The Macroeconomic Effects of Defense Spending News[*]

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Abstract

We estimate the macroeconomic effects of government spending by constructing a new series of defense spending surprises using a high-frequency identification approach. We identify events in the U.S. federal budget process that reveal news about defense spending, focusing on dates when different versions of defense appropriations bills are passed in the House or the Senate. We then quantify the defense spending surprise associated with each event using daily stock returns of large U.S. defense contractors. A positive defense spending surprise predicts a persistent increase in future defense spending that is entirely passed through to total government spending. On average, the identified spending increases are financed with a combination of taxes and debt, and are met with a muted monetary policy response. We estimate the dynamic causal effects of defense spending and find sizable increases in output and consumption. Our estimates imply a cumulative fiscal multiplier—the cumulative output response divided by the cumulative spending response—of 1.2 over a five-year horizon. Our results indicate that government spending stimulates ("crowds in") economic activity in the private sector. A standard heterogeneous-agent New Keynesian model can match our empirical evidence.

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1 Introduction

How do changes in government spending affect aggregate economic activity? The answer to this question is typically summarized by a fiscal multiplier: the percentage change in output that results from increasing government spending by one percent of GDP.[1] There is broad consensus that government spending increases output, but the empirical literature is divided on whether fiscal multipliers tend to be smaller or larger than one—that is, does an increase in government spending tend to dampen ("crowd out") or stimulate ("crowd in") private consumption and investment?

Isolating the causal effect of government spending on output is challenging. Observed changes in spending could reflect an endogenous policy response to the state of the economy. For example, policymakers have routinely turned to government spending as a tool for stabilizing the economy in recessions, such as the New Deal in the 1930s or the American Recovery and Reinvestment Act of 2009.[2] To mitigate concerns about reverse causation, a long empirical literature uses variation from defense spending and wars, arguing that this type of spending is unlikely to respond to economic events (Barro, 1981; Hall, 1986; Rotemberg and Woodford, 1992; Ramey and Shapiro, 1998; Hall, 2009; Barro and Redlick, 2011; Ramey, 2011*b*; Ramey and Zubairy, 2018).

However, even if wars are typically not triggered by the business cycle, the decision of how much to spend on a war—or how much to spend on defense in peacetime—could still depend on the economy. For instance, Defense Secretary Gates stated in 2010: *"Given America's difficult economic circumstances and parlous fiscal condition, military spending on things large and small can and should expect closer, harsher scrutiny. [...] The gusher has been turned off, and will stay off for a good period of time."*[3] Wars also affect the macroeconomy through other channels than fiscal policy, such as labor force participation or uncertainty, obscuring the direct effect of government spending.[4]

On top of these endogeneity concerns, identification is also complicated by anticipation effects (Ramey, 2011*b*; Mertens and Ravn, 2012; Leeper, Walker and Yang, 2013). Implementation and legislative lags imply that changes in government spending are often known in advance. If a change in government spending is anticipated, then part of its effects on the economy may occur in response to *news*, before any actual spending takes place. News shocks violate the invertibility assumption imposed in structural vector autoregression (VAR) approaches (e.g., Blanchard and Perotti, 2002), which leads to confounding of anticipated and unanticipated policy changes.[5]

In this paper, we construct a new series of defense spending surprises to address these empirical challenges and isolate the effects of government spending on the macroeconomy. Our empirical strategy is to measure surprises in a stock index of large U.S. defense contractors in a narrow window around legislative events that reveal news about U.S. defense spending. The idea is

[1] Or equivalently, the dollar change in output that results when the government spends an additional dollar.

[2] The policy response could also be procyclical. For example, a weak economy may constrain the fiscal space and lead politicians to cut spending.

[3] The Wall Street Journal (2010).

[4] This limitation of using wars to identify fiscal multipliers is well-known in the literature (e.g., Ramey, 2011*a*).

[5] Intuitively, the identified shocks from this approach are forecast errors of government spending after projecting out quarterly lags of spending and output. If these lags do not capture news, then anticipated changes in spending may be misclassified as unanticipated. Ramey (2011*b*) shows that the Blanchard and Perotti (2002) shocks are predictable.

that the financial market reaction to such events is informative about defense spending news because defense contractors' cash flows depend heavily on defense spending. If asset prices reflect all available information, then our surprises will capture only *unanticipated* changes in defense spending, since anticipated changes are already priced in. By measuring the surprise in a narrow window around events that specifically relate to U.S. defense spending, we can plausibly rule out that information about other aspects of the economy changes simultaneously. A recession may be the reason for defense spending cuts, but expectations about how the recession affects the economy should already be priced in before the cuts are announced.

We construct the defense spending surprises in two steps. The first step is to identify events that are likely to reveal news about U.S. defense spending. We focus on the two main ways U.S. Congress provides funding for defense: the regular annual defense appropriations bills and the supplemental defense appropriations bills that provide additional budget authority. We exclude consolidated bills ("omnibus bills") that have been common in recent years because they likely also communicate news about other types of spending. We collect data on the legislative actions and timeline of each individual bill from the Congressional Record since 1947. For each bill, we isolate three central event dates when different versions of the bill pass: the days when the House and the Senate pass their separate versions of the bill, and the day when the two chambers agree on the final version. These events resolve uncertainty and reveal information about which version of the bill will eventually become law. Information is also signaled in other ways: The event days often feature extensive debates about defense spending, and members of Congress propose, debate, and vote on amendments to the bill.

The second step is to quantify the defense spending news communicated on the event dates. Following Fisher and Peters (2010), we construct a stock index of large U.S. defense contractors using the Department of Defense reports on the top 100 defense contractors for each fiscal year. The underlying assumption is that an event that communicates news of an increase in future defense spending will increase the stock prices of U.S. defense contractors as market participants raise their expectations of future profits. We measure the surprise on each event date using the excess returns of defense contractors relative to a broader market index to purge the surprises of market fluctuations unrelated to defense. The resulting surprise series measures excess returns on 213 unique event dates.

To validate the defense spending surprises as an instrument for defense spending, we perform a set of diagnostic checks to assess their statistical properties. The variance of excess returns is more than twice as high on event dates as on regular trading days, indicating a disproportionate release of cash flow news about defense contractors. In line with the definition of macroeconomic shocks in Ramey (2016), we find that the surprises are mean-zero, serially uncorrelated, and not Granger-caused by standard macroeconomic and financial variables. We also provide specific event-study examples to illustrate the variation we exploit. For instance, in 1949, disagreement between the House and the Senate over Air Force funding significantly delayed the final passage of the defense appropriations bill. When the Senate eventually relented on its demands for Air Force cuts and passed the bill, defense contractors experienced substantial excess returns.

Next, we aggregate the daily defense spending surprises to quarterly frequency and estimate the macroeconomic effects of a defense spending surprise using local projections.

A positive defense spending surprise predicts a persistent increase in defense spending that is entirely passed through to total government spending. We find no spending response on impact, confirming that a surprise reflects news shocks about future spending. In the quarters following a surprise, defense spending gradually rises and peaks after 3–4 years, staying elevated for several years. The high persistence of the response can be explained by the long duration of defense contracts (Cox et al., 2024) and is consistent with earlier findings that do not primarily rely on large wars (Blanchard and Perotti, 2002; Fisher and Peters, 2010). The dynamic response of *total* government spending closely resembles the defense spending response, indicating little to no change in other types of spending. The modest response of nondefense spending is also consistent with our event dates isolating news specific to defense spending. The magnitude of the shocks is economically meaningful: A one-standard-deviation defense spending surprise leads to a persistent increase in defense spending that peaks at 0.25 percent of GDP.[6] The cumulative government spending response—the relevant first stage for estimating cumulative fiscal multipliers—is highly statistically significant with a first-stage F-statistic of 19 over a five-year horizon.

The identified changes in defense spending are partially tax-financed, and they do not seem to be counteracted by monetary policy "leaning against the wind." The fiscal and monetary policy responses are central to interpreting our results. Standard macroeconomic models suggests that the size of fiscal multipliers depend crucially on how the spending is financed and the response of monetary policy. Models with non-Ricardian agents, such as the old textbook IS-LM model or the modern heterogeneous-agent New Keynesian literature (Kaplan, Moll and Violante, 2018; Auclert, Rognlie and Straub, 2024), predict that tax-financed spending is less effective in stimulating output relative to debt financing. Similarly, fiscal stimulus may be less effective if it is counteracted by contractionary monetary policy.

Output and consumption rise persistently following a defense spending surprise. On impact, the aggregate response is close to zero, mirroring the response of government spending. Output then rises faster than spending, which is consistent with agents reacting to news about future demand. Private consumption is crowded in, peaking at 50 cents per dollar of government spending. The consumption gains are concentrated in non-durables and services, with little movement in durables. The investment response is positive, but not statistically significant. Together, these patterns suggest that government spending stimulates private economic activity.

We summarize the effects of government spending on output by estimating cumulative fiscal multipliers—the cumulative output response divided by the cumulative government spending response to a defense spending surprise. Our baseline estimate is a cumulative fiscal multiplier

[6] Even though this implies a large cumulative spending response, the changes in spending identified from a defense spending surprise are much smaller than those associated with major wars such as World War II and the Korean War, which much of the previous literature relies on.

of 1.2 measured over a five-year horizon. Our multiplier estimates are larger at shorter horizons because output tends to respond earlier than spending, consistent with agents responding to news. When we remove event dates that are relatively more likely to include confounding news, our multiplier estimates increase. Overall, we interpret our fiscal multiplier results as evidence that fiscal multipliers can be greater than one.

Standard theoretical models can rationalize the aggregate effects of defense spending we estimate. Our baseline model builds on the two-asset heterogeneous-agent New Keynesian (HANK) model of Auclert, Rognlie and Straub (2024). We feed the empirically estimated path of government spending into the model and calibrate the policy rules so the policy responses are consistent with the data. This calibrated quantitative HANK model provides a good fit to the estimated impulse responses. More generally, models with high marginal propensities to consume and substantial nominal and real rigidities perform similarly. For instance, an analytically tractable HANK model, similar to Angeletos, Lian and Wolf (2024) and Debortoli and Galí (2025), also rationalizes our results. In contrast, a representative-agent model with Ricardian households and low marginal propensities to consume struggles to replicate the observed increase in private consumption without a counterfactual decline in real interest rates.

Related Literature This article contributes to a large empirical literature that estimates aggregate fiscal multipliers. One strand of the literature employs structural VARs to identify government spending shocks (Blanchard and Perotti, 2002).[7] The other main strand of the literature focuses on defense spending and wars and assumes that this type of variation is exogenous (Barro, 1981; Hall, 1986; Rotemberg and Woodford, 1992; Hall, 2009; Barro and Redlick, 2011). To account for anticipation effects, a connected literature has focused on identifying news shocks that capture changes in defense spending when they are announced (Ramey and Shapiro, 1998; Fisher and Peters, 2010; Ramey, 2011*b*; Ben Zeev and Pappa, 2017; Melosi et al., 2025). In a seminal contribution, Ramey (2011*b*) uses a narrative approach to create a quarterly series of defense news shocks based on newspaper articles.[8] We contribute to this literature by providing a new series of defense news shocks based on a high-frequency identification approach. Overall, the time series literature tends to find aggregate fiscal multiplier estimates in the range 0.6–1.0 (Ramey, 2019; Ilzetzki, 2025). Our empirical evidence suggests that aggregate fiscal multipliers can exceed one and that private consumption in particular is crowded in.

Closest to our paper is Fisher and Peters (2010), who compute the accumulated monthly excess returns of defense contractors and order this variable last in a recursive VAR. We also use asset price responses of defense contractors to measure defense spending news. However, they use *all* variation in excess returns, whereas we only use the variation that occurs on specific event dates.

[7] See also Edelberg, Eichenbaum and Fisher (1999), Burnside, Eichenbaum and Fisher (2004), Galí, López-Salido and Vallés (2007), Perotti (2007), Monacelli and Perotti (2008), Mountford and Uhlig (2009), Auerbach and Gorodnichenko (2012), Corsetti, Meier and Müller (2012), Ilzetzki, Mendoza and Végh (2013), and Caldara and Kamps (2017).

[8] Recently, Antolin-Diaz and Surico (2025) study the long-run effects of government spending using these shocks. Antonova, Luetticke and Müller (2025) study the role of reallocation of resources between sectors in military buildups.

Excess returns fluctuate for many reasons unrelated to U.S. defense spending. Using all variation introduces noise that reduces statistical power and could be endogenous to the business cycle.[9] For example, some of the largest daily excess returns in their sample occur in response to financial crises. Presidential elections, which likely reveal both defense and other news, also often lead to substantial excess returns.

Our work is also connected to a literature that estimates relative (or local) fiscal multipliers in the cross-section using regional data. Nakamura and Steinsson (2014) exploit cross-sectional variation in U.S. states exposure to national military buildups. Other papers that study defense spending in this context include Hooker and Knetter (1997), Dupor and Guerrero (2017), Auerbach, Gorodnichenko and Murphy (2020, 2024), Biolsi (2019), Hebous and Zimmermann (2021), Brunet (2024), and Amodeo and Briganti (2025).[10] The identification assumptions required in the cross-section are more plausible, but translating relative fiscal multipliers into aggregate fiscal multipliers requires a model (see also Farhi and Werning (2016)). Chodorow-Reich (2019) reviews this literature and finds a median estimate of 1.8. Our evidence helps reconcile the relatively large local fiscal multipliers with the low estimates that dominate the time series literature.

Methodologically, our paper relates to the literature that uses high-frequency asset price surprises to identify macroeconomic shocks. This approach to identification was first applied to monetary policy surprises (see, e.g., Gürkaynak, Sack and Swanson, 2005; Gertler and Karadi, 2015; Nakamura and Steinsson, 2018) and has since been applied to several other settings.[11] Our paper is the first to apply these methods to study the macroeconomic effects of government purchases (i.e. government consumption and investment in national accounts) and estimate fiscal multipliers.[12] Recent work has studied the effects of deficit news on asset prices (Cotton, 2024; Gomez Cram, Kung and Lustig, 2025; Wiegand, 2025). Wiegand (2025) estimates effects of deficit news using events when the Congressional Budget Office (CBO) releases new forecasts. Our empirical methodology differs in that we use the asset market surprises to quantify the news being communicated, whereas Wiegand instead assumes that changes in CBO forecasts are unanticipated and studies how asset price respond as an outcome. Hazell and Hobler (2025) combine narrative and high-frequency methods to study the effect of deficit news (mostly transfers) from a Senate election runoff on inflation.

Roadmap The article proceeds as follows. In section 2, we lay out our identification strategy and describe how we construct defense spending surprises. In Section 3, we present our empirical spec-

[9] Ramey (2016) finds first-stage F-statistics close to zero using the Fisher and Peters (2010) shocks in her specification.

[10] There is a large literature estimating local fiscal multipliers using other types of spending and transfers, e.g. Chodorow-Reich et al. (2012), Shoag (2013), Acconcia, Corsetti and Simonelli (2014), Suárez Serrato and Wingender (2016), and many others. See Chodorow-Reich (2019) for an overview.

[11] Examples include oil supply (Känzig, 2021), carbon pricing (Känzig, 2023), dollar swap lines (Kekre and Lenel, 2025), bank regulation (Drechsel and Miura, 2025), Treasury supply (Bi, Phillot and Sarah, 2025), economic data releases (Boehm and Kroner, 2025), and supply chains (Känzig and Raghavan, 2025).

[12] Military spending almost exclusively consists of government consumption and investment (as opposed to transfers). Deficits are broader in that they may arise due to changes in either government consumption and investment, transfers, or taxes

ification and estimate the dynamic effects of defense spending surprises. In Section 4, we estimate cumulative fiscal multipliers and discuss how our results compare to the previous literature. In Section 5, we show that a standard heterogeneous-agent New Keynesian model can match our empirical evidence. Section 6 concludes.

2 A New Measure of Defense Spending News

In this section, we construct a new series of defense spending news shocks using a high-frequency identification approach. We call them *defense spending surprises* to emphasize that they reflect financial market surprises. We begin by identifying legislative events in the U.S. federal budget process that are likely to communicate news about defense spending. We then construct a stock index of U.S. defense contractors, building on work by Fisher and Peters (2010). Finally, we measure the surprise in the excess returns of the stock index in daily windows around each event. We provide concrete examples to illustrate the underlying variation we exploit and discuss the statistical properties of the surprise series.

2.1 Institutional Background: Defense Appropriations and Contracting

National defense accounts for more than half of federal government spending and explains a majority of the variation in total government spending.[13] The U.S. Department of Defense is primarily funded by the annual defense appropriations bill, the largest of the twelve appropriations bills passed by Congress each fiscal year. This subsection describes the institutional details of how defense spending is funded in the United States and provides the basis for how we select event dates.

The Defense Appropriations Process The House and Senate Appropriations Committees each have a Subcommittee on Defense that is responsible for developing, drafting, and managing the consideration of the defense appropriations bill. The House and Senate subcommittees generally operate in parallel.[14]

After the President submits the annual budget request to Congress, the subcommittees hear testimonies from senior Department of Defense officials and other relevant parties. Members of Congress outside the committees may also submit requests and recommendations. Following these hearings, the subcommittees draft and mark up the defense appropriations bill and report it to the full appropriations committees, who may also make amendments before reporting the bill for floor consideration.

Ordinarily, the bill is first considered in the House, which typically occurs in May or June. After being publicly debated and amended on the floor, the House passes the bill. The Senate then

[13] A linear regression of total government spending on defense spending in quarterly growth rates yields an R^2 of 0.72 in our sample period 1947–2019.

[14] See Saturno and Lynch (2023, 2024) for a more detailed overview.

subsequently debates, amends and passes its own version of the bill. Any disagreements between the House and Senate must be resolved before the bill can be presented to the President. For most of the bills we consider, the House and Senate agree to form a conference committee to negotiate the final version of the bill and report the results in a conference report. Alternatively, the two chambers can exchange amendments until they arrive at identical measures. The final version of the bill is then presented to the President for their signature or veto.

Supplemental Defense Appropriations Outside of the regular appropriations process, additional defense spending can be funded by supplemental defense appropriations. These measures traditionally cover urgent needs, but they have also been used to regularly pay for military campaigns. For example, the wars in Iraq and Afghanistan in the 2000s were to a large extent financed by supplemental appropriations. Congress passed one major "emergency" supplemental defense bill per year during 2002–2010. Since these bills evolved into a regular annual stream of war funding, they were largely anticipated. Supplemental spending bills follow a process similar to the one for the regular defense spending bills, though often at an accelerated rate. For example, the Supplemental Defense Appropriations Act 2005 was introduced and passed in the House on March 11 and 16. The Senate passed the bill on April 21, and a conference report was agreed to on May 10; the bill was signed into law the next day.

Omnibus Appropriations Bills and Continuing Resolutions Historically, Congress has usually passed each regular appropriations bill separately and on time. However, since the 2000s, the appropriations process has often deviated from standard practices. First, it has become increasingly common to combine several of the twelve appropriations bills into a single measure, a so-called consolidated, or "omnibus", appropriations bill. Second, Congress has increasingly failed to pass the regular appropriations bills before the start of the fiscal year on October 1st. To avoid government shutdowns, Congress has often temporarily extended funding at current levels by passing a continuing resolution ("CR").

Defense Contractors and Procurement The Department of Defense relies heavily on contractors to supply military equipment and other goods and services (Neenan, 2024*a*,*b*). Defense contracts account for the majority of federal contracts, and federal contracts in turn explain most of the variation in total government spending (Cox et al., 2024). Defense contracts are approximately evenly split between goods and services. The Department of Defense awards contracts to hundreds of firms, yet a majority of the (dollar-weighted) contracts are awarded to a handful of large defense contractors such as Lockheed Martin, General Dynamics, and Raytheon.

Defense contracts often span several years. Cox et al. (2024) document that the median federal contract duration is 3–4 years and the 90th percentile is around 12 years. Even though defense appropriations bills are specific to a fiscal year, they provide budget authority several years into the future. The main reason is that procurement of military investment goods, such as aircraft, ships, and armored vehicles,[15] is funded under a *full funding policy*, which requires that the entire procurement cost is appropriated in the year that item is procured. Congress has imposed this policy on defense spending since the 1950s.[16]

2.2 Event Dates

When is news about defense spending communicated to the public? The ideal event for our empirical strategy is one that reveals information about U.S. defense spending without simultaneously conveying news about other factors that influence economic conditions. Our analysis focuses on key legislative events in the defense appropriations process that directly determine U.S. defense spending. Alternative political events—such as State of the Union addresses or election outcomes—also convey information about defense priorities, but they are often confounded by other policy developments. For instance, it is difficult to isolate the effects of defense spending news from a presidential election if presidents who tend to raise defense spending also tend to pursue, say, financial deregulation.

We concentrate on the two main types of legislation that provide funding for defense: regular defense appropriations bills and supplemental defense appropriations bills. For each bill, we collect detailed information from the Congressional Record on its timeline and legislative actions, from initial introduction to final enactment. We exclude defense appropriations that are passed as part of omnibus spending packages, as well as continuing resolutions, which provide only temporary funding and are typically anticipated.

We identify three central legislative events that mark the progression of each bill through Congress: passage in the House, passage in the Senate, and the approval of the final version of the bill. Passage is an important event because it resolves uncertainty and because the approved bill is reported. These events are also highlighted as milestone events in the Congressional Record (e.g., in the overview section of the Daily Digest publication) and are most likely to be reported in the news. In addition, debates and amendments tend to cluster on these days. For example, the House considers the regular appropriations bill under a so-called "special rule" that governs debate and amendment. Since debate is usually limited to 1–2 hours, most of the activities related to the House version of the bill occur on the same day. When the date of a legislative event is not available from the Congressional Record's online database, we either manually locate the event in the full texts of the Congressional Record, or consult *CQ Almanac*, which provides detailed narrative overviews of each bill's content and legislative history.

Consider for example the Department of Defense Appropriations Act 1982, which was debated, amended, and passed in the House on November 18, 1981. On this event date, 28 amendments were proposed and voted on by House members, with 17 of them passing. For example, one amendment proposed to reduce funds for procurement and research and development by two percent, but failed by a close vote of 197–202. Another amendment proposed *"to decrease from 13,957,598,000*

[15]Satellites, missiles, weapons, and ammunition also fall under this category.
[16]See Daggett and O'Rourke (2007).

dollars to 12,156,598,000 dollars funds for Air Force aircraft procurement. The intent of the amendment is to strike funds for the B-1 bomber." The B-1 bomber program was one of the most controversial defense programs of the late Cold War, both politically and within the defense establishment (Norman, 1988). In the end, most of the proposed cuts failed, whereas the House passed other amendments to increase funding for Navy shipbuilding and Air Force missile procurement, among other things.

2.3 A Stock Index of Defense Contractors

To quantify the defense spending news released on event dates, we construct a stock index of large U.S. defense contractors following Fisher and Peters (2010). The index is based on the annual Top 100 Contractor Reports published by the Department of Defense since 1958. These reports rank the top 100 companies that were awarded the largest total dollar volume of prime contracts during a fiscal year (including their subsidiaries). The reports include information on firm names, their rank, and the dollar value of their awarded contracts. We digitize this information and string-match the firm names to daily financial data from the Center for Research in Security Prices (CRSP) database. We complement the data with annual sales data from the Compustat database.

Which firms should be included in the index to best capture defense news? On the one hand, it is desirable to include as many firms from the reports as possible to minimize noise from individual firms. On the other hand, we want to exclude firms that are not perceived as defense contractors by financial markets. For example, some firms may only be listed temporarily (such as Moderna and Pfizer during the COVID-19 pandemic), or defense contracts may only account for a tiny fraction of a firm's total sales (such as FedEx). Our goal is not necessarily to include as large a fraction of defense contracts as possible, but rather to extract as clear a signal about defense spending news as possible.

We impose the following requirements for a firm to be included in our index. First, we require that firms appear in the reports at least five times. Second, we restrict our analysis to firms that belong to a defense-related industry as defined by the list of four-digit SIC codes in Fisher and Peters (2010). This classification is relatively broad but excludes firms that are not primarily engaged in defense-related activities such as health insurance companies. To ensure that the firms are exposed to defense contracts, the third requirement is that defense contracts must account for at least 20 percent of the firm's total sales on average. Fourth, we target relatively large contractors by requiring that a firm's defense contracts must account for at least one percent of the total contract volume on average. Finally, we exclude any private and foreign firms that are not covered by CRSP. This requirement is not very restrictive, as large defense contractors are almost exclusively publicly traded U.S. companies.

Our baseline set of firms replicates the list of firms considered in Fisher and Peters (2010) by additionally imposing that firms must appear in the top three at some point, and by excluding

Boeing.[17] We weight the firms by their average share of total contract volume. Our stock index includes 14 individual stocks and covers 35 percent of defense contracts on average. Figure B.2 shows that the share of contracts awarded to the firms in the index has been relatively stable over time. Following Fisher and Peters (2010), we extrapolate our list of defense contractors back to 1947. We verify that the firms in the list were large defense contractors in this period by consulting official accounts from the Korean War (United States Senate, 1951).

We construct alternative stock indices that do not impose the top 3 requirement; that include Boeing; and that select a higher number of firms based on recent reports (for example, firms appearing in the top 25 in the last three years). Overall, all of these alternative indices are highly correlated with our baseline index because the defense industry is dominated by the top 5–10 largest defense contractors, such as Lockheed Martin, Raytheon, General Dynamics, Northrop Grumman, and most of these firms and their predecessors have existed for the whole sample period.

2.4 Measuring Defense Spending Surprises

On each event date, we measure the excess returns of defense contractors relative to a broader stock market index. Conceptually, an event that communicates news of an increase in future defense spending leads to excess returns of U.S. defense contractors as market participants raise their expectations of future profits.

Let P_τ^{def} denote the closing price of our stock index of defense contractors on a trading day τ. Define the daily return as $r_\tau^{def} \equiv \log P_\tau^{def} - \log P_{\tau-1}^{def}$ where $\tau - 1$ is the previous trading day. Similarly, let P_τ^{mkt} be the closing price of the value-weighted market index in the CRSP database with daily return r_τ^{mkt}. Now consider N event dates $\{\tau_1, \ldots, \tau_N\}$ during which news about defense spending are communicated. For each event date τ_i, we define the daily defense spending surprise as the excess return:

$$surprise_{\tau_i} = r_{\tau_i}^{def} - r_{\tau_i}^{mkt}.$$

When an event falls on a non-trading day, we measure the return on the next trading day.

We use daily event windows as in e.g. Känzig (2021) and Drechsel and Miura (2025). Fiscal policy is communicated less clearly than monetary policy, so the exact timing can be difficult to pin down and markets may need some time to process or interpret the announcement. Furthermore, exact time stamps from the Congressional Record and intraday financial data are unavailable for most of our sample period.

Returns vs. Excess Returns Our goal is to construct an *instrument* for defense spending that can be used to identify fiscal multipliers. Therefore, we only need to identify the surprises up to scale. While the idea behind using a defense stock index is that spending news affect returns as cash flow

[17] Fisher and Peters (2010) drop Boeing because of its exposure to the relatively volatile commercial airline industry. Our approach is not sensitive to this choice because we focus only on specific event dates that are dominated by announcements about defense.

news, we do not strictly need to assume that this channel is the only channel. For example, expected market cash flows might react to defense spending news (e.g. due to multiplier effects), but as long as the surprise we measure reflects a reaction to defense news, and not other confounding shocks, the surprise variable remains a valid instrument. We theoretically decompose the surprises to lay out this point in detail and show that we can allow for market cash flows and discount rates to react in Appendix A. Still, standard asset pricing theory suggests that the surprises *do* reflect changes in expected cash flows, which is our preferred interpretation.

