Why Does GDP Move Before Government Spending? It's all in the Measurement*

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Abstract

We find that the early impact of defense news shocks on GDP is due to a rise in business inventories, as contractors ramp up production for new defense contracts. These contracts do not affect government spending (G) until payment-on-delivery, which occurs 2-3 quarters later. Novel data on defense procurement obligations reveals that contract awards Granger-cause shocks to G identified via Cholesky decomposition, but not defense news shocks. We show that Cholesky shocks to G miss early changes in inventories, and thus result in lower multiplier estimates relative to defense news shocks.
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The fiscal policy literature has long aimed to quantify the effects of government spending (G) and its underlying transmission mechanism.[1] To do so, researchers must first identify unpredictable government spending shocks that are exogenous to

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[1] Government Spending (G) is the sum of government consumption expenditure and gross investments. It is one component of GDP in the classical decomposition Y = C + I + NX + G. More information on the accounting origin of G in the National Income and Product Account is reported in the Online Appendix D.1.

the business cycle. According to Ramey (2016), the two most commonly used approaches for identification are the Cholesky decomposition (Blanchard and Perotti (2002)) and the narrative method (Ramey (2011)). The Cholesky decomposition approach places G first in a vector autoregressive (VAR) model, relying on the assumption that G is predetermined at time t due to decision lags. Practically, this entails regressing G on its lags and on lags of other pertinent state variables, assuming that the resulting OLS residuals represent structural shocks (henceforth Cholesky shocks). By contrast, the narrative approach uses an instrument (e.g., defense news shocks) which reflects the anticipated shifts in defense spending brought on by exogenous military events, and places this instrument first in a VAR. Both approaches are valid under the right assumptions. Yet, the Cholesky-based method estimates smaller multipliers than the narrative method (i.e., "multiplier-gap"), especially at small horizons. This paper provides an empirical explanation of the multiplier-gap.

We start from the key empirical finding that GDP increases immediately while G increases with a delay following narratively-identified shocks to government spending.[2] Since narrative shocks predict Cholesky-identified shocks to G, proponents of the narrative approach use this as evidence that Cholesky-identified shocks fail to account for anticipation effects of fiscal policy. For instance, Ramey (2011) shows that war-dates Granger-cause (or predict) Cholesky shocks, thus leading to an identification problem since those shocks capture military build-ups with a delay. Moreover, delaying war-dates in the VAR can reconcile resulting estimates from the two methods (i.e., "*it's all in the timing*").

However, one question still remains. What causes GDP to move before G in the narrative approach? Ramey (2011) suggests that it is Ricardian behavior of agents to drive the anticipation effect of government spending. In particular, the existence of implementation lags during military build-ups leads to a time-mismatch between the agents' expectations of future G and the actual change in G. Since Ricardian agents respond to changes in the present discounted value of G and taxes, GDP responds even before any actual change in G. However, the strength of this mechanism is still

[2] See Ramey and Shapiro (1998), Edelberg, Eichenbaum, and J. Fisher (1999), Burnside, Eichenbaum, and J. D. Fisher (2004), Eichenbaum and J. Fisher (2005), Ramey (2011), Barro and Redlick (2011), Ben Zeev and Pappa (2017) and Ramey and Zubairy (2018). Leeper, Walker, and S.-C. S. Yang (2013)'s also suggests to control for anticipation effects to correctly identify fiscal shocks.

a matter of debate among economists.[3]

We provide empirical evidence of an alternative mechanism. In particular, we show that an increase in business inventories accounts for the initial movement of GDP following a narrative shock. We trace back the inventory effect to an increase in newly awarded defense procurement contracts following a defense news shock. However, war-related contract awards and associated early-stage production occur several quarters before payment-on-delivery. Since government spending tracks payments, early-stage production is recorded in aggregate inventories until delivery. The differential response of aggregate inventories explains the difference in government spending multipliers calculated via the narrative method and the Cholesky decomposition (i.e., "*it's all in the measurement*").

We start by decomposing the increase in GDP after a defense news shock, using quarterly data from the National Income and Product Accounts (NIPA). At the aggregate level, we observe that G responds two quarters after the defense news shock, while GDP has a positive and significant response on impact and in the first quarter. The impact (horizon 0) response is entirely driven by durable consumption, but is not robust to the exclusion of the Korean war from the sample.[4] The horizon 1 response is entirely driven by a strong and robust increase in aggregate investment, and more specifically the business inventories component of investment. Even more specifically, we find from a panel of manufacturing industries that the increase in inventories after war events is driven exclusively by higher real inventories in defense sectors. In other words, the response of inventories is a result of contractors ramping-up production.

We directly document the time delay between obligations and payments using our novel quarterly time-series of defense procurement spending and defense procurement obligations. We find that obligations precede payments (and G) by an average of 2-3 quarters. The time-mismatch is discussed in the Department of Commerce's Government Transaction Methodology Paper, which shows that the

[3]For instance, Monacelli and Perotti (2008), Galí, López-Salido, and Vallés (2007) and Gabaix (2020) propose theoretical models which can dampen the strength of this mechanism. Coibion, Gorodnichenko, and Weber (2020) find little survey evidence in support of a strong negative income effect.

[4]This is a well-known fact in the fiscal policy literature (see Perotti (2014) and Ramey (2016)).

production of government contractors is not immediately reflected in government spending. Rather, G primarily tracks payments which occur after the delivery of the ordered items, and defense production takes time. To summarize, the recorded time-delay between payments and new orders provides an accounting origin of the positive response of inventories during a military build-up: it is the unpaid production-in-progress which does not yet show up in G.

To better capture shocks to obligated government funds, we order defense procurement obligation first in a VAR. We show that these shocks Granger-cause the Cholesky shocks of government spending. Shocks to obligations, however, do not predict defense news shocks. Intuitively, fluctuations in real government spending, as measured by NIPA, reflect changes in defense spending brought on by military events. The Cholesky shocks to NIPA government spending thus capture these fluctuations. The timing of these shocks, however, is delayed relative to the initial economic impact of a military event reflected in new government orders. As a result, shocks to defense procurement obligations predict the Cholesky shocks. On the other hand, defense news shocks are recorded at the start of a military build-up, when new contracts are awarded and contractors increase production. Thus, defense news shocks are not predictable by shocks to defense procurement obligations.

Finally, we show that narrative shocks lead to higher estimates of the fiscal multiplier than the Cholesky shocks and, on average, more than 84% of their difference (multiplier-gap) is explained by the differential response of inventories. In other words, whenever defense production is characterized by long time-to-build, and contractors are paid after-delivery, the Cholesky shocks will overlook the initial production by defense contractors that is recorded in inventories. Therefore, under these conditions, our findings support the robustness of the narrative method in accurately (i) identifying government spending shocks, and (ii) estimating fiscal multipliers. Under the assumption that obligated funds are predetermined, identification via Cholesky decomposition is still valid as long as the government spending variable is set to obligations, which better captures the timing of federal funds as soon as they are committed to be spent.

