Defense spending and fiscal multipliers: it's all in the variance

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Abstract

We provide estimates of U.S. government expenditure multipliers for defense and non-defense spending over 1939-2014, using a fairly standard DSGE model that includes anticipated military spending changes ("war news shocks"), and find the following. First, our model's war news shocks compare favorably to Ramey's (2011) narrative-based "defense news" shocks. Second, war news shocks have little effect on model variables regardless of the period under examination. Unanticipated military expenditure accounts for substantial movements in output, but only when observations from 1939 to 1954 are considered. Apart from that, movements in output are entirely driven by total factor productivity shocks. Third, our structural model can generate defense expenditure multipliers above unity under two conditions: (i) the multiplier is calculated using the peak of the impulse-response function and (ii) a large number of observations before and up to the Korean War are included. When multipliers are calculated according to Mountford and Uhlig's (2009) present-value definition, they never exceed unity, regardless of the sample under analysis.

JEL codes: E32, E62, H56.
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1 Introduction

What portion of output fluctuations can be accounted by discretionary fiscal policy? Do different kinds of public expenditure have the same impact on output? To what extent can government spending be anticipated? And is this anticipation more important for business cycles than fiscal surprises? In this paper, we address these questions using a dynamic stochastic general equilibrium (DSGE) model for the U.S. economy. We differentiate between non-defense and defense spending, as wars can be taken as a natural experiment that allows to track the effects of transitory public expenditures over the economy.

A number of recent papers use military expenditure to explore the effects of fiscal policy on output: among others, Hall (2009), Barro and Redlick (2011), and Ramey (2009, 2011). These works illustrate that defense outlays account for the bulk of the transitory component of U.S. government spending. Additionally, this variable can be taken as exogenous. By exploiting this exogeneity, these authors estimate fiscal multipliers both through simple regressions and structural vector autoregression (SVAR) techniques. Following a narrative approach, Ramey (2009) compiles "defense news" from *Business Week* and other newspapers across the 20th century that reflect beliefs about build-ups in military spending, and constructs an estimate of the change in the expected present value of government spending. Ramey (2011) shows that SVARs generate biased estimates of the fiscal shock unless these defense news are added.

Different from Ramey (2011), we adopt a non-narrative approach to uncover anticipated military expenditure shocks, following the methodology proposed by Beaudry and Portier (2004, 2007) and extended by Schmitt-Grohé and Uribe (2012), who focus on news of forthcoming technological progress. We work upon these studies and consider "war news shocks," understood as anticipations of defense spending changes. To our knowledge, we are the first to incorporate this variable within the news shock literature. While we share Ramey's strategy of using defense spending to identify the shocks, our identification is based on a fairly standard DSGE model with real frictions, no nominal rigidities, and where the war news shocks and structural parameters are estimated with Bayesian techniques. Therefore, our impulse response functions and fiscal multipliers are based upon a structural model and not an SVAR.

Our model also considers a set of fiscal rules for government expenditure and taxes following Leeper, Plante, and Traum (2010). Both public expenditure and tax rates respond to business cycle conditions (i.e., automatic stabilizers) and to the state of debt. Unlike the contribution of Leeper et al., we extend the fiscal component of our model in two directions. First, public expenditure is decomposed into defense and non-defense spending, where the former is fully exogenous from output and debt, and the latter is adjusted when the defense budget is activated.[1] Second, the fiscal rules are augmented by the war news shock, so that military expenditure changes can be anticipated as conflicts and war episodes loom in the horizon, and the effect of anticipation remains orthogonal to other fiscal shocks and allows us to accurately measure the defense spending multiplier.

We use a yearly sample that runs from 1939 to 2014—a period that contains several war episodes—and this allows us to gauge the effects that defense (and other kinds of) spending has over U.S. aggregate fluctuations. We start by estimating a fiscal multiplier based on defense spending—along the line suggested by Hall (2009), Barro and Redlick (2011), and Ramey (2011)—that relies on the correlation between output growth and defense spending growth. Our results suggest that a break in the estimate of the multiplier occurs around the onset of the Korean War. This result has been highlighted by Ramey (2011). Guided by this evidence, we decide to split the sample into two

[1] Hence, non-defense expenditure is more elastic than its defense counterpart, an assumption consistent with the conduction of fiscal policy during war times. In the model, if military expenditure needs to increase, the government budget automatically reduces non-defense spending.

periods: one that spans 1939 to 1954, covering World War II (hereafter, WWII) and the Korean War, and another from 1955 to 2014, a period with war episodes whose volume of spending are of minor importance than those in the first one. Section 3 offers additional insights regarding our decision to split the sample in two.

Our results can be summarized in three main points. First, we show that our DSGE-based model does a good job in uncovering the war news shocks, relative to the defense news identified by the narrative approach of Ramey (2011). The correlation coefficient between both series is positive and moderately high. Comparing them over time, our war news shocks correctly anticipate the government spending increase of WWII, although the Korean War appears as a surprise. For the remaining conflicts, the shocks from both approaches overlap. We conclude that our DSGE model is a valid framework to identify anticipated changes in defense spending—at least for the U.S.

Second, a variance decomposition exercise suggests that unanticipated military expenditure shocks generate substantial movements in output in the sample that includes WWII and the Korean War. For the second sample, fiscal spending shocks play a minor role on model variables; instead, the bulk of the variability of the model variables is mostly accounted by total factor productivity (TFP) shocks. Surprisingly, we find that the war news shock is of secondary importance in both samples. In addition, the simulated moments generally reproduce observed moments in the business cycle correlogram for both periods. Interestingly, model simulations imply a decline in the correlation between output and defense spending for the second sample relative to the first one, which imply a fall in the OLS estimates of the multiplier, a fact also noted by Hall (2009), Barro and Redlick (2011), and Ramey (2011), after the Korean War.

