector New-Keynesian model shows an improved performance relative to the one-sector model. The basic one-sector model predicts a markup decline in response to government spending shocks—a prediction at odds with evidence put forward by Nekarda and Ramey (2011, 2013, 2020). In the two sector model, we obtain a more nuanced picture. If the shock originates in sector 2, markups in sector 2 decline, but they increase in sector 1, which we show in the right column of Figure A.23, which is based on the same simulation as in Section 4.2 in the main text.

Intuitively, higher government spending in sector 2 pushes up marginal costs in sector 2, inducing a markup decline as prices adjust only sluggishly. But since the marginal utility of wealth declines, labor supply increases in both sectors, causing a drop in marginal costs in sector 1 and an increase of the markup. The drop in sector-2 markups is larger than the increase of sector-1 markups because of differential price stickiness (in our baseline model). Depending on where shocks originate, markups can be either pro-cyclical or counter-cyclical at the aggregate level depending on how sectors are aggregated. It is crucial to deviate from a one-sector model to arrive at these insights which help explain the common empirical difficulties to identify a clear sign in the measured markup responses, see, for instance, Born and Pfeifer (2021).
E A simplified version of the model

In this section we rely on a simplified variation of our baseline model, similar in spirit to that in Pasten et al. (2018), to provide intuition for our theoretical results in Section 4.1. The model is identical to that developed in Section D, with the exception of the pricing friction and the monetary policy setup. On the downside, this model is static, so it lacks dynamics and it can only speak about impact effects of shocks without front loading. On the upside, we can derive a full analytical solution with no need of the specific assumptions made in Section 4.1, so we can evaluate the robustness of results obtained there.

Setup. For an abridged exposition, we restrict attention to the log-linear approximation of aggregate dynamics. Sectoral demands given by (D.3.2) and (D.3.3) together with sectoral
labor supply yield

\begin{align*}
  w_{1,t} &= A_1 (c_t + p_{C,t}) + (1 - \zeta) \frac{\varphi}{n} g_{1,t} - \frac{\omega\zeta \varphi}{n} p_{1,t}, \\
  w_{2,t} &= A_2 (c_t + p_{C,t}) + (1 - \zeta) (1 - \gamma) \frac{\varphi}{1 - n} g_{2,t} - \frac{(1 - \omega) \zeta \varphi}{1 - n} p_{2,t}.
\end{align*}

Note that \( A_1 \equiv 1 + \frac{\zeta \omega \varphi}{n} \) and \( A_2 \equiv 1 + \frac{\zeta \varphi(1 - \omega)}{1 - n} \) capture effect of variation of private nominal aggregate demand on wages. In turn, to normalize sectoral government shocks by steady-state output, as we do in the main text, we must multiply \( g_{1,t} \) and \( g_{2,t} \) respectively by \( (1 - \zeta) \frac{\gamma}{n} \) and \( (1 - \zeta)(1 - \gamma) \frac{1}{1 - n} \). The magnitude of a sectoral government shock relative to the size of its labor market is respectively given by \( n^{-1} \) and \( (1 - n)^{-1} \) while the sectoral steady-state composition of aggregate private demand is respectively given by \( \omega \) and \( 1 - \omega \). Finally, how much variations in sectoral demand affect sectoral wages depends on the inverse-Frisch elasticity \( \varphi \).

Next, let sectoral prices be \( p_{kt} = (1 - \lambda_k) w_{kt} \) for \( k = 1, 2 \). This friction may be rationalized by three assumptions: (1) zero steady-state inflation, (2) i.i.d. shocks, and (3) firms with fully flexible prices but with sector-specific probability \( \lambda_1 \) and \( \lambda_2 \) to observe the realization of shocks only after setting prices. Firms which observe shocks set their price equal to a constant markup over marginal costs while firms which cannot observe shocks set steady-state prices. Thus, deviations of sectoral prices from steady-state depend on \( \lambda_1 \) and \( \lambda_2 \), respectively.