The idea that inventories absorb the time-to-build of defense contractors can be traced back to Ginsburg (1952)'s analysis of the US economy during the Korean war. Ginsburg argues that changes in government spending have effects before the actual disbursement of money, as captured by G, and that these effects are temporarily reflected in inventories.[5] Therefore, researchers should take into account new government orders to fully understand the impact of government spending changes. To overcome this implementation lag problem, Leduc and Wilson (2013) study the effects of local fiscal policy using obligations rather than outlays.

Similarly, Brunet (2020) suggests that the National Income and Product Account "measures G too late in the process", and constructs an annual measure of funds appropriations by the Department of Defense, termed budget authority. Brunet finds that this measure leads G and uses it to estimate a fiscal multiplier between 1.3 and 1.6, which is higher than typical estimates from the national multiplier literature (see Ramey (2016)). Brunet attributes the difference to implementation-lags and time-to-build in the government spending process, which leads to increased production reflected in private inventory investment before government expenditures.

Our work contributes to this literature in a few ways. To the best of our knowledge, we are the first to study the aggregate and sectoral effects of fiscal shocks on inventories.[6]Although Ginsburg (1952) also studies inventories, the analysis is restricted to the outbreak of the Korean War. Moreover, we focus on national government spending multipliers and relate them to aggregate obligations. This complements the cross-sectional analysis of Leduc and Wilson (2013), who use obligations to study the effects of state-level highway-construction expenditure, and estimate cross-sectional government spending multipliers.[7]

[5]Extract from page 10 of their NBER book: "*It is apparent that a defense mobilization will provide a stimulus to economic expansion if government expenditures increase the aggregate demand for goods and services. However, the expansion need not await the actual growth of government expenditures. In the first place, some government expenditures for defense will lag behind the placement of orders. For a time, the increased production consequent on the orders will be reflected in private inventory investment rather than in government expenditures.*"

[6]Researchers have historically overlooked the role of inventories in analyzing government spending shocks, likely due to the use of log-transformations in VAR models, which cannot handle negative inventory values. However, the adoption of other transformation of the data, such as the Gordon and Krenn (2010)'s transformation, does not require the adoption of logs and allows us to analyze the response of aggregate inventories to fiscal policy shocks.

[7]It is well-known that national and local multipliers are two different objects. In particular, the local multiplier is a rough lower bound of the deficit-financed, closed-economy, no-monetary-policy-response national multiplier (see Chodorow-Reich (2019)).

We also build on the work of Brunet (2020), who provides accounting evidence on the behavior of inventories during a military build-up. We verify this theory empirically using both an aggregate and sectoral analysis of inventories. Additionally, our novel quarterly measure of federal defense procurement obligations has several advantages relative to Brunet (2020)'s annual budget authority series. Firstly, our measure is available at the quarterly frequency rather than annual, which (i) considerably increases the sample size, (ii) allows for a more direct comparison with the other quarterly multiplier estimates from the literature, and (iii) allows us to understand the time-mismatch between contracts and payments at sub-annual frequencies.

With two quarterly series on defense procurement obligations and defense procurement spending, we are able to precisely quantify the time-mismatch between newly awarded contracts and payment to contractors. The focus on defense contracts illustrates the role of time-to-build in generating an accounting delay. Our results show that obligations precede payments (and G) by an average of 2-3 quarters, which could not have been detected with annual data. Finally, we directly relate this accounting delay to the anticipation effect measured by Ramey (2011), and use our findings to reconcile the difference in multiplier estimates obtained using narrative and Cholesky shocks.

The paper is organized as follows. Section 1 establishes the positive response of contractor inventories following a defense news shock. Section 2 carries out the sectoral level analysis of inventories. Section 3 studies the underlying economic and accounting mechanisms driving the response of inventories using novel procurement data. Section 4 explores implications of our results in estimating government spending multipliers. Section 5 concludes.

I. Response of Inventories to Fiscal Shocks

In this section, we decompose changes in the components of real output that are driven by news about future government spending rather than actual government spending. We find that the early response of GDP to defense news shocks is driven by a positive and robust response in business inventories.[8]

Our starting point is Ramey (2011), who finds that aggregate output reacts immediately to news about future war-related defense spending (defense news shocks), while government spending itself has a delayed response.[9] We replicate this result in the top panels of Figure 1. Note that GDP responds immediately, while G only responds starting from the second period, marked with a dashed red line.

In particular, we estimate the quarterly impulse response function (IRF) of some outcome y_t of interest (e.g., GDP) using lag-augmented local projections:[10]

$$y_{t+h} = \theta_h \cdot \text{Shock}_t + \beta \cdot \mathbf{X}_t + \varepsilon_{t+h} \tag{1}$$

where y_{t+h} is the outcome, Shock_t is the updated series of narratively identified defense news shocks from Ramey and Zubairy (2018), and $\mathbf{X}_t$ is a vector of four lags of shocks, government spending, consumption, investments, net-exports, hours worked by the private sector, the three-month Treasury Bill rate and a linear time trend. Following Ramey and Zubairy (2018), we divide all nominal variables by real potential output and the GDP price deflator.

To further investigate the underlying mechanism here, we decompose GDP and estimate the aggregate response of consumption, fixed investment, inventories, government spending, and net-exports to defense news shocks. Note that the IRF of GDP (top-left panel) can be obtained by summing up the ones of all its components.[11] The middle-left panel of Figure 1 shows the IRF of Fixed Investments, the

[8] Note that we use the term "inventories" to refer to "Aggregate Changes in Business Inventories", which is one component (along with fixed - residential plus non-residential - investment) of I in the decomposition $GDP = C + I + G + NX$.

[9] See similar results in Ramey and Shapiro (1998), Edelberg, Eichenbaum, and J. Fisher (1999), Eichenbaum and J. Fisher (2005), Ben Zeev and Pappa (2017).

[10] See Jordà (2005) for local projections, LPs, and Montiel Olea and Plagborg-Møller (2020) for econometric details on lag-augmented LPs. Notice that the IRFs obtained via LPs are asymptotically equivalent to the IRFs estimated via VAR (Plagborg-Møller and Wolf (2020)). LPs are more precise in terms of bias-reduction than VAR, however, this comes at a great efficiency cost (Li, Plagborg-Møller, and Wolf (2021)). We use LPs for their simplicity and to compare with the literature (e.g. Ramey and Zubairy (2018)).