Finally, we calculate a set of multipliers, based on defense and non-defense government expenditure, following two alternative definitions. The first definition follows the present-value multipliers proposed by Mountford and Uhlig (2009). We find that these values never exceed unity, regardless of the expenditure series considered; in the short run, the range is $[0.75, 0.81]$ for non-defense expenditure and $[0.59, 0.67]$ for military spending. The second definition of multiplier is based on the peak of the model's impulse-response function. In this case, we do find multipliers above unity for defense spending: 2.19 when the full sample is considered and 6.11 for the sample that runs from 1939 to 1954, which includes two major war episodes. We argue that this result is due to a moderation in the variance of the structural fiscal shocks observed after the Korean War, which mainly affected defense spending. Regardless of the sample or the definition, multipliers based on defense expenditure are never larger than 0.8.[2]

The paper is structured as follows. Section 2 briefly surveys related research. Section 3 introduces some preliminary evidence concerning U.S. government spending and estimates of the fiscal multiplier. The DSGE model and the fiscal rules are presented and described in Section 4. Section 5 reports our main results: the identified news of war, impulse-responses, variance decompositions, and fiscal multipliers. The last section offers several concluding remarks.

2 Related literature

This paper is connected with three branches of research. The first is related to studies that have highlighted the role of anticipation on business cycles. The second brand of research deals with assessing how fiscal policy affects economic activity and the estimation of fiscal multipliers. The last

[2] As a publicly-provided public good—like street lighting or a well-functioning legal system—defense spending has a reduced margin for discretional changes, which reduces its usefulness as a fiscal policy tool. While our model is able to generate multipliers above unity when considering defense spending in a sample that includes WWII and the Korean War, this shouldn't be considered as an endorsement to use war to stimulate the economy.

one is focused on anticipation of warfare and conflicts through information content in newspapers or in financial assets and aggregate series, such as defense spending.

News shocks The path-breaking papers by Beaudry and Portier (2004, 2007) set forth a research program that explores how news of forthcoming neutral technological progress affect current decisions. This research was later extended by Schmitt-Grohé and Uribe (2012) to incorporate other kinds of news shocks (e.g., government expenditure, investment-specific technological progress, wage-markup, or preference shocks); they find that news shocks can account for about 50% of the variance of output, consumption, investment, and hours worked. Born, Peter, and Pfeifer (2013) offer a refinement of Schmitt-Grohé and Uribe by incorporating anticipated changes in capital and labor tax rates in a New Keynesian DSGE model. While they share Schmitt-Grohé and Uribe's conclusion that anticipated variables are important determinants of the business cycle, they find that fiscal shocks (both anticipated and unanticipated) have little impact over real variables.

Another line of research has extended this methodology to focus solely on anticipated changes in taxes and spending. Mertens and Ravn (2011) analyze whether a DSGE model can account for the effect of anticipated and unanticipated changes in federal tax liability changes; by including habit formation, variable capacity utilization, adjustment costs, and consumer durable spending, they find that the model can account for most of the empirical responses to a fall in tax liabilities. While not necessarily stressing the role of news shocks, the New Keynesian model in Leeper, Traum, and Walker (2017) allows for anticipation in government expenditure and transfers. After performing a prior predictive analysis[3] between different modeling frameworks, they select a New Keynesian specification that includes government expenditure in the utility. Taking their model to the data, they find evidence supportive of multipliers above unity in the short run, in the range $[0.93, 1.41]$. Ben Zeev and Pappa (2017) calculate a series for defense news shocks following the SVAR-based identification approach of Barsky and Sims (2011), and find that expected changes in defense spending have sizable effects on output, hours worked, inflation, and the interest rate. By contrast, as we comment later, we find that military spending (anticipated or not) plays a reduced role in U.S. fluctuations, especially during the last decades.

Expenditure and business cycles The fiscal multiplier can be defined as the output change relative to a discretionary fiscal variation; i.e., a change in non-automatic fiscal incentives. The original definition of the multiplier dates back to Keynes's ideas—later developed by the Keynesian school—through the concept of marginal propensity to consume (MPC). As is usually explained in introductory textbooks, since $\text{MPC} \in (0, 1)$, the multiplier is given by $1/(1 - \text{MPC}) > 1$. However, the literature has not reached a consensus regarding the empirical value of the fiscal multiplier. For example, Spilimbergo, Symansky, and Schindler (2009) calculate multipliers for different countries and find that the values are within the interval $[-1.5, 5.2]$. Hall (2009) concludes that the multiplier may range from 0.7 to unity for the U.S. economy; he argues that a multiplier value of 1.7 could be reached if the nominal interest rate has hit the zero lower bound.

Many authors have estimated the multiplier using SVARs. We count, among many others: Blanchard and Perotti (2002), Galí, López-Salido, and Vallés (2007), Perotti (2008), Mountford and Uhlig (2009), Ramey (2011), Auerbach and Gorodnichenko (2012), and Ramey and Zubairy (2018). Aside from the last three papers in this list, these multiplier estimates are based on orthogonalization conditions that generate a set of structural shocks from forecasting errors. Many of these SVAR-based studies propose using defense spending as a tool to identify the fiscal shocks,

[3] See Geweke (2010, chap. 3).

given that it is considered exogenous to output. Under this identification scheme, the impulse-response functions from fiscal shocks are used to estimate the value of the multiplier. These authors provide output multipliers that range between 0.3 and 0.9 on impact, and reaching values above one for peak impulse-responses after several quarters.