Under these assumptions and using the expression for sectoral wages obtained above, the aggregate consumption price \( p_{C,t} \), also interpreted as the private demand aggregate price, is

\[ p_{C,t} = (1 - \bar{L})^{-1} \left[ \bar{L}c_t + \omega (1 - \zeta) \frac{\varphi}{n} L_1 g_{1,t} + (1 - \omega)(1 - \zeta)(1 - \gamma) \frac{\varphi}{1 - n} L_2 g_{2,t} \right] \]

where \( \bar{L} \equiv \omega L_1 A_1 + (1 - \omega) L_2 A_2 \), \( L_1 \equiv \frac{1 - \lambda_1}{1 + (1 - \lambda_1) \frac{\omega \varphi}{n}} \) and \( L_2 \equiv \frac{1 - \lambda_2}{1 + (1 - \lambda_2) \frac{(1 - \omega) \varphi}{1 - n}} \).

For monetary policy, let assume that the monetary instrument \( m_t \) is such that \( m_t = p_{C,t} + c_t \) which can be rationalized as a cash-in-advanced constraint for private demand or simply as an objective of monetary policy. The policy rule is \( m_t = \phi_p p_{C,t} + \phi_c c_t \) which allows for many alternatives. Strict inflation targeting is implemented by \( \phi_c = 1 \) and \( \phi_p \neq 1 \). More broadly, central bank seeking to control prices and deviations of private demand from the zero-inflation steady state sets \( \phi_p < 0 \) and \( \phi_c < 0 \). Although this rule depends on aggregate prices instead of inflation, it captures the (in this case, static) relationship between consumption and aggregate prices in a standard New-Keynesian model with a Taylor rule. Later we explore the implications

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that the monetary policy rule depends instead on the output gap.

**Solution and intuition.** Monetary policy implies \( p_{C,t} = (\phi_c - 1) c_t / (1 - \phi_p) \) which together with the solution for \( p_{C,t} \) yields

\[
c_t = -\frac{(1 - \phi_p)(1 - \zeta) \varphi}{1 - \phi_p \bar{L} - (1 - \bar{L}) \phi_c} \left[ \frac{\omega \gamma}{n} L_1 g_{1,t} + \frac{(1 - \omega)(1 - \gamma)}{1 - n} L_2 g_{2,t} \right]. \tag{E.0.1}
\]

As sectoral multipliers critically depend on the extent of the crowding out of private real demand, we concentrate on this expression. This solution recovers Proposition 2 in Section 4.1 for \( \Lambda_0 = \beta = 0 \) once we assume no nominal price rigidity in sector 1 and strict inflation targeting.

More generally, the (negative) crowding out of government sectoral demand on \( c_t \) is increasing (less negative) in \( L_1 \) and \( L_2 \), which are decreasing in \( \lambda_1 \) and \( \lambda_2 \). The intuition in Section 4.1 applies here: the higher price rigidity in a sector, the milder the response of aggregate prices is to shocks in that sector, so does monetary policy and the crowding out is weaker. In turn, the higher price rigidity in a sector, monetary policy has bolder reaction to a shock the other sector, so crowding out is stronger. In addition, crowding out is increasing in \( \phi_p \) (less negative) and decreasing in \( \varphi \) and \( \phi_c \) (more negative). As \( \phi_p \) becomes less negative, monetary policy becomes less responsive to aggregate prices and thus to sectoral government demand shocks. Larger inverse-Frisch elasticity \( \varphi \) implies stronger response of wages to these shocks, so do prices and the monetary response is stronger. Finally, as \( \phi_c \) is less negative, the monetary rule has weaker response to consumption deviations (also interpreted as real aggregate private demand), so the crowding out is stronger as \( \bar{L} < 1 \) by construction. Importantly, variations in monetary policy rule governed by \( \phi_c \) and \( \phi_p \) only have a scale effect on the extent of crowding out. We revisit this result below when we allow monetary policy to depend on the output gap.

To see the role of composition of private and government demand, assume the extent of the price friction in both sectors, \( \lambda_1 = \lambda_2 \) and normalize sectoral shocks by steady-state output. The ratio of the crowding out of a government demand shock to sector 1 relative to sector 2 is

\[
\frac{1-n}{(1-\omega)(1-\lambda_2)} + \zeta \varphi \frac{n}{\omega (1-\lambda_1)} + \zeta \varphi.
\]

Heterogeneity in sectoral government multipliers depends sectoral bias only, i.e., \( \omega \equiv C_1/C \) relative to \( n \equiv \omega \zeta + \gamma (1 - \zeta) \) with \( \zeta \equiv C/Y \), \( \gamma \equiv G_1/G \) and assuming that the inverse-Frisch elasticity \( \varphi \) is the same for both sectors. Intuitively, and focusing on sector 1, \( n^{-1} \) captures the
magnitude of a government shock relative to the size of sector 1’s labor market while $\omega$ enters because it captures the incidence of variations in consumption resulting from the shock and monetary policy on sector 1’s wages. If $\gamma$ increases, then $n/\omega$ increases as $n = \zeta \omega + (1 - \zeta) \gamma$. In turn, if $\omega$ increases, then $n/\omega$ decreases. Finally, if there is no sectoral bias, $\omega = \gamma$, then $n/\omega$ remains constant.