Alternative measures of excess returns If our defense stock index does not move one-for-one with the market, then simply subtracting the market return may be insufficient to control for market fluctuations. To address this concern, we also compute excess returns based on a standard CAPM model and the Fama–French three-factor model.[18] Overall, these alternative measures of excess returns are nearly perfectly correlated with our baseline measure and consequently produce close to identical results. We find that the estimated market beta for our defense stock index is close to one (0.90). This finding is consistent with defense index funds such as BlackRock's iShares U.S. Aerospace & Defense ETF index, which reports a market beta of 0.95 as of September 2025.

2.5 Examples of Defense Spending Surprises

In this subsection, we provide two concrete event study examples using events that communicated defense news that resulted in excess returns.

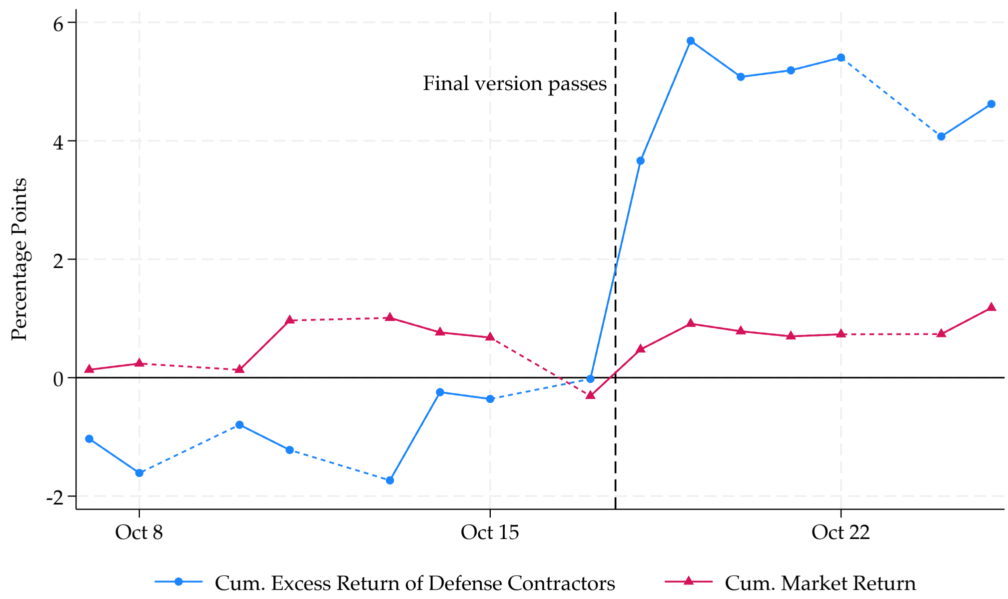
Example 1: National Military Establishment Act 1950 Our first example is the final Congressional approval of the National Military Establishment Act for the fiscal year 1950—the regular defense appropriations bill of that year—on October 18, 1949. *CQ Almanac* provides a detailed narrative account of the progression of this bill. At the time, the measure was the largest peacetime appropriations bill in U.S. history. In early October, after weeks of lengthy sessions, the conference committee reported that they had reached agreement on 73 of the 100 items that the House and the Senate bills disagreed on. The main source of disagreement concerned four amendments in which the Senate proposed substantial cuts to the Air Force. Both chambers refused to give in, so the conference committee went back to work. In the end, the Senate gave in at the end of a night session on October 17. The Air Force cuts did not materialize and the bill was passed the next day.

Figure 1a plots the cumulative excess returns of the defense stock index in October 1949. When the Senate gave in on their demands to cut the Air Force, defense stock rallied with excess returns of about four percentage points. In this example, it was most likely the passage itself that communicated news by resolving uncertainty about Air Force funding. All other disagreements had already been agreed to.

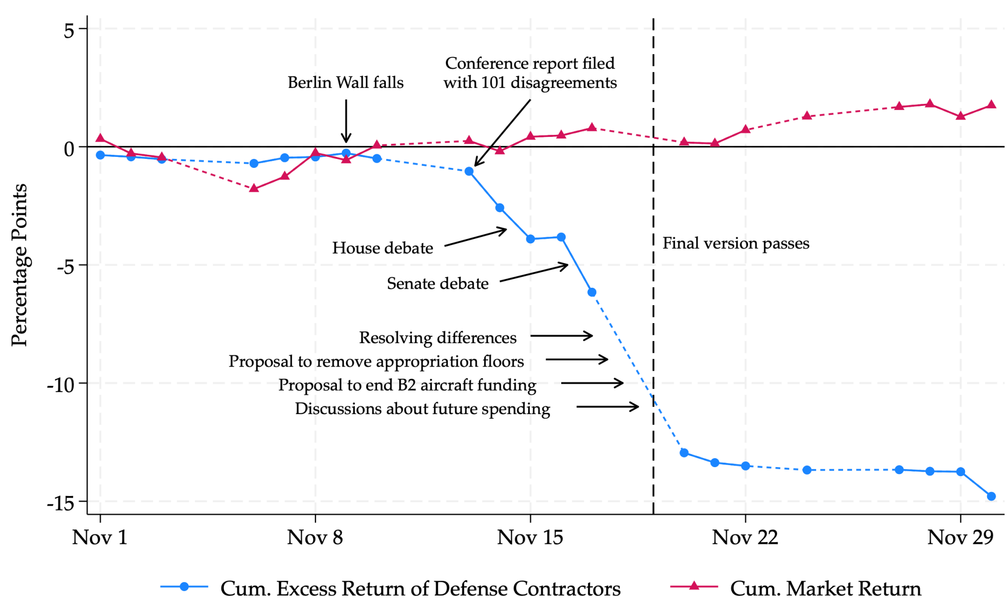
[18] We estimate these measures of excess returns using daily data on all trading days for our sample period 1947–2019. For the CAPM model, we regress the returns of the defense stock index on the market index and obtain the excess return as the residual. The Fama–French specification additionally controls for size and value risk factors.

Figure 1: Event Study Examples

(a) Defense Appropriations Act for Fiscal Year 1950



(b) Defense Appropriations Act for Fiscal Year 1990



Notes: This figure illustrates two examples of defense spending surprises by plotting the cumulative excess returns of the defense stock index around two of our event dates. In both panels red triangles represent market returns and blue circles represent excess returns. Panel (a) shows the cumulative returns around the final passage of the National Military Establishment Act 1950 on October 18, 1949 (with October 6 excess returns normalized to zero). Panel (b) shows in blue circles the cumulative returns around the final passage of the Department of Defense Appropriations Act 1990 in November 1989 (with October 31 excess returns normalized to zero).

Example 2: Department of Defense Appropriations Act 1990 We now consider an example of an event that led to a large negative surprise: the annual defense appropriations bill that provided funding for the fiscal year 1990. The first version of the bill was introduced in the House on August 1, 1989. After debating and amending the bill, the house passed their version of the bill three days later on August 4. The Senate version of the bill was passed in late September with several significant amendments. To resolve the differences between the House and Senate versions of the bill, a conference committee with members was appointed to. Usually, the conference committee reaches an agreement, but in this case the conference report came out of committee with more than 101 disagreements on Monday November 13, so the House and the Senate had to debate the bill again to resolve their differences before reaching an agreement the following weekend.

Figure 1b shows the cumulative excess returns of our defense stock index in November 1989. The stock prices of major defense contractors began to decline gradually during the week, consistent with investors revising expectations about future defense budgets. The final version of the bill was passed the following weekend after intense negotiations and public discussion about potential reductions in defense spending. When markets reopened, defense contractor stocks fell sharply. Broader market indices were largely unchanged during this period, suggesting that the decline in defense stocks reflected sector-specific news rather than general macroeconomic developments.

2.6 Defense Spending Surprise Series

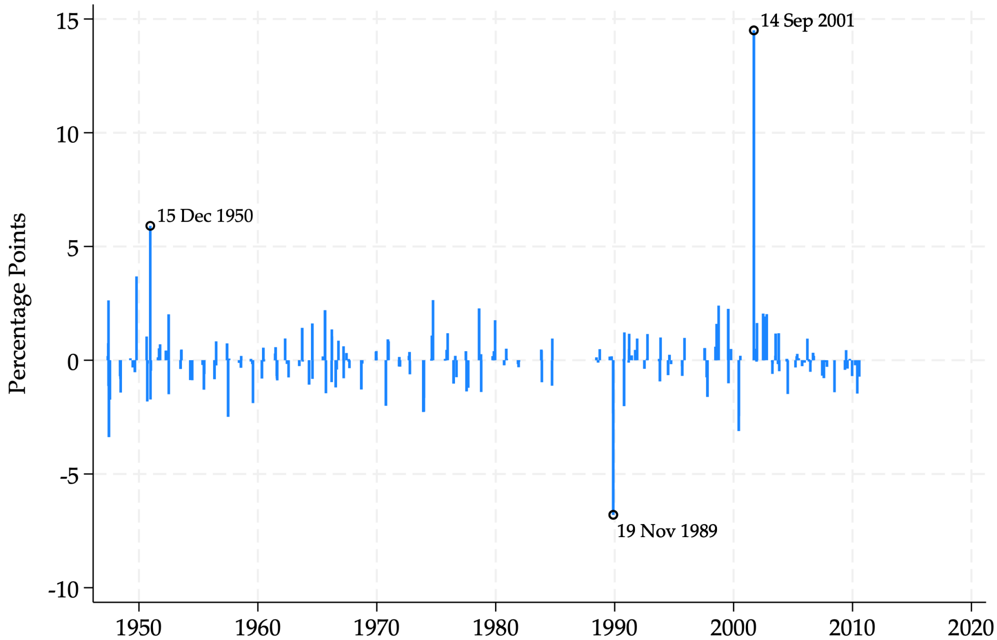
Figure 2 plots the daily defense spending surprises on each of our 213 event dates. The mean surprise is 0.00, suggesting that there is no evidence of systematic excess returns on our event dates. The standard deviation of the surprises is 1.57 percentage points, which indicates that the variance is more than twice as high on event dates compared to a sample that includes all trading days.

Are the surprises we identify autocorrelated or predictable? Figure B.5 shows the the autocorrelation and partial autocorrelation functions of our surprise series. A standard Ljung-Box test indicates that we cannot reject the null of no autocorrelation with a p-value of 0.84. To assess predictability, we conduct Granger causality tests in line with the previous literature on news shocks (e.g. Ramey, 2011*b*; Känzig, 2021). Figure B.6 shows that standard macroeconomic and financial do not significantly predict our defense spending surprises.

3 The Dynamic Effects of Defense Spending News

In this section, we present our empirical specification and estimate the effects of a defense spending surprise on the macroeconomy. We show that a positive defense spending surprise predicts a persistent increase in future defense spending that is entirely passed through to total government spending. The identified spending increases are financed with a mix of taxes and debt, and we find muted responses of nominal interest rates and inflation. We find a sizable and persistent increases in output and consumption, as well as a decline in the unemployment rate. In the next section,

Figure 2: Daily Defense Spending Surprises



Notes: This figure shows the daily defense spending surprise series, constructed as the excess returns of a stock index of defense contractors on 213 event dates on which different versions of defense appropriations bills passed in the Congress.

we estimate cumulative fiscal multipliers to summarize the dynamic responses of government spending and output.

3.1 Empirical Specification

We now estimate impulse response functions to a defense spending surprise using local projections (Jordà, 2005). We aggregate our daily series of surprises to quarterly frequency by summing them within each quarter. We then convert them from excess returns to dollar surprises by multiplying them by lagged real defense spending per capita G_{t-1}^{def}. Our main interest lies in the dynamic responses of government spending, output, and their components. We estimate regressions

$$\frac{X_{t+h} - X_{t-1}}{Y_{t-1}} = \alpha_h + \beta_h \frac{surprise_t}{Y_{t-1}} + \sum_{j=1}^{p} \gamma_h^{j\prime} \boldsymbol{W}_{t-j} + u_{t+h}, \tag{1}$$

for each horizon $h = 0, 1, ..., H$, where X_{t+h} denotes an outcome variable measured in real dollars per capita (e.g. government spending or output) measured at time $t + h$, Y_{t-1} is lagged GDP in real dollars per capita, $surprise_t$ is the defense spending surprise in real dollars per capita, $\boldsymbol{W}_t$ is a vector of control variables, and u_{t+h} is an error term.

We measure the components of aggregate demand in percent of GDP by normalizing by Y_{t-1} because we are ultimately interested in multipliers (rather than elasticities). Similarly, we normalize the surprise so the right-hand side variable of interest $\frac{surprise_t}{Y_{t-1}}$ is also measured in percent of GDP. We emphasize that we interpret the surprise series as an *instrument* for changes in defense spending, and we do not claim to identify the scale. We scale the defense spending surprises such that the impulse response of defense spending peaks at one percent of GDP. Since multipliers are unit-less, this normalization of the reduced-form responses to a surprise can also be interpreted as a peak of one dollar per capita.

We estimate the regressions in long-differences for two reasons. First, this formulation is the natural extension of estimating contemporaneous multipliers in first-differences as in Hall (2009) and Barro and Redlick (2011). Second, the simulation evidence of Jorda and Taylor (2025) suggests that long-differencing suppresses the small sample bias highlighted by Herbst and Johannsen (2024), and hence long-differencing obviates the need to apply a bias correction procedure.

We choose our control variables based on Montiel Olea et al. (forthcoming) who recommend including several lags of the outcome, the regressor, as well as strong predictors of either. We control for $p = 6$ lags of the surprise series, output, defense and total spending, inflation, short-term interest rate, and the unemployment rate.[19] When the outcome variable is not already in this list of controls (e.g., consumption), we also include six lags of this variable.

We use quarterly data for the U.S. 1947–2019 obtained from the FRED database. We use standard variables from the national income and product accounts (NIPA) to measure government spending, GDP, and private consumption and investment. We express these variables in real 2017-dollars per capita terms. We report heteroskedasticity-robust standard errors (Montiel Olea and Plagborg-Møller, 2021).[20]

3.2 Defense Spending and Total Government Spending Responses

Our first result is that a defense spending surprise predicts a persistent increase in future defense spending that is passed through to total government spending. The first panel of Figure 3 shows the estimated response of defense spending, with the peak response normalized to one. The dependent variable is $\frac{G^{def}_{t+h} - G^{def}_{t-1}}{Y_{t-1}}$, where G^{def}_t is level of defense spending and Y_t is the level of GDP. The impact response is a precisely estimated zero effect. The absence of an immediate spending response is consistent with our interpretation that the surprises capture *news*. In the quarters following a surprise, defense spending increases steadily for 2–3 years, after which it stays elevated for several years. The magnitude of the shocks is economically meaningful: A one-standard-deviation defense spending surprise leads to a persistent increase in defense spending that peaks at 0.25 percent of GDP.

The second panel of Figure 3 shows that the response of total government spending (the sum of defense and nondefense spending) closely mirrors the defense spending response. Our surprise

[19] Inflation is year-on-year percentage change is in the GDP deflator, and the short-term interest rate is the yield on 3-month Treasury bills.

[20] This choice is conservative as heteroskedasticity and autocorrelation robust standard errors tend to yield smaller standard errors in our setting.

series almost exclusively predicts changes in defense spending, not other types of spending. The confidence bands are only slightly wider for total spending, consistent with the well-known fact that defense spending accounts for most of the variation in U.S. government spending.

What explains the high persistence of the spending responses? First, U.S. defense spending is generally a highly persistent process outside of large wars such as World War II and the Korean War.[21] In addition, more recent military campaigns such as the Vietnam War, the 1980s Carter-Reagan buildup, and the wars in Afghanistan and Iraq, featured longer buildups and drawdowns.

A second reason is that defense contracts have long durations. Cox et al. (2024) document that the median federal contract is 3–4 years with a 90th percentile of approximately 12 years. If a defense spending surprise reflects a decision to build new fighter jets or Navy ships, then we should expect high persistence. Measurement and implementation lags may also play a role. Recently, Briganti, Brunet and Sellemi (2025) have shown that government spending, as measured in national accounts (NIPA), lags budget authorization by 3–4 quarters. The timing in NIPA may reflect the delivery time of the final good to the government, or the timing of the associated Treasury outlays (which can occur gradually for large defense projects). However, while this timing mismatch likely contributes to the persistence of our defense spending response, it is unlikely to be the main driver because we find persistence effects that last several years.

We estimate dynamic responses up to a maximum horizon of 6 years throughout. While we have sufficient statistical power to estimate the spending responses in Figure 3 at longer horizons, the responses of other macroeconomic outcomes are difficult to estimate far into the future because they are influenced by many other factors.[22] We show the spending responses at longer horizons in Figure B.8. When we restrict our sample to the post-1955 period, which excludes the Korean War, the spending response is more transitory, although still highly persistent (see Figure B.9).

3.3 Responses of Taxes and Deficits

By definition, an increase in defense spending must be financed in one of three ways: decreasing other types of spending, increasing tax revenue, or by running a deficit. This result follows from the government budget identity:

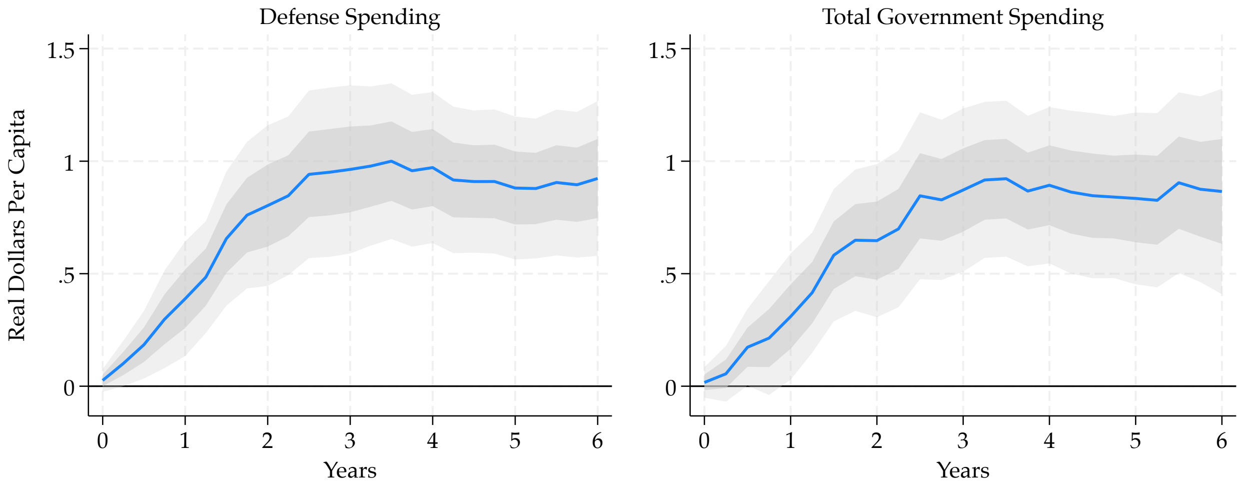
$$\underbrace{G_t^{def} + G_t^{nondef}}_{\text{Gov't purchases}} = \underbrace{T_t}_{\text{taxes}} + \underbrace{B_t - (1 + r_{t-1})B_{t-1}}_{\text{deficit}} \tag{2}$$

where G_t^{def} and G_t^{nondef} denote defense spending and nondefense spending, T_t denote tax revenue (net of transfers), B_t is the debt issued in period t, and r_t is the real interest rate. Macroeconomic models with non-Ricardian agents and high marginal propensities to consume (MPCs), such as

[21] For example, Barro (1981) observes that *"defense spending associated with wars is largely transitory, while other changes in defense spending turn out to be predominantly permanent."*

[22] Antolin-Diaz and Surico (2025) study the long-run effects government spending using the shock series from Ramey and Zubairy (2018) and a Bayesian VAR with 60 quarterly lags. Even in this setting, they find that variation from large wars (World War I, World War II or the Korean War) is necessary to have sufficient power with 90 percent confidence bands.

Figure 3: Defense Spending Surprises Predict Future Defense Spending



Notes: This figure plots the response of defense spending and total government spending to a defense spending surprise, normalized so the defense spending response peaks at one dollar per capita (chained 2017-dollars). The solid blue lines are our estimates of β_h in Equation (1) for different horizons h. The dark and light shaded areas are 68% and 95% confidence intervals.

the old textbook IS-LM model or the modern heterogeneous-agent New Keynesian literature,[23] predict that the size of fiscal multipliers strongly depend on how the spending is financed. When spending is debt-financed, current disposable income rises without an immediate tax increase. Non-Ricardian high-MPC households therefore spend more today, so the boost to consumption is larger than under tax financing.

Figure 4 shows how the identified spending changes are financed. The first panel replicates the response of defense spending from the previous subsection. The second panel plots the response of nondefense spending, which accounts for the small difference between defense and total government spending. The bottom two panels show the responses of taxes (net of transfers) as well as the federal deficit. For taxes, the outcome variable is $\frac{T_{t+h}-T_{t-1}}{Y_{t-1}}$, where T_t is the current federal tax receipts minus current federal transfers payments. For deficits, the dependent variable is $\frac{D_{t+h}-D_{t-1}}{Y_{t-1}}$, where D_t is the federal deficit including interest payments (defined as current expenditures minus current receipts in NIPA). These responses are less precisely estimated than the spending responses in the first row and indicate that the spending increases are financed with a mix of taxes and debt. The tax response peaks at 50 cents and is borderline significant when the defense spending response peaks at 1 dollar. This increase suggests that, on average, taxes and transfers do a play role in financing the identified defense spending increases. Hence, the government spending increases we identify should not be interpreted as a purely deficit-financed as in the literature on local fiscal multipliers (Nakamura and Steinsson, 2014; Farhi and Werning, 2016; Chodorow-Reich, 2019).

[23]See, e.g., Galí, López-Salido and Vallés (2007), Kaplan, Moll and Violante (2018), and Auclert, Rognlie and Straub (2024).

One likely explanation for why it is difficult to obtain precise estimates for tax and deficit responses is time variation in the fiscal rule. What matters for fiscal multipliers is whether government spending is tax-financed or debt-financed *at the margin*. It is well-documented that the financing of defense spending and wars have varied considerably over time (Goldin, 1980; Ohanian, 1997). For example, the U.S. government implemented tax rate increases and ran a balanced budget during the Korean War, whereas later episodes such as the Carter-Reagan buildup and the wars in Afghanistan and Iraq, were financed almost entirely through deficits (Barro and Redlick, 2011). Auerbach and Yagan (2025) provide empirical evidence that, in recent decades, Congress has stopped responding to higher projected deficits with fiscal adjustments. Consistent with this evidence, we show in Figure B.12 that excluding the post-2000 part of our sample increases both the magnitude and the precision of the estimated tax response. We also find some evidence that excluding the pre-1955 period (which includes the Korean War) leads to a larger deficit response, but only after 4–6 years (see Figure B.13). Finally, we note that interpreting the fiscal policy response is complicated by the presence of automatic stabilizers (e.g., McKay and Reis, 2016) and by feedback from output to tax revenues through a "tax-base channel" (Angeletos, Lian and Wolf, 2024). Part of the estimated increase in taxes may reflect these mechanical forces rather than deliberate tax policy changes, such as the major tax bills enacted during the Korean War.

3.4 Responses of Monetary Policy and Inflation

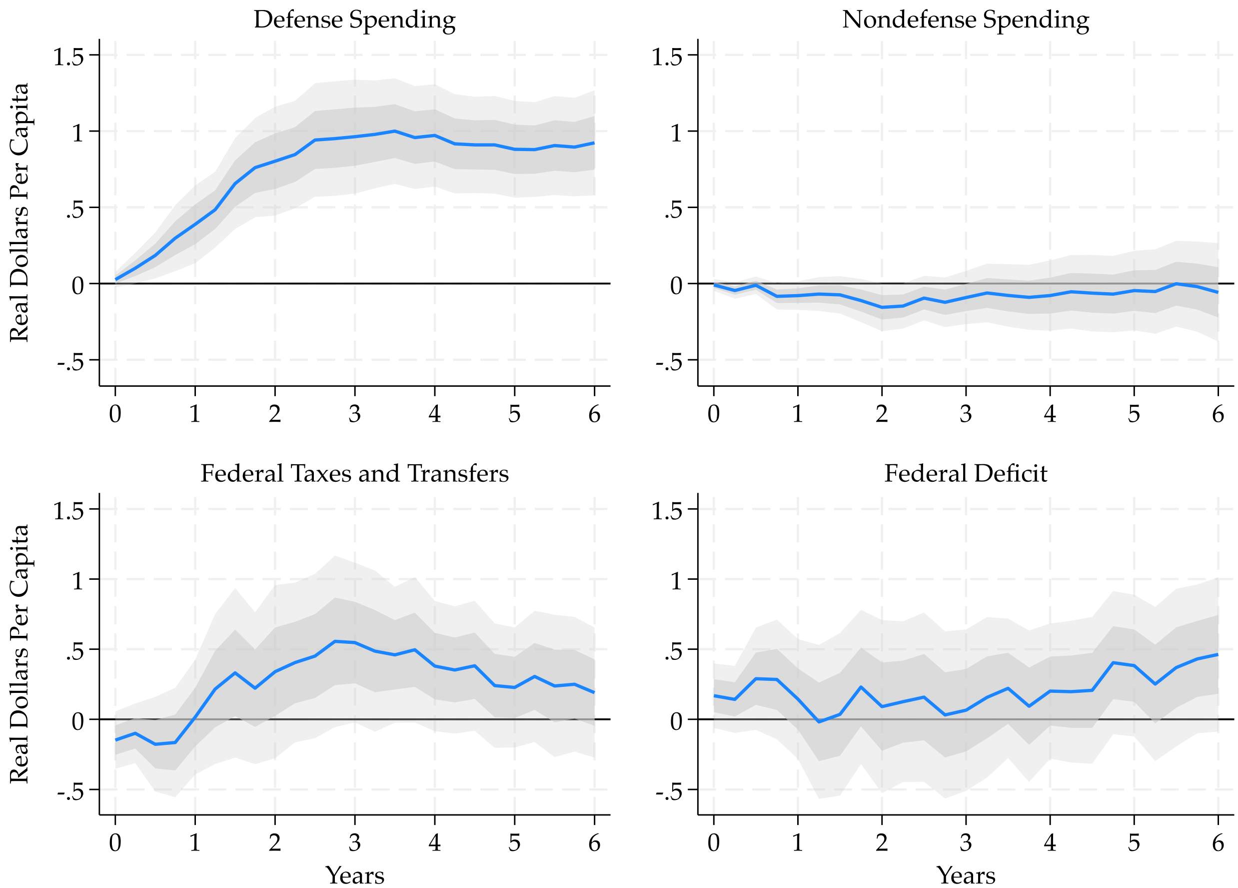
Are the spending increases we identify dampened (or amplified) by a monetary policy response? Textbook New Keynesian models predict that the size of fiscal multipliers depend crucially on the monetary policy response (Woodford, 2011; Christiano, Eichenbaum and Rebelo, 2011; Auclert, Rognlie and Straub, 2024). In Figure 5, we present the responses of the short-term nominal interest rate and the PCE inflation rate to a defense spending surprise. The responses are normalized such that the defense spending response peaks at one percent of GDP (corresponding to a surprise of about four standard deviations). We do not find evidence that spending increase are met with a strong monetary policy response. The estimated response of the nominal interest rate stays close to zero, suggesting that monetary policy does not respond. The inflation response is not statistically significantly different from zero and ranges from slightly positive in the first two years after a surprise to slightly negative in years 2–4. These findings are generally in line with the previous empirical literature: Researchers often find that nominal interest rates do not respond to identified government spending shocks,[24] whereas the evidence on inflation responses is mixed (Jørgensen and Ravn, 2022).