As we have already mentioned, Ramey (2011) warns that a portion of fiscal shocks identified using SVAR tools might be anticipated, so that they cannot be used to assess the fiscal multiplier. Instead, she uses the defense news collected from her narrative approach; as long as the series reflects beliefs about future changes in military spending, they allow her to identify unanticipated fiscal shocks. She estimates peak impulse multipliers between 1.1 and 1.2.[4] Auerbach and Gorodnichenko (2012) use both the identification strategy of Blanchard and Perotti (2002) and the defense news series of Ramey (2011) to calculate multipliers during expansions and recessions; they find that using Ramey's values generates larger values in both cases. Ramey and Zubairy (2018) elaborate on the work of Ramey (2011) by first building a quarterly-frequency GDP series that runs from 1889 to 2015. Using this expanded dataset, they ask whether the size of the multiplier depends on slack conditions (e.g., high vs. low unemployment) or the presence zero lower bound. In general, they cannot find evidence for large multipliers in the former scenario, but do find multipliers above unity when certain conditions are met in the latter one.

Regarding DSGE models, Cogan, Cwik, Taylor, and Wieland (2010) show that standard New Keynesian models (e.g., Smets and Wouters 2007) cannot generate multipliers above unity under a permanent increase in government expenditure; they ask whether adding non-Ricardian consumers (Galí et al. 2007) can offer higher values, but find it cannot. Zubairy (2014) uses a model with nominal frictions, deep habits,[5] and a rich fiscal policy block with automatic stabilizers to find multipliers that are above unity in the short run. We should add that neither of these models considers anticipation effects.

Anticipation of warfare Finally, forecasting conflicts has received increasing attention within the fields of economics and political science using, for instance, newspaper texts as in Ramey (2011, see also Chadefaux 2014, Mueller and Rauh 2017, and the references therein). Overall, this literature finds that war episodes are hardly predictable. Other research studies how financial variables incorporate information about the likelihood of a conflict: Hall (2004) does so for the Swiss exchange rate during World War I and Rigobon and Sack (2005) for the Iraq War in 2003. Similarly, Chadefaux (2017) reports evidence that market participants tend to underestimate the risk of war, and react with surprise immediately thereafter. Using long run series of government bond yields from 1816 through 2007, for France, the UK, and Germany, he finds that market participants have historically underestimated the probability of war prior to its outbreak, and the onset typically led to a large correction. Although our intention is not to predict the onset of warfare, we use the smoothed shocks from the estimation procedure to identify the news of war implied by our model.

3 Preliminary evidence

Figure 1 presents defense, non-defense, and total government spending for the U.S., from 1929 to 2015. We borrow two lessons from these series. First, the years surrounding WWII (1941-1945) exhibit an unprecedented increase in military spending. A few years later, the Korean War

[4] See also the work of Ben Zeev and Pappa (2015), who find that unexpected increases in military spending push TFP and output upwards, generating a multiplier of 0.94, but that this response goes to zero once the TFP channel is shut down.

[5] See Ravn, Schmitt-Grohé, and Uribe (2006).

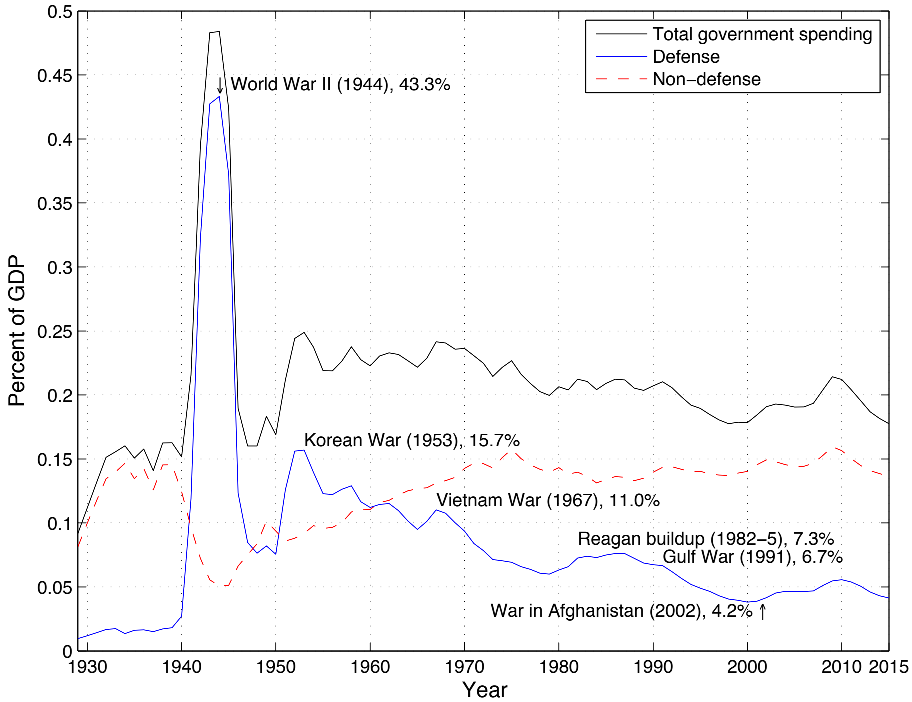

Figure 1: Government expenditure (total, defense, and non-defense), 1929-2015.

brought an increase in defense spending, but of smaller magnitude relative to WWII (the defense spending series peaks a bit over 43% of GDP in 1944; its value in 1953 is considerably lower at 16% of GDP). Nonetheless, defense expenditure accounts for the bulk of the transitory component in total government expenditure. Second, there is a budgetary tradeoff in defense and non-defense expenditure—particularly evident in the decades after the Korean War.