We now turn on heterogeneity in the pricing friction. The counterparts here of the expressions obtained in Proposition 2 are

$$
\Theta_1 = \frac{(1 - \phi_p) \varphi}{1 - \phi_p \bar{L} - (1 - \bar{L}) \phi_c n} L_1; \Theta_2 = \frac{(1 - \phi_p) \varphi}{1 - \phi_p \bar{L} - (1 - \bar{L}) \phi_c} \frac{1 - \omega}{1 - n} L_2
$$

Conceptually, the only new element is that $\bar{L}$ now is a weighted average of $L_1$ and $L_2$ depending on $\omega$. Intuitively, $\omega$ captures the relative importance of sectors on aggregate prices, so determining the strength of the monetary policy response.

In a limiting case, Proposition 2 stresses that $\Theta_1$ can be infinite. To see this here, assume that monetary policy follows strict inflation targeting, $\phi_c = 1$ and $\phi_p \neq 1$, and prices in sector 1 and 2 respectively are fully flexible and fully rigid, i.e., $\lambda_1 = 0$ and $\lambda_2 = 1$. Then $L_1 = A_1^{-1}$, $L_2 = 0$ and $\bar{L} = \omega$ such that $\Theta_1 = \frac{\omega}{\omega} \left( \frac{n}{\omega} + \zeta \varphi \right)^{-1}$. Then, $\Theta_1 \to \infty$ when here is no sectoral bias, $\omega = n$ and $\omega \to 0$. This condition is met when sector 1 has almost no participation in private and government demand in steady state. In such a case, a government demand shock in sector 1 has inflationary effects due to two offsetting effects. On the one hand, the size of sector 1 is very small, and so is its labor market. Thus, a positive government shock in sector 1 strongly pushes wages and prices up in that sector. But, on the other hand, $\omega$ is the weight of sector 1 on aggregate prices, which is very little. As these two effects enter in $\Theta_1$ as $n/\omega$, they offset each other when there is no sectoral bias, so the shock has sizable inflationary effects. In addition, as sector 2 has fully rigid prices, the monetary policy response must be very strong to engineer strict inflation targeting given that all the adjustment must be done by prices in sector 1 which, again, weight little on aggregate inflation. In the limit, crowding out can get infinite. Under less stringent monetary policy rules, one can show that crowding out does not get to infinity.

Finally, revisiting Proposition 3, the output multiplier of government demand shock in sector $k = 1, 2$ normalized by steady-state output is $1 - \zeta \Theta_k$, so the multiplier of, for instance,
sector 1, can get negative if

\[(1 - \phi_p)(\omega/n)\varphi L_1 - \zeta\,(\phi_c - \phi_p)\bar{L} > \zeta^{-1}(1 - \phi_c).\]

This condition is easier to meet if sectoral bias implies \(\omega > n\), the inverse Frisch elasticity \(\varphi\) is large, the pricing friction is milder in sector 1 \((\lambda_1 < \lambda_2)\), steady-state government demand is small \((\zeta \equiv C/Y\) is close to 1\)) or depending on the monetary policy rule. Under strict inflation targeting rule, this condition is met when \((\omega/n)\varphi L_1 > \zeta^{-1}\bar{L}\). If \(\phi_p < 0\) and \(\phi_c < 0\), this condition is easier to meet when \(\phi_p < \phi_c\) and \(\phi_c\) is close to zero.