3.5 Output, Consumption, and Investment Responses

In Figure 6, we present the responses of GDP and its components in the national income identity $Y = C + I + G + NX$. The top row shows that a defense spending surprise generates a substantial

[24] See, for example, the discussion in Angeletos, Lian and Wolf (2024).

Figure 4: Responses of Taxes and Deficits to a Defense Spending Surprise

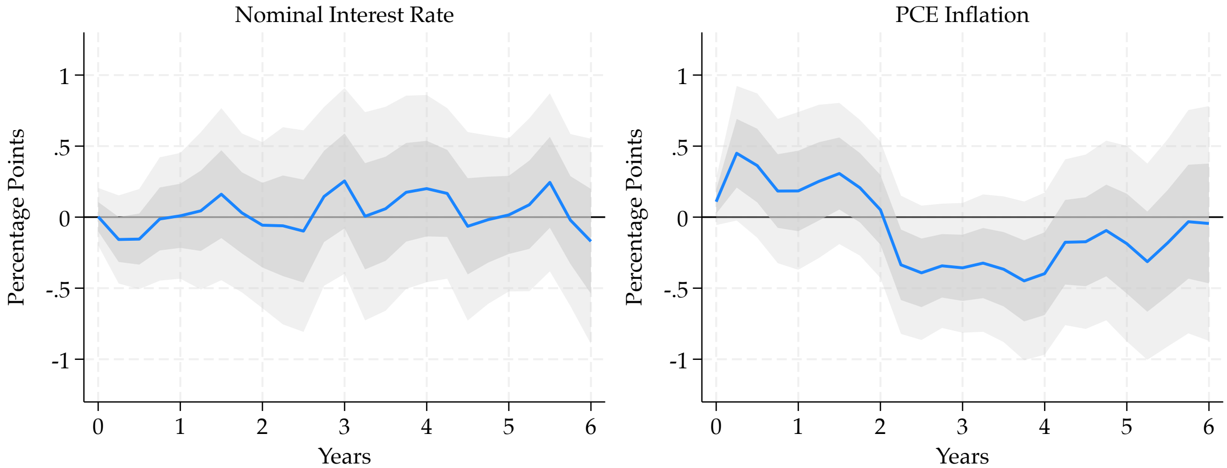


Notes: This figure plots the response of defense spending, nondefense spending, federal taxes and transfers, and the federal deficits to a defense spending surprise, normalized so the defense spending response peaks at one dollar per capita (chained 2017-dollars). For taxes, the outcome variable is $(T_{t+h} - T_{t-1})/Y_{t-1}$, where T_t is the current federal tax receipts minus current federal transfers payments as defined in NIPA. For deficits, the dependent variable is $(D_{t+h} - D_{t-1})/Y_{t-1}$, where D_t is the federal deficit including interest payments (defined as current expenditures minus current receipts in NIPA). The solid blue lines are our estimates of β_h in Equation (1) for different horizons h. The dark and light shaded areas are 68% and 95% confidence intervals.

increase in output that largely has the same shape as the spending response. Even though the spending path is back-loaded, output increases gradually and does not increase on impact. Yet, output rises faster than spending: while the spending response only reaches its peak after three years, output is almost at its peak after only one year. A potential explanation is that agents are responding to news about future government spending by increasing private expenditures.

The second row shows the private consumption responses to a defense spending surprise. Private consumption accounts for about 70 percent of GDP, so the consumption response is an key determinant of fiscal multipliers. The left panel shows that households gradually increase their consumption of non-durables and services. Once again, we do not find evidence of an immediate jump on impact. At first glance, the absence of an immediate response may appear

Figure 5: Muted Monetary Policy Response



Notes: This figure plots the responses of the nominal interest rate (3-month Treasury bill rate) and PCE inflation (year-on-year) to a defense spending surprise. The responses are normalized so the defense spending responses peaks at one percent of the GDP. The solid blue lines are our estimates of β_h in Equation (1) for different horizons h. The dark and light shaded areas are 68% and 95% confidence intervals.

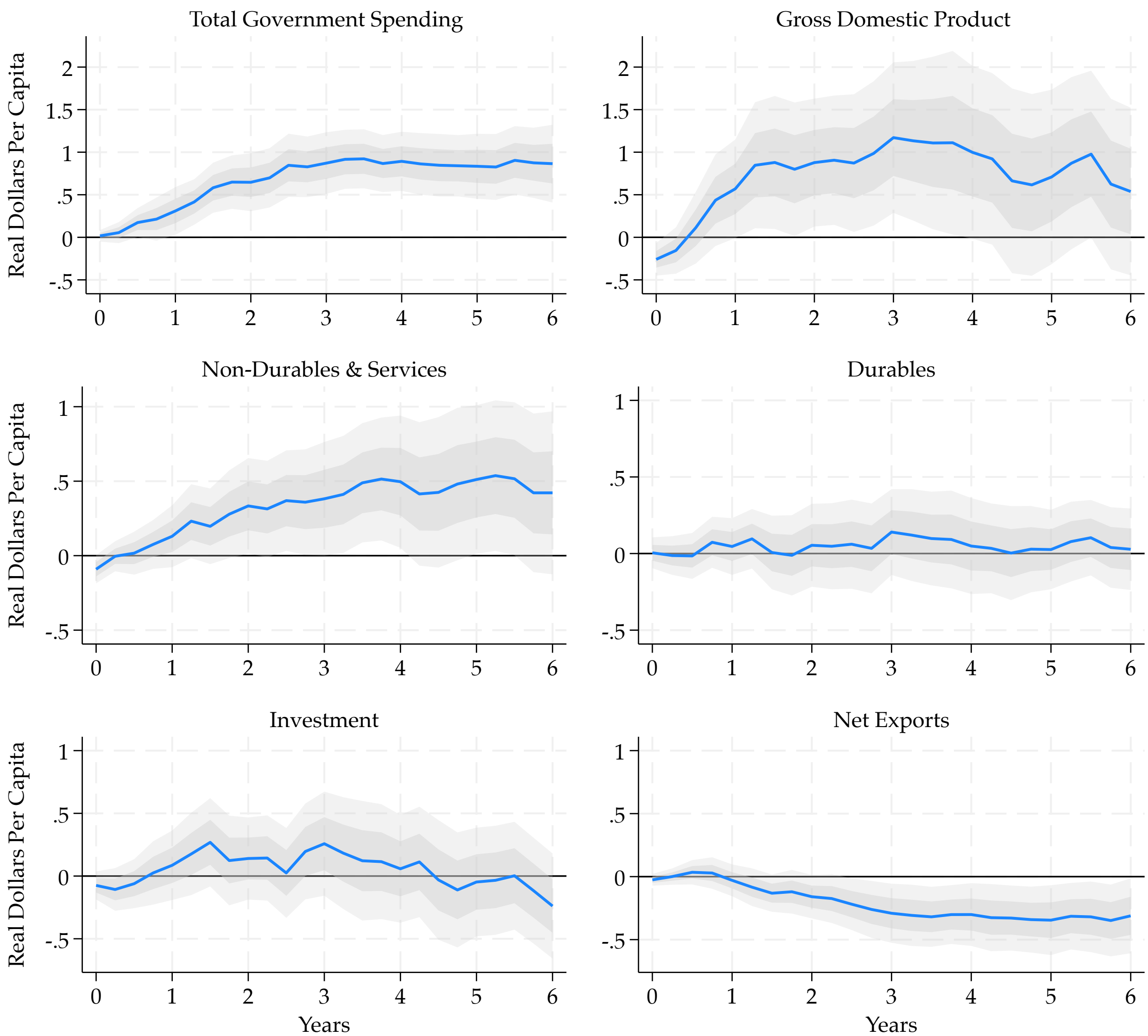
inconsistent with the behavior of forward-looking household in standard macroeconomic models. However, this finding is less puzzling given the absence of a real interest rate response that we documented in the previous section. The consumption response is persistent and peaks at a level that is about half of the spending response. In contrast, consumption of durables does not respond to a defense spending surprise. Overall, private consumption is crowded in, rather than crowded out as predicted by standard neoclassical models (Woodford, 2011). This result contrasts with the literature that relies on large wars for identification, as these papers find negative consumption responses (Barro, 1981; Hall, 1986; Ramey and Shapiro, 1998; Hall, 2009; Barro and Redlick, 2011; Ramey, 2011*b*).

The third row shows the responses of investment and net exports. The investment response is moderately positive but statistically insignificantly different from zero. For completeness, we also show the response of net exports, which fall gradually to a level that accounts for about half of the increase in consumption. This decline may reflect an appreciation of the U.S. dollar standard open economy models predict, and which Auerbach and Gorodnichenko (2016) provide evidence for. Alternatively, it may reflect government imports, or imports of intermediate goods by defense contractors. We note that the decline in net exports response suggests that foreign demand for defense goods does not seem to be a major driver of the output response.

3.6 Labor Market Responses

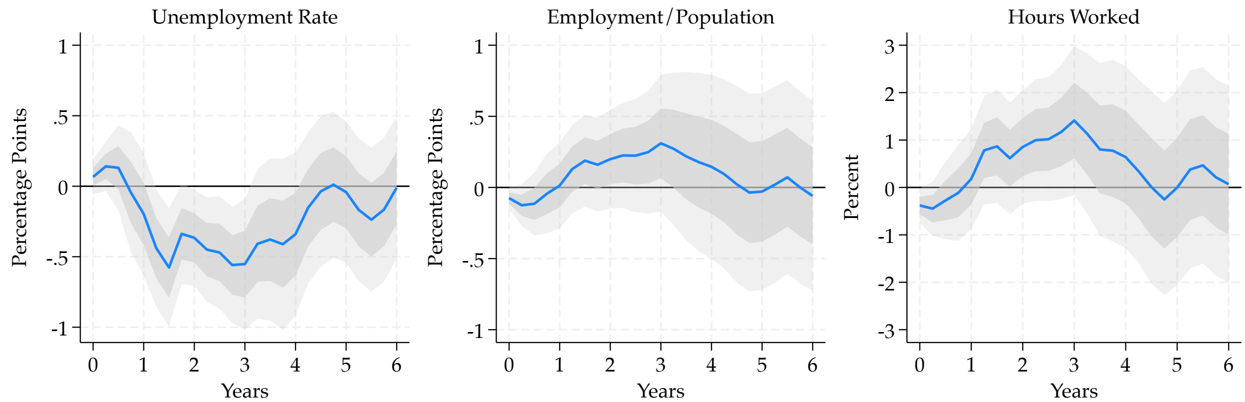
Figure 7 shows that the response of the labor market to a defense spending surprise that generates a defense spending peak of one percent of GDP. The first panel shows that the unemployment

Figure 6: Government Spending Stimulates Private Economic Activity



Notes: This figure plots the responses of total government spending, output, non-durable and services consumption, durables consumption, investment, and net exports to a defense spending surprise, normalized so the defense spending response peaks at one dollar per capita (chained 2017-dollars). The solid blue lines are our estimates of β_h in Equation (1) for different horizons h. The dark and light shaded areas are 68% and 95% confidence intervals.

Figure 7: Labor Market Responses to a Defense Spending Surprise



Notes: This figure plots the responses of the unemployment rate, the employment-population ratio, and log hours worked to a defense spending surprise, normalized so the defense spending response peaks at one percent of GDP. The solid blue lines are our estimates of β_h in Equation (1) for different horizons h. The dark and light shaded areas are 68% and 95% confidence intervals.

rate falls by about 0.5 percentage points. This effect is consistent with Okun's law, since GDP rises by about one percent in response to the same shock. The second and third panels show that the responses of employment-to-population ratio and hours worked mirror the unemployment response, but with wider confidence bands.

4 Aggregate Fiscal Multipliers

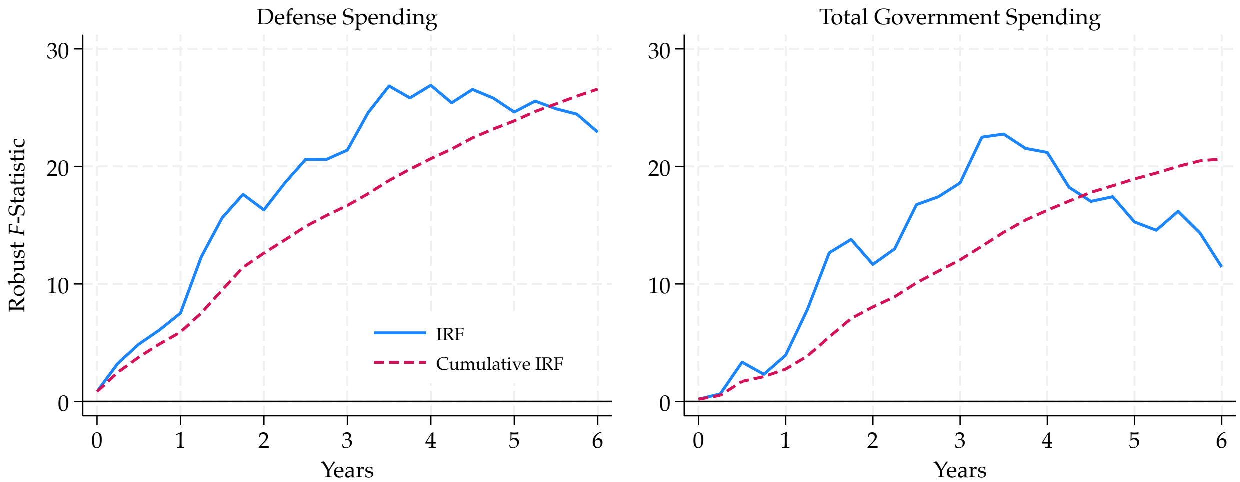
In this section, we summarize the effects of government spending on output using cumulative fiscal multipliers (Mountford and Uhlig, 2009; Farhi and Werning, 2016). The cumulative fiscal multiplier is the cumulative output response divided by the cumulative government spending response to a defense spending surprise. While the impulse responses contain strictly more information, the multiplier is useful for summarizing the effects of government spending on output.

We estimate cumulative fiscal multipliers using a local projections instrumental variables (LP-IV) approach (Stock and Watson, 2018; Ramey and Zubairy, 2018). For a given horizon h, we regress the cumulative output response on the cumulative government spending response:

$$\sum_{j=0}^{h} \frac{Y_{t+j} - Y_{t-1}}{Y_{t-1}} = \delta_h + \mathcal{M}_h \sum_{j=0}^{h} \frac{G_{t+j} - G_{t-1}}{Y_{t-1}} + \sum_{j=1}^{p} \gamma_h^{j\prime} \boldsymbol{W}_{t-j} + u_{t+h} \tag{3}$$

using our surprise series as an instrument. G_t denotes total government spending and Y_t denotes the level of GDP. The coefficient of interest is $\mathcal{M}_h$, which represents the cumulative fiscal multiplier at horizon h. The control variables $\boldsymbol{W}_t$ are the same we used to estimate the impulse responses in the previous section.

Figure 8: First-stage F-Statistics



Notes: This figure plots robust first-stage F-statistics from testing the responses of defense spending and total government spending to a defense spending surprise. The solid blue line plots the F-statistics from pointwise tests that the impulse responses in Figure 3 are equal to zero at each horizon. The dashed red line plots the F-statistics from testing that the *cumulative* impulse responses (up to the given horizon) are equal to zero. The dashed red line is the relevant first-stage F-statistic for estimating cumulative fiscal multipliers using our defense spending surprises as an instrument.

4.1 First Stage

To reliably estimate the cumulative fiscal multiplier at horizon h, the defense spending surprise must be a relevant instrument for the cumulative spending response $\sum_{j=0}^{h} \frac{G_{t+j}-G_{t-1}}{Y_{t-1}}$. The dashed red line in Figure 8 plots the first-stage F-statistics at each horizon h.[25] These are the test statistics from testing the null that the integral under the impulse responses in Figure 3 equals zero at a given horizon. At short horizons, the instrument is weak because no actual spending has occurred yet. At longer horizons, the surprise series predicts more spending and the F-statistics rise. We use the total government spending variable to estimate fiscal multipliers. At a five-year horizon, the F-statistic is almost 20, which indicates that our surprises series is a sufficiently strong instrument for cumulative government spending.

4.2 Fiscal Multiplier Estimates

Table 1 presents our estimates of the cumulative fiscal multipliers $\mathcal{M}_h$ in Equation 3 at horizons of 2–6 years. The first column shows the results for our baseline specification, which uses all 213 event dates and the full postwar sample from 1947 to 2019. We estimate a cumulative fiscal multiplier of 1.2 over a five-year horizon. The multiplier estimates decline with the horizon because the estimated output response to a spending surprise is slightly more front-loaded than the spending response. Consistent with the rise in private consumption that we documented in the previous section, the

[25] We report robust F-statistics. Since we are in the just-identified case, these are equivalent to the efficient F-statistic of Montiel Olea and Pflueger (2013).

multipliers are above one, suggesting that government spending crowds in private-sector economic activity.

In line with the positive consumption response documented in the previous section, our cumulative fiscal multiplier estimates are always above one. However, we recognize that we cannot reject fiscal multipliers of one—a common finding in the empirical literature on fiscal multipliers. Ramey (2016, Table 4) estimates cumulative fiscal multipliers using the identified shocks of Blanchard and Perotti (2002), Ramey (2011*b*), and Ben Zeev, Ramey and Zubairy (2023) using post-1947 quarterly data and likewise finds that none of the multiplier estimates are statistically significantly different from one. The local fiscal multiplier estimates Nakamura and Steinsson (2014, Table 2) fall in the range 1.4–1.9 with confidence bands that include one. One exception to this pattern is the extended defense news shocks series of Ramey and Zubairy (2018) that covers World War I, World War II, and the Korean War—three large and relatively sudden buildups. Using this series, together with either their specification or ours, we obtain a cumulative multiplier estimates around 0.7 that are precise enough to rule out one at the 5% level.

In columns (2) to (4) of Table 1, we investigate how our multiplier estimates depend on the selected event dates. In column (2), we remove the largest shock in our series, namely the emergency appropriations bill passed shortly after the September 11 attacks in 2001. A potential concern is that the event window around the passage of this bill includes confounding news and that our relatively large multipliers are driven by this event. The estimates presented in column (2) show this is not the case. Instead, our estimates increase The event-study graph around this event in Figure B.7 confirms that most of the excess returns are driven by defense contractors' stocks rather than market returns. More generally, we may worry that supplemental appropriations bills are more likely to violate the exclusion restriction if they happen turbulent times with lots of other news. To assess the role of supplemental appropriations, we exclude *all* supplemental appropriations bills and present the resulting multiplier estimates in column (3). We find that the multiplier estimates increase further to around 2. As expected, the first stage is somewhat weaker with F-statistics around 12 at longer horizons.

The final column of Table 1 reports our multiplier estimates for a sample starting in 1955, thereby excluding the Korean War period. At short horizons, we lack sufficient statistical power to estimate multipliers precisely, partly because the spending response is more back-loaded. At longer horizons, however, we find large multiplier estimates, consistent with earlier findings that the Korean War period is associated with smaller estimated multipliers Galí, López-Salido and Vallés (2007); Dupor and Guerrero (2017). At the five-year horizon, the lower bound of the 95 percent confidence interval is 0.83—above the cumulative multiplier estimates of Ramey (2011*b*), as reported in Ramey (2016).[26] An important contribution of our paper is that our defense spending surprise series allows us to estimate fiscal multipliers reliably in the post-1954 sample.

[26]Ramey (2011*b*) does not directly estimate cumulative fiscal multipliers, so we rely on the estimates from Ramey (2016), which uses the same shocks.

Table 1: Cumulative Fiscal Multiplier Estimates

Horizon (Years)	Baseline (1)	No September 11 (2)	Regular Appropriations (3)	Post-1954 (4)
2	1.35	2.02	3.74	6.99
	(0.83)	(0.96)	(1.64)	(8.17)
	$[F = 8.04]$	$[F = 7.38]$	$[F = 4.13]$	$[F = 0.9]$
3	1.29	1.71	2.66	4.03
	(0.62)	(0.69)	(0.89)	(2.50)
	$[F = 12.1]$	$[F = 11.8]$	$[F = 8.18]$	$[F = 3.44]$
4	1.27	1.57	2.31	2.98
	(0.56)	(0.62)	(0.75)	(1.23)
	$[F = 16.3]$	$[F = 16.1]$	$[F = 11.4]$	$[F = 7.65]$
5	1.17	1.39	2.00	2.44
	(0.52)	(0.59)	(0.72)	(0.82)
	$[F = 18.9]$	$[F = 17.7]$	$[F = 12.3]$	$[F = 10.1]$
6	1.12	1.29	1.82	2.09
	(0.49)	(0.56)	(0.68)	(0.63)
	$[F = 20.6]$	$[F = 18.0]$	$[F = 12.4]$	$[F = 12.4]$
Sample	1947–2019	1947–2019	1947–2019	1955–2019

Notes: This table reports our IV estimates of the cumulative fiscal multiplier $\mathcal{M}_h$ in Equation (3). Along the rows, we report estimates at different forecast horizons (in years). Along the columns, we estimate multipliers using different samples. The first column is our baseline sample, which includes all event dates from regular and supplemental appropriations bills 1947–2019. The second column excludes the event around the September 11 attacks. The third column drops all events related to supplemental appropriations and only considers regular appropriations bills. The final column drops the years before 1955 (which include the Korean War). Below each estimate we report the heteroskedasticity-robust standard error in parentheses, and the first stage F-statistic in brackets.

Taken together, these results suggest that government spending has sizable and persistent effects on output. Across specifications, our estimated cumulative multipliers remain above one. We interpret these findings as evidence that fiscal multipliers can exceed one.

5 Aggregate Fiscal Multipliers in Standard Models

Our empirical analysis shows that government spending has substantial effects on economic activity. Are these results consistent with standard models of fiscal policy? In this section, we develop a theoretical framework to show that the answer is yes. Our model builds on the two-asset heterogeneous-agent New Keynesian (HANK) model of Auclert, Rognlie and Straub (2024) and the work of Kaplan and Violante (2014, 2022). As first proposed in Galí, López-Salido and Vallés (2007), the presence of both non-Ricardian high-MPC households and nominal rigidities enables the model to replicate the positive consumption response to government spending that we see in the data.[27] Our results can also be rationalized by an analytically tractable two-agent New Keynesian (TANK) model (Galí, López-Salido and Vallés, 2007; Bilbiie, 2008; Angeletos, Lian and Wolf, 2024). On the other hand, our results are inconsistent with standard representative-agent New Keynesian models, since these cannot match the increase in consumption without a counterfactual decrease in real interest rates.[28]

5.1 Quantitative Model

Environment Time is discrete and infinite, indexed by $t = 0, 1, 2, \ldots$. The economy is populated by households, labor unions, production firms, banks, a monetary authority, and a fiscal authority. All agents have perfect foresight over aggregate variables.

Households The economy is populated by a unit continuum of ex-ante identical households i with preferences

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_{it}^{1-1/\sigma} - 1}{1 - 1/\sigma} - \frac{N_{it}^{1+1/\eta}}{1 + 1/\eta} \right) \tag{4}$$

where C_{it} and N_{it} are consumption and hours worked of household i at time t, σ is the intertemporal elasticity of substitution, and η is the Frisch elasticity of labor supply. Households face idiosyncratic income risk: Each hour worked provides e_{it} units of effective labor, where the labor productivity e_{it} follows a Markov process with fixed transition matrix Ω. The proportion of households in productivity state e is always $\omega(e)$, where $\omega(e)$ is the probability of e in the stationary distribution of Ω. The average labor productivity level is normalized to one, so $\sum_e \omega(e)e = 1$. Households earn nominal wage W_t per unit of effective labor and take their hours worked N_{it} as given (since hours are determined by labor union demand). Aggregate efficiency-weighted hours worked is $N_t = \int e_{it} N_{it}\, di$. Following Auclert, Rognlie and Straub (2024), we assume a proportional allocation rule for labor hours ($N_{it} = N_t$) and model progressive labor taxation as in Heathcote, Storesletten and Violante (2017). Household i's post-tax labor income is then $Z_{it} = \frac{e_{it}^{1-\theta}}{\int e_{it}^{1-\theta}} Z_t$, where Z_t is aggregate post-tax labor income, and θ is the progressivity of labor income taxation.

Households can hold their assets in liquid (A_{it}) or illiquid ($\tilde{A}_{it}$) accounts. Both accounts generate a net return of r_t, but holding liquid assets is subject to a flow cost $\zeta(1 + r_{t-1})A_{it-1}$ each period. We model illiquidity à la Calvo as in Bayer, Born and Luetticke (2024): Household i can transfer funds

[27] The main alternative way of generating an increase in consumption has been to use non-separable preferences that exhibit complementarity between consumption and hours worked (Basu and Kimball, 2003; Bilbiie, 2011; Monacelli and Perotti, 2008; Nakamura and Steinsson, 2014). This approach has largely fallen out of favor because it implies unrealistically high marginal propensities to earn out of wealth (Auclert, Bardóczy and Rognlie, 2023). Finally, consumption increases can also be achieved using a monetary policy rule that decreases real interest rates in response to government spending (Woodford, 2011; Christiano, Eichenbaum and Rebelo, 2011), but such a policy reaction is not consistent with our estimated interest rate response.

[28] Standard neoclassical models predict crowding out of private consumption and fiscal multipliers substantially below one (Woodford, 2011, e.g.,), hence we can immediately conclude that they are unable to match our empirical evidence. See also Aiyagari, Christiano and Eichenbaum (1992) and Baxter and King (1993) who study the neoclassical wealth effect on labor supply.

between the liquid and illiquid accounts only when the i.i.d. Bernoulli variable Λ_{it} equals one, which happens with probability λ in each period. At time t, the budget constraints for household i are

$$C_{it} + A_{it} = Z_{it} + (1-\zeta)(1+r_{t-1})A_{i,t-1} - H_{it}\Lambda_{it} \tag{5}$$

$$\tilde{A}_{it} = (1+r_{t-1})\tilde{A}_{i,t-1} + H_{it}\Lambda_{it} \tag{6}$$

where H_{it} denotes net transfers from the liquid to illiquid account. The household also face borrowing constraints for both accounts:

$$A_{it} \geq 0, \quad \tilde{A}_{it} \geq 0. \tag{7}$$

The two-account setup introduces a trade off: Holding assets in the liquid account insures against idiosyncratic income shocks, but it also entails a per-period return penalty $\zeta(1+r_{t-1})$. To avoid penalties, households can keep a portion of their wealth in the illiquid account, where it earns a higher return, but this also leaves them more exposed to negative income shocks that can push them up against their borrowing constraints. The two-account structure also has the advantage that it enables us to match both high MPCs and realistic income-to-asset ratios Kaplan and Violante (2022). We provide first-order conditions and further details in Appendix C.3.