A straightforward way to quantify the relation between output and government spending is the regression

$$\frac{\Delta Y_t}{Y_{t-1}} = a + m_Y \frac{\Delta M_t}{Y_{t-1}} + e_t, \tag{3.1}$$

where Y_t and M_t denote real GDP and defense expenditure at time t. This specification is used by Hall (2009) and Barro and Redlick (2011), who show that the OLS estimator m_Y can be interpreted as a weighted-value output multiplier

$$m_Y = \frac{\operatorname{cov}(\Delta Y_t/Y_{t-1}, \Delta M_t/Y_{t-1})}{\operatorname{var}(\Delta M_t/Y_{t-1})} = \frac{\sum_t \left(\frac{\Delta M_t}{Y_{t-1}}\right)\left(\frac{\Delta Y_t}{Y_{t-1}}\right)}{\sum_t \left(\frac{\Delta M_t}{Y_{t-1}}\right)^2} = \sum_t \omega_t \frac{\Delta Y_t}{\Delta M_t},$$

with weight $\omega_t \equiv \left(\frac{\Delta M_t}{Y_{t-1}}\right)^2 / \sum_t \left(\frac{\Delta M_t}{Y_{t-1}}\right)^2$.

We redo Hall's exercise, expanding the end period to 2014. Table 1 collects our estimates (together with those reported by Hall, Table 1). Our regressions produce smaller estimates for the output multiplier than those reported by Hall (0.55 vs. 0.48). That said, the peak and the trough coincide for the same subperiods, 1939-1948 and 1960-2008, respectively.

To verify whether these results are robust to the starting year of the sample, we estimate a series of regressions in a moving window that begins in 1930 and changes the starting year up to 1995 (for all the regressions the sample ends in 2014). Figure 2 presents the estimates of the output

Table 1: Robustness check for output multipliers.

Sample		Hall (2009)		Own estimate	
Start	End	Mean	SD	Mean	SD
1930	2014	—	—	0.48	0.06
1930	2008	0.55	0.08	0.48	0.06
1948	2008	0.47	0.28	0.42	0.22
1960	2008	0.13	0.65	0.26	0.61
1939	1948	0.53	0.07	0.46	0.05
1949	1955	0.48	0.56	0.40	0.38
1939	1944	0.36	0.10	0.33	0.09
1945	1949	0.39	0.08	0.33	0.05

multiplier m_Y (66 multipliers for 66 shrinking samples) along with their corresponding t-statistic. As an example, note that the first multiplier (1930-2014) is estimated as 0.48, which coincides with the value found in Table 1. The last estimate is -2.8, which corresponds to 1995-2014. The multiplier hovers around a value of 0.5 for all samples starting between 1930 and the outbreak of the Korean War; though it takes a negative value in 1955 (m_Y = -0.36), the coefficient is not statistically significant (the t-statistic is 0.4). In practice, the multipliers for all the samples starting in 1967 (and afterwards) are negative but not statistically significant.

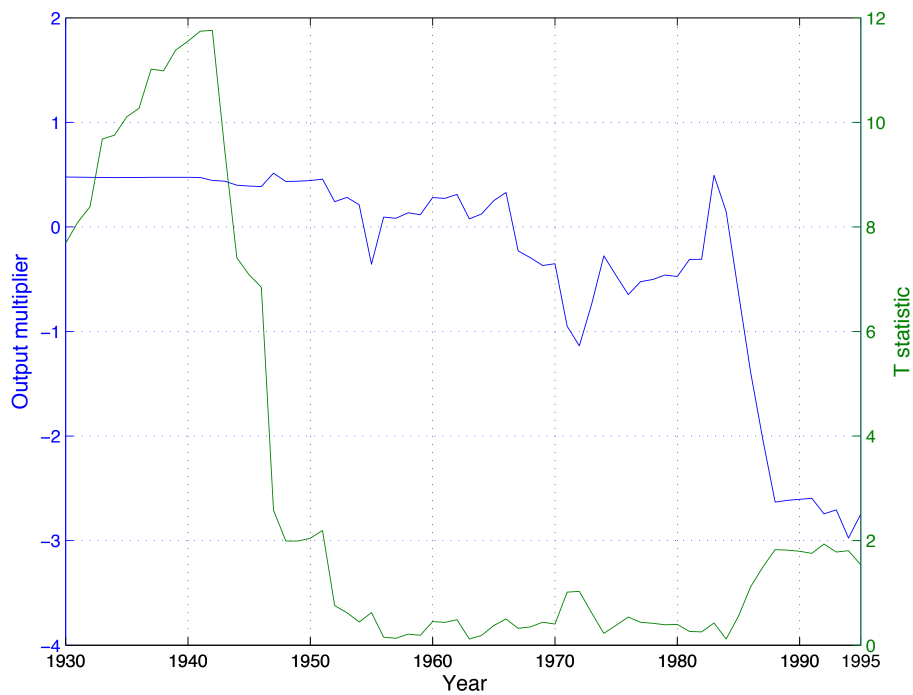

Figure 2: Output multiplier and associated t-statistic (forward).

Moreover, the t-statistics are smaller than the critical threshold (1.7) for the samples starting after 1952. For the last set of regressions, the t-statistics exceed this threshold, but the multiplier values are negative.[6] Overall (and consistent with Hall and Barro and Redlick), we find fiscal

[6] We repeat this experiment but change the direction of the rolling window: for each regression, one final year of

multipliers around 0.5, but only when our sample includes WWII and the Korean War. In our second sample, the fiscal multiplier estimates are not statistically significant—so they must be taken as zero. Samples that include recent military episodes, such as the Gulf War or the conflict in Afghanistan, cannot generate fiscal multipliers of the same magnitude reported by Barro and Redlick (2011) or Hall (2009).