**Extension.** We now assume that monetary policy responds to output gap instead of deviations of steady-state consumption. Approximated output and potential output are

\begin{align*}
y_t &= \zeta c_t + (1 - \zeta) \gamma g_{1,t} + (1 - \zeta) (1 - \gamma) g_{2,t}, \\
y^*_t &= \zeta c^*_t + (1 - \zeta) \gamma g_{1,t} + (1 - \zeta) (1 - \gamma) g_{2,t}
\end{align*}

such that the output gap \(y_t - y^*_t = \zeta(c_t - c^*_t)\) where \(c^*_t\) is the response of aggregate private demand (here, consumption) in absence of the price friction:

\[c^*_t = -\left[\omega (1 - \zeta) \gamma \frac{\varphi}{n} A_1^{-1} g_{1,t} + (1 - \omega) (1 - \zeta) (1 - \gamma) \frac{\varphi}{1 - n} A_2^{-1} g_{2,t}\right].\]

When the monetary rule is \(m_t = \phi_p p_{C,t} + \phi_c(y_t - y^*_t)\), then \(p_{C,t} = \frac{\zeta \phi_c - 1}{1 - \phi_p} c_t - \frac{\zeta \phi_c}{1 - \phi_p} c_t^*\), so

\[c^GAP_t = -\left(1 - \phi_p\right) (1 - \zeta) \frac{\varphi}{1 - \phi_p \bar{L} - (1 - \bar{L})} \frac{\omega \gamma}{n} L_1 g_{1,t} + \frac{1 - \omega}{1 - n} (1 - \gamma) L_2 g_{2,t}\]  

\[-\zeta \phi_c \frac{(1 - \bar{L})}{1 - \phi_p \bar{L} - (1 - \bar{L})} \zeta \phi_c c^*_t.\]

The first term on the right-hand side of \(c^GAP_t\) is almost identical to (E.0.1) but now \(\zeta\) multiplies \(\phi_c\). The last term is new. Now the crowding out is stronger (more negative) here than in (E.0.1). By how much depends on the “average” degree of nominal price rigidity \(\bar{L}\), the inverse Frisch elasticity \(\varphi\) and sectoral bias, \(\omega/\gamma\). Among them, only sectoral bias contributes to sectoral heterogeneity of government spending multipliers.
F Model Extensions

This section considers extensions of the baseline model, introduced in Section D above. First, for hand-to-mouth households as in Galí et al. (2007) and, second, for partially myopic agents as in Gabaix (2020). Both extensions illustrate that the mechanism emphasized in the main text also operates when there is less crowding out of private consumption or even crowding in.

F.1 Hand-to-Mouth Households

Let assume an exogenous fraction of hand-to-mouth households. Although simple, a convenient feature of this model variant is that a single parameter controls the effect of non-Ricardian agents on the crowding out of a sectoral government demand shock such that the fiscal multiplier can be larger than one. Our main results is that the sources of sectoral heterogeneity in multipliers still are sectoral differences in the pricing friction and the steady-state composition of private and government demand. Although a new source arises here depending on the sectoral composition of labor income for hand-to-mouth households in steady state, it is not strong enough to quantitatively change the ranking of sectoral multipliers.

Setup. We provide an abridged description of the setup as most of it remains the same as in the baseline model. A fraction $\lambda$ of households are “hand-to-mouth” while the fraction $1 - \lambda$ of households remain “standard”. Both types of households have the same objective function as in the baseline model. They also consume the same bundle of intermediate goods and firms do not discriminate among them either in the goods and labor markets. The only differences with standard households are that those “hand-to-mouth” only have labor income and do not have access to any vehicle to smooth consumption, such that

$$P_{C,t}C^h_t = W_{1,t}^h L_{1,t}^h + W_{2,t}^h L_{2,t}^h - T^h_t$$

(F.1.1)

where $L_{1,t}^h$ and $L_{2,t}^h$ are hours worked by hand-to-mouth households on both sectors, $W_{1,t}^h$ and $W_{2,t}^h$ are sectoral wages and $T^h_t$ denotes lump-sum taxation for hand-to-mouth households. Sectoral wages are determined by

$$\frac{W_{k,t}}{P_{C,t}} = \xi_k (L_{k,t}^h)^\gamma C^h_t$$

(F.1.2)
for sector \( k = 1, 2 \) where \( \xi_k^T \) are parameters set to ensure symmetric firms in steady state.

Standard households’ consumption satisfies a standard Euler equation. Households’ demand functions remain the same as in the baseline model after adding a upper-index \( \tau = h, s \).

Production is linear in labor and the pricing friction is modeled as a sector-specific Calvo parameter \( \alpha_k \) where the optimal price is given by (D.3.13). We investigate the two monetary policy rules used in Section 4: strict inflation targeting \( \pi_t = 0 \) and the Taylor rule \( i_t = \phi_\pi \pi_t \).