Labor Unions and Nominal Wage Rigidity We assume sticky nominal wages and demand-determined labor as in Erceg, Henderson and Levin (2000) and Auclert, Rognlie and Straub (2024). Sticky wages have been shown to be particularly important in the context of fiscal multipliers because they help avoid countercyclical profits and unrealistically large income effects on labor supply (Auclert, Bardóczy and Rognlie, 2023; Broer, Krusell and Öberg, 2023). We briefly present the setup here and provide a detailed derivation of the wage Phillips curve in Appendix C.4. Each household i belongs to a labor union k. There is a continuum of differentiated unions k, and the members of each union are representative of the entire population. Unions set the nominal wage to maximize the utility of its members subject to quadratic adjustment costs as in Rotemberg (1982). A competitive labor packer combines the differentiated labor services of the unions using a standard CES aggregator. The labor packer then sells the aggregated labor services to firms. We extend the framework to allow for partial indexation of nominal wages to wage inflation. Optimization by the labor unions at a symmetric equilibrium leads to an aggregate non-linear wage Phillips Curve with inertia:

$$\begin{aligned}\left(\frac{1+\pi_t^w}{\left(1+\pi_{t-1}^w\right)^{\iota^w}} - 1\right)\frac{1+\pi_t^w}{\left(1+\pi_{t-1}^w\right)^{\iota^w}} &= \kappa^w\left[N_t v'(N_t) - \mu^w(1-\theta)Z_t\, u'(C_t^*)\right] \\ &\quad + \beta\left(\frac{1+\pi_{t+1}^w}{\left(1+\pi_t^w\right)^{\iota^w}} - 1\right)\frac{1+\pi_{t+1}^w}{\left(1+\pi_t^w\right)^{\iota^w}}.\end{aligned} \tag{8}$$

where $\pi_t^w = \frac{W_t}{W_{t-1}} - 1$ is the wage inflation rate, $u'(C_t^*) = \int \frac{e_{it}^{1-\theta} u'(C_{it})}{\int e_{it}^{1-\theta} di} di$ is the marginal utility of the "virtual" consumption aggregate[29] C_t^*, κ^w is the slope of the wage Phillips curve, μ^w is the optimal steady-state wage markup, and ι^w is the degree of wage indexation.

Firms We adopt the common two-tier production structure, in which the final good is produced by a representative competitive firm and the intermediate goods are produced by monopolistically competitive firms. The final goods firm uses a CES production function to combine intermediate inputs. A continuum of intermediate goods firms own capital and hire labor to produce intermediate goods using a Cobb-Douglas production function. The firms must pay quadratic adjustment costs to adjust investment and nominal prices (Rotemberg, 1982). Prices are partially indexed to inflation. The intermediate goods firms maximize profits and issue equity that earn dividends, which are held by households in their liquid or illiquid accounts. The symmetric equilibrium yields an aggregate nonlinear Phillips curve with partial indexation:

$$\left(\frac{1+\pi_t}{(1+\pi_{t-1})^{\iota^p}} - 1\right)\frac{1+\pi_t}{(1+\pi_{t-1})^{\iota^p}} = \kappa^p Y_t(\mu_t - \mu) + \frac{1}{1+r_t}\left(\frac{1+\pi_{t+1}}{(1+\pi_t)^{\iota^p}} - 1\right)\frac{1+\pi_{t+1}}{(1+\pi_t)^{\iota^p}} \tag{9}$$

where $\pi_t = \frac{P_t}{P_{t-1}} - 1$ is the inflation rate, r_t is the real interest rate on government bonds, $\mu_t = \frac{1}{1-\alpha}\frac{W_t N_t}{P_t Y_t}$ is the real marginal cost, α is the capital share, μ is the optimal markup in steady-state, κ^p is the slope of the Phillips curve, and ι^p is the degree of nominal price indexation. At the symmetric equilibrium, two standard Q-theory equations for capital demand and investment hold:

$$Q_t = \frac{1}{1+r_t}\left(\alpha\mu_{t+1}\frac{Y_{t+1}}{K_t} + (1-\delta)Q_{t+1}\right) \tag{10}$$

$$(g_{Xt} - 1) = \delta\xi(Q_t - 1) + \frac{g_{Xt+1}}{1+r_t}(g_{Xt+1} - 1) \tag{11}$$

where X_t is investment in period t, $g_{Xt} = \frac{X_t}{X_{t-1}}$ is the growth rate of investment, Q_t is Tobin's Q, δ is the depreciation rate of capital, and ξ is the sensitivity of investment growth to Q. We derive the equations for the nonlinear Phillips curve and the capital dynamics in Appendix C.2.

Financial Intermediaries There is a representative competitive bank that holds real and nominal government bonds. The nominal bonds ("reserves") are in zero net supply and can only be traded by banks and the central bank. The banks maximize profits, which implies a no-arbitrage condition for nominal and real bonds that in turn implies that the Fisher equation holds at all time:

$$1 + r_t = \frac{1+i_t}{1+\pi_{t+1}}. \tag{12}$$

The only role of the banks in the model is to enforce this Fisher equation.

[29] The virtual consumption aggregate C_t^* summarizes how the consumption distribution across households affects the aggregate wealth effect on labor supply.

Monetary and Fiscal Policy The central bank implements monetary policy by directly setting the nominal interest rate i_t on the nominal bonds held by banks. The monetary authority follows a forward-looking Taylor rule with interest-rate smoothing:

$$i_t = \rho_i i_{t-1} + (1 - \rho_i)(r + \phi^\pi \pi_{t+1}) \tag{13}$$

where i_t is nominal interest rate at time t, r is the steady-state real interest rate at steady-state, ϕ^π is the hawkishness of the central bank, and ρ_i is the degree of interest-rate smoothing.[30] The fiscal authority must respect the real government budget constraint

$$G_t + (1 + r_{t-1})B_{t-1} = T_t + B_t \tag{14}$$

where G_t is the level of government purchases at time t, T_t is the aggregate tax revenue, and B_t is the debt issued at time t. The fiscal authority follows the fiscal rule (Leeper, 1991):

$$dT_t = \phi^g dG_t + \phi^b dB_t \tag{15}$$

where $dX_t = X_t - \bar{X}_t$ is the deviation of a variable X_t from its steady-state value $\bar{X}$. The coefficients $\phi^y > 0$ and $\phi^b > 0$ are the responsiveness of taxes to changes in government spending and public debt.

Equilibrium Given initial values of the nominal wage W_{-1}, price level P_{-1}, government debt B_{-1}, capital K_{-1}, and investment X_{-1}, and an initial distribution of households over their state variables such the economy is initially at a steady state, and given an exogenous path of government spending $\{G_t\}$, a perfect foresight general equilibrium is a path of prices $\{P_t, W_t, r_t, Q_t, i_t, \pi_t, \pi_t^w\}$ and aggregate quantities $\{Y_t, K_t, N_t, C_t, X_t, T_t, B_t\}$ such that households optimize, labor unions optimize, firms optimize, banks optimize, monetary and fiscal policy satisfy their rules, and all markets clear. Market clearing in the goods market implies that

$$C_t + X_t + G_t + \Psi_t^p + \Xi_t + \zeta(1 + r_{t-1})A_{t-1} = Y_t \tag{16}$$

where $C_t = \int C_{it}\, di$ is aggregate consumption, Ψ_t^p is the aggregate price adjustment costs, Ξ_t is the aggregate real adjustment costs, and $\zeta(1 + r_{t-1})A_{t-1} = \zeta(1 + r_{t-1}) \int A_{it-1} di$ are the aggregate costs of holding liquid assets. Appendix C.8 presents a full list of equilibrium conditions and steady state values.

Calibration We use a three-step calibration procedure. First, we externally calibrate standard parameters such as the intertemporal elasticity of substitution, the Frisch elasticity and the slope of the Phillips curve. We convert price adjustment frequencies to slopes using the same method as Auclert, Rognlie and Straub (2024). Namely, the slope equals $\kappa = \chi \frac{r+f}{1+r} \frac{f}{1-f}$, where $\chi = 1/6$ is

[30] We use the winding number algorithm of Auclert et al. (2021) to guarantee determinacy.

Table 2: Model Calibration

Parameter	Description	Value	Source
Internally calibrated parameters:			
β	Discount factor	0.97	Match iMPC
λ	Adjustment probability	0.4	Match income/assets
ξ	Investment growth elasticity	1.69	Match empirical IRFs
(ϕ_π, ρ_i)	Taylor rule	$(1.20, 0.16)$	Match empirical IRFs
(ϕ_g, ϕ_b)	Fiscal rule	$(0.51, 0.00)$	Match empirical IRFs
Externally calibrated parameters:			
r	Real interest rate	0.02	Standard
σ	Intertemporal elasticity of substitution	1	Standard
η	Frisch elasticity of labor supply	0.5	Standard
$\zeta(1+r)$	Liquid-illiquid spread	0.02	Auclert, Rognlie and Straub (2024)
ρ^e	Persistence of income process $\log e$	0.976	Floden and Lindé (2001)
σ^e	Std. dev. of income process $\log e$	0.92	Auclert and Rognlie (2018)
α	Capital share	0.294	Standard
δ	Depreciation rate of capital	0.02	Standard
θ	Progressivity of income tax	0.181	Heathcote, Storesletten and Violante (2017)
μ	Steady-state price markup	1	Standard
μ^w	Steady-state wage markup	1	Standard
κ^p	Slope of Phillips curve	0.015	Nakamura and Steinsson (2008)
κ^w	Slope of wage Phillips curve	0.002	Grigsby, Hurst and Yildirmaz (2021)
ι^p	Degree of price indexation	0.26	Benigno and Eggertsson (2024)
ι^w	Degree of wage indexation	0.55	Galí (2011)
Z/Y	Ratio of income to GDP	0.5	U.S. Labor Share
A/Z	Ratio of assets to income	22.56	Kaplan and Violante (2022)
K/Y	Ratio of capital to GDP	9.8	Standard
B/Y	Ratio of public debt to GDP	2.8	Standard
G/Y	Ratio of public spending to GDP	0.2	Standard

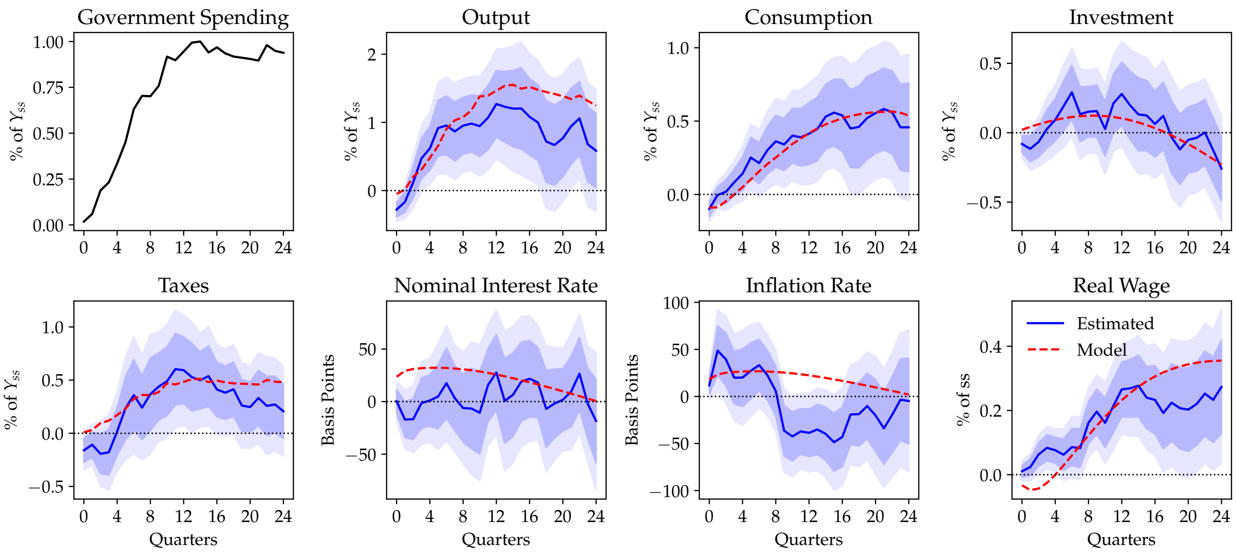
Notes: This table describes our baseline model's calibration. The first column gives the mathematical representation of the calibrated parameter, the second column describes the parameter, the third column reports the value of the calibrated parameter, and the final column reports the calibration method. The top panel lists the internally calibrated parameters, while the bottom panel lists the externally calibrated parameters.

a real rigidity parameter taken from Auclert, Rognlie and Straub (2024), r is the real interest rate, and f is the frequency of price adjustment. Second, we calibrate the household block parameters β (discount factor) and λ (the probability that a household is allowed to adjust their illiquid account) to match a quarterly MPC of 0.2 on impact and a ratio of aggregate assets to post-tax income (A/Z) of 22.56. This quarterly MPC target is consistent with the estimates from Johnson, Parker and Souleles (2006), Parker et al. (2013), and Orchard, Ramey and Wieland (2025) among others. Third, we internally calibrate the investment growth elasticity (ξ), the Taylor rule (ϕ_π, ρ_i), and the fiscal rule (ϕ_g, ϕ_b) to match our empirical impulse response functions. Our methodology for impulse response matching closely follows Auclert, Rognlie and Straub (2020).[31]

For variable k at horizon h, let $\hat{J}_{k,h}$ and $\hat{\Sigma}_{k,h}$ be the estimated impulse responses and standard errors from our empirical section, and $J_{k,h}(\Phi)$ be the model generated impulse response to the

[31] Our estimate of the interest-rate smoothing parameter ρ_i is smaller than typically found in papers that use monetary policy shocks to estimate the monetary policy reaction function (e.g., Coibion and Gorodnichenko, 2012).

Figure 9: Estimated and Model Implied IRF Response to Defense News Shock



Notes: This figure plots the estimated and model implied responses out output, consumption, investment, taxes, nominal interest rates, inflation rates, and real wages to a defense spending surprise, normalized so the defense response peaks at one percent of GDP. The sold blue lines are our estimates of β_h in Equation (1) for different horizons h. The dark and light shaded areas are the 68% and 95% confidence intervals. The red dashed line is the baseline (calibrated to table 2) model's response to the government spending shock in the first panel.

estimated government spending shock $\{\hat{J}_{G,h}\}_{h=0}^{H}$ for a set of parameters $\Phi = \{\xi, \phi_\pi, \rho_i, \phi_g, \phi_b\}$. The sum of squared errors between the estimated and model-implied impulse response functions, scaled by the estimated standard errors, is

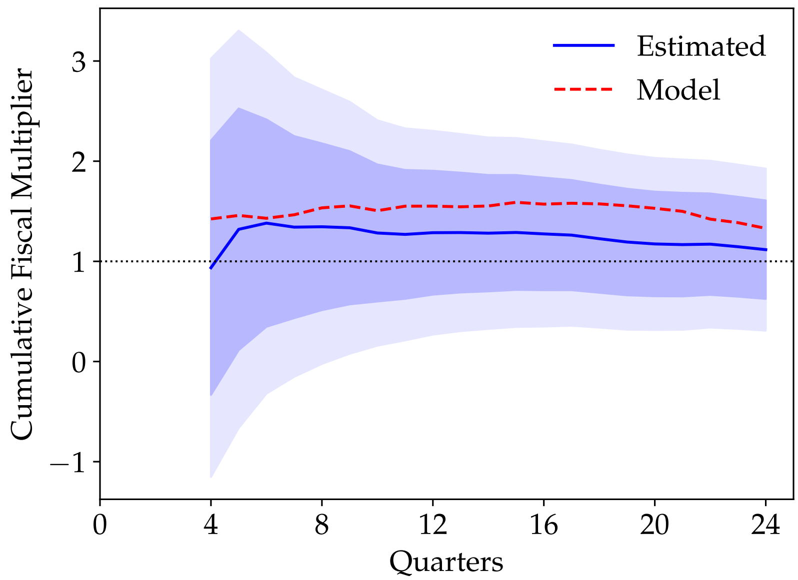
$$SSE(\Phi) = \sum_k \sum_{h=0}^{H} \frac{(\hat{J}_{k,h} - J_{k,h}(\Phi))^2}{\hat{\Sigma}_{k,h}}. \tag{17}$$

The estimated parameters $\widehat{\Phi}$ minimize the sum of square errors, i.e., $\widehat{\Phi} = \arg\min_\Phi SSE(\Phi)$ and the minimized sum of squared errors is $\widehat{SSE} = SSE(\widehat{\Phi})$. We estimate the parameters to match the impulse responses of output, consumption, investment, taxes, and the nominal interest rate up to the 24th quarter. All variables are normalized to a government spending shock that peaks at one percent of output. We solve the model numerically using the sequence-space Jacobian method of Auclert et al. (2021). The externally and internally calibrated parameters can be found in table 2.

5.2 Effects of a Government Spending News Shock

To compare our empirical analysis with our quantitative model, we directly feed in our estimated government spending shock $\{\hat{J}_{G,h}\}_{h=0}^{H}$ as a government spending shock to our model. We plot the model responses of key macroeconomic variables against our empirical findings. The first panel in Figure 9 plots the estimated response of defense spending to a defense news shock. Dark blue lines are the estimated impulse responses to a defense news shock, and the dark and light shaded

Figure 10: Estimated and Model Implied Fiscal Multiplier



Notes: This figure plots the estimated and model implied cumulative fiscal multiplier. The sold blue lines are our estimates of $\mathcal{M}_h$ in Equation (3) for different horizons h. The dark and light shaded areas are the 68% and 95% confidence intervals. The red dashed line is the baseline (calibrated to table 2) model's response to the government spending shock in the first panel.

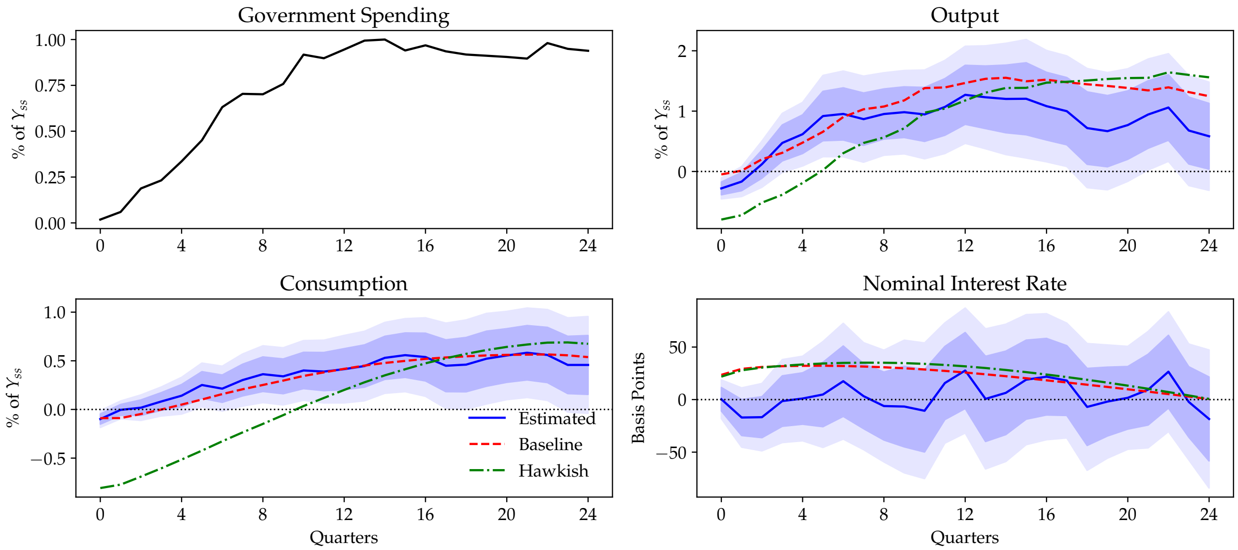
areas are the 68 and 90% confidence intervals. The red dashed line is the impulse response of our quantitative model to the government spending shock in the first panel.

The quantitative model closely matches the estimated impulses responses of output, consumption, and investment; the model generally matches the estimated responses of taxes, nominal interest rates. The inflation rate and real wage, which are targeted, broadly match the estimated responses. The model-implied responses of the NIPA variables mimic the hump-shaped empirical responses, and matches their values on impact and at their respective peaks. Although the model's output response lies above the estimated response, Figure 10 makes clear that the estimated fiscal multiplier closely matches the estimated values across the horizon.[32]

Role of Monetary Policy Our estimates of the Taylor rule ($\phi_\pi = 1.2$), from the IRF matching exercise, suggest that the monetary policy response to defense spending shocks is relatively loose. This loose monetary policy is essential to explaining the responses we find in the data and model. To show this, we consider a more hawkish monetary policy rule ($\phi_\pi^{Hawk} = 1.5$), leaving the rest of the calibration fixed at the baseline. This policy rule is more reactive to future inflation than the baseline and does not smooth interest-rates. Calibrated to this more hawkish monetary policy, we again look at the impulse responses to our estimated government expenditure shock. Figure 11

[32]Although households and firms smooth consumption and investment, the output response is not smooth. Output partially inherits the uneven government expenditure response via the goods market clearing condition, i.e., $Y_t = G_t + C_t + X_t + \Psi_t + \Xi_t + \zeta(1 + r_{t-1})A_{t-1}$.

Figure 11: Role of Monetary Policy



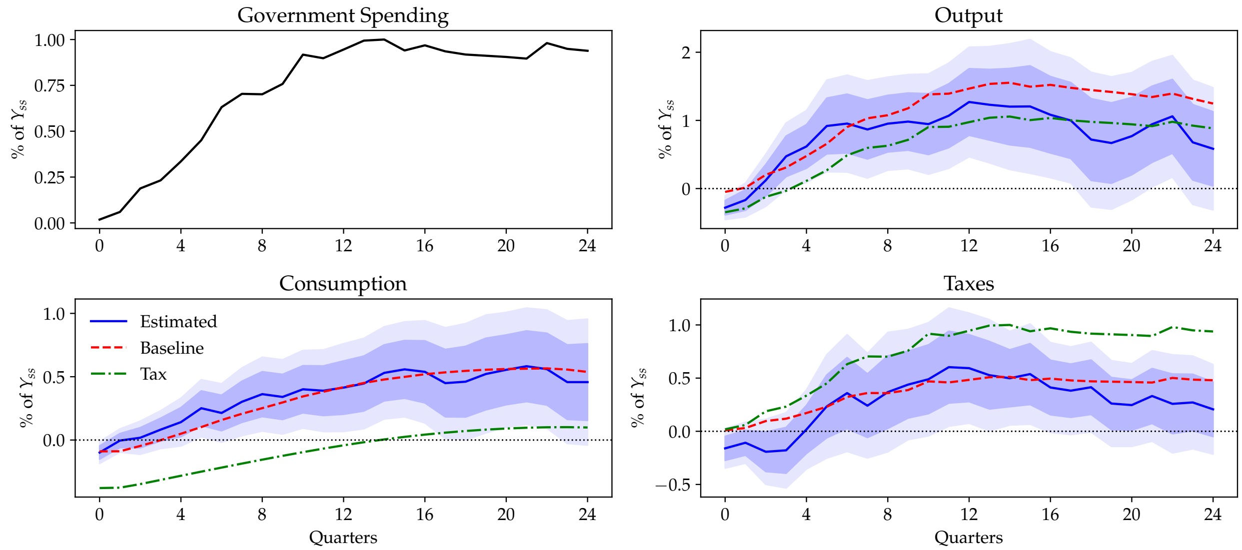
Notes: This figure plots the estimated and model implied responses out output, consumption, and nominal interest rates to a defense spending surprise, normalized so the defense response peaks at one percent of GDP. The sold blue lines are our estimates of β_h in Equation (1) for different horizons h. The dark and light shaded areas are the 68% and 95% confidence intervals. The red dashed line is the baseline model's response to the government spending shock in the first panel. The green dot-dashed line is the hawkish monetary policy ($\phi_\pi = 1.5$) model's response to the government spending shock in the first panel.

plots these responses. More hawkish monetary policy mutes the inflation response by amplifying the nominal interest rate response beyond what we observe in the data. This additional rise in the real interest rate mutes the consumption and investment responses leading to a fall in output on impact. Hazell and Hobler (2025) and Gagliardone and Gertler (2023) similarly find that loose monetary policy is key to explaining the inflationary effects of fiscal and oil shocks. Figure D.1 in Appendix D.1 presents the responses of all other variables of interest.

Role of Fiscal Policy The Leeper rule we estimate ($\phi_g = 0.51, \phi_b = 0.00$) indicates that a significant proportion of defense expenditure is debt-financed. Debt-financing government expenditure is essential to matching the consumption response we observe. To illustrate this importance we consider an alterative balanced budget rule ($\phi_g^{BB} = 1, \phi_b^{BB} = .00$) which entirely tax finances government expenditure. We leave the rest of the calibration at the baseline, then study the model response to our estimated government expenditure shock. Figure 12 plots theses responses. The larger tax response causes consumption to fall. Auclert, Rognlie and Straub (2024) also find that debt financing government expenditure is key to producing larger fiscal multipliers. Figure D.2 in Appendix D.2 presents the response of all other variables of interest.

Alternative Models Our baseline model is a two-asset HANK model with large iMPCs, nominal rigidities, and significant real rigidities. To understand the impact of these three elements we

Figure 12: Role of Fiscal Policy



Notes: This figure plots the estimated and model implied responses out output, consumption, and taxes to a defense spending surprise, normalized so the defense response peaks at one percent of GDP. The sold blue lines are our estimates of β_h in Equation (1) for different horizons h. The dark and light shaded areas are the 68% and 95% confidence intervals. The red dashed line is the baseline model's response to the government spending shock in the first panel. The green dot-dashed line is the tax-financed fiscal policy (with $\phi_g = 1$) model's response to the government spending shock in the first panel.

consider a number of alternative models that relaxes each. Ultimately, we find that all three are necessary to match the impulses responses we estimate.

To evaluate the importance of large iMPCs we repeat our three-step estimation procedure (see section 5.1) with a representative agent New Keynesian (RANK) model and a two-agent bonds-in-the-utility (TABU) New Keynesian model. The former features low iMPCs while the latter can match the iMPCs in our baseline model. The RANK model resembles the canonical DSGE model in Smets and Wouters (2007) while the TABU model resembles the tractable HANK model in Angeletos, Lian and Wolf (2024). We present these models in full and plot their impulses responses (Figures D.3 and D.4) in Appendix D.3. We show that the HANK models is unable to match the strong consumption response we observe, while the TABU model performs similarly to the baseline model in matching the aggregate responses.

Nominal rigidities are essential to matching the impulses responses we observe. Both sticky prices and sticky wages play an important role. To elucidate their impact we consider two alternative models with flexible prices and wages. The flexible price and wage models separately feature steeper Phillips curves and wage Phillips curves.[33] We repeat our three-state calibration procedure (see section 5.1) and plot the impulses responses of the flexible price model (Figure D.5) and flexible

[33] In these alterative models prices and wages are not perfectly flexible but rather feature significantly lower nominal adjustment costs. Specifically, the slopes of the Phillips curves are ten times the baseline calibration, i.e., $\kappa^p = .15$ and $\kappa^w = .02$, in the flexible price and wage calibrations.

wage model (Figure D.6) in Appendix D.3. The flexible price model exhibits an excessively high inflation and consumption response, as well as a negative real wage response. The flexible wage model features excessive real wage, inflation, investment, consumption, and output responses.

Additional real rigidities, beyond those in the canonical NK model, are necessary to match the estimated impulse responses to monetary policy shocks (e.g. Smets and Wouters (2007)). We also find these DSGE-style rigidities are necessary to match the estimated responses to fiscal policy shocks. Investment adjustment costs are crucial to matching the investment response, price and wage indexing are key to matching the initially muted response of consumption and output. To see this we piecewise remove these rigidities and repeat our three-state calibration procedure (see section 5.1). We plot the impulses responses of capital adjustment model (Figure D.7) and non-indexation model (Figure D.8) in Appendix D.3. These alternative models lead to excessive responses of consumption and output. In Appendix D.4 we conduct a number of other exercises, including a recalibration with a larger Frisch elasticity (Figure D.10), a recalibration without interest-rate smoothing (Figure D.9), and plotting the models response to an AR(1) government expenditure shock (Figure D.11).