Following Ohanian (1997), Ramey (2011) argues that for samples starting after 1954, the declining fiscal multiplier can be attributed to the different fiscal instruments used by the U.S. government in both wars. Indeed, Ohanian claims that the distortions resulting from the tax increase in the Korean War were higher than those produced from higher debt in WWII. Guided by this evidence and Ramey (2011)'s arguments, we split the sample in two: a first sample that considers 1939 to 1954—which includes both WWII and the Korean War—and another from 1955 to 2014, a period with war episodes whose volume of spending are of minor importance than those of the first one.

4 The benchmark model

The model economy has three kinds of agents: a representative household, a representative firm, and a government. We discuss each of these in turn and then present a notion of equilibrium.

4.1 Household

We assume that the economy is inhabited by a representative household whose utility function depends on consumption and hours worked. Household's decisions are constrained by a budget: gross income must be distributed between consumption, savings, and taxes. Saving can be done through a government bond or a physical capital. Our model also includes habit formation in consumption and capital adjustment costs. In particular, the household chooses sequences of consumption c_t, labor supply n_t, investment x_t, utilization rate of capital u_t, and bond holdings b_t to solve the following problem:

$$\max \quad E_0 \sum_{t=0}^{\infty} \beta^t \log(c_t - \mu c_{t-1}) - \phi \frac{n_t^{1+\chi}}{1+\chi} \tag{4.1}$$

$$\text{s.t.} \quad c_t + x_t + b_t = r_t u_t k_t + w_t n_t + r_t^b b_{t-1} - \zeta_t \tag{4.2}$$

$$\zeta_t = \tau_{kt} r_t u_t k_t + \tau_{nt} w_t n_t + \tau_{ct} c_t - \tau_t - \delta(u_t)\tau_{kt} k_t \tag{4.3}$$

$$k_{t+1} = (1 - \delta(u_t))k_t + x_t[1 - S(x_t/x_{t-1})]. \tag{4.4}$$

In the above, $\beta \in (0, 1)$ is a discount factor, $\mu \in [0, 1)$ is a parameter governing habit persistence, $\phi > 0$ controls the relative weight of consumption and leisure, and $\chi > 0$ denotes the inverse of the Frisch elasticity of labor supply. Equation (4.2) represents the household's budget constraint: the stock of physical capital is denoted by k_t, which is rented to the representative firm at a rental rate r_t. The real wage is denoted by w_t. In addition, r_t^b denotes the gross rate of return on government bonds (the rate is fixed in period $t-1$) and ζ_t denotes the fiscal policy component of the household budget. Following (4.3), the nonnegative processes $\{\tau_{kt}, \tau_{nt}, \tau_{ct}\}$ represent tax rates levied over capital income, labor income, and the purchase of consumption goods, respectively, while τ_t denotes government lump-sum transfers/taxes. The last term in (4.3) represents a depreciation allowance. Equation (4.4) is the law of motion for capital, where the depreciation rate δ depends

the sample is added, taking the starting period 1930 to 1950 as fixed. In this case, the multiplier hovers around 0.48 while the statistical significance of these estimates displays an upward trend (as one year is added at the end of the sample) that is always above the critical threshold.

on capital utilization and there are investment adjustment costs parametrized by function S. We impose the following functional forms over δ and S:

$$\delta(u_t) = \delta_0 + \delta_1(u_t - 1) + \frac{\delta_2}{2}(u_t - 1)^2 \tag{4.5}$$

$$S(x_t/x_{t-1}) = \frac{\kappa}{2}(x_t/x_{t-1} - 1)^2. \tag{4.6}$$

Equation (4.5) shows that the depreciation of physical capital is a (quadratic) function of the utilization rate u_t. We normalize the stationary capital utilization rate to $u = 1$; thus, $\delta_0 \in (0, 1)$ is the steady state depreciation rate of the capital stock and $\delta_1, \delta_2 \geq 0$ are parameters of the depreciation function. Finally, equation (4.6) characterizes the (quadratic) adjustment cost of installing new capital.

As usual, we assume that the household behaves competitively and takes the processes for prices $\{r_t, w_t, r_t^b\}_{t=0}^{\infty}$ and fiscal policy $\{\tau_{kt}, \tau_{nt}, \tau_{ct}, \tau_t\}_{t=0}^{\infty}$ as given when it makes its decisions.

4.2 Firm

The representative firm rents capital K_{Ft} and labor services N_{Ft} from the household and transforms them into output y_t. We assume that the firm behaves competitively, takes the processes for the rental prices $\{r_t, w_t\}_{t=0}^{\infty}$ as given, and solves the following profit maximization problem:

$$\begin{aligned} \max \quad & A z_t K_{Ft}^{\alpha} N_{Ft}^{1-\alpha} - r_t K_{Ft} - w_t N_{Ft} \\ \text{s.t.} \quad & K_{Ft}, N_{Ft} \geq 0. \end{aligned}$$

In the above, $A > 0$ is a scaling factor, $\alpha \in (0, 1)$ represents the capital share, and z_t is a stationary technology disturbance. We assume that z_t follows

$$\log z_t = (1 - \rho_z) \log z + \rho_z \log z_{t-1} + \varepsilon_{zt}, \tag{4.7}$$

where z is the steady-state level of z_t, $\rho_z \in (0, 1)$ is a persistence parameter, and ε_{zt} is an i.i.d. process with mean zero and standard deviation σ_z.