**Fiscal policy.** We relax the assumption of a balanced Government budget although we keep it in steady state. The Government’s budget constraint every period is

\[
T_t + B_t = I_{t-1}B_{t-1} + P^G_t G_t
\]

where \( T_t = \lambda T^h_t + (1-\lambda) T^s_t \) with \( T^s_t \) denoting lump-sum taxation on standard households. We must model procurement prices. To keep it simple, we assume procurement prices to be fully flexible. This assumption allows us to highlight that the responsiveness of prices paid by private agents to sectoral government demand shocks is the crucial ingredient for the mechanism for sectoral heterogeneity of fiscal multipliers in the baseline model. Finally, we must specify a rule for taxation, which we do in log-linear terms below.

**Log-linear system.** We approximate the equilibrium around a steady state with symmetric firms, zero inflation, no Government debt and satisfying that both types of households choose the same level of consumption and labor. The latter assumption is the only new element with respect to the baseline model, which is obtained by the proper choice of the additional preference parameters \( \xi_k^h \) and steady state taxation \( T^h \) and \( T^s \). Thus, we do not present the steady state here except to pin down some key parameters, which we discuss further below. This additional assumption helps to simplify the algebra without affecting the core of the analysis: The log-linear system is identical to the baseline model except for the fiscal block and aggregate private demand. Small cases denote log-linear deviation from steady state except for bonds \( b_t = B_t / P Y \) given that \( B = 0 \). For the fiscal block, equation (F.1.3) becomes

\[
b_t = \beta^{-1} b_{t-1} + (1 - \zeta) (g_t + p^G_t - t_t)
\]
where \( t_t = \phi_b b_{t-1} + \phi_g (g_t + p_t^G) \). We implicitly assume the same taxation rule for hand-to-mouth and standard households. These latter two expressions jointly imply

\[
b_t = (\beta^{-1} - (1 - \zeta) \phi_b) b_{t-1} + (1 - \zeta)(1 - \phi_g) (g_t + p_t^G)
\]

such that \((1 - \zeta) \phi_b > \beta^{-1} - 1\) to ensure a non-explosive path for Government debt.

Consumption of standard households is given by the log-linear Euler equation:

\[
c_s^t - E_t c_s^{t+1} = - (i_t - E_t \pi_{t+1})
\]

while consumption of hand-to-mouth agents is given by the log-linearization of (F.1.1):

\[
c_h^t = \left( \frac{W_1 L_1^h}{PC_h} \right) (w_{1,t} - p_{C,t} + l_{1,t}) + \left( \frac{W_2 L_2^h}{PC_h} \right) (w_{2,t} - p_{C,t} + l_{2,t}) - \frac{T_h}{PC_h} (t_t - p_{C,t})
\]

To solve for \( c_h^t \), we plug (F.1.2) for \( \tau = h \) and its aggregation with (F.1.2) for \( \tau = s \) into this expression to obtain

\[
c_h^t = A_1 l_{1,t} + A_2 l_{2,t} + A_C c_t - A_T (t_t - p_{C,t})
\]

where we have used the linear production function to replace sectoral labor for sectoral output.

In the baseline analysis \((\lambda = 0)\), the responsiveness of inflation, and thus of monetary policy, to sectoral government demand shocks generates sectoral heterogeneity of fiscal multipliers. Here this mechanism is reinforced. The effect of monetary policy on aggregate consumption is
increasing in $\lambda$ if $A_C > 1$, as captured in the first term on the right hand side of (F.1.5). This is because, although hand-to-mouth households do not directly react to monetary policy, they do react to the response of wages to monetary policy. When $A_C > 1$, which is satisfied if $T^h > 0$, hand-to-mouth response is even stronger than that of standard households.

New sources for heterogeneity in crowding out arising here also are captured on the right-hand side of (F.1.5). As hand-to-mouth consumption responds to variation in their labor income, then it responds to variation in worked hours (or sectoral production, which is linear in labor). How strong this response is depends on steady-state sectoral composition of labor of hand-to-mouth households. In addition, hand-to-mouth consumption responds to variations in taxation; thus, how much taxes respond affect the scale of multipliers but not their heterogeneity when sectoral fiscal shocks are normalized by steady-state output, as we do through this paper.