[11] This follows from (i) the linearity of the OLS estimator used in local projections and (ii) the way NIPA constructs GDP, as the sum of the components of final demand. See Online Appendix A for the formal proof.

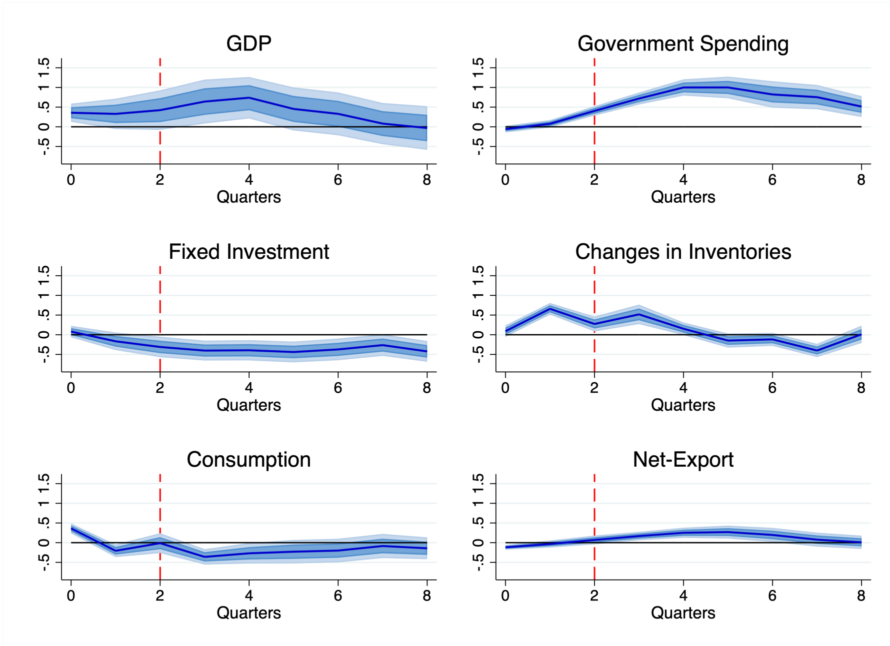


Figure 1: Response of GDP and Its Components to a Defense News Shock

Notes: IRFs of GDP, G, Investment and Changes in Inventories to a defense news shock are obtained via lag-augmented local projections. Bands represent the 68% and 90% heteroskedasticity robust standard errors. Defense news shocks are obtained from the updated series in Ramey and Zubairy (2018). Sample goes from 1947Q1 to 2015Q4. Values in the Figures are normalized by the peak response of G.

middle-right panel the one of Inventories, the bottom-left panel the one of consumption and, finally, the bottom-right panel the one of net-export. Values are normalized by the peak response of G.

Firstly, consumption at horizon 0 is almost 50% of the peak response of government spending and accounts for almost all of the impact response of GDP. However, it is a well-known fact in the fiscal policy literature that this response is driven by durable consumption at the onset of the Korean war.[12]

Secondly, the positive response of inventories at horizon 1 is equal to more than 50% of the peak response of G. Since we detect either negative or insignificant responses of fixed investment (middle-left panel), consumption (bottom-left panel) and net-export (bottom-right panel) at horizon 1, it is clear that the early increase in

[12] See Ginsburg (1952), Hickman (1955), Ramey (2016) and Binder and Brunet (2021). Consistently with the literature, we detect no significant effect of durables in samples which exclude the Korean war.

GDP relative to G following a defense news shock initially shows up as an increase in inventories.

To the best of our knowledge, we are the first to detect positive effects of inventories to defense news shocks and relate it to the anticipation effect of G detected in Ramey (2011).[13]

Robustness The positive response of inventories is robust to the exclusion of the Korean War (the largest military build-up after World War II) from the sample, indicating that the response of inventories is not driven by periods in which defense shocks dominate.[14]

Secondly, we find that the positive response of inventories is robust to the adoption of other types of fiscal shocks. In particular, we use the Cholesky shocks and shocks identified from a VAR which orders defense procurement obligations first, where defense procurement obligations capture the all universe of defense prime contract awards (we will discuss the construction of this variable in the next sections). We report all robustness checks in the Online Appendix B.

Next, we show in the panel of manufacturing industries that the aggregate response of inventories is driven by an increase in industries which heavily contract to the federal government.

II. Industry Analysis: Who is Responding?

Given the positive and robust aggregate response of inventories, we study heterogeneity in this response across industries in response to war events. We find that the positive response is driven by defense industries which increase inventories during a military build-up. To do so, we use monthly data from the Bureau of Economic Analysis (BEA) to construct a panel of real inventories for 18 manufacturing indus-

[13] Fatas and Mihov (2001) estimate the effect of shocks to G identified via Cholesky decomopsition on a multitude of variables and also find a positive early response of inventories. They do not discuss this result in the paper.

[14] We believe that it is important to include the largest war events in the sample as they mimic natural experiments involving government spending. However, we are aware of potential confounding factors (see Perotti (2007), J. D. Fisher and Peters (2010), Perotti (2014) and Ramey (2016)).

tries between January 1959 and December 1997.[15]

The production of defense goods is concentrated in the manufacturing sector (see e.g., Ramey and Shapiro (1998), Nekarda and Ramey (2011) and Cox et al. (2021)). However, the level of government involvement varies greatly among manufacturing sub-industries. For example, the "Other Transportation Equipment" sector has 34% of its sales directly from the government. Accounting for indirect sales via input-output connections, the sector's dependence on government purchases rises to 42% and 44% with first and second order downstream connections included (as done in Nekarda and Ramey (2011)). This heavy reliance on government purchases is unsurprising given that the sector includes sub-industries like Aircraft, Ship Building, Guided Missiles, and Space Vehicles. Conversely, the "Wood Products" sector has no sales to the government as it does not include any defense item producers.

Therefore, we construct a weight θ_i for each industry which captures the long-run average share of industry sales coming from government purchases. Using industry-by-industry input-output matrices, our weights include up to second-order downstream connections.[16] Then we estimate the following equation:

$$\text{Invt}_{i,t+h} = \lambda_{ih} + \alpha_h \cdot \text{War}_t + \beta_h \cdot \text{War}_t \cdot \theta_i + \sum_{p=1}^{12} \varphi_{ph} \cdot \text{Invt}_{i,t-p} + \varepsilon_{i,t+h} \qquad (2)$$

where $h = 0, 1, ..., 24$, Invt_{it} is total real inventories of industry i in month t, λ_{ih} is an industry fixed-effect, and War_t is war dates.[17] Consistent with Ramey and Shapiro (1998) and Eichenbaum and J. Fisher (2005), our war event variable is a weighted dummy with value 1 on March 1965 and 0.3 on January 1984 to indicate the start of the Vietnam War and Soviet invasion of Afghanistan, respectively.