4.3 Government and fiscal rules

The government trades bonds B_t with the household and levies taxes over consumption and capital and labor income. It uses these resources to finance bond payments $r_t^b B_{t-1}$ and exogenous sequences of military purchases m_t and non-military consumption g_t. Lump-sum transfers τ_t are positive if resources are rebated from the public sector to the households and negative otherwise. The government's budget constraint is

$$g_t + m_t + r_t^b B_{t-1} + \tau_t = B_t + \tau_{kt} r_t u_t k_t + \tau_{nt} w_t n_t + \tau_{ct} c_t - \delta(u_t) \tau_{kt} k_t. \tag{4.8}$$

We specify a set of fiscal rules for public spending, transfers, and tax rates. In these rules, variables without a time subindex denote a stationary position. We assume that defense spending m_t does not respond to output or the state of public debt—our way of addressing the non-discretionary behavior of the variable—and require it to follow the law of motion

$$(m_t - m) = \rho_m (m_{t-1} - m) + \varepsilon_{mt} + \varepsilon_{m,t-1}^{\text{war}}. \tag{4.9}$$

Equation (4.9) indicates that military spending m_t evolves with relative persistency ρ_m and that deviations from its steady state can be due to a pure (non-anticipated) fiscal shock ε_{mt} or the war news shock $\varepsilon_{m,t-1}^{\text{war}}$, which becomes known one period in advance. The war news shock is key to properly measuring the effects of military expenditure over the economy, as changes in the variable are often anticipated. Both innovations are i.i.d. processes with mean zero and standard deviation σ_m and σ_{war}, respectively.

Non-defense expenditure follows an augmented version of the fiscal rule suggested by Leeper et al. (2010):

$$(g_t - g) = \rho_g (g_{t-1} - g) - \theta_g^m (m_t - m) - \theta_g^y (y_{t-1} - y) - \theta_g^b (b_{t-1} - b) + \varepsilon_{gt}. \tag{4.10}$$

From (4.10), g_t adjusts automatically to past values and in response to defense spending (see Figure 1), the business cycle, and the state of debt. Hence, there is a systematic correction in non-defense spending when (1) defense spending differs from its steady-state value m, (2) output fluctuates around its steady state position, or (3) debt accumulates relative to the stationary state. Parameters $\left\{\theta_g^m, \theta_g^y, \theta_g^b\right\}$ are expected to be positive. Finally, non-defense spending is impulsed by a fiscal shock ε_{gt}, which is an i.i.d. process with mean zero and standard deviation σ_g.

The remaining fiscal rules are specified as in Leeper et al.:

$$(\tau_t - \tau) = \rho_\tau(\tau_{t-1} - \tau) - \theta_\tau^y(y_{t-1} - y) - \theta_\tau^b(b_{t-1} - b) + \varepsilon_{\tau t}, \tag{4.11}$$

$$(\tau_{kt} - \tau_k) = \rho_k(\tau_{k,t-1} - \tau_k) + \theta_k^y(y_{t-1} - y) + \theta_k^b(b_{t-1} - b) + \varepsilon_{kt}, \tag{4.12}$$

$$(\tau_{nt} - \tau_n) = \rho_n(\tau_{n,t-1} - \tau_n) + \theta_n^y(y_{t-1} - y) + \theta_n^b(b_{t-1} - b) + \varepsilon_{nt}, \tag{4.13}$$

$$(\tau_{ct} - \tau_c) = \rho_c(\tau_{c,t-1} - \tau_c) + \varepsilon_{ct}. \tag{4.14}$$

Except for the consumption tax rate, there is an automatic response with respect to output fluctuations and to the level of debt: $\left\{\theta_\tau^y, \theta_\tau^b, \theta_k^y, \theta_k^b, \theta_n^y, \theta_n^b\right\}$ are expected to be positive. Unlike Leeper et al., we assume that the non-anticipated fiscal shocks are all orthogonal. These fiscal impulses are i.i.d. processes with mean zero and standard deviation σ_j for $j = \{\tau, k, n, c\}$.

Finally, the feasibility constraint of the economy dictates that output must be either consumed (by households or by the government) or invested:

$$y_t = c_t + x_t + g_t + m_t. \tag{4.15}$$

4.4 Equilibrium

Let $\xi_t = (k_t, b_t)$ denote the vector of individual state variables. Given a government policy,

$$\{g_t, m_t, \tau_t, \tau_{kt,}, \tau_{nt}, \tau_{ct}\},$$

a competitive equilibrium is a set of decision rules $\{c(\xi_t), n(\xi_t), u(\xi_t), k(\xi_{t-1}), b(\xi_{t-1})\}$, aggregate choices $\{C(\xi_t), N_F(\xi_t), K_F(\xi_{t-1}), B(\xi_{t-1})\}$, and prices $\{w(\xi_t), r(\xi_t), r_t^b(\xi_t)\}$, such that

1. Given the government policy and factor prices, the household's utility is maximized, subject to the budget constraint and the state equation for capital.

2. Factors of production (labor and capital) are hired at their marginal productivities.

3. The government satisfies its budget equation given the fiscal rules.

4. Markets clear: labor demand is equal to labor supply, capital demand is equal to capital supply, and the aggregate feasibility condition holds.