**Strict inflation targeting.** We argue that in this case all analytical results in Section 4 hold. When monetary policy engineer a strict inflation targeting, $\pi_t = 0$, the Euler equation in (F.1.5) is not used to obtain the response of aggregate consumption and output.

**Taylor rule.** Now new forces enter to affect the multipliers. We solve this case numerically. We take the same calibration than in the main text. Parameters to specify are $\lambda$, $W_1L^h_1P_C^h_1$, $W_2L^h_2P_C^h_2$, $T^h_1P_C^h_1$, $\phi_g$ and $\phi_b$. Some of them are pinned down by the steady-state solution of the model: $T^h = PG - \Pi$, such that $T^hP_C^h = (\mu \zeta)^{-1} - 1$, $W_1L^h_1P_C^h_1 = n(\mu \zeta)^{-1}$ and $W_2L^h_2P_C^h_2 = (1 - n)(\mu \zeta)^{-1}$. We set the steady-state markup $\mu = 1.20\%$, share of non-Ricardian agents $\lambda = 20\%$ and parameters in the taxation rule $\phi_g = 10\%$ and $\phi_b = 5\%$. Finally, it turns out that the calibration of the monetary policy rule in the main text is too strong to get multipliers larger than one, so we assume here $\phi_{\pi} = 1.2$.

Results are in Figure A.24, which follows the same structure than Figure 5. Qualitatively, all results remain. If sectors are assumed symmetric such that the price friction is the same, $\alpha_1 = \alpha_2 = 0.84$, and there is no sectoral bias, $\omega = \gamma = 0.5$, the response of inflation is the same regardless the sector shocked (dash red lines) and so does monetary policy and output. In contrast, when sector 1 has larger share of steady state consumption, $\omega = 0.76$, somewhat larger share of government demand, $\gamma = 0.56$, and the price friction is $\alpha_1 = 0.78$ and $\alpha_2 = 0.9$, the response of inflation (in solid blue lines) to a sector-1 shock is larger than in the symmetric calibration while it is smaller if the shock is in sector 2. Monetary policy reacts accordingly, such that the response of output is much milder after a sector-1 shock. Notably, the multiplier
Figure A.24: Effects of Government Spending Shocks on Aggregate Output, Model with Hand-to-Mouth Households

Notes. Shock equals one percent of steady-state output in each scenario; horizontal axis: time in months, vertical axis: deviation from steady state. Blue solid line correspond to baseline model. Red dashed line: symmetric counterfactual.

can be larger than 1 on impact if the shock is in sector 2.

One feature worth noting is the small differences in inflation responses while the responses of output are largely different. The reason is that the introduction of hand-to-mouth households has only indirect effect on firms’ pricing decisions, but it directly affects the scale of crowding out regardless the sector where the government demand shock hits. In addition, the new mechanisms introduced by and-to-mouth households explained above could in principle alter the ranking of multipliers with respect to the baseline model. However, an extreme calibration is required for the steady-state sectoral composition of labor income for hand-to-mouth households.
F.2 Behavioral Agents

We now augment the baseline two-sectors new-Keynesian model to include behavioral agents following Gabaix (2020). With bounded rational households and firms, the multiplier of government spending can be larger than one as households do not fully internalize the future effects on taxation and firms do not fully internalize the future effects on marginal costs. This section shows that, besides a scale effect, these forces do not create new sources of heterogeneity of sectoral multipliers; as in our baseline model, its main drivers are sectoral differences in price stickiness and the steady-state composition of private and government demand.

Setup. We now sketch the main departures from our baseline model. The key assumption is that households and firms form expectations underestimating deviations from steady state, for instance, \( \mathbb{E}_t^{BR} x_{t+s} = \mathbb{E}_t x_{t+s} \) with \( \mathbb{E} \in [0, 1] \). Under this assumption, up to a log-linear approximation, inflation in sector \( k = 1, 2 \) is governed by

\[
\pi_{k,t} = \alpha_k \beta M^f_k \mathbb{E}_t \pi_{k,t+1} + \kappa_k \psi_{k,t} \tag{F.2.1}
\]

where \( \kappa_k \equiv (1 - \alpha_k)(1 - \beta \alpha_k) / \alpha_k \), \( \psi_k = w_{k,t} - p_{k,t} \) and \( M^f_k = \mathbb{E}_{t} \left( \alpha_k + \frac{1 - \beta \alpha_k}{1 - \beta \alpha_k \mathbb{E}_t} (1 - \alpha_k) \right) \). The derivation of (F.2.1) follows exactly Gabaix (2020) except that all variables are sectoral. The difference between \( M^f \) and \( \mathbb{E}_t \) is due to the mapping from firms’ optimal reset price to the (sectorally) aggregated price, as standard with Calvo pricing. To see this, note that \( M^f = \mathbb{E}_t \) when prices in a sector are flexible, \( \alpha_k = 1 \). The expressions for \( \psi_k \) are the same as in the baseline model as they are static and do not involve expectations.