6 Conclusion

In this paper, we use a high-frequency identification approach to estimate the effects of government spending on macroeconomic outcomes. We create a new instrument for defense spending by measuring surprises in a stock index of major U.S. defense contractors within a narrow time window around legislative events that communicate news about defense spending. The defense spending surprises that we identify have large and persistent effects on actual future defense spending and are passed through one-for-one to total government spending. Our findings indicate that government spending stimulates private economic activity and provides empirical evidence that aggregate fiscal multipliers can exceed one. We show that our empirical results are consistent with a standard heterogeneous-agent New Keynesian model with non-Ricardian households and realistic marginal propensities to consume. Representative agent models without these features struggle to generate an increase in consumption without a counterfactual decrease in real interest rates.

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Appendices

A Campbell-Shiller Decomposition

Let P_t be the price of a stock index of defense contractors, and let D_t denote dividends. The gross return from period t to $t+1$ is $R_{t+1} = \frac{P_{t+1}+D_{t+1}}{P_t}$. We can express the log price $p_t \equiv \log(P_t)$ as follows using the Campbell-Shiller approximation:

$$p_t - d_t = \sum_{j=0}^{\infty} \rho^j (\Delta d_{t+1+j} - r_{t+1+j}) + \frac{\kappa}{1-\rho}$$

where lowercase variables are in logs and $\rho = \frac{1}{1+\frac{D}{P}} \approx 0.99$. We can solve this for the return r_{t+1}:

$$r_{t+1} = d_t - p_t + \sum_{j=0}^{\infty} \rho^j \Delta d_{t+1+j} - \sum_{j=1}^{\infty} \rho^j r_{t+1+j} + \frac{\kappa}{1-\rho}.$$

We can do the same exercise for a broader market index with price P_t^m and subtract the market return to get the excess return of defense contractors relative to the market:

$$r_{t+1} - r_{t+1}^m = (d_t - p_t) - (d_t^m - p_t^m) + \sum_{j=0}^{\infty} \rho^j (\Delta d_{t+1+j} - \Delta d_{t+1+j}^m) - \sum_{j=1}^{\infty} \rho^j (r_{t+1+j} - r_{t+1+j}^m).$$

This equation holds ex post, so it also holds ex ante for rational expectations and for non-rational expectations that respect identities (see Campbell's textbook). We assume rational expectations and take the expectation conditional on information available at time t:

$$\mathbb{E}_t(r_{t+1} - r^m_{t+1}) = (d_t - p_t) - (d^m_t - p^m_t) + \mathbb{E}_t \sum_{j=0}^{\infty} \rho^j (\Delta d_{t+1+j} - \Delta d^m_{t+1+j}) - \mathbb{E}_t \sum_{j=1}^{\infty} \rho^j (r_{t+1+j} - r^m_{t+1+j}).$$

Now consider an announcement that affects the expected the path of future dividends and discount rates. Let $\mathbb{E}_t$ be the expectation immediately *before* the announcement that does not take the new information into account, and let $\tilde{\mathbb{E}}_t$ denote the expectation immediately *after* the announcement, but before $t+1$. The change in excess return when the news arrive is

$$\underbrace{(\tilde{\mathbb{E}}_t - \mathbb{E}_t)(r_{t+1} - r^m_{t+1})}_{\text{Our shock } z_t} = \underbrace{(\tilde{\mathbb{E}}_t - \mathbb{E}_t) \sum_{j=0}^{\infty} \rho^j (\Delta d_{t+1+j} - \Delta d^m_{t+1+j})}_{\text{Cash flow news}} - \underbrace{(\tilde{\mathbb{E}}_t - \mathbb{E}_t) \sum_{j=1}^{\infty} \rho^j (r_{t+1+j} - r^m_{t+1+j})}_{\text{Discount rate news}}.$$

Consider the following set of assumptions:

1. The announcement contains news about the path of future defense spending $\{G_{t+k}\}_{k\geq 1}$
2. Defense cash flows depend on defense spending through the simple relation:

   $$\Delta d_t = \alpha + \gamma G_t + e_t$$

   where $\gamma > 0$ and $e_t \sim iid(0, \sigma^2_e)$.
3. Market cash flows are unaffected by the announcement. (This is stronger than necessary. It is enough to assume that they are affected less than defense stocks.)
4. The announcement affects the expected future discount rates r_t and r^m_t in the same way (so the discount rate news term drops out).

Under these assumptions, we get

$$(\tilde{\mathbb{E}}_t - \mathbb{E}_t)(r_{t+1} - r^m_{t+1}) = (\tilde{\mathbb{E}}_t - \mathbb{E}_t) \sum_{j=0}^{\infty} \rho^j \gamma \Delta G_{t+1+j},$$

so in this case our shocks reflect news about future defense spending.

What could go wrong? If the announcements contains no or little news, or if the cash flows don't depend on spending ($\gamma = 0$), then we would have no first stage (but this is testable and we find that our shocks are highly predictive of future defense spending). Another possibility is that markets are irrational and the assumption that asset prices reflect all available information is a not a good approximation. In this case, stock prices may not react to news about defense spending. If they consistently over- or under-react, then our shock series is still a valid instrument, since the shocks are only identified up to scale. Nonetheless, we will simply assume expectations are rational.

Another possibility is that assumption is violated and market cash flows rise (future earnings expectations go up). Defense stocks constitute about 2–3% of total public market capitalization in the U.S., so direct effect of higher defense cash flows is small. However, as we emphasize in the paper, there may be multiplier effects: An increase in defense spending can potentially stimulate economic activity more broadly. Assume that defense spending news affect market cash flows *less* than defense contractor cash flows:

$$\Delta d_t^m = \alpha^m + \lambda \gamma G_t + e_t^m$$

where $\lambda \in [0, 1)$ determines how much the market is affected relative to the defense industry. Maintaining the other assumption, we get

$$(\tilde{\mathbb{E}}_t - \mathbb{E}_t)(r_{t+1} - r_{t+1}^m) = (\tilde{\mathbb{E}}_t - \mathbb{E}_t) \sum_{j=0}^{\infty} \rho^j (1 - \lambda) \gamma \Delta G_{t+1+j},$$

i.e. this simply re-scales the instrument.

Finally, discount rates may move differentially in response to the announcement. The discount rates reflect time preference and risk premia. For instance, if the announcement affects the risk premium of the defense stock index relative to the market, then our shock will also reflect discount rate news.

Why does the expected path of defense spending change when a defense bill passes in Congress? We can consider two edge cases:

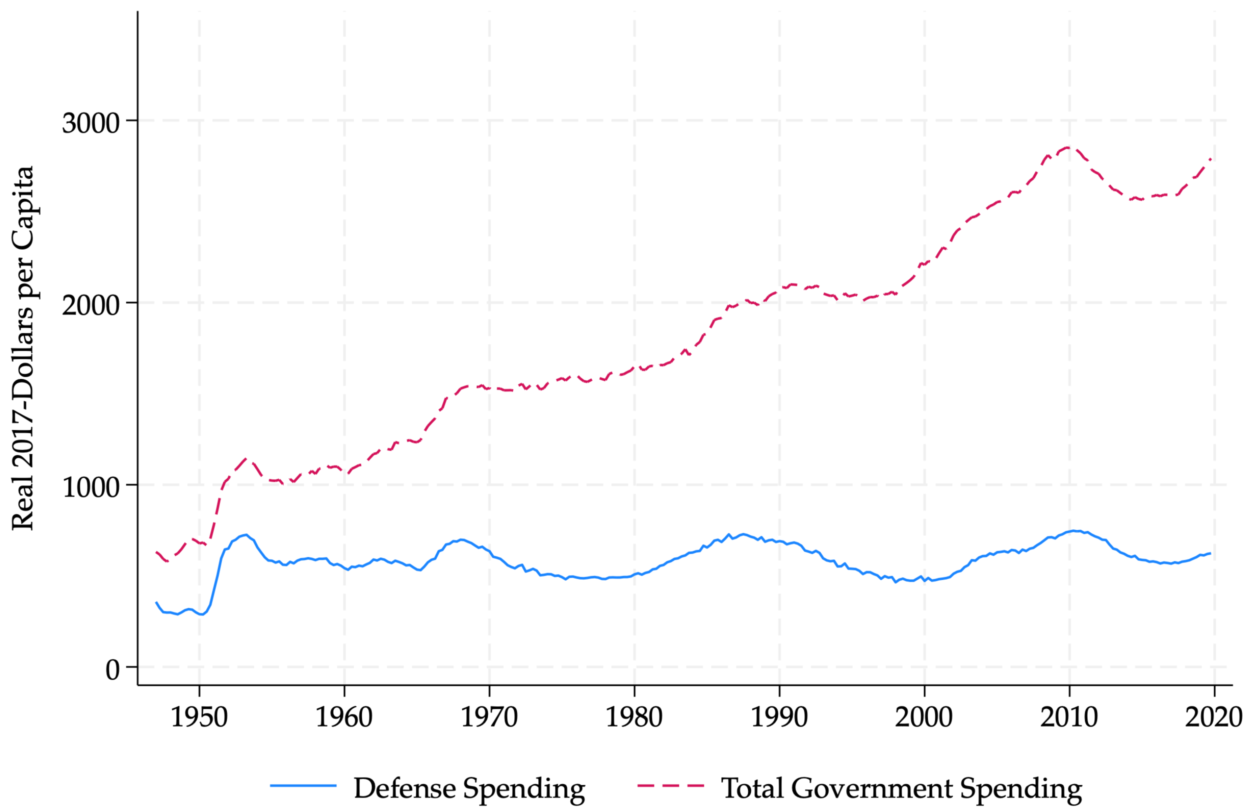
- Investors expected (with high confidence) a different level of spending than the one that was announced. For example, they knew the bill was going to pass, but in the last hours additional spending was added.

- Investors were uncertain about future levels of spending and the announcement resolved this uncertainty. For example, the bill is set in stone, but it is a coin flip whether it is going to pass. The expected spending increase is $G^e = \frac{1}{2} G^{pass} + \frac{1}{2} G^{fail}$, and if the bill passes the surprise is $G^{pass} - G^e$ and defense stocks go up.

Our reading of the Congressional Record and the news coverage around is that late changes to the bill do occur, but the second case is more common.

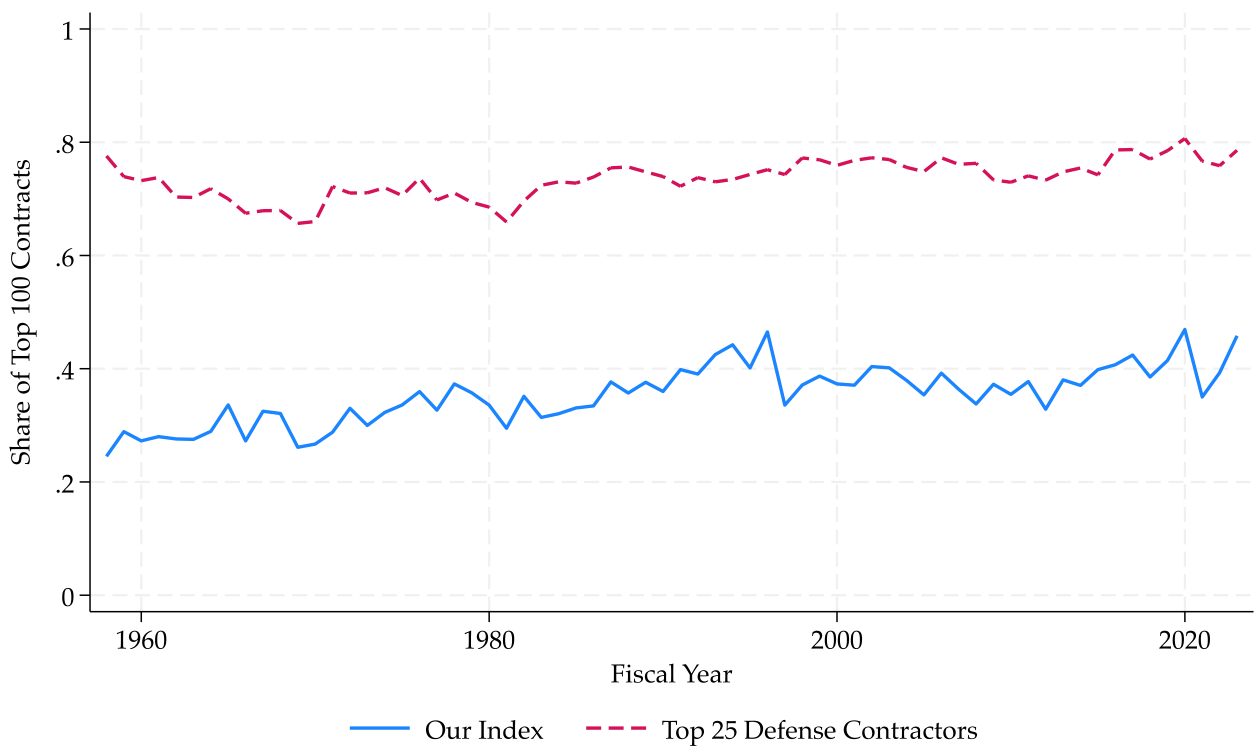
B Additional Figures

Figure B.1: Real Government Spending per Capita in the United States



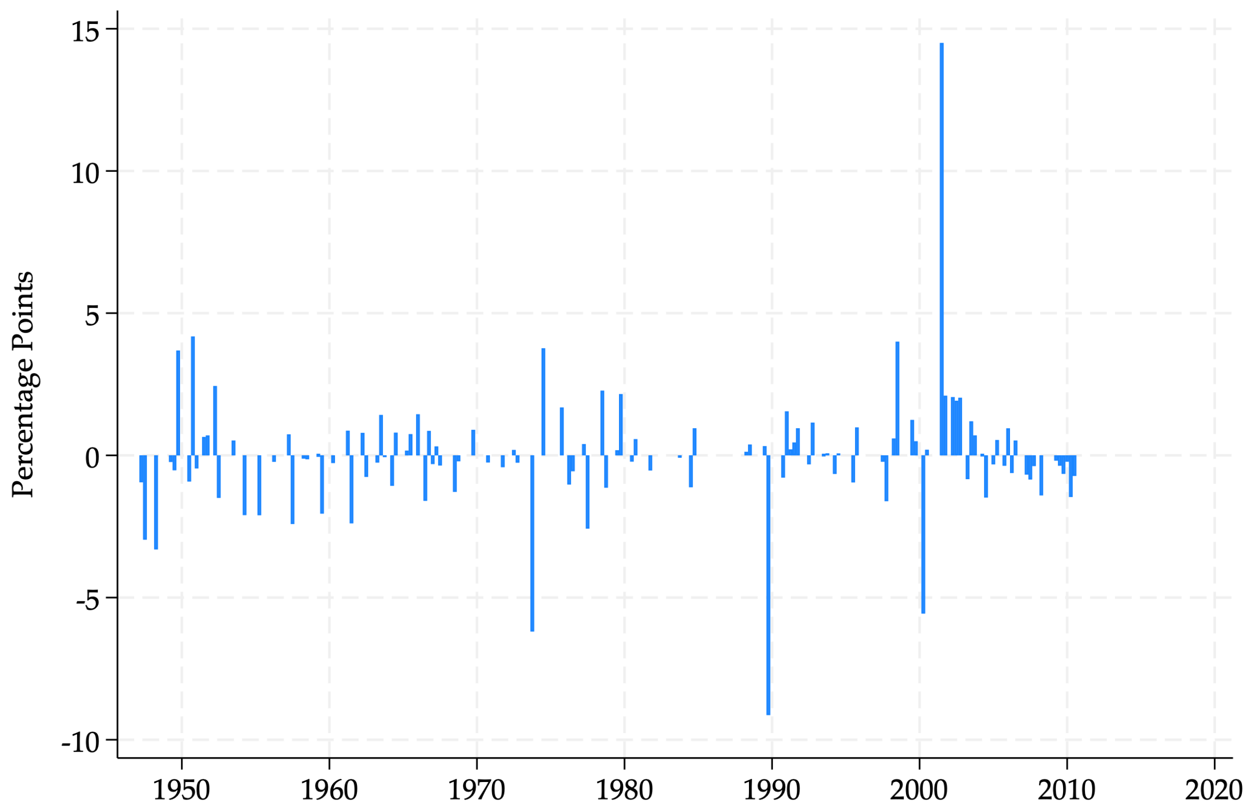
Notes: This figure plots defense spending and total government spending in real 2017-chained dollars quarterly from 1947 to 2020.

Figure B.2: Defense Stock Index Coverage: Share of Top 100 Defense Contracts



Notes: This figure plots the coverage of our index, as well as the top 25 defense contractors, as a percentage of the top 100 defense contracts in dollar terms quarterly from 1958 to 2023.

Figure B.3: Quarterly Defense Spending Surprises

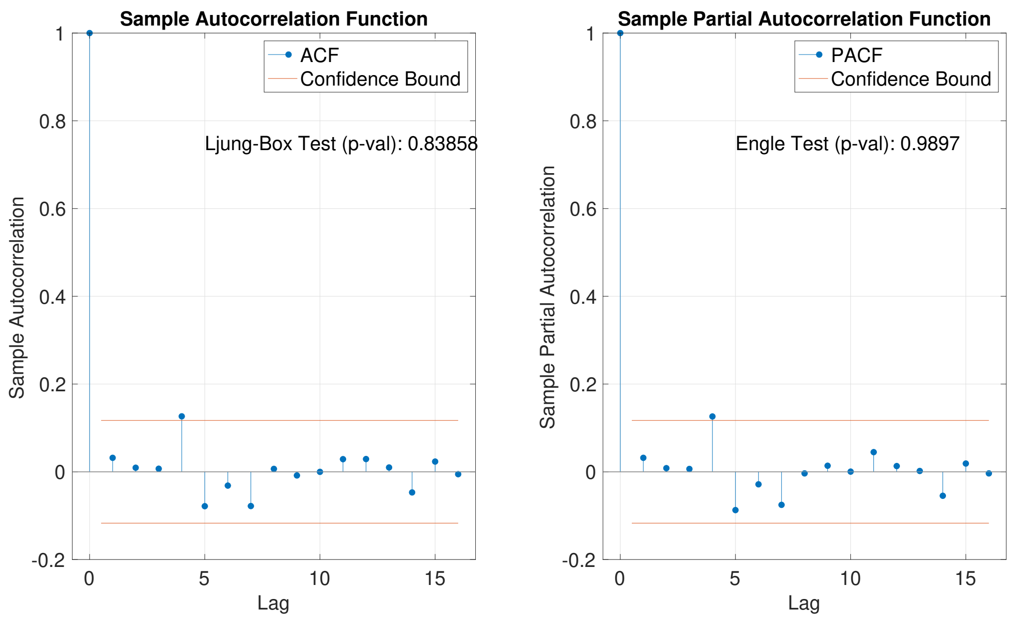


Notes: This figure plots our defense spending surprise series quarterly from 1947 to 2010. We convert our daily series to quarterly by summing all shocks in a given quarter.

Figure B.4: Quarterly Defense Spending Surprises

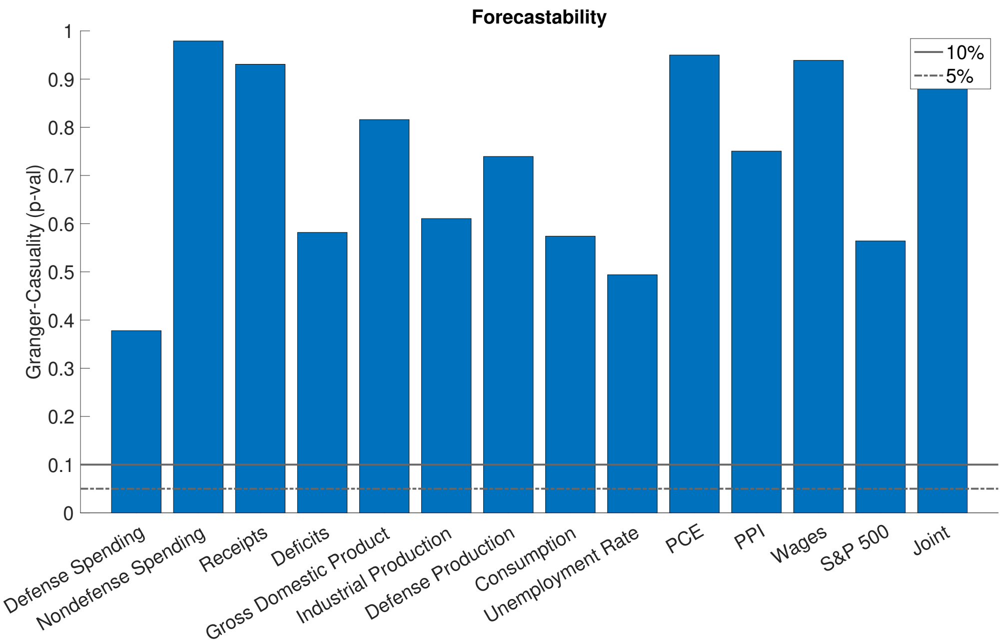
Notes: This figure plots our defense spending surprise series against (Ramey, 2011*a*)'s narrative shocks quarterly from 1947 to 2010. We convert our daily series to quarterly by summing all shocks in a given quarter. The defense spending series is measured in excess returns while the narrative series is measured as a percentage of GDP.

Figure B.5: Shock Autocorrelation



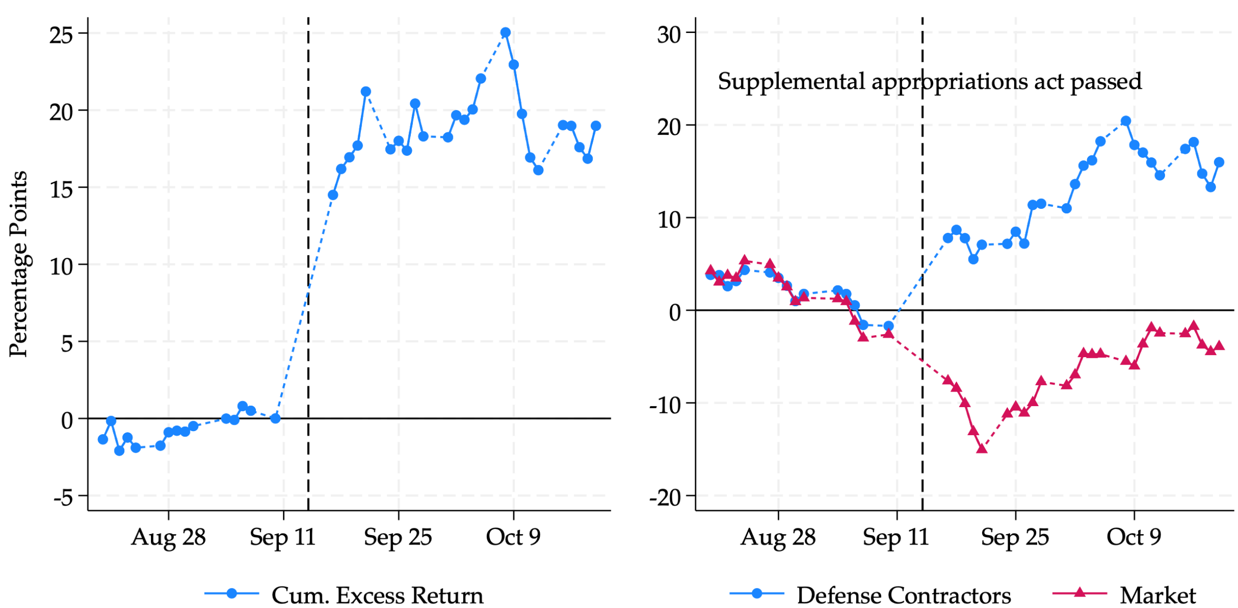
Notes: This figure plots autocorrelation tests of our defense spending surprise series. The left panel plots the sample autocorrelation and the p-value of a Ljung-Box test of autocorrelation. The right panel plots the partial sample autocorrelation and the p-value of an Engle test.

Figure B.6: Shock Predictability (Granger Causality Tests)



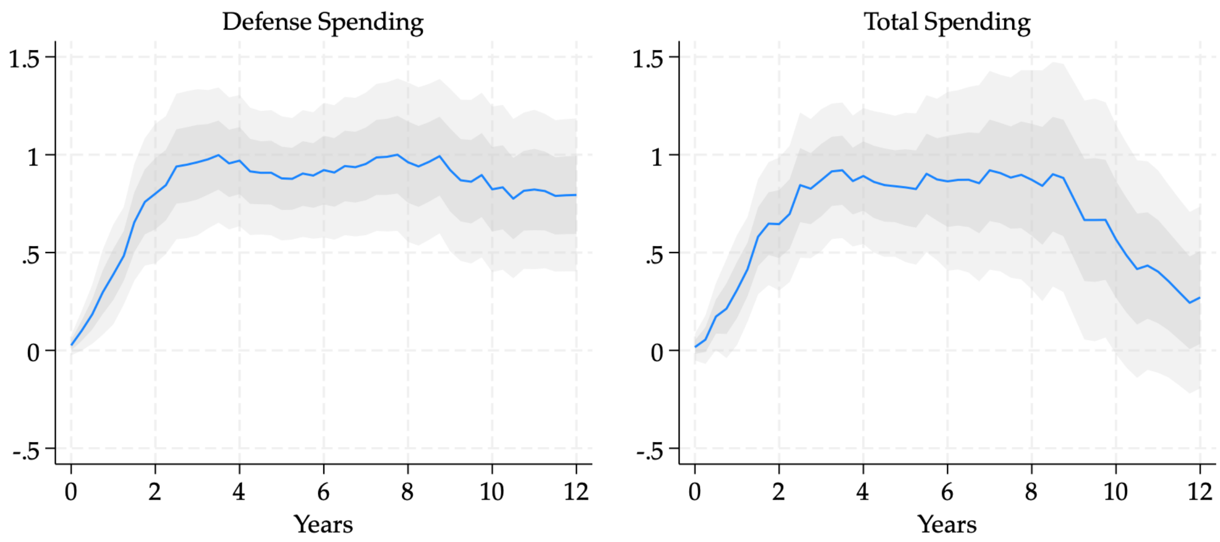
Notes: This figure plots the p-values of a series of Granger-Causality tests. Each column reports the p-value from a test of whether that variable Granger-Causes the defense spending surprise series. The last column reports the p-value from a joint test of all variables in the proceeding columns.

Figure B.7: Defense and Market Returns in September 2001



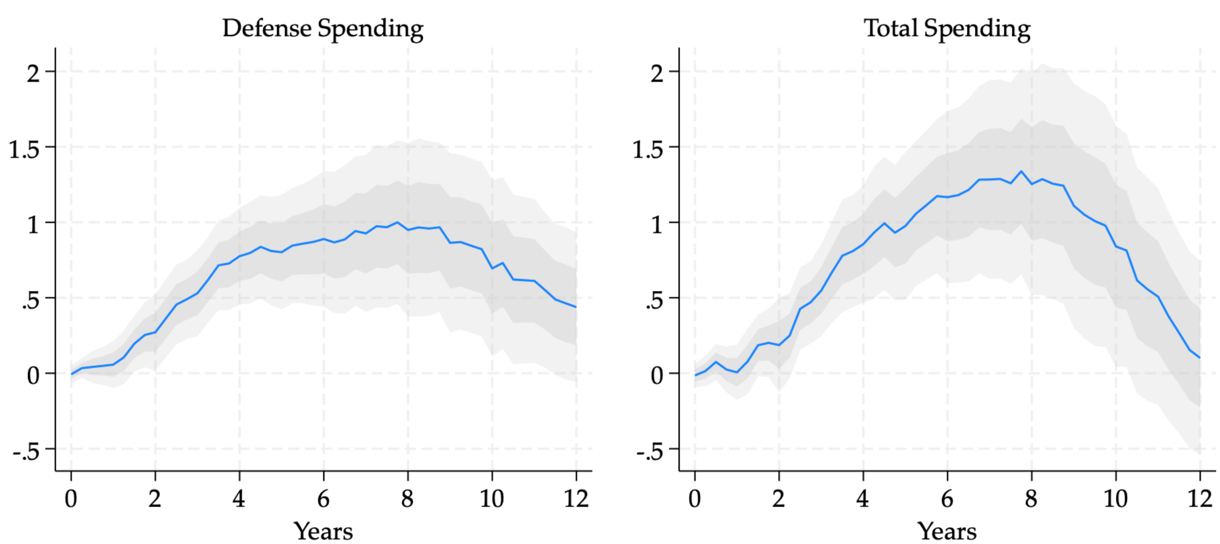
Notes: This figure plots the returns of defense contractors and the market around the September 11 attacks. The left panel plots the cumulative excess returns (with September 11th normalized to zero). The right panel plots the corresponding returns of defense contractors in blue circles and the market in red triangles.