5. The representative agent condition holds; i.e., aggregate choices coincide with individual ones when the latter is representative:

$$\begin{aligned} C(\xi_t) &= c(\xi_t) \\ N_F(\xi_t) &= n(\xi_t) \\ K_F(\xi_{t-1}) &= u(\xi_t)k(\xi_{t-1}) \\ B(\xi_{t-1}) &= b(\xi_{t-1}). \end{aligned}$$

5 Results

5.1 Estimation

We first provide some details regarding the parametrization of the model. In an initial step, we calibrate a subset of parameters and steady state values using sample averages, and then use Bayesian techniques to estimate the remaining ones.

Table 2 introduces the set of parameters determined ex-ante, together with the target values that the model aims to reproduce in the steady state. The capital income share is set to $\alpha = 1/3$ for both samples. We normalize steady state output to unity and GDP components are expressed in relative terms, using sample averages of U.S. accounts. Stationary tax rates are calculated as an average of calculated values (see Appendix A for details on data construction). Between the two samples, the main difference concerns the composition and magnitude of public expenditure, disaggregated into defense and non-defense spending. Consumption relative to output is stable around 0.54, while investment moves opposite total government spending.

Table 2: Parameters determined ex-ante and target values.

	Before Korean War 1939-1954	After Korean War 1955-2014	Full sample 1939-2014
Parameter			
Capital income share α	0.333	0.333	0.333
Capital income tax rate τ_k	0.346	0.262	0.279
Labor income tax rate τ_n	0.108	0.189	0.172
Consumption tax rate τ_c	0.052	0.052	0.052
Target			
Normalized output y	1.000	1.000	1.000
Consumption c	0.541	0.543	0.542
Investment rate x	0.198	0.250	0.239
Non-defense spending g	0.088	0.135	0.125
Defense spending m	0.172	0.072	0.093
Lump-sum transfers τ	-0.148	-0.044	-0.066
Debt-to-output b/y	0.770	0.526	0.577
Capital utilization u	1.000	1.000	1.000

After log-linearizing the model, we estimate the remaining parameters using Bayesian techniques. The following nine series are assumed to be observable: output y_t, consumption c_t, defense and non-defense government spending $\{m_t, g_t\}$, transfers τ_t, tax rates $\{\tau_{kt}, \tau_{nt}, \tau_{ct}\}$, and debt b_t.

Table 3 presents the prior and posterior distributions that result from the econometric exercise. The habit persistence parameter μ increases in value for the second sample, from 0.74 to 0.83. The estimated Frisch elasticity of labor changes from 1.87 in the first sample to 0.67 for the second.[7] The estimates for $\{\delta_0, \delta_2, \kappa\}$ show standard values (see Leeper et al.), while the cost on capital adjustment κ increases.

Combining the parameters of the first panel in Table 3 with the targets reported in Table 2, the model is calibrated for the U.S. economy for the different samples. Table 4 summarizes these results. The annual capital-output ratio is 2.28 on the full sample. The long-run bond treasury rates are 4.4, 2.4, and 3.0%, which imply a subjective discount rate of $\beta \in [0.957, 0.976]$. The rental price r, the linear component δ_1 from the depreciation function, the utility weight ϕ, and the scaling parameter A in the production function are calculated using the steady state conditions.

Table 5 reports the prior and posterior distributions; we believe that four results are worth noting. First, the persistency of fiscal rules and the TFP shocks has increased following the end of the Korean War. Second, non-defense spending declines in response to military spending build-up as $-\theta_g^m$ is negative in both samples. Third, in the post-Korean War sample, the tax rates exhibit a higher response to variations in output, but a smaller response to variation in debt.

Finally, as the bottom panel in Table 5 shows, all standard deviations are smaller in the second period. This moderation affects not only the volatility of the TFP shock σ_z, but also those of the the fiscal shocks σ_j for $j = \{m, g, \tau, k, n, c\}$. Of major importance is the moderation in the volatility of military spending σ_m and that of the war news shock σ_{war}, lower by a factor of 27 and 12, respectively. The standard deviations for the tax rates also experience a sensible moderation, becoming between 1.8 and 4.0 times smaller.[8]

5.2 Identifying the news of war

We use the smoothed shocks from the estimation procedure to identify the news of war implied by our model. To this end, Figures 3 and 4 compare the war news shocks obtained from our model to the defense news derived from the narrative approach of Ramey (2011).

Figure 3 considers the first sample, 1939-1954. The DSGE-based approach does a good job in capturing the dynamics of the defense news of Ramey (2011). Note that for 1946, the narrative approach suggests an increase in the defense while our approach shows a fall in the value of the war news shock; this seems to be consistent with the fact that the war ended by 1945, just a year before. While the DSGE-based shocks reproduce the ones from the narrative approach for WWII, our results suggest that the Korean War was largely unanticipated.[9]

Figure 4 replicates the results from Figure 3 using the full sample estimation results. (This explains why the values for 1939-1954 are not identical to those in Figure 3.) Even though the narrative approach series has gaps in the values provided, our estimates track these results fairly well.[10] For the remaining war episodes, our non-narrative approach anticipates a larger fraction of fiscal increases in military spending relative to Ramey's approach. For instance, our model

[7] Heathcote, Storesletten, and Violante (2010) and Chetty, Guren, Manoli, and Weber (2011)—who use a married couple as the notion of household—propose an estimate of 0.72.

[8] Fernández-Villaverde, Guerrón-Quintana, Kuester, and Rubio-Ramírez estimate fiscal rules for spending and tax rates with time varying volatility. The do not consider anticipated changes in government spending or the tax rates, though. They report evidence that these shocks to the time varying volatility of fiscal variables can produce adverse effects on economic activity.

[9] Secretary of State Dean Acheson, during his speech in the National Press Club in January 1950, did not consider the Korean Peninsula to be a part of the all-important "defense perimeter" of the U.S. The Korean War broke out shortly after, on June 25 1950.