Our setup for households is a bit different than in Gabaix (2020), so we cannot just state his results, although we follow exactly his steps. Let start from their budget constraint:

\[
P_t^Y Y_t + I_{t-1} B_{t-1} = B_t + P_t^C C_t + T_t
\]

which remains the same as in the baseline analysis but we have used that total nominal output equals total compensation to workers plus firms’ profits and that aggregate consumption expenditure equals the sum of sectoral consumption expenditure. The log-linear approximation
of consumption for rational agents then yields

$$\zeta c_t - s_b b_{t-1} = (1 - \beta) \sum_{s=0}^{\infty} \beta^s \mathbb{E}_t A_{t+s} - \beta \zeta \sum_{s=0}^{\infty} \beta^s \mathbb{E}_t (c_{t+s} - \pi_{t+s+1})$$  \hspace{1cm} (F.2.2)$$

where $s_b \equiv (1 - \beta)/\beta$, $A_{t+s} \equiv y_{t+s} + p^g_{t+s} - (1 - \zeta)t_{t+s} - \zeta p^G_{t+s}$ and all variables are log-deviations from steady state but $b_{t+s} \equiv B_{t+s}/PY$ as we assume no steady-state government debt, $B = 0$.

The fiscal block is identical to Appendix F.1. The government’s budget constraint is given by (F.1.3), such that

$$b_t = \beta^{-1} b_{t-1} + (1 - \zeta)(g_t + p^G_t - \tau_t).$$

One can show that the standard Euler equation holds by using this expression, (F.2.2), and that $y_t = \zeta c_t + (1 - \zeta)g_t$ and $p^y_t = \zeta p^e_t + (1 - \zeta)p^G_t$. For behavioral agents, (F.2.2) becomes

$$\zeta c_t - s_b b_{t-1} = (1 - \beta) \sum_{s=0}^{\infty} (\beta m)^s \mathbb{E}_t A_{t+s} - \beta \zeta \sum_{s=0}^{\infty} (\beta m)^s \mathbb{E}_t (c_{t+s} - \pi_{t+s+1}),$$

such that

$$c_t = \zeta^{-1} s_b (1 - \overline{m}) b_t + \overline{m} \mathbb{E}_t c_{t+1} - (i_t - \mathbb{E}_t \pi_{t+1})$$  \hspace{1cm} (F.2.3)$$

To close the model, the taxation rule in log-linear form is $\tau_t = \phi_b b_{t-1} + \phi_b (g_t + p^G_t)$ such that (F.1.4) holds. Labor supply and the good market clearing condition remain as in the baseline model as they are static relationships where expectations are not explicitly involved.

**Strict inflation targeting.** In this case, equation (F.2.3) is not required to solve for aggregate output and inflation. Thus, the only modification introduced by behavioral agents is in equations (F.2.1), which are isomorphic to those for rational firms once $\beta$ is replaced by $\beta_k \equiv \beta M^f_k$. Besides this, Propositions 1, 2 and 3 in Section 4.1 apply. Intuitively, firms partially miss the future effects on their marginal costs of a persistent government demand shock, so the inflation response and the monetary policy reaction are muted. As $M^f_k$ is decreasing in $\alpha_k$, this is a new channel for heterogeneity in sectoral fiscal multipliers which, however, also depends on the sectoral distribution of the pricing friction.

**Taylor rule.** As in Appendix F.1, a flexible monetary policy rule allows for non-Ricardian households to affect fiscal multipliers as the solution of output and inflation depend on (F.2.3). Here, households’ myopia scales multipliers up by reducing the crowding out generated by
monetary policy. Intuitively, a government demand shock not fully financed by current taxes increases consumption as households miss the future increase in taxes required to converge to the zero-debt steady state. However, when shocks are normalized by steady-state output, this channel does not contribute to the sectoral heterogeneity in fiscal multipliers.

Appendix References