Figure B.8: Spending Responses to a Defense Spending Surprise (Baseline, Long Horizon)



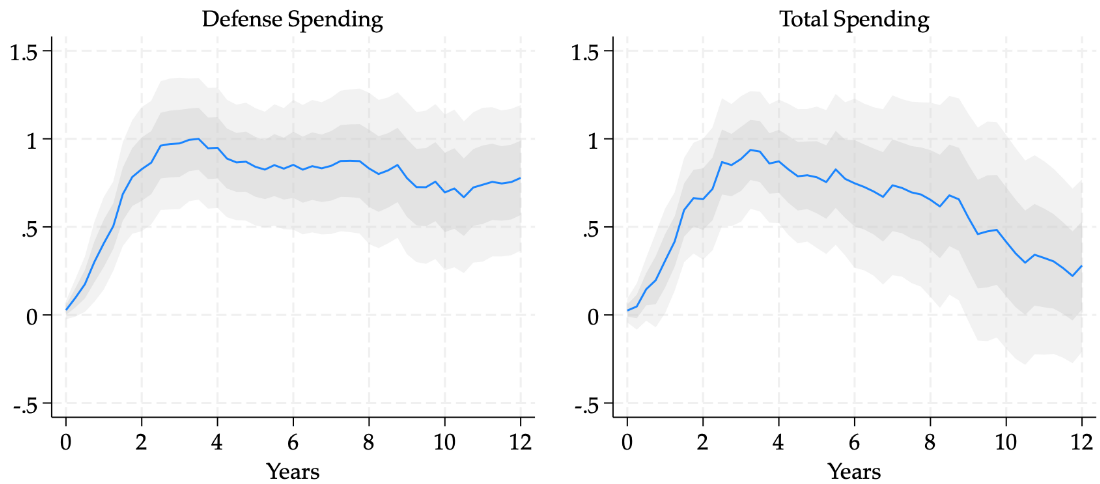
Notes: This figure plots the response of defense spending and total government spending to a defense spending surprise, normalized so the defense spending response peaks at one dollar per capita (chained 2017-dollars). The solid blue lines are our estimates of β_h in Equation (1) for different horizons $h = 0, 1, 2, ...48$. The dark and light shaded areas are 68% and 95% confidence intervals.

Figure B.9: Spending Responses to a Defense Spending Surprise (Post 1955, Long Horizon)



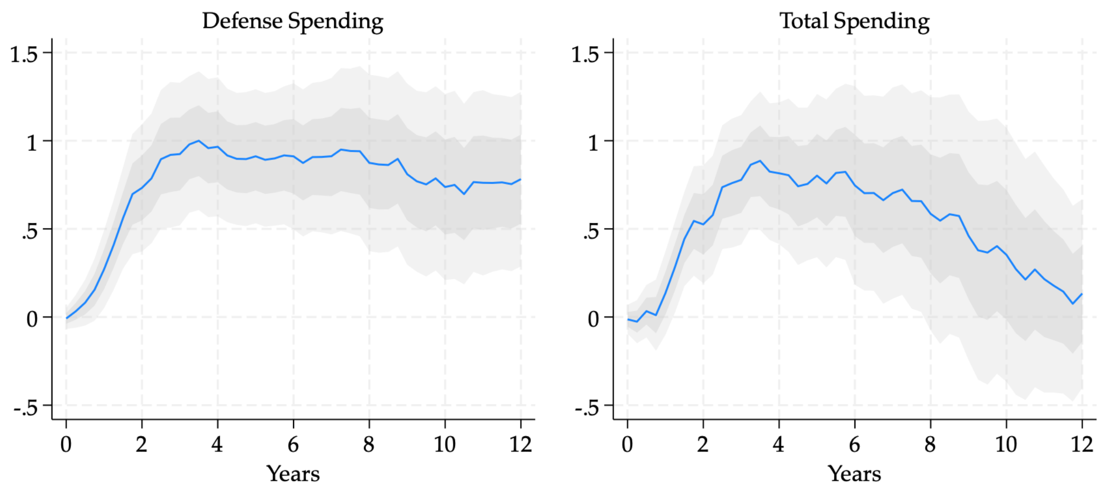
Notes: This figure plots the response of defense spending and total government spending to a defense spending surprise, normalized so the defense spending response peaks at one dollar per capita (chained 2017-dollars), restricting the sample to post-1955. The solid blue lines are our estimates of β_h in Equation (1) for different horizons $h = 0, 1, 2, ...48$. The dark and light shaded areas are 68% and 95% confidence intervals.

Figure B.10: Spending Responses to a Defense Spending Surprise (Excluding September 11 Attacks, Long Horizon)



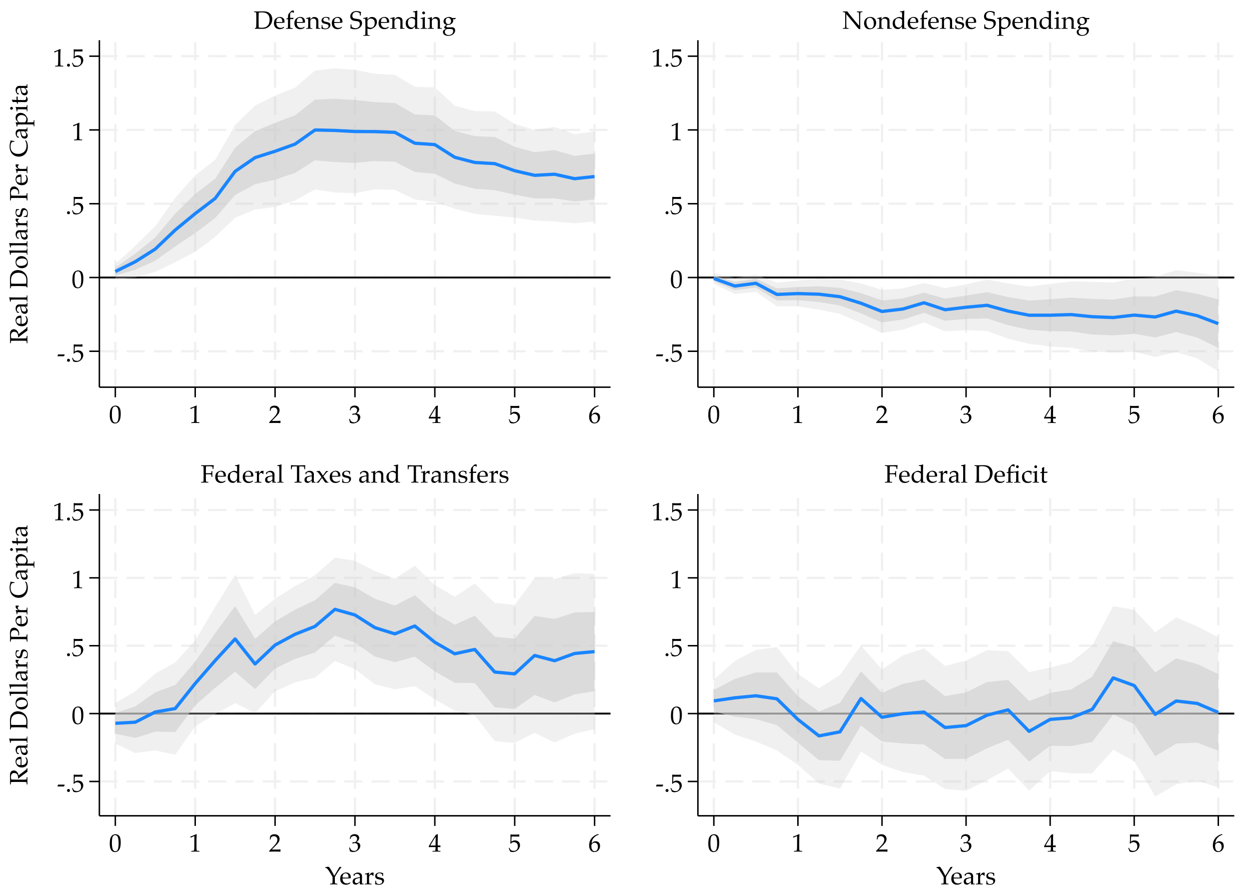
Notes: This figure plots the response of defense spending and total government spending to a defense spending surprise, normalized so the defense spending response peaks at one dollar per capita (chained 2017-dollars), excluding the September 11th attacks from the defense spending surprise series. The solid blue lines are our estimates of β_h in Equation (1) for different horizons $h = 0, 1, 2, ...48$. The dark and light shaded areas are 68% and 95% confidence intervals.

Figure B.11: Spending Responses to a Defense Spending Surprise (Excluding Supplemental Appropriations, Long Horizon)



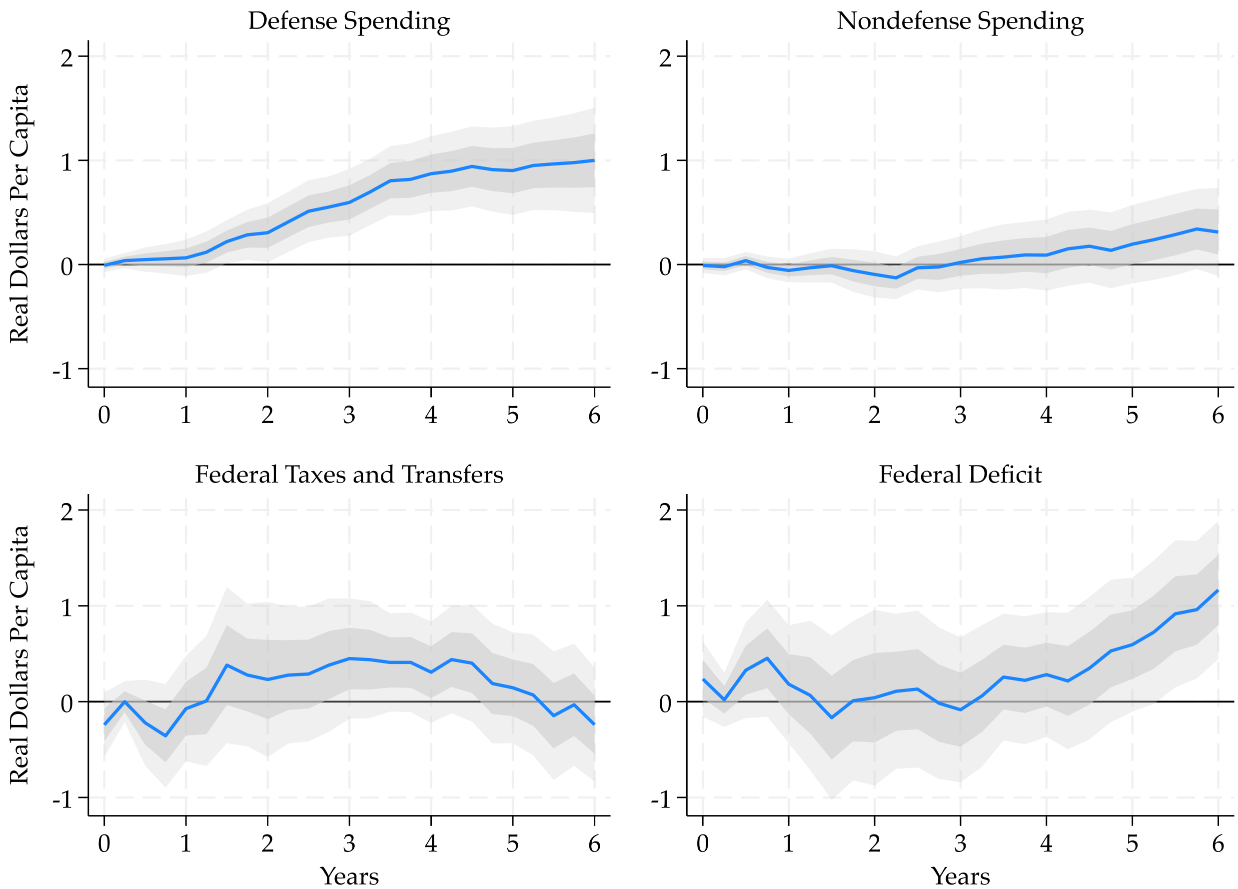
Notes: This figure plots the response of defense spending and total government spending to a defense spending surprise, normalized so the defense spending response peaks at one dollar per capita (chained 2017-dollars), excluding supplemental appropriations from the defense spending surprises. The solid blue lines are our estimates of β_h in Equation (1) for different horizons $h = 0, 1, 2, ...48$. The dark and light shaded areas are 68% and 95% confidence intervals.

Figure B.12: Response of Taxes and Deficits to a Defense Spending Surprise (Pre-2000 Subsample)



Notes: This figure plots the response of defense spending and total spend to a defense spending surprise, normalized so the defense spending response peaks at one dollar per capita (chained 2017-dollars), using the pre-2000 sample. The solid blue lines are our estimates of β_h in Equation (1) for different horizons h. The dark and light shaded areas are 68% and 95% confidence intervals.

Figure B.13: Response of Taxes and Deficits to a Defense Spending Surprise (Post-1954 Subsample)



Notes: This figure plots the response of defense spending, nondefense spending, federal taxes and transfers, and the federal deficits to a defense spending surprise, normalized so the defense spending response peaks at one dollar per capita (chained 2017-dollars), using the post 1954 sample. The solid blue lines are our estimates of β_h in Equation (1) for different horizons h. The dark and light shaded areas are 68% and 95% confidence intervals.

C Model

The construction and presentation of this model closely resembles the two-account HANK models of Auclert, Rognlie and Straub (2024) and Kaplan, Moll and Violante (2018).

C.1 Environment

Time is discrete, and all agents have perfect foresight over aggregate shocks. The economy is populated by final good producers, intermediate good producers, households, labor packers, individual labor unions, banks, a monetary authority, and a fiscal authority.

C.2 Firms

We adopt the common two-tier production model with a continuum of monopolistically competitive intermediate goods producers that sell their output to a final goods producer.

Final Good Producer The final good Y_t is a composite, made from combining intermediate inputs $Y_{j,t}$ using a CES technology: $Y_t = \left(\int_0^1 Y_{j,t}^{\frac{\nu^p - 1}{\nu^p}} \, dj \right)^{\frac{\nu^p}{\nu^p - 1}}$. The price of intermediate input j is $P_{j,t}$. The final good producer sells the final good Y_t to consumers at price P_t. The final good producer maximizes $P_t Y_t - \int_0^1 P_{j,t} Y_{j,t} \, dj$. Profit maximization by the final goods producer generates a demand curve for each intermediate good:

$$Y_{j,t} = \left(\frac{P_{j,t}}{P_t} \right)^{-\nu^p} Y_t \tag{C.1}$$

where $P_t = \left(\int P_{j,t}^{1-\nu^p} \, dj \right)^{\frac{1}{1-\nu^p}}$. In symmetric equilibrium, all firms set the same price $P_{j,t} = P_t$, so the final good producer makes no profit from production.

Intermediate Goods Producers Intermediate goods producers combine labor $N_{j,t}$ and capital $K_{j,t-1}$ to produce the intermediate good $Y_{j,t}$. The production function is Cobb-Douglas, i.e., $Y_{jt} = K_{jt-1}^{\alpha} N_{jt}^{1-\alpha}$. They pay nominal wage W_t for workers, investment costs X_{jt}, and sell their product for price $P_{j,t}$. Each producer faces both nominal and real rigidities. Specifically, each producer faces Rotemberg price adjustment costs with partial indexation $\Psi_{j,t}^p = \frac{\psi^p}{2} \left(\frac{P_{j,t}}{(\Pi_{t-1})^{\iota^p} (\Pi)^{1-\iota^p} P_{j,t-1}} - 1 \right)^2$ and investment adjustment costs $\Xi_{j,t} = \frac{1}{2\delta\xi} (\frac{X_{j,t}}{X_{j,t-1}} - 1)^2 X_{t-1}$. Here, $\Pi_t = \frac{P_t}{P_{t-1}}$ is the gross nominal inflation rate, Π is the steady-state inflation rate, ι^p is the degree of price indexation, and X_{t-1} is the aggregate investment last period which intermediate producers take as given. Intermediate goods producers choose their nominal price, labor, and capital to maximize their value

$$\begin{aligned} J_t(S_{j,t-1}) = \max_{N_{j,t},S_{j,t}} \Bigg\{ & \frac{P_{j,t}}{P_t}\left(\frac{P_{j,t}}{P_t}\right)^{-\nu^p} Y_t - \frac{W_t}{P_t}N_{j,t} - X_{j,t} - \mu_t\left[\left(\frac{P_{j,t}}{P_t}\right)^{-\nu^p} Y_t - F(K_{j,t-1}, N_{j,t})\right] \\ & - Q_t\left[K_{j,t} - (1-\delta)K_{j,t-1} - X_{j,t}\right] - \Xi_{j,t} - \Psi^p_{j,t} + \frac{J_{t+1}(S_{j,t})}{1+r_t}\Bigg\} \end{aligned} \tag{C.2}$$

where $S_{j,t} = \{K_{j,t}, P_{j,t}, X_{j,t}\}$ are the state variables, and $1 + r_t$ is the risk-free rate. The envelope conditions of the problem are

$$\begin{aligned} J_{K,t} &= \mu_t F_{K,t} + (1-\delta)Q_t \\ J_{X,t} &= \frac{1}{\delta\xi}\left(\frac{X_{j,t}}{X_{j,t-1}} - 1\right)\frac{X_{j,t}X_{t-1}}{X^2_{j,t-1}} \\ J_{P,t} &= \psi^p\left(\frac{P_{j,t}}{(\Pi_{t-1})^{\iota^p}(\Pi)^{1-\iota^p}P_{j,t-1}} - 1\right)\frac{P_{j,t}}{(\Pi_{t-1})^{\iota^p}(\Pi)^{1-\iota^p}P^2_{j,t-1}} \end{aligned}$$

and the optimality conditions for state variables $S_{j,t}$ are

$$\begin{aligned} 0 &= -Q_t + \frac{J_{K,t+1}}{1+r_t} \\ 0 &= (Q_t - 1) - \frac{1}{\delta\xi}\left(\frac{X_{j,t}}{X_{j,t-1}} - 1\right)\frac{X_{t-1}}{X_{j,t-1}} + \frac{J_{X,t+1}}{1+r_t} \\ 0 &= (1-\nu^p)\left(\frac{P_{j,t}}{P_t}\right)^{1-\nu^w}\frac{Y_t}{P_{j,t}} + \mu_t\nu^p\left(\frac{P_{j,t}}{P_t}\right)^{-\nu^w}\frac{Y_t}{P_{j,t}} \\ &\quad - \psi^p\left(\frac{P_{j,t}}{(\Pi_{t-1})^{\iota^p}(\Pi)^{1-\iota^p}P_{j,t-1}} - 1\right)\frac{1}{(\Pi_{t-1})^{\iota^p}(\Pi)^{1-\iota^p}P_{j,t-1}} + \frac{1}{1+r_t}J^y_{P,t+1}. \end{aligned}$$

In symmetric equilibrium, all firms set the same prices ($P_{j,t} = P_t$), labor demand ($N_{j,t} = N_t$), marginal cost ($\mu_{j,t} = \mu_t$), capital demand ($K_{j,t} = K_t$), and investment ($X_{j,t} = X_t$).

Taking first-order conditions with respect to labor, we see that at the symmetric equilibrium

$$(1-\alpha)\mu_t Y_t = \frac{W_t}{P_t}N_t \tag{C.3}$$

where μ_t is the real marginal cost.

Q-Theory of Investment The above conditions imply two standard Q-theory equations for capital demand and investment:

$$\begin{aligned} Q_t &= \frac{1}{1+r_t}[\mu_{t+1}F_{K,t+1} + (1-\delta)Q_{t+1}] \\ (g_{X,t} - 1) &= \delta\xi[Q_t - 1] + \frac{g_{X,t+1}}{1+r_t}(g_{X,t+1} - 1) \end{aligned} \tag{C.4}$$

where $g_{X,t} \equiv \frac{X_t}{X_{t-1}}$ is the (gross) growth rate of investment.

New Keynesian Phillips Curve Combining the envelope condition for past prices, and the optimal pricing equation yields the nonlinear New Keynesian Phillips Curve

$$\begin{aligned} \left(\frac{\Pi_t}{(\Pi_{t-1})^{\iota^p}(\Pi)^{1-\iota^p}} - 1\right)\frac{\Pi_t}{(\Pi_{t-1})^{\iota^p}(\Pi)^{1-\iota^p}} &= Y_t(\mu_t - \mu) \\ &+ \frac{1}{1+r_t}\left(\frac{\Pi_{t+1}}{(\Pi_t)^{\iota^p}(\Pi)^{1-\iota^p}} - 1\right)\frac{\Pi_{t+1}}{(\Pi_t)^{\iota^p}(\Pi)^{1-\iota^p}} \end{aligned} \tag{C.5}$$

where $\mu = \frac{\nu^p - 1}{\nu^p}$ is the optimal markup in steady state and $\kappa^p = \frac{\nu^p}{\psi^p}$ is the slope of the Phillips curve.

Production Dividends The per-period dividend earned by intermediate production is

$$D_t = Y_t - \frac{W_t}{P_t}N_t - X_t - \Xi_t - \Psi_t^p. \tag{C.6}$$

The ex-dividend price of the firm satisfies

$$P_t^y = J_t(S_{t-1}) - D_t. \tag{C.7}$$

The intermediate firms issue equity, which is held by households.

C.3 Household

The economy is populated by a unit mass of households, facing income uncertainty. Each household i in period t faces an idiosyncratic ability shock e_{it}, which follows a Markov process. The proportion of households with ability e in a given period is $\omega(e)$, the stationary probability of transition matrix Ω. The average ability is normalized to 1, such that $\int \omega(e)de = 1$. Household i consumes $C_{i,t}$ and receive flow utility $u(C_{it})$. Household i's post-income is $Z_{it} = \frac{e_{it}^{1-\theta}}{\int e_t(h)^{1-\theta}dh}Z_t$, where $Z_t = \frac{W_t}{P_t}N_t - T_t$ is aggregate post-tax income. Households hold liquid A_{it} and illiquid $\tilde{A}_{it}$ assets. Holding the liquid asset incurs flow cost $\zeta(1+r_t)A_{it-1}$. Let Λ_{it} be an independent Bernoulli distribution, which equals 1 with probability λ and 0 with probability $1-\lambda$. If $\Lambda_{it} = 1$, households can able to transfer funds H_{it} between these accounts, otherwise, households cannot transfer funds. Households face borrowing constraints for both liquid and illiquid assets $A_{it}, \tilde{A}_{it} \geq 0$. The households budget constraints are

$$\begin{aligned} C_{it} + A_{it} &= Z_{it} + (1+r_{t-1})(1-\zeta)A_{it-1} - H_{it}\Lambda_{it} \\ \tilde{A}_{it} &= (1+r_{t-1})\tilde{A}_{it-1} + H_{it}\Lambda_{it} \end{aligned}$$

For ease of notation, we drop the i from the following analysis of households optimality conditions. Households solve the following optimization problem

$$\begin{aligned}
V_t(A,\tilde{A},\epsilon,\Lambda) = \max_{C,A,\tilde{A},T} u(C) - v(N) + \beta \mathbf{E}[V_{t+1}(A',\tilde{A}',\epsilon',\Lambda')] \\
\text{s.t. } C + A' = \epsilon Z_t + (1+r_{t-1})(1-\zeta)A - T\Lambda \\
\tilde{A}' = (1+r_{t-1})\tilde{A} + T\Lambda \\
A',\tilde{A}' \geq 0
\end{aligned}$$

where $\epsilon = \frac{e^{1-\theta}}{\int e(i)^{1-\theta}di}$ is defined for simplicity and assumed to follow a Markov process with the same transition matrix as e. While there is perfect foresight for aggregate shocks, households do not have perfect foresight over idiosyncratic shocks. We assume that labor unions make labor supply choices N_{it} for households.

Liquid Assets The first order condition for liquid savings is:

$$u'(C) \geq \beta \mathbf{E}[V_{At+1}(A',\tilde{A}',\epsilon',\Lambda')|\epsilon,\Lambda].$$

When the borrowing constraints both bind the consumption function becomes $C_t(A,\tilde{A},\epsilon,\Lambda) = \epsilon Z_t + (1+r_{t-1})(1-\zeta)(A+\Lambda\tilde{A})$. Notice that the inability to access illiquid assets (i.e. $\Lambda = 0$) amplifies the severity of hitting the borrowing constraint. Moreover, this allows for wealthy hand-to-mouth households. The envelope condition for liquid assets is:

$$V_{At}(A,\tilde{A},\epsilon,\Lambda) = (1+r_{t-1})(1-\zeta)u'(C_t(A,\tilde{A},\epsilon,\Lambda)).$$

Combining the envelope condition with the first condition yields an Euler equation for liquid assets

$$u'(C_t(A,\tilde{A},\epsilon,\Lambda)) \geq (1-\zeta)\beta(1+r_t)\mathbf{E}[u'(C_{t+1}(A',\tilde{A}',\epsilon',\Lambda'))|\epsilon.\Lambda]. \tag{C.8}$$

which features excessive discounting of the future, due to the flow costs of holding liquid assets embodied in the parameter ζ.

Illiquid Assets Repeating this exercise for illiquid assets, is complicated by the ability or inability to access assets. Without access (i.e. $\Lambda = 0$), the next period illiquid assets are given by the budget constraint $\tilde{A}' = (1+r_t)\tilde{A}$. With access (i.e. $\Lambda = 1$), an Euler equation for illiquid asset emerges

$$\begin{aligned}
u'(C_t(A,\tilde{A},\epsilon,1)) \geq \quad & \lambda\beta(1+r_t)\mathbf{E}[u'(C_{t+1}(A',\tilde{A}',\epsilon',1))|\epsilon] \\
& +(1-\lambda)\beta(1+r_t)\mathbf{E}[V_{\tilde{A}t+1}(A',\tilde{A}',\epsilon',0)|\epsilon]
\end{aligned} \tag{C.9}$$

where $V_{\tilde{A}t}(A,\tilde{A},\epsilon,0)$ is the marginal value of illiquid assets without assets. By the envelope condition, this marginal value equals

$$V_{\tilde{A}t}(A,\tilde{A},\epsilon,0)=\beta(1+r_t)\mathbf{E}[V_{\tilde{A}t+1}(A',\tilde{A}',\epsilon',\Lambda')|\epsilon,\Lambda] \tag{C.10}$$

C.4 Labor Union

We adopt the usual two-tier union structure with a continuum of monopolistically competitive differentiated labor unions that sell their labor services to a representative competitive labor packer.