We are interested in the estimands α_h and $\alpha_h + \beta_h$. The former is the response of inventories for those industries not connected to the government (i.e., $\theta_i = 0$).

[15] We thank Valerie Ramey for providing this data. Our data ends in 1997, however, most of the variation in defense spending comes from before the Nineties (Vietnam War and Soviet invasion of Afghanistan).

[16] We don't find that downstream linkages matter beyond the second order degree of connection. See Online Appendix C.2 for a detailed derivation of industry weights.

[17] We use war dates instead of defense news shocks since the former can easily be converted into monthly frequency to match our inventories data.

The latter is the response of industries which are highly connected to the government through government purchases (i.e., $\theta_i = 1$). If war dates have a differential positive effect on sectoral inventories which is proportional to the degree of connection to the government, we expect $\beta_h > 0$.[18]

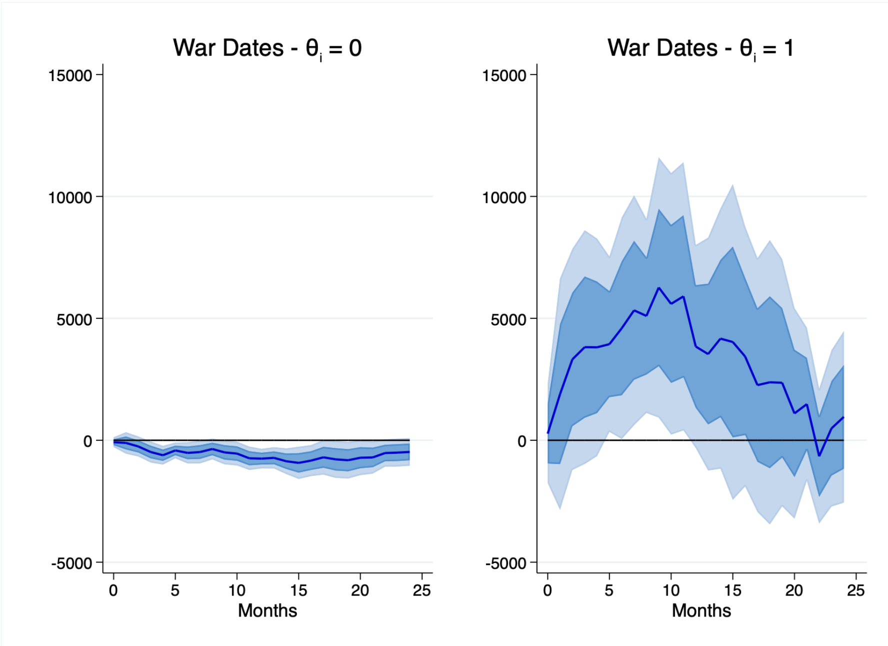


Figure 2: Response of Sectoral Inventories to War Events.

Notes: Left panel shows estimates of α_h (response when $\theta_i = 0$), right panel reports estimates of $\alpha_h + \beta_h$ (response when $\theta_i = 1$). Weights are normalized by maximum weight (i.e. the one of Other Transportation Equipment Manufacturing). Since Real Inventories are trending, data is filtered using Hamilton (2018)'s filter (we set $h = 24$ and $p = 12$, that is two years lag plus one more year of lags). The unit of real inventories is millions of 2005 chained dollars. Sample goes from 1959-Jan to 1997-Dec and uses 18 sectors breakdown of Manufacturing. Confidence bands are 68% and 90%. Standard errors are obtained via Bootstrap (standard Stata routine for `xtreg`: we use `vce(boot)` and set the seed for replicability of results; Stata uses a non-parametric type of bootstrap which resamples data with replacement).

Figure 2 shows a significant positive and long-term differential response ($\alpha_h +$

[18]Our approach differs from traditional shift-share methods, such as those examined in Goldsmith-Pinkham, Sorkin, and Swift (2020) and Borusyak, Hull, and Jaravel (2022). Unlike those studies, which primarily focus on cross-sectional frameworks and require instrumental variables, we investigate the impact of an aggregate exogenous shock (i.e., war-dates) on sectoral inventories and its heterogeneous effects on defense industries, as captured by the interaction between the shock and industry weights. Moreover, since we use long-run averages for our industry weights and we account for any time-invariant fixed effects through industry fixed effects, we are not concerned about the potential endogeneity of our industry weights.

β_h) of defense industries' inventories to war dates. On the other hand, the change in inventories for those industries who do not supply the government (α_h) is negative and close to zero. Therefore, all of the effect of war dates on inventories is explained by the degree of connection of each sector to the government.

Robustness We verify that this differential response of defense industries' inventories is not driven by their different sensitivity to the business-cycle. In particular, we replace War_t with monetary policy shocks constructed narratively by C. D. Romer and D. H. Romer (2004) and updated by Wieland and M.-J. Yang (2020) and estimate the differential response ($\alpha_h + \beta_h$) to be statistically indistinguishable from zero. This confirms that the reaction of federal contractors to defense news shocks is driven by war-related forces and not the associated business-cycle fluctuations.[19]

Furthermore, we make sure that the differential response of defense industries during a military build-up is not driven by spurious correlation. In particular, we re-estimate Equation (2) using randomly re-shuffled weights as commonly done in the production network literature (e.g. see Ozdagli and Weber (2020)). Again, we estimate the differential response ($\alpha_h + \beta_h$) to be statistically indistinguishable from zero and we report the results of these robustness checks in the Online Appendix C.1.

III. Why Inventories and not G?

This section explains why the early stage production of defense industries during a military build-up is absorbed by inventories and not government spending (G). Briefly, part of the production process occurs between contract award and delivery, and contractors are paid after delivery. Since G is constructed primarily using payments, it measures production with delay (see also Brunet (2020)). To accurately track production as it happens, NIPA uses inventories to align the timing of production with the contract award and payment. Chapter 7 of NIPA's Handbook states:[20]

"*A general principle underlying NIPA accounting is that production should be*

[19] We thank Juan Herreño for suggesting this test.

[20] We thank Junyuan Chen and Valerie Ramey to bring up to our attention this meaningful passage.

recorded at the time it occurs. [...] The recording of movements of goods in inventory — materials and supplies, work-in-process, and finished goods — and from inventories to final sales provides the means to allocate production to the period in which it occurred."