Labor Packer A competitive labor packer combines tasks N_{kt} into an aggregate employment services using a CES technology: $N_t = [\int N_{kt}^{\frac{\nu^w-1}{\nu^w}}]^{\frac{\nu^w}{\nu^w-1}} dk$. Workers in each union earn a task-specific wage W_{kt}. The labor packer maximizes profit $W_t N_t - \int W_{kt} N_{kt} dk$. Maximization produces demand curve for each task:

$$N_{kt}=\left(\frac{W_{kt}}{W_t}\right)^{-\nu^w} N_t \tag{C.11}$$

where $W_t = \left(\int W_{kt}^{1-\nu^w}\, dk\right)^{\frac{1}{1-\nu^w}}$ is the aggregate nominal wage. At the symmetric equilibrium, all unions set the same wage $W_{kt} = W_t$, so the labor packer earns mo profit.

Individual Union Problem Households i rent their labor services to individual labor unions k. Each union k aggregates the effective services of its members into a union specific task $N_{kt} = \int e_{it} N_{ikt}\, di$, where N_{ikt} represents the hours supplied by household i to union k at time t and e_{it} is the labor efficiency. Hence, $\int e_{it} N_{ikt}\, di$ represents the efficiency-weighted hours worked. Households spend a portion, possibly zero, of their labor hours working at each union. Each task is paid a wage W_{kt}. Each individual union faces utility costs for adjusting the union-specific nominal wage W_{kt}. Namely, individual labor unions face Rotemberg adjustment costs with partial indexing. At any time t, union k sets is wage W_{kt} to maximize welfare for all workers it employs,

$$\sum_{\tau=0}^{\infty}\beta^{t+\tau}\left[\int\left(u(C_{it})-v(N_{it})\right)d\Upsilon_{i,t+\tau}-\frac{\psi^w}{2}\left(\frac{W_{k,t+\tau}}{(\Pi^w_{t-1})^{\iota^w}(\Pi^w)^{1-\iota^w}W_{k,t+\tau-1}}-1\right)^2\right] \tag{C.12}$$

where $\Pi_t^w = \frac{W_t}{W_{t-1}}$ is the gross aggregate nominal wage inflation at time t, $\pi_w = \Pi_t^w - 1$ is wage inflation in equilibrium, and ι^w is the degree of wage indexation. Taking as given, the initial distribution of households Ω_{it} and the union specific demand curve.

The first-order condition of the union k with respect to W_{kt} is therefore

$$\begin{aligned}
0 = &\int\left(\frac{\partial C_{it}}{\partial W_{kt}}u'(C_{it})-\frac{\partial N_{it}}{\partial W_{kt}}v'(N_{it})\right)d\Upsilon_{it}\\
&-\psi^W\left(\frac{W_{kt}}{(\Pi^w_{t-1})^{\iota^w}(\Pi^w)^{1-\iota^w}W_{kt-1}}-1\right)\frac{1}{(\Pi^w_{t-1})^{\iota^w}(\Pi^w)^{1-\iota^w}W_{kt-1}}\\
&+\beta\psi^w\left(\frac{W_{kt+1}}{(\Pi^w_{t})^{\iota^w}(\Pi^w)^{1-\iota^w}W_{kt}}-1\right)\left(\frac{W_{kt+1}}{(\Pi^w_{t})^{\iota^w}(\Pi^w)^{1-\iota^w}W_{kt}}\right)\frac{1}{W_{kt}}
\end{aligned}$$

Given the labor demand curve from the representative labor packer, the marginal impact of a task-specific wage increase on labor hours is

$$\frac{\partial N_{it}}{\partial W_{kt}} = -\nu^w \left(\frac{W_{kt}}{W_t}\right)^{-\nu^w - 1} \frac{N_t}{W_t}$$

Each household i, working for union k earns total real earnings,

$$Z_{it} = \tau_t \left(\frac{W_{kt}}{P_t} e_{it} N_{kt}\right)^{1-\theta} = \tau_t \left(e_{it} W_{kt}^{1-\nu^w} \frac{N_t}{P_t W_t^{-\nu^w}}\right)^{1-\theta}.$$

By the envelope theorem, we know that if households consume all income from the wage increase that $\frac{\partial C_{it}}{\partial W_{kt}} = \frac{\partial Z_{it}}{\partial W_{kt}}$. Therefore, the marginal impact of a wage increase on household i consumption is

$$\frac{\partial C_{it}}{\partial W_{kt}} = (1 - \nu^w)(1 - MTR_{it}) e_{it} \left(\frac{W_{kt}}{W_t}\right)^{-\nu^w} \frac{N_{kt}}{P_t}$$

where $MTR_{it} = 1 - (1-\theta)\tau_t \left(\frac{W_{kt}}{P_t} e_{it} N_{kt}\right)^{-\theta}$ is household $i's$ marginal tax rate at time t.

Wage Phillips Curve We exploit the fact that at a symmetric equilibrium, wages across unions are equal $W_{kt} = W_t$, and thus labor supply is equalized across unions $N_{kt} = N_t$ and thus across households $N_{it} = N_t$. Therefore we can rewrite the optimal wage formula:

$$\begin{aligned}\left(\frac{\Pi_t^w}{(\Pi_{t-1}^w)^{\iota^w}(\Pi^w)^{1-\iota^w}} - 1\right) \frac{\Pi_t^w}{(\Pi_{t-1}^w)^{\iota^w}(\Pi^w)^{1-\iota^w}} &= \frac{\nu^w}{\psi^w} N_t \int \left(v'(N_{it}) - \frac{\nu^w - 1}{\nu^w}(1 - MTR_{it}) e_{it} \frac{W_t}{P_t} u'(C_{it})\right) di \\ &+ \beta \left(\frac{\Pi_{t+1}^w}{(\Pi_t^w)^{\iota^w}(\Pi^w)^{1-\iota^w}} - 1\right) \frac{\Pi_{t+1}^w}{(\Pi_t^w)^{\iota^w}(\Pi^w)^{1-\iota^w}}\end{aligned}$$

Note that in equilibrium,

$$(1 - MTR_{it}) e_{it} \frac{W_t}{P_t} = (1-\theta)\tau_t e_{it}^{1-\theta} \left(\frac{W_t}{P_t}\right)^{1-\theta} N_t^{-\theta} = (1-\theta) \frac{e_{it}^{1-\theta}}{\int e_{it}^{1-\theta} di} \frac{Z_t}{N_t}$$

where Z_t is average post-tax income. Replacing consumption with the "virtual aggregate consumption" term C_t^*, we arrive at a non-linear New Keynesian Wage Phillips Curve:

$$\begin{aligned}\left(\frac{\Pi_t^w}{(\Pi_{t-1}^w)^{\iota^w}(\Pi^w)^{1-\iota^w}} - 1\right) \frac{\Pi_t^w}{(\Pi_{t-1}^w)^{\iota^w}(\Pi^w)^{1-\iota^w}} &= \frac{\nu^w}{\psi^w} \left(N_t v'(N_t) - \frac{\nu^w - 1}{\nu^w}(1-\theta) Z_t u'(C_t^*)\right) \\ &+ \beta \left(\frac{\Pi_{t+1}^w}{(\Pi_t^w)^{\iota^w}(\Pi^w)^{1-\iota^w}} - 1\right) \frac{\Pi_{t+1}^w}{(\Pi_t^w)^{\iota^w}(\Pi^w)^{1-\iota^w}}\end{aligned} \tag{C.13}$$

where $u'(C_t^*) = \int \frac{e_{it}^{1-\theta} u'(C_{it})}{\int e_{it}^{1-\theta} di} di$. Where $\kappa^w = \frac{\nu^w}{\psi^w} N v'(N) = \frac{\nu^w}{\psi^w}$ because $N = 1$ in steady-state, and $\mu^w = \frac{\nu^w - 1}{\nu^w}$.

C.5 Financial Markets

The financial system includes a representative bank and production firms that issue equity.

Banks There is a single representative competitive bank. Let B_t real bonds, and B_t^n be a nominal bond in zero net-supply, that can only be held by the bank. Banks' real profits each period are

$$D_t^b = (1 + r_{t-1}) B_{t-1} + (1 + i_{t-1}) \frac{B_{t-1}^n}{P_t} - B_t - \frac{B_t^n}{P_t}$$

where r_t is the interest rate earned on real bonds, and i_t is the interest rate earned on nominal bonds. Profit maximization by banks and a no arbitrage conditions implies that the bank discounts at the real rate $\tilde{r}_t = r_t$, and that the Fisher equation

$$1 + r_t = \frac{1 + i_t}{1 + \pi_{t+1}} \tag{C.14}$$

holds for all $t \geq 0$. In equilibrium, these banks make no profits from buying and selling bonds. Since nominal bonds are in zero net supply, $B_t^n = 0$ for all banks. As in Auclert, Rognlie and Straub (2024), we also assume that the banks start with zero assets, so we have $B_t = 0$ at all times.

Liquid and Illiquid Accounts For simplicity, we assumed that households could only trade liquid A_{it} or illiquid $\tilde{A}_{it}$ assets. Now we show how these accounts are constructed. Suppose households can now hold assets in either real bonds or shares of production. Under this assumption, household i's budget constraints become

$$C_{it} + P_t^y V_{it} + B_{it} = Z_{it} + (1 - \zeta)[(P_t^y + D_t) V_{it-1} + (1 + r_{t-1}) B_{it-1}] - H_{it} \Lambda_{it}$$
$$P_t^y \tilde{V}_{it} + \tilde{B}_{it} = (P_t^y + D_t) \tilde{V}_{it-1} + (1 + r_{t-1}) \tilde{B}_{it-1} + H_{it} \Lambda_{it}$$

where $\{B_{it}, \tilde{B_{it}}\}$ are household i's liquid and illiquid holdings of bonds, $\{V_{it}, \tilde{V}_{it}\}$ are household i's liquid and illiquid shares of equity, and $\{P_t^y, D_t\}$ are the price and dividend of the firm share. The no arbitrage conditions implies that these prices must equal

$$P_t^y + D_t = (1 + r_{t-1}) P_{t-1}^y$$

By defining the liquid and illiquid asset position to be $A_{it} \equiv P_t^y V_{it} + B_{it}$ and $\tilde{A}_{it} \equiv P_t^y \tilde{V}_{it} + \tilde{B}_{it}$ we can rewrite the household budget constraints as

$$
\begin{aligned}
C_{it} + A_{it} &= Z_{it} + (1-\zeta)(1+r_{t-1})A_{it-1} - H_{it}\Lambda_{it} \\
\tilde{A}_{it} &= (1+r_{t-1})\tilde{A}_{it-1} + H_{it}\Lambda_{it}
\end{aligned} \tag{C.15}
$$

C.6 Monetary and Fiscal Policy

Monetary Policy The central bank implements monetary policy by directly setting the nominal interest rate i_t on the nominal bonds (i.e. "reserves") held by banks. The monetary authority adjusts the nominal interest rate in response to inflation deviations, while aiming to smooth interest rates across time. The central bank obeys a Taylor rule with interest-rate smoothing

$$
i_t = \rho_i i_{t-1} + (1-\rho_i)[r + \phi^{\pi}\pi_t] \tag{C.16}
$$

where ϕ^p is the responsiveness of monetary policy, and ρ_i is the degree of interest rate smoothing.

Fiscal Policy The flow budget constraint of the government is

$$
G_t + (1+r_{t-1})B_{t-1} = T_t + B_t \tag{C.17}
$$

The fiscal authority adjusts taxes in response to government spending and debt deviations. Specifically, the fiscal authority follows a Leeper rule with tax smoothing

$$
dT_t = \phi^g dG_t + \phi^b dB_t \tag{C.18}
$$

where dG_t, dT_t, and dB_t are the change in government expenditure, taxes, and the real debt, $\phi^g > 0$ is the responsiveness of taxes to government spending, and $\phi^b > 0$ is the responsiveness of taxes to debt. In the baseline calibration we set this smoothing parameter to zero, but in alternative calibrations we allow it to be non-zero.

C.7 Market Clearing

Market clearing in the goods market implies that

$$
C_t + G_t + X_t + \Psi_t^p + \Xi_t + \zeta(1+r_{t-1})A_{t-1} = Y_t \tag{C.19}
$$

where $C_t = \int C_{it} di$ is aggregate consumption, Ψ_t^p are the aggregate nominal adjustment costs, Ξ_t are the aggregate real adjustment costs, and $\zeta(1+r_{t-1})A_{t-1}$ are the costs of holding liquid assets, where we have used that $A_t = \int A_{it} di$. Market clearing in financial markets implies

$$\begin{aligned} \int (V_{it} + \tilde{V}_{it}) di &= 1 \\ \int B^n_{it} di &= 0 \\ \int (B_{it} + \tilde{B}_{it}) di &= B_t \\ \int K_{jt} dj &= K_t \end{aligned} \tag{C.20}$$

Walras's Law Aggregating budget constraints across households, we have

$$\begin{aligned} \int C_{it} di + \int (B_{it} + \tilde{B}_{it}) di + P^y_t \int (V_{it} + \tilde{V}_{it}) di = \int Z_{it} di \\ +(P^Y_t + D_t) \int (V_{it-1} + \tilde{V}_{it-1}) di + (1 + r_{t-1}) \int (B_{it-1} + \tilde{B}_{it-1}) di \\ -\zeta(1 + r_{t-1}) \int A_{it-1} di \end{aligned}$$

which, given market clearing, means

$$C_t + B_t = Z_t + D_t + (1 + r_{t-1}) B_{t-1} - \zeta(1 + r_{t-1}) A_{t-1} \tag{C.21}$$

Combining this expression with the government budget constraint, and the definition of post tax labor income $Z_t = \frac{W_t}{P_t} N_t - T_t$, and the definition of the dividend D_t, we arrive at the goods market clearing condition $C_t + X_t + G_t + \Psi^p_t + \Xi_t + \zeta(1 + r_{t-1}) A_{t-1} = Y_t$.

C.8 Equilibrium

Variables

Equations Production

$$Y_t = \Theta K^\alpha_{t-1} N^{1-\alpha}_t \tag{C.22}$$

Evolution of marginal cost

$$(1 - \alpha) \mu_t Y_t = \frac{W_t}{P_t} N_t \tag{C.23}$$

New Keynesian Phillips Curve

$$\begin{aligned} \left(\frac{\Pi_t}{(\Pi_{t-1})^{\iota^p} (\Pi)^{1-\iota^p}} - 1\right) \frac{\Pi_t}{(\Pi_{t-1})^{\iota^p} (\Pi)^{1-\iota^p}} &= \frac{\nu^p}{\psi^p} Y_t [\mu_t - \mu] \\ &+ \frac{1}{1 + r_t} \left(\frac{\Pi_{t+1}}{(\Pi_t)^{\iota^p} (\Pi)^{1-\iota^p}} - 1\right) \frac{\Pi_{t+1}}{(\Pi_t)^{\iota^p} (\Pi)^{1-\iota^p}} \end{aligned} \tag{C.24}$$

The Q-theory of investment

Name	Symbol
Output	Y_t
Consumption	C_t
Virtual consumption	C_t^*
Government expenditure	G_t
Aggregate taxes	T_t
Post-tax income	Z_t
Capital stock	K_t
Investment	X_t
Liquid assets	A_t
Illiquid assets	$\tilde{A}_t$
Nominal wage	W_t
Price level	P_t
Gross price inflation	Π_t
Gross wage inflation	Π_t^w
Real interest on capital	R_t^k
Real interest rate	R_t
Nominal interest rate	I_t
Rental rate of capital	Q_t
Marginal cost	μ_t
Capital adjustment cost	Ξ_t^k
Investment adjustment cost	Ξ_t^x
Price adjustment cost	Ψ_t^p
Wage adjustment cost	Ψ_t^w

Table C.1: Variable names and symbols

$$\begin{aligned} Q_t &= \frac{1}{1+r_t}[\mu_{t+1}F_{Kt+1} + (1-\delta)Q_{t+1}] \\ (g_{Xt}-1)g_{Xt} &= \frac{X_t}{\xi}[Q_t - 1] + \frac{1}{1+r_t}(g_{Xt+1}-1)g_{Xt+1} \end{aligned} \tag{C.25}$$

Adjustment costs

$$\begin{aligned} \Xi_t &= \frac{\xi}{2}(\frac{X_t}{X_{t-1}} - 1)^2 \\ \Psi_t^p &= \frac{\psi^p}{2}(\frac{\Pi_t}{(\Pi_{t-1})^{\iota^p}(\Pi)^{1-\iota^p}} - 1)^2 \\ \Psi_t^w &= \frac{\psi^w}{2}(\frac{\Pi_t^w}{(\Pi_{t-1}^w)^{\iota^w}(\Pi^w)^{1-\iota^w}} - 1)^2 \end{aligned} \tag{C.26}$$

Dividend

$$D_t^y = Y_t - \frac{W_t}{P_t}N_t - X_t - \Xi_t - \Psi_t^p. \tag{C.27}$$

Asset market clearing and no arbitrage conditions

$$A_t = B_t + P_t^y$$
$$P_t^y = \frac{1}{1+r_t}(D_t + P_{t+1}^y) \tag{C.28}$$

Euler equation

$$u'(C_t(\epsilon, A_-)) \geq \beta(1+r_t)\mathbf{E}[u'(C_{t+1}(\epsilon', A))|\epsilon]. \tag{C.29}$$

The Wage Phillips curve

$$\begin{aligned}(\frac{\Pi_t^w}{(\Pi_{t-1}^w)^{\iota^w}(\Pi^w)^{1-\iota^w}} - 1)\frac{\Pi_t^w}{(\Pi_{t-1}^w)^{\iota^w}(\Pi^w)^{1-\iota^w}} &= \frac{\nu^w}{\psi^w}[N_t v'(N_t) - \frac{\nu^w - 1}{\nu^w}(1-\theta)Z_t u'(C_t^*)] \\ &+ \beta(\frac{\Pi_{t+1}^w}{(\Pi_t^w)^{\iota^w}(\Pi^w)^{1-\iota^w}} - 1)\frac{\Pi_{t+1}^w}{(\Pi_t^w)^{\iota^w}(\Pi^w)^{1-\iota^w}}\end{aligned} \tag{C.30}$$

Wage consistency condition

$$\Pi_t^w = \Pi_t \frac{W_t/P_t}{W_{t-1}/P_{t-1}} \tag{C.31}$$

Goods market clearing

$$C_t + G_t + X_t + \Psi_t + \Xi_t = Y_t \tag{C.32}$$

where $\Psi_t = \Psi_t^p + \Psi_t^w$ are the aggregate nominal adjustment costs, and Ξ_t are the aggregate real adjustment costs.

Fisher Equation

$$1 + r_t = \frac{1+i_t}{1+\pi_{t+1}} \tag{C.33}$$

Taylor Rule

$$i_t = \rho_i i_{t-1} + (1-\rho_i)[r + \phi^\pi \pi_t] \tag{C.34}$$

Government budget constraint

$$B_t = G_t + (1+r_{t-1})B_{t-1} - T_t \tag{C.35}$$

Fiscal rule

$$dT_t = \phi^g dG_t + \phi^b dB_t \tag{C.36}$$

Steady State

$$Y = \Theta K^\alpha N^{1-\alpha} \tag{C.37}$$

$$\mu = \frac{\nu^p - 1}{\nu^p} \tag{C.38}$$

$$\mu = (1-\alpha)\frac{WN}{PY} \tag{C.39}$$

$$r + \delta = \alpha\mu\frac{Y}{K} \tag{C.40}$$

$$Q = 1 \tag{C.41}$$

$$X = \delta K \tag{C.42}$$

$$D = (1-\mu)Y \tag{C.43}$$

$$1 \geq (1+r)\beta \tag{C.44}$$

$$Nv'(N) = \mu^w(1-\theta)(Y-T)u'(C^*) \tag{C.45}$$

$$\Pi^w = \Pi \tag{C.46}$$

$$1 + r = \frac{1+i}{1+\pi} \tag{C.47}$$

$$T = G + rB \tag{C.48}$$

$$Z = \frac{W}{P}N - T \tag{C.49}$$

$$C + G + X + \zeta(1+r)A = Y \tag{C.50}$$

$$A = B + P^y \tag{C.51}$$

$$P^y = \frac{(1-\mu)}{r}Y \tag{C.52}$$

$$C = \mathcal{C}(\{Z, r\}, P^y + D; \beta) \tag{C.53}$$

$$C^* = \mathcal{C}^*(\{Z, r\}, P^y + D; \beta) \tag{C.54}$$

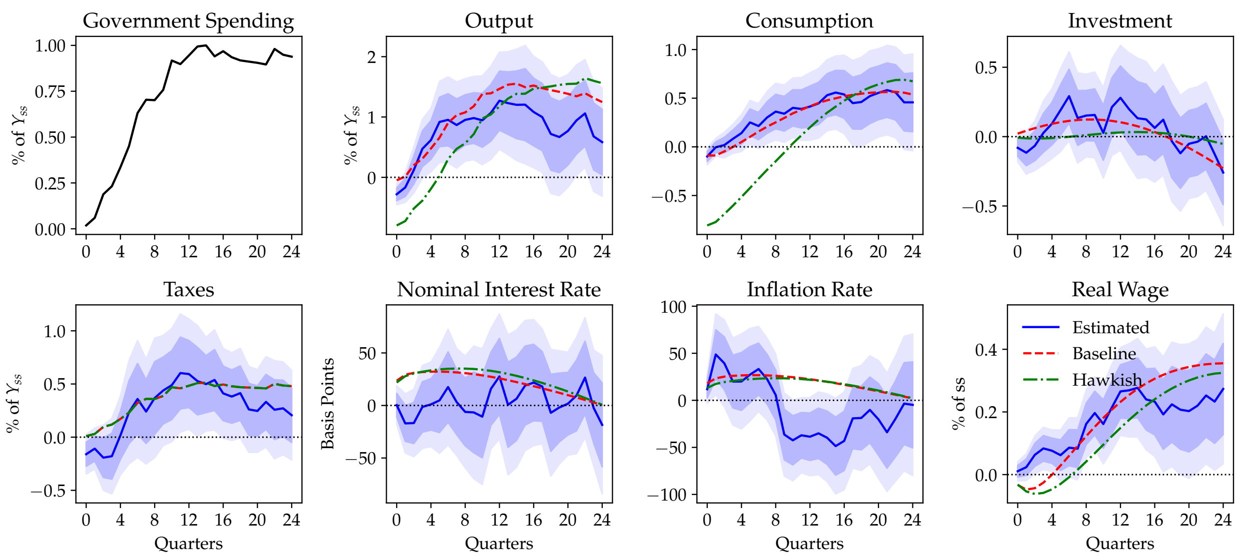
$$g_X = 0 \tag{C.55}$$

$$\Xi = 0 \tag{C.56}$$

D Additional Model Results

D.1 Role of Monetary Policy

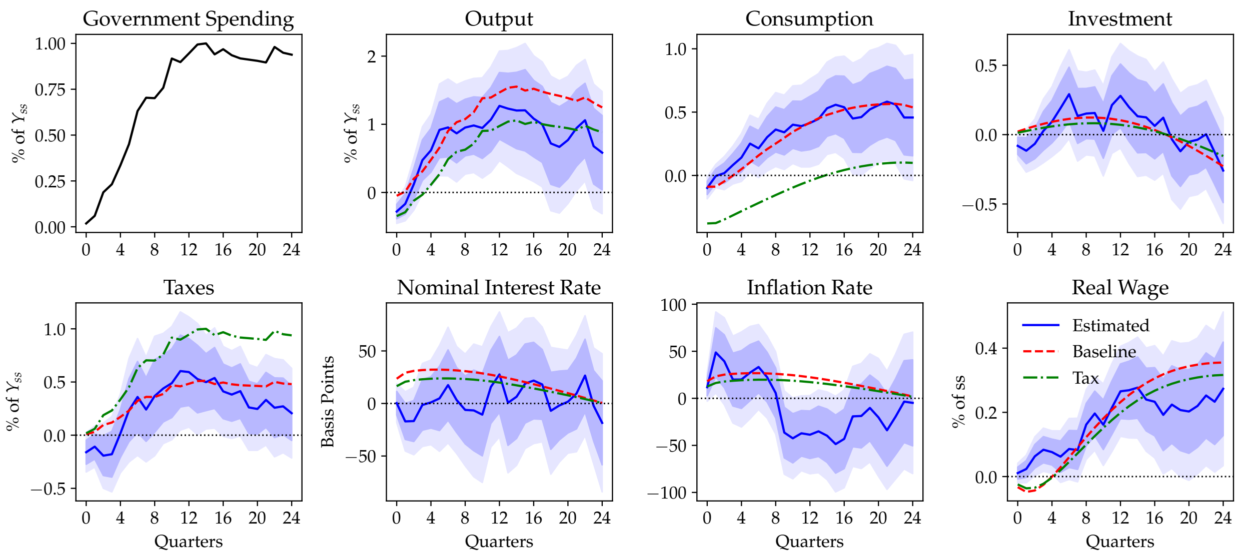
Figure D.1: Role of Monetary Policy



Notes: This figure plots the estimated and model implied responses out output, consumption, investment, taxes, nominal interest rates, inflation, and real wages to a defense spending surprise, normalized so the defense response peaks at one percent of GDP. The sold blue lines are our estimates of β_h in Equation (1) for different horizons h. The dark and light shaded areas are the 68% and 95% confidence intervals. The red dashed line is the baseline model's response to the government spending shock in the first panel. The green dot-dashed line is the hawkish monetary policy ($\phi_\pi = 1.5$) model's response to the government spending shock in the first panel.

D.2 Role of Fiscal Policy

Figure D.2: Role of Fiscal Policy



Notes: This figure plots the estimated and model implied responses out output, consumption, investment, taxes, nominal interest rates, inflation, and real wages to a defense spending surprise, normalized so the defense response peaks at one percent of GDP. The sold blue lines are our estimates of β_h in Equation (1) for different horizons h. The dark and light shaded areas are the 68% and 95% confidence intervals. The red dashed line is the baseline model's response to the government spending shock in the first panel. The green dot-dashed line is the tax-financed fiscal policy ($\phi_g = 1$) model's response to the government spending shock in the first panel.

D.3 Alternative Models

Analytical Models The representative agent New Keynesian (RANK) model and the two-agent bonds-in-the-utiliy function New Keynesian (TABU) model are different calibrations of the same underlying analytical model. There are two types of agents: constrained and unconstrained. The $1-\mu$ mass of unconstrained agents earn income $Z_t = \frac{W_t}{P_t} N_t - T_t$ and have access to a one-period risk-free bond, which pays interest r_t. Given their initial asset position A_{-1} the unconstrained households solve

$$\max_{\{C_{ut}, N_{ut}, A_{ut}\}_{t=0}^{\infty}} \frac{C_{ut}^{1-1/\sigma} - 1}{1-1/\sigma} - \frac{N_{ut}^{1+1/\eta}}{1+1/\eta} + w(A_{ut})$$
$$C_{ut} + A_{ut} = Z_t + (1 + r_{t-1}) A_{ut-1}$$

where C_{ut}, N_{ut} and , A_{ut} are the unconstrained consumption, labor supply, and asset position, σ is the intertemporal elasticity of substitution, η is the Frisch elasticity, and $w(\cdot)$ is the household demand for liquidity. This demand for liquidity, $w(\cdot)$, is weakly concave. The remaining μ

portion of the population is hand-to-mouth, with no access to financial markets. These constrained households maximize:

$$\max_{C_{ct},N_{ct}} \frac{C_{ct}^{1-1/\sigma}-1}{1-1/\sigma} - \frac{N_{ct}^{1+1/\eta}}{1+1/\eta}$$
$$C_{ct} = Z_t$$

each period t. Aggregate consumption is $C_t = (1-\mu)C_{ut} + \mu C_{ct}$, aggregate labor supply is $N_t = (1-\mu)N_{ut} + \mu N_{ct}$, and the aggregate assets are $A_t = (1-\mu)A_{ut}$.