The Procurement Process In the defense procurement process, obligations and spending are two distinct stages. The process starts with the award of a contract, which is when the government is legally bound to pay for goods/services. Although contractors are notified of contract opportunities before the award date through pre-award solicitations, these solicitations are typically posted in the same quarter as the award date and made available to contractors on a federally managed online database.[21]

After contracts are awarded, contractors launch a potentially long production process. In particular, contract-level data indicates that the mean and median duration of $1 defense procurement contract are 4.2 and 5.4 years, respectively. We measure duration as the period of performance, or the number of days between award date and contract end (full delivery) date. We find that total defense procurement spending is dominated by few very large contracts with very long duration. Using the same data, Cox et al. (2021) report a very short average contract duration. However, their estimated duration is not weighted by contract size. Weighting is necessary to find the duration of $1 of spending and not the average duration of contracts. This difference matters, since most of procurement spending comes from few very large contracts. If we do not weigh by contract size, our results are consistent.[22]

Given that production takes a long time, when do associated payments actually occur? According to the Federal Acquisition Regulation (FAR), the canonical rule for payments to federal contractors from government agencies is *payments-after-delivery* (see FAR 32.904).[23] Finally, NIPA constructs G using mainly outlays, that

[21] Generally, solicitations are posted on beta.sam.gov and are linked to the eventual contract award using the solicitation ID. Further discussion can be found in the Online Appendix D.5

[22] We use defense contract data from the federal procurement data system (FPDS) from 2000 to 2020. FPDS encompasses every federal transaction at daily frequency. We report results in the Online Appendix D.2.

[23] Certain contracts are also subject to partial-delivery-payments. However, given the multiple year average duration of $1 of procurement spending, we still observe several quarter-long delays in

is, payments to contractors (see Brunet (2020)).

Therefore, NIPA's accounting rules result in a delay in tracking defense production due to the time it takes to produce items. In the following sections, we create a measure of defense procurement spending and obligations to directly observe the time gap between the start of production (when the contract is awarded) and when NIPA records it (at delivery).

Construction of Defense Procurement Spending and Obligations We construct a novel database of defense procurement spending and obligations. Spending measures payments from federal agencies to contractors, while obligations measure the total value of federal funds as soon as they are contractually obligated to firms. To construct the spending series, we use the accounting identity discussed in Cox et al. (2021):[24]

$$\begin{aligned}
(\text{Procurement Spending})_t &\approx (\text{Intermediate Goods \& Services Purchased})_t + \\
&+ (\text{Change in Government Fixed Assets})_t + \\
&- (\text{Investment R\&D})_t \\
&\approx (\text{Payment to Contractors})_t,
\end{aligned}$$

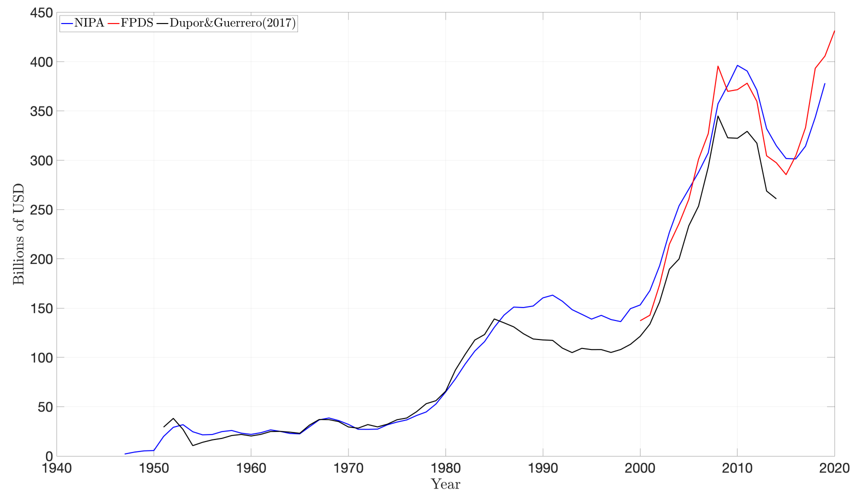
where all variables are obtained from the National Income and Product Accounts (NIPA). The top panel of Figure 3 plots this measure of defense procurement spending along with the annual measure of procurement spending of Dupor and Guerrero (2017), aggregated over states. The two measures are virtually identical before 1984, but afterwards the Dupor and Guerrero (2017) series omits contract actions with value less than \$25,000 and thus systematically underestimates our NIPA-based series. From 2000 onward, we also aggregate federal agency payments from the universe of procurement contracts, available in the Federal Procurement Data System (FPDS), and find that our measure is consistent.

To construct the obligations series, we aggregate the value of procurement con-

partial deliveries. We further clarify this point in the Online Appendix D.3.

[24]Further details on the accounting origin of procurement spending is discussed in the Online Appendix D.1.

(a) Annual Defense Procurement Spending



(b) Time Lag in “BCD”

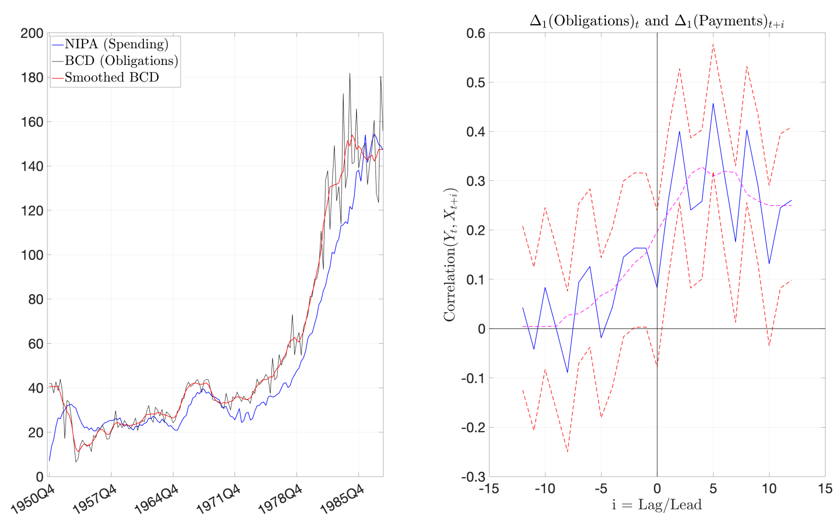


Figure 3: Federal Defense Procurement Obligations Vs Spending.