The Euler equation of this model, $C_{ut}^{-1/\sigma} = \beta(1+r_t)C_{ut+1}^{-1/\sigma} + w'(A_{ut})$, implies that in steady-state

$$\beta(1+r) = 1 - \frac{w'(A_{ut})}{(C_u)^{-1/\sigma}} \tag{D.1}$$

the interest rate is below the inverse of the discount factor, i.e., $r < \beta^{-1} - 1$, if the marginal value of liquidity $w'(A_{ut})$ is positive. Moreover, Auclert, Rognlie and Straub (2024) (section 4) show that the intertemporal marginal propensity to consume at the steady-state is

$$\begin{aligned} \mathbf{M} &= \mu\mathbf{I} + (1-\mu)\mathbf{M}^{BU} \\ \text{s.t. } M_{t0}^{BU} &= (1 - \frac{\lambda}{1+r})\lambda^t,\ \forall t \geq 0 \end{aligned} \tag{D.2}$$

where λ is a parameter that maps to the shape of the liquidity demand function $w(\cdot)$, and M_{t0}^{BU} is the first column of $\mathbf{M}^{BU}$. See Appendix D.2 of Auclert, Rognlie and Straub (2024) for more details.

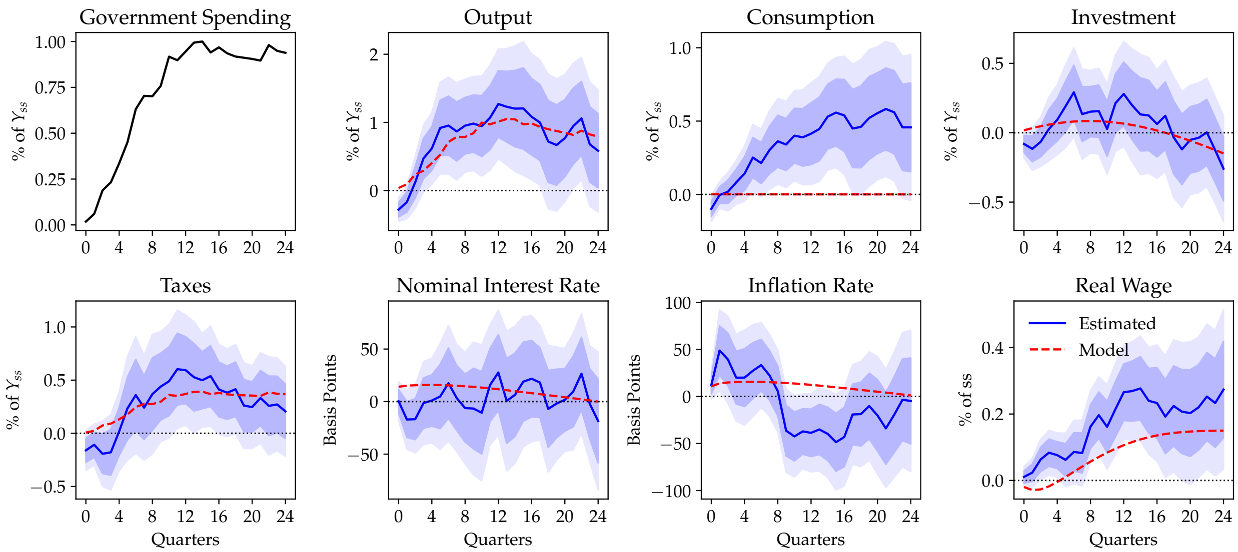
Beyond the usual household preferences, i.e., σ, η, β, this model is characterized by the proportion of hand-to-mouth agents μ and the degree of liquidity demand λ. When there are no hand-to-mouth agents ($\mu = 0$) and no demand for liquidity ($\lambda = 0$), this model collapses to the RANK formulation with marginal propensity to consume

$$M_{t0}^{RA} = (1-\beta)\beta^t, \forall t \geq 0 \tag{D.3}$$

in the first column of the iMPC matrix $\mathbf{M}$. On the other hand, if there were hand-to-mouth households ($\mu > 0$) but not liquidity demand ($\lambda = 0$) the model would collapse to standard TANK model (e.g. Galí, López-Salido and Vallés (2007)).

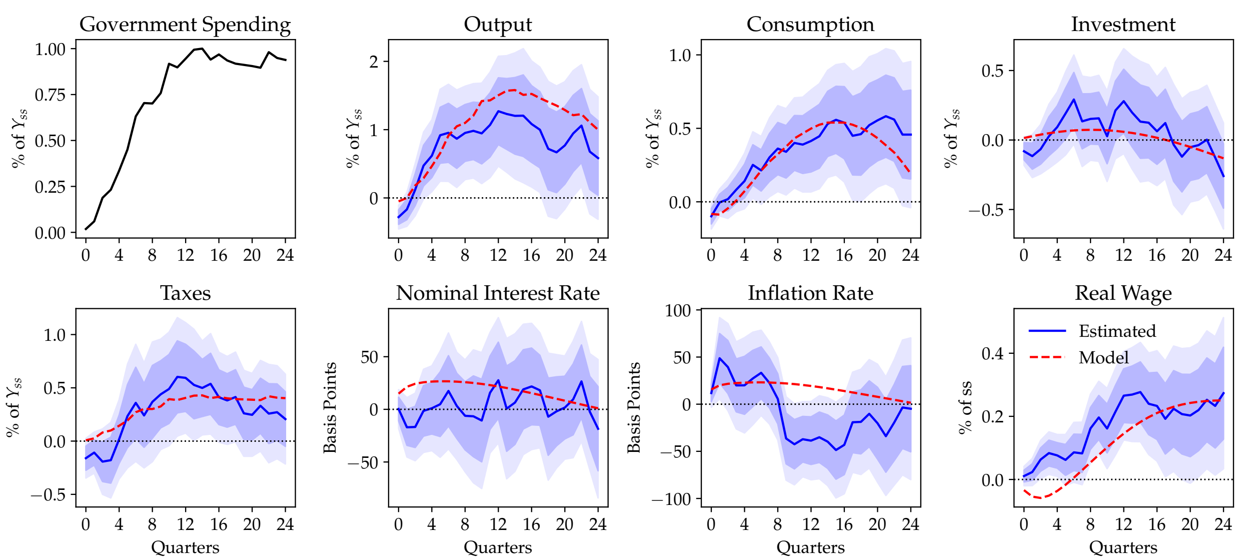
In the main text we compare out baseline model to a RANK ($\mu = 0, \lambda = 0$) variation and a TA BU ($\mu > 0, \lambda > 0$) variation. To calibrate the RANK model, we use the discount factor β to discipline the iMPC matrix. To calibration the TABU model we match the first two iMPCs, $M_{00}^{TABU}, M_{10}^{TABU}$ to match the first and second iMPC from a one-asset HANK model, i.e. $M_{00}^{HA1}, M_{10}^{HA1}$. This sets $\beta = .965, \mu = .138, \lambda = .946$.

Figure D.3: Alternative Model: RANK



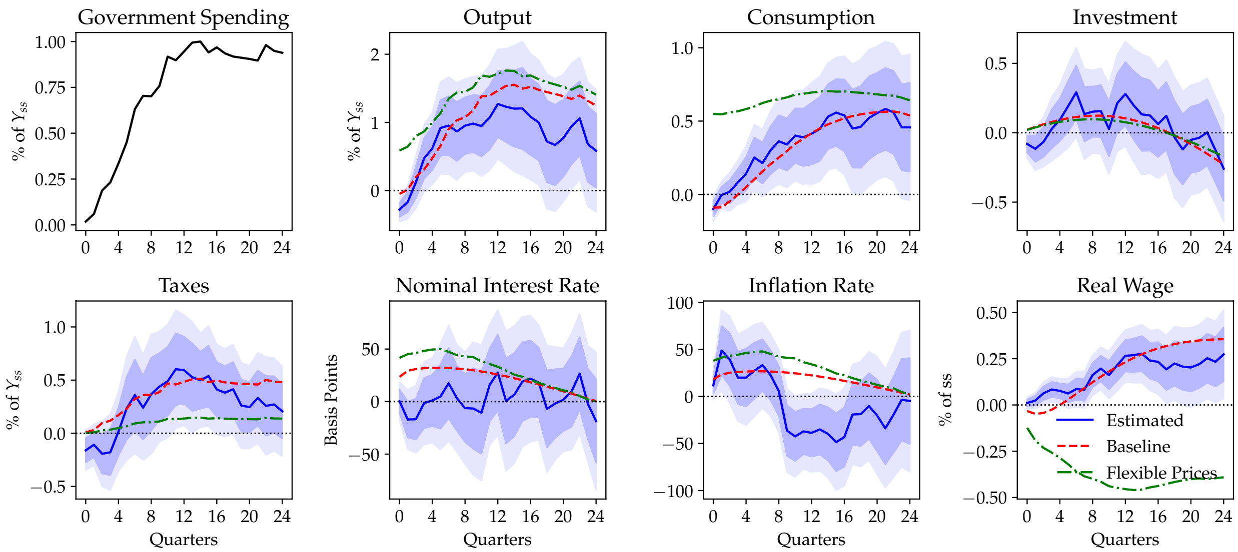
Notes: This figure plots the estimated and model implied responses out output, consumption, investment, taxes, nominal interest rates, inflation, and real wages to a defense spending surprise, normalized so the defense response peaks at one percent of GDP. The sold blue lines are our estimates of β_h in Equation (1) for different horizons h. The dark and light shaded areas are the 68% and 95% confidence intervals. The red dashed line is the baseline model's response to the government spending shock in the first panel. The green dot-dashed line is the RANK model's response to the government spending shock in the first panel.

Figure D.4: Alternative Model: TABU



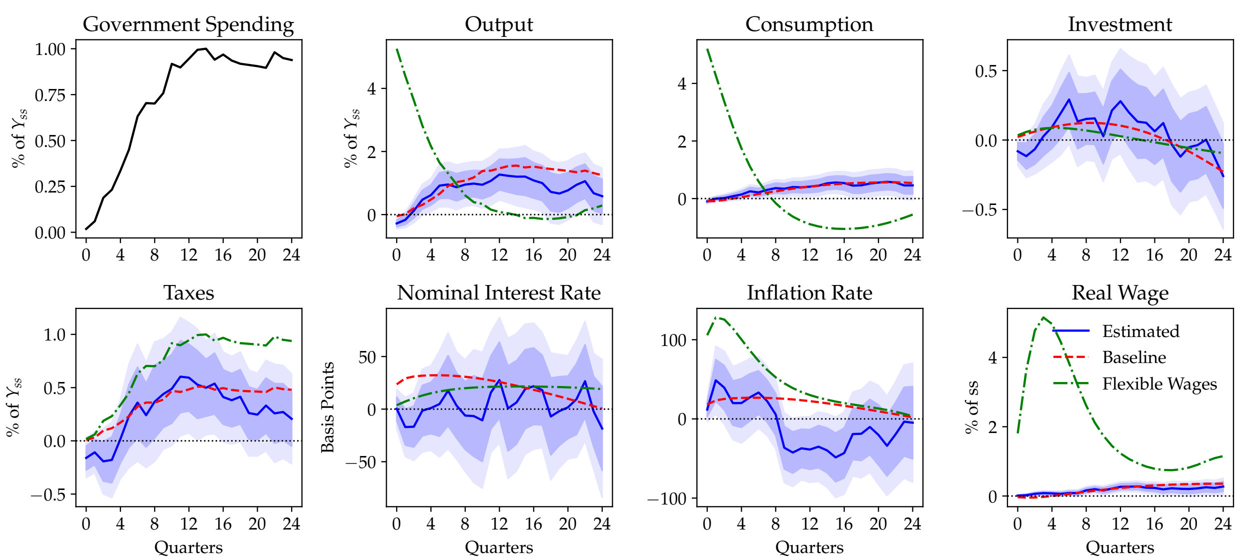
Notes: This figure plots the estimated and model implied responses out output, consumption, investment, taxes, nominal interest rates, inflation, and real wages to a defense spending surprise, normalized so the defense response peaks at one percent of GDP. The sold blue lines are our estimates of β_h in Equation (1) for different horizons h. The dark and light shaded areas are the 68% and 95% confidence intervals. The red dashed line is the baseline model's response to the government spending shock in the first panel. The green dot-dashed line is the TABU model's response to the government spending shock in the first panel.

Figure D.5: Alternative Model: Flexible Prices



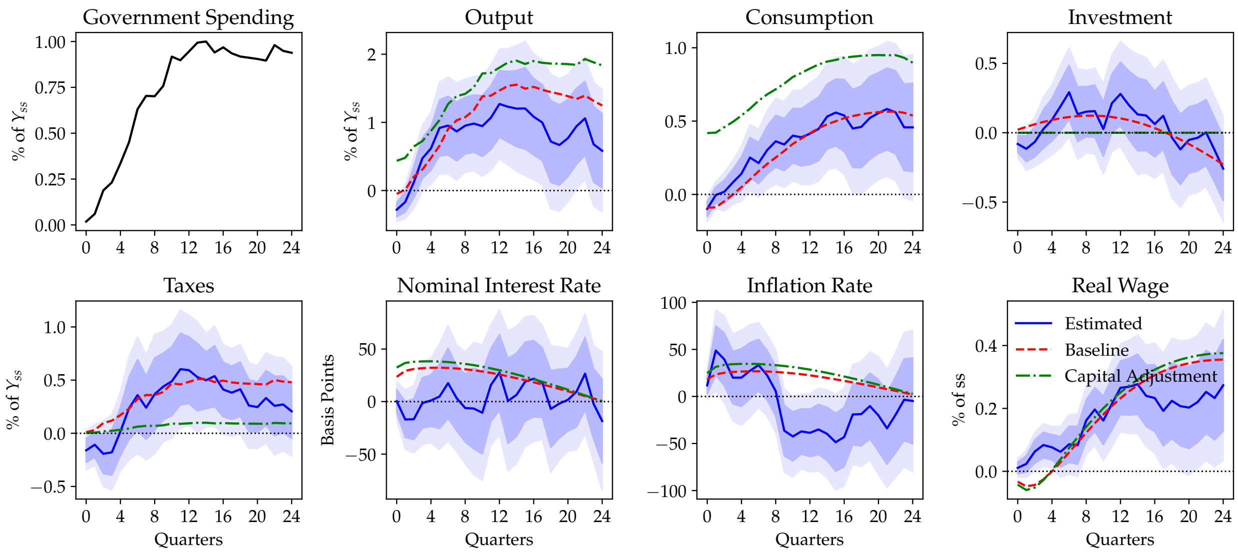
Notes: This figure plots the estimated and model implied responses out output, consumption, investment, taxes, nominal interest rates, inflation, and real wages to a defense spending surprise, normalized so the defense response peaks at one percent of GDP. The sold blue lines are our estimates of β_h in Equation (1) for different horizons h. The dark and light shaded areas are the 68% and 95% confidence intervals. The red dashed line is the baseline model's response to the government spending shock in the first panel. The green dot-dashed line is the flexible price model's response.

Figure D.6: Alternative Model: Flexible Wages



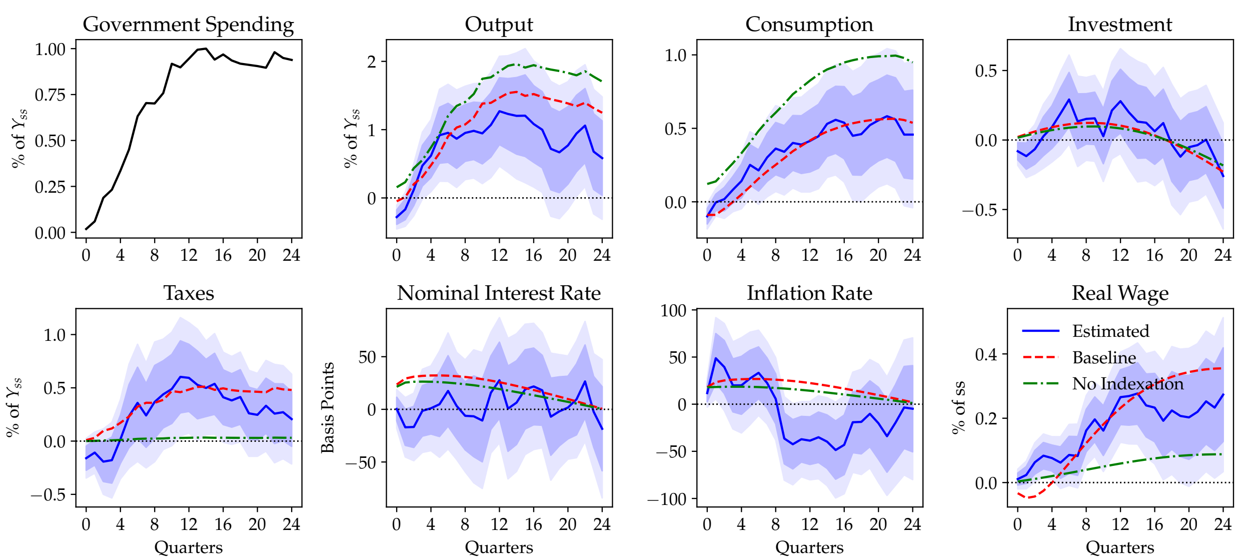
Notes: This figure plots the estimated and model implied responses out output, consumption, investment, taxes, nominal interest rates, inflation, and real wages to a defense spending surprise, normalized so the defense response peaks at one percent of GDP. The sold blue lines are our estimates of β_h in Equation (1) for different horizons h. The dark and light shaded areas are the 68% and 95% confidence intervals. The red dashed line is the baseline model's response to the government spending shock in the first panel. The green dot-dashed line is the flexible wage model's response to the government spending shock in the first panel.

Figure D.7: Alternative Model: Capital Adjustment



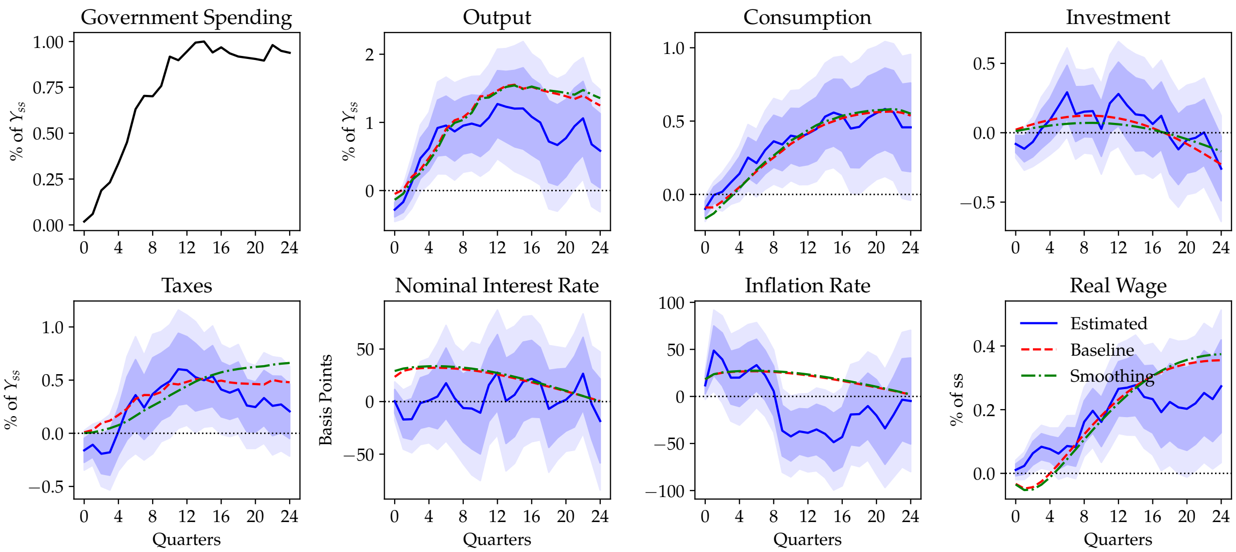
Notes: This figure plots the estimated and model implied responses out output, consumption, investment, taxes, nominal interest rates, inflation, and real wages to a defense spending surprise, normalized so the defense response peaks at one percent of GDP. The sold blue lines are our estimates of β_h in Equation (1) for different horizons h. The dark and light shaded areas are the 68% and 95% confidence intervals. The red dashed line is the baseline model's response to the government spending shock in the first panel. The green dot-dashed line is the capital adjustment model's response to the government spending shock in the first panel.

Figure D.8: Alternative Model: No Price Indexation



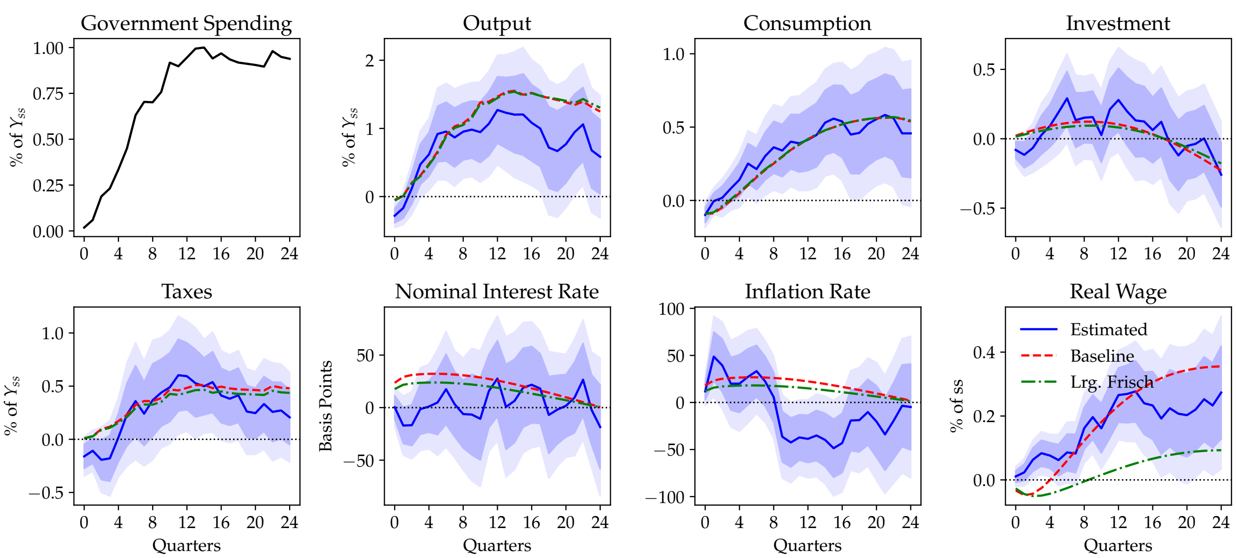
Notes: This figure plots the estimated and model implied responses out output, consumption, investment, taxes, nominal interest rates, inflation, and real wages to a defense spending surprise, normalized so the defense response peaks at one percent of GDP. The sold blue lines are our estimates of β_h in Equation (1) for different horizons h. The dark and light shaded areas are the 68% and 95% confidence intervals. The red dashed line is the baseline model's response to the government spending shock in the first panel. The green dot-dashed line is the no indexation model's response to the government spending shock in the first panel.

Figure D.9: Alternative Model: Policy Smoothing



Notes: This figure plots the estimated and model implied responses out output, consumption, investment, taxes, nominal interest rates, inflation, and real wages to a defense spending surprise, normalized so the defense response peaks at one percent of GDP. The sold blue lines are our estimates of β_h in Equation (1) for different horizons h. The dark and light shaded areas are the 68% and 95% confidence intervals. The red dashed line is the baseline model's response to the government spending shock in the first panel. The green dot-dashed line is the no policy smoothing model's response to the government spending shock in the first panel.

Figure D.10: Alternative Model: larger Frisch elasticity ($\eta^{-1} = 1$)



Notes: This figure plots the estimated and model implied responses out output, consumption, investment, taxes, nominal interest rates, inflation, and real wages to a defense spending surprise, normalized so the defense response peaks at one percent of GDP. The sold blue lines are our estimates of β_h in Equation (1) for different horizons h. The dark and light shaded areas are the 68% and 95% confidence intervals. The red dashed line is the baseline model's response to the government spending shock in the first panel. The green dot-dashed line is the larger Frisch elasticity model's response to the government spending shock in the first panel.

D.4 Additional Results

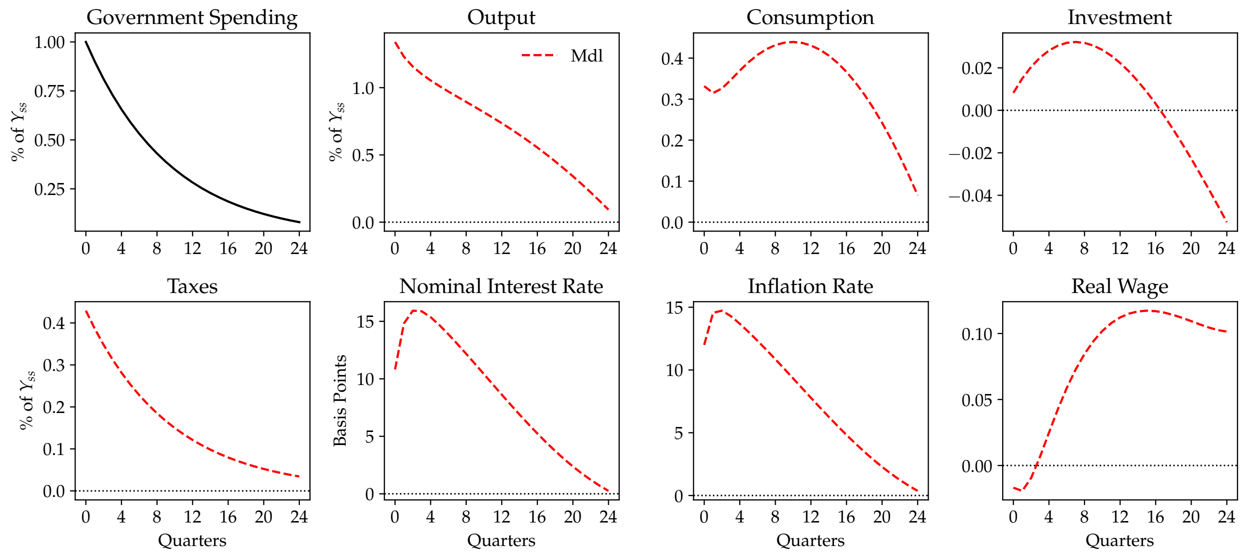


Figure D.11: Effect of an AR(1) Defense Spending Shock

Notes: This figure plots the model implied responses out output, consumption, investment, taxes, nominal interest rates, inflation, and real wages to an AR(1) government spending surprise. The red dashed line is the baseline model's response to the government spending shock in the first panel.

Model	Hawkishness (ϕ^{π})	Interest-smoothing (ρ_i)	Fiscal reaction to G (ϕ^{g})	Fiscal reaction to B (ϕ^{b})	Investment elasticity (ξ^{I})
Baseline	1.206	0.164	.511	0.0	1.694
RANK	1.020	0.0	.392	0.0	1.151
TABU	1.158	0.358	.429	0.0	.970
Flexible price	1.046	0.036	.147	0.0	1.313
Flexible wage	1.045	0.972	1.00	0.0	.389
Capital adjustment	1.106	0.069	.099	0.0	0.0
No indexation	1.423	0.173	.033	0.0	1.273
Without policy smoothing	1.200	0.000	.524	0.0	.800
Larger Frisch	1.322	0.152	.465	0.0	1.673

Table D.1: Alternative calibrations.