Notes: Top panel (a) compares different measures of defense procurement at annual frequency. The bottom-left panel (b) compares defense procurement spending (i.e. payments) as we construct it from NIPA data, to defense procurement obligations (i.e. awards) from “BCD”. The bottom-right panel shows the lead-lag correlation map between the two: $Corr\left(\Delta_1(\text{Obligations})_t, \Delta_1(\text{Payments})_{t+i}\right)$, where Δ_1 is the first difference operator. Sample: 1951Q1 to 1988Q4.

tracts awarded by the Department of Defense (DoD) from the universe of procurement contracts recorded in the Federal Procurement Data System (FPDS). Since this data is only available from 2000 onward, we also collect historical information from the periodical *Business Conditions Digest* (henceforth BCD) which is available from January 1951 to November 1988. We use information from the contract and spending data to impute missing quarters and construct a quarterly time series of defense procurement obligations.[25]

Direct Evidence of Time Mismatch in Defense Procurement The bottom-left panel of Figure 3 plots spending and obligations from Jan 1951-Nov 1988. From the figure it appears that spending lags behind obligations.[26] The bottom-right panel reports the lead-lag correlation.[27] From the right panel, the average lead-lag correlation significantly peaks in the North-East quadrant of the map. This suggests that changes in obligations are more highly correlated with delayed changes in spending rather than current changes in spending. The results replicate for more recent obligations data obtained from FPDS and when we look at quarterly year-to-year changes instead of simple changes. We report these robustness checks in the Online Appendix D.2. On average, we find that obligations lead spending by 2-3 quarters.

The payment (or government outlay) thus occurs several quarters after the defense contract award. This finding is consistent with the results of Leduc and Wilson (2013) and Brunet (2020) in the context of highway spending and the aggregate annual defense budget. Moreover, this is confirmed directly by the Department of Commerce's Government Transaction Methodology Paper:[28]

[25] Many thanks to Valerie Ramey for providing the BCD data. We remand to our Online Appendix D.4 for extra details on the sources of contract level data and the construction of the series.

[26] We recognize the significant disparities in the two series during and after the Korean War period. These disparities are likely due to the broad awarding of contracts, subsequent cancellations, and the accounting methods utilized by the Department of Defense before McNamara's term. We appreciate Emi Nakamura for pointing out this issue, initially identified during the drafting of Nakamura and Steinsson (2014).

[27] Lead-lag correlations are useful for studying relationships in time between variables. For example, Smets, Tielens, and Van Hove (2019) use it to study the timing of propagation of inflation from upstream to downstream sectors.

[28] Many thanks to Gillian Brunet for redirecting us to that document.

"*The largest timing difference is for national defense gross investment for relatively long-term production items, such as aircraft and missiles, for which the work in progress is considered as part of business inventories until the item is completed and delivered to the Government.*"

In other words, early-stage production associated with long procurement contracts is recorded at an aggregate level in inventories until the delayed payment-on-delivery. The value of completed and paid contract work is then moved from inventories to G. We can observe the delay between defense contract awards and payment directly from our data.

Finally, in the Online Appendix E, we distinguish between the response of defense contractors to actual contract awards and the anticipation of future contract awards. Firms may increase their inventories in preparation for future awards, whether to minimize adjustment costs or reduce delivery times (i.e., production smoothing). While we identify evidence of the latter, it is of lesser importance compared to the response to actual contract awards.

IV. Implications for the Government Spending Multiplier

In this section, we argue that the Cholesky shocks to government spending as measured by NIPA do not capture early-stage production associated with newly awarded federal procurement contracts during a military build-up. This leads to lower multiplier estimates relative to the narrative method. We show that 84% of the difference in multipliers (multiplier gap) is driven by a differential early response of inventories following a defense news shock.

Shock Predictability Ramey (2011) shows that narrative shocks predict (Granger-cause) the Cholesky shocks, which implies that those shocks are missing part of the early response in GDP. To show that the missing early response is associated with early-stage production related to defense procurement contracts, we further show that shocks to defense procurement obligations Granger-cause the Cholesky shocks to G, while do not Granger-cause defense news shocks. We construct defense procurement obligation shocks by ordering defense procurement obligations first in a VAR.[29] In turn, we use two series of defense procurement obligations: one which goes from 1947Q1 to 1988Q4, which uses data from BCD ("*BCD series*") and one which uses information from defense procurement spending and FPDS to extend the BCD data up to 2015Q4 ("*extended series*"). Our full sample spans 1947Q1 to 2015Q4, and Table 1 summarizes the results.

Table 1: Predictability of Cholesky Shocks via Obligations

Predicted	Predictor	F	Pvalue	Korea
Cholesky Shocks	Obligation Shocks (Extended Series)	5.63	0.0%	Yes
Cholesky Shocks	Obligation Shocks (BCD Series)	3.45	0.1%	Yes
Cholesky Shocks	Obligation Shocks (Extended Series)	4.24	0.0%	No
Cholesky Shocks	Obligation Shocks (BCD Series)	2.41	1.9%	No
Obligation Shocks (Extended Series)	Cholesky Shocks	1.07	38.7%	Yes
Obligation Shocks (BCD Series)	Cholesky Shocks	0.57	84.2%	Yes
Obligation Shocks (Extended Series)	Cholesky Shocks	1.67	10.7%	No
Obligation Shocks (BCD Series)	Cholesky Shocks	1.12	35.31%	No
Defense News Shocks	Obligation Shocks (Extended Series)	0.73	66.1%	Yes
Defense News Shocks	Obligation Shocks (BCD Series)	0.75	64.4%	Yes
Defense News Shocks	Obligation Shocks (Extended Series)	0.32	95.7%	No
Defense News Shocks	Obligation Shocks (BCD Series)	0.59	78.7%	No

Notes: Granger Causality test is a Wald test on the 8 lags of the predictor while controlling for 4 lags of the predicted variable. In Appendix F, we report analogous results for Cholesky shocks to an index of Top 3 defense contractor excess returns, constructed as in J. D. Fisher and Peters (2010). We find no significant predictability in either direction for this index.

The top panel of Table 1 shows that shocks to defense procurement obligations predict the Cholesky shocks. On the other hand, the second panel shows a much weaker relationship in the other direction, especially when you omit the Korean War from the sample. Our results are consistent with Ramey (2011). The bottom panel shows that shocks to defense procurement obligations do not predict defense news shocks. This indicates that early economic effects of newly awarded contracts, which are missed by the Cholesky shocks to G, are captured using defense news shocks.

Government Spending Multipliers In most macroeconomic studies, researchers are interested in the economic effects of government spending from the moment funds are contractually obligated and contractors begin reacting. In this setting, the actual transfer of cash is not the main focus. Given our results from the previous

[29] The variables employed here are identical to the ones utilized in Section 1.

section, we argue that the Cholesky shocks are capturing transfers of cash rather than obligation of funds.

We begin with an illustrative example of this problem around the outbreak of the Korean War in the top-panel of Figure 4.

In the summer of 1950 (Q3), we observe a large defense news shock associated with the outbreak of the Korean War. However, the Cholesky shock to NIPA's measure of G does not spike until 2-3 quarters later. Unsurprisingly, G has a slow positive response. On the other hand, defense procurement obligations react almost immediately to the shock. In other words, the DoD begins awarding defense procurement contracts at the onset of the war. We also observe quick increases in inventories starting from 1950Q4 as well as in defense production, proxied by average hours of production and non-supervisory workers in the aircraft industry.[30] Therefore, the Cholesky shocks fail to capture the initial production of defense industries in response to newly granted contracts at the onset of the Korean war. This is consistent with our previous Granger-causality test results.

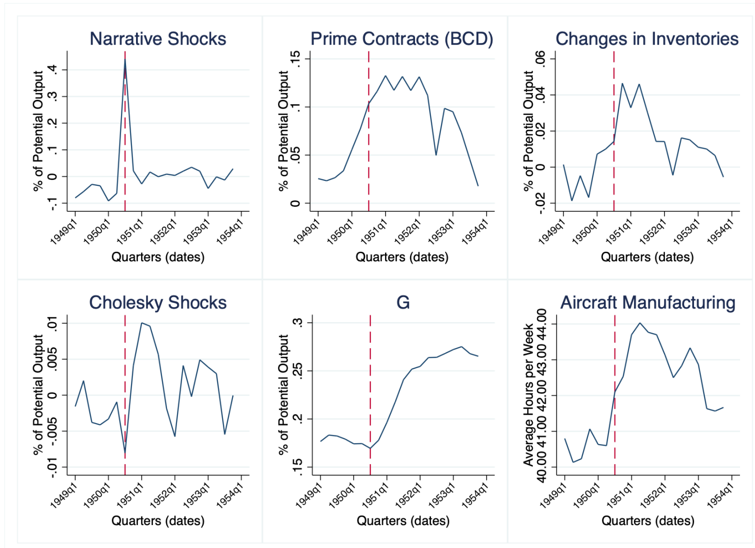
We now show that this delay leads to the underestimation of the fiscal multiplier when using Cholesky decomposition as an identification method. In particular, we show that, on average, 84% the difference in fiscal multipliers estimated using the Cholesky and narrative methods is explained by a difference in capturing the early response of inventories.

Following Ramey (2016), we estimate cumulative fiscal multipliers using LP-IV with both Cholesky shocks to G and narratively identified defense news shocks. We use the following estimation equation:[31]

[30] Production workers account for 82% of total private employment, on average (see Nekarda and Ramey (2020)). We choose the Aircraft industry since it specializes in defense production and we use average hours of production workers since total hours is a lagged measure of production (see Bils and Cho (1994) and Fernald (2012)). We further clarify this point in the Online Appendix C.3. Furthermore, in the Online Appendix C.1 we show that this measure of defense production responds strongly and positively to both defense news shocks and defense procurement obligations.

[31] More technical details on LP-IV are available in Stock and Watson (2018).

(a) Illustration of the Delay - Korean War



(b) Consequences of the Delay - Multiplier Underestimation

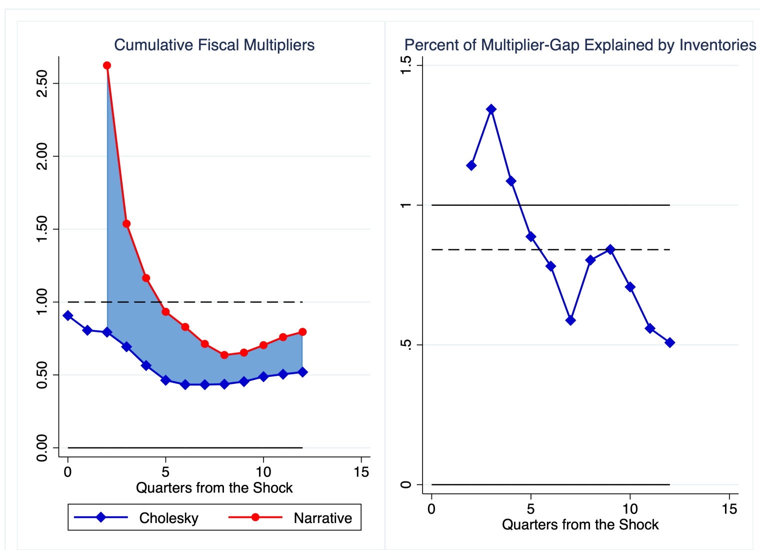


Figure 4: Illustration and Consequences of the Delay

Notes: Top panel (a) illustration of the delay during the Korean war. The bottom-left panel (b) compares the point estimates of the calculated fiscal multipliers from horizon 0 to 12 quarters. Sample: 1947Q1 to 2015Q4. The bottom-right panel shows the share of *multipliers-gap* explained by the differential response of inventories (dashed black line is the average of the response). Share is calculated only when the multiplier gap is finite and positive.

$$\sum_{h=0}^{H} y_{t+h} = \gamma_H + \hat{\mathcal{M}}(H) \cdot \underbrace{\sum_{h=0}^{H} g_{t+h}}_{\text{instrument with Shock}_t} + \text{lags}_t + \varepsilon_{t+h}, \tag{3}$$

where $\hat{\mathcal{M}}(H)$ is the cumulative government spending multiplier at horizon H, y_t is GDP at time t, g_t is government spending at time t, Shock_t is an exogenous instrument for cumulative government spending, and lags_t contains lagged values of the shock, government spending, consumption, investment, hours worked and 3 months T-Bill rate. We rescale nominal variables by potential output. The narrative method sets Shock_t equal to the defense news shock variable, while the Cholesky identification is equivalent to setting Shock_t equal to G.

The bottom-left panel of Figure 4 shows that the Cholesky method delivers uniformly lower point estimates of the multiplier relative to the narrative method. To investigate how much of the multiplier gap can be explained by a differential response in inventories, we break down the multiplier in different components, each accruing to one of the components of GDP.

We start from the result discussed in Ramey (2016) and Stock and Watson (2018), that the one-step LP-IV approach delivers an estimate of the multiplier which is analytically equivalent to the one obtained following a two steps procedure consisting in (i) estimating the cumulative impulse response functions of GDP and G to a government spending shock via local projections and (ii) by taking their ratio:

$$\hat{\mathcal{M}}_{GDP}(H) = \frac{\sum_{h=0}^{H} \hat{\theta}_{GDP,h}}{\sum_{h=0}^{H} \hat{\theta}_{G,h}}, \quad \forall H = 0, 1, ...$$

where $\hat{\theta}_{GDP,h}$ and $\hat{\theta}_{G,h}$ are the estimated IRFs of G and GDP to a government spending shock. For instance, if we used defense news shocks, they would be equal to the estimated IRFs of GDP and G shown in the top-left and top-right panel of Figure 1. Furthermore, since IRF of GDP can be obtained by summing up the IRFs of each of its components, we can break down the fiscal multiplier as follows:

$$\underbrace{\frac{\sum_{h=0}^{H}\hat{\theta}_{GDP,h}}{\sum_{h=0}^{H}\hat{\theta}_{G,h}}}_{\hat{\mathcal{M}}_{GDP}(H)} = 1 + \underbrace{\frac{\sum_{h=0}^{H}\hat{\theta}_{C,h}}{\sum_{h=0}^{H}\hat{\theta}_{G,h}}}_{\hat{\mathcal{M}}_{\text{C}}(H)} + \underbrace{\frac{\sum_{h=0}^{H}\hat{\theta}_{I_{\text{Fixed}},h}}{\sum_{h=0}^{H}\hat{\theta}_{G,h}}}_{\hat{\mathcal{M}}_{I_{\text{Fixed}}}(H)} + \underbrace{\frac{\sum_{h=0}^{H}\hat{\theta}_{I_{\text{Invy}},h}}{\sum_{h=0}^{H}\hat{\theta}_{G,h}}}_{\hat{\mathcal{M}}_{I_{\text{Invy}}}(H)} + \underbrace{\frac{\sum_{h=0}^{H}\hat{\theta}_{NX,h}}{\sum_{h=0}^{H}\hat{\theta}_{G,h}}}_{\hat{\mathcal{M}}_{\text{NX}}(H)}$$

Notice that each component of the fiscal (GDP) multiplier corresponds to the ratio of the area under the IRF of the corresponding component of GDP and the area under the IRF of G. For instance, the inventory-multiplier obtained via defense news shocks, $\hat{\mathcal{M}}_{I_{\text{Invy}}}^{\text{News}}(H)$, is equal to the area under the IRF of inventories up to horizon H, shown in the middle-right panel of Figure 1, divided by the one of Government spending, plotted in the top-right panel of the same figure.

If we differentiate the above expression, and divide by the left-hand side, we have:

$$(\forall H) \quad 1 = \underbrace{\frac{d\hat{\mathcal{M}}_{I_{\text{Invy}}}(H)}{d\hat{\mathcal{M}}_{GDP}(H)}}_{:=\Delta\% I_{\text{Invy}}(H)} + \underbrace{\frac{d\hat{\mathcal{M}}_{\text{C}}(H)}{d\hat{\mathcal{M}}_{GDP}(H)} + \frac{d\hat{\mathcal{M}}_{I_{\text{Fixed}}}(H)}{d\hat{\mathcal{M}}_{GDP}(H)} + \frac{d\hat{\mathcal{M}}_{\text{NX}}(H)}{d\hat{\mathcal{M}}_{GDP}(H)}}_{\Delta\%\text{Other}(H)}$$

$$1 = \Delta\% I_{\text{Invy}}(H) + \Delta\%\text{Other}(H),$$

where $\Delta\% I_{\text{Invy}}(H)$ represents the share of the multiplier-gap, $d\hat{\mathcal{M}}_{GDP}(H)$, explained by differences in the response of inventories, $d\hat{\mathcal{M}}_{I_{\text{Invy}}}(H)$, while $d\Delta\%\text{Other}(H)$ refers to all the other components of GDP.

Therefore, we calculate and breakdown the fiscal multiplier using both defense news shocks (News) and Cholesky shocks (Chol), then we calculate the share of multiplier gap explained by inventories, as suggested by the previous expression:

$$\Delta\% I_{\text{Invy}} = \frac{\hat{\mathcal{M}}_{I_{\text{Invy}}}^{\text{News}}(H) - \hat{\mathcal{M}}_{I_{\text{Invy}}}^{\text{Chol.}}(H)}{\hat{\mathcal{M}}_{\text{GDP}}^{\text{News}}(H) - \hat{\mathcal{M}}_{\text{GDP}}^{\text{Chol.}}(H)}$$

which computes the proportion of the multiplier gap (denominator) arising from using the narrative and Cholesky methods, explained by differences in the inventory multiplier (numerator). The bottom-right panel of Figure 4 plots $\Delta\% I_{\text{Invy}}(H)$ up to horizon 8 (solid pink line) along with its average (dark dash line). On average, 84%

of the multiplier gap can be explained by the differential response of inventories as captured by the shocks. In the Online Appendix F, we show that this result is robust to the exclusion of the Korean War.

To summarize, the identification of government spending shocks via Cholesky decomposition fails to fully capture early-stage defense production which is reflected in inventories, which results in underestimated multipliers. This is due to NIPA G's delayed tracking of defense production during military build-ups. Our Granger-causality test results are consistent with this intuition. This finding raises a major challenge in identifying government spending shocks through the Cholesky decomposition, provided there exists a long enough time-mismatch between orders and payments in the government spending process.

V. Conclusion

The National Income and Product Accounts (NIPA) tracks production by monitoring changes in inventories. During a military buildup, defense industries increase production in response to new procurement contracts, which results in a rise in inventories and GDP. Once the production of defense items, such as aircraft and missiles, is finished, they are delivered to the government and the contractors receive payment. This causes inventories to decrease and government spending (G) to increase as payments are recorded. The onset of a war results in GDP responding faster than G due to (1) accounting procedures and (2) the time required for production in the defense sector.

The findings of our study support the idea that the early rise in GDP relative to G after a defense news shock, as described by Ramey (2011), can be attributed to an increase in inventories. Our analysis of manufacturing sector data reveals that defense industries are responsible for the rise in inventories. By creating new quarterly time series that track defense procurement contract awards and payments, we were able to observe a 2-3 quarter gap between the two. This delay provides evidence for the existence of a time-to-build period for defense production.

Our study has three significant implications. Firstly, it provides a straightforward explanation for the early reaction of GDP compared to G in response to a defense news shock, which was previously believed to be due to households' Ricardian behavior (negative wealth effect). Secondly, the results indicate that shocks to defense procurement obligations predict Cholesky shocks to government spending, which is a major issue in the identification of macroeconomic shocks (as noted by Ramey (2016)). Lastly, the delay in these shocks leads to an under-estimation of the response of inventories which is responsible for 84%, on average, for the under-estimation of the fiscal multiplier estimated by the narrative method. The impact of shocks to defense procurement obligations on macroeconomic variables extends beyond the scope of this paper and remains a subject for future investigation.

Our findings highlight the significance of the early effects of G, as reflected in the increase in inventories. Policymakers and economists should take into account measurement delays in government spending when evaluating the impact of government purchases on the economy.

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