[10] The correlation coefficients are 0.58 for the first sample and 0.71 for the full sample.

Table 3: Prior and posterior distributions for model parameters (household and firm).

Parameter	Prior distribution			Posterior distribution for sample									
				1939-1954			1955-2014			1939-2014			Relative
	Density	Mean	SD	Mean	95% interval		Mean	95% interval		Mean	95% interval		
Hours worked n	Beta	0.30	0.03	0.30	0.24	0.36	0.30	0.24	0.36	0.30	0.24	0.36	1.00
Habit formation μ	Beta	0.50	0.20	0.74	0.60	0.89	0.83	0.71	0.99	0.69	0.62	0.75	0.89
Frisch elasticity $1/\chi$	Gamma	2.00	0.60	1.87	0.92	2.90	0.67	0.32	1.05	1.92	1.10	2.82	2.80
Depreciation δ_0	Beta	0.10	0.01	0.10	0.08	0.12	0.10	0.08	0.12	0.10	0.09	0.12	1.02
Depreciation δ_2	Inverse Gamma	1.00	0.30	0.97	0.52	1.53	0.94	0.53	1.47	0.84	0.49	1.27	1.03
Adjustment cost κ	Gamma	5.00	0.50	5.17	4.21	6.16	5.65	4.67	6.66	5.70	4.75	6.70	0.92

Table 4: Parameters that require solving the model and implied steady state values.

	Before Korean War 1939-1954	After Korean War 1955-2014	Full sample 1939-2014
Parameter			
Discount rate β	0.957	0.976	0.971
Depreciation δ_1	0.109	0.096	0.105
Leisure weight ϕ	37.114	7.873	34.751
Steady state (annual rate)			
Capital-output ratio K/Y	1.986	2.561	2.281
Bond gross rate r^b	0.044	0.024	0.030
Capital rental rate r	0.168	0.130	0.146

identifies wider anticipated positive changes during the 1960s through the Vietnam War, and warns for a reduction in defense spending across the first half of the 1970s. Accordingly, our approach also suggests anticipated military buildup following President Reagan's Strategic Defense Initiative in 1983. Both approaches deem that the first Gulf War, after Iraq's invasion of Kuwait in 1990, was largely unanticipated, though Ramey's narrative approach suggests a contraction in defense spending by the end of the 1980s. With the Cold War ending and nuclear arsenals shrinking, the 1990s were mostly peaceful, so changes in military spending can be taken as unanticipated during this decade. Both approaches anticipate similar shocks for the Afghanistan War and the second Iraq War during the first half of 2000s. Finally, there is a point for discrepancy after 2005: while the narrative approach calls for a military spending increase, ours moves in the opposite direction.

5.3 Impulse-response functions

Figure 5 shows the impulse-response functions for output following a one-standard deviation increase in TFP, defense and non-defense expenditure, and the war news shocks. Comparing the non-anticipated defense expenditure shocks (panel [a]) and the war news shock (panel [b]), we see that both of these are fairly sizable in the first sample but flat in the second one. Changes in non-defense expenditure (panel [c]) have the right shape but negligible magnitude; shocks to TFP (panel [d]) also have the right shape and seem to be more important in the first sample.

More precisely, output increases on impact (and declines afterward) in response to the unanticipated fiscal shocks $\{\varepsilon_{gt}, \varepsilon_{mt}\}$ (see panel [a]). Due to the negative wealth effect caused by the fiscal expansion, households reduce their consumption and work more hours. Both public debt and bond yields move up. These facts, combined with the arbitrage condition that comes from the model's first-order conditions, boost the real interest rate and reduce investment. After 3-4 periods, the positive effects on output from the fiscal expansion are dampened by the fall in private expenditure. Note that output is more sensible to short-run fiscal shocks during the first sample, given the moderation in variances (see Table 5). A positive shock to the unanticipated defense shock ε_{mt} (shown in panel [c]) boosts military expenditure and readjusts the government budget internally, reducing non-defense spending by θ_m^g for any marginal dollar spent on defense needs above the steady state value m. Conversely, a shock to non-defense spending ε_{gt} has no impact on defense spending. This asymmetrical adjustment results in a different response on output depending on the type of the fiscal shock.

Anticipated military expansions impact differently over output, especially in the short run (see panel [b]). The war news shock $\varepsilon_{mt}^{\text{war}}$ has no effect on current spending g_t but does impact future

Table 5: Prior and posterior distributions for model parameters (exogenous processes).

Parameter	Prior distribution			Posterior distribution for sample									Relative
				1939-1954			1955-2014			1939-2014			Relative
	Density	Mean	SD	Mean	95% interval		Mean	95% interval		Mean	95% interval		
AR coefficient ρ_z	Beta	0.50	0.20	0.28	0.08	0.48	0.42	0.32	0.53	0.39	0.28	0.49	0.7
AR coefficient ρ_m	Beta	[a]	[b]	0.69	0.50	0.87	0.83	0.67	0.99	0.73	0.58	0.87	0.8
AR coefficient ρ_g	Beta	[a]	[b]	0.64	0.41	0.88	0.75	0.58	0.91	0.47	0.31	0.63	0.9
AR coefficient ρ_τ	Beta	[a]	[b]	0.55	0.39	0.70	0.81	0.67	0.95	0.81	0.68	0.93	0.7
AR coefficient ρ_k	Beta	[a]	[b]	0.61	0.45	0.77	0.66	0.52	0.79	0.78	0.68	0.88	0.9
AR coefficient ρ_n	Beta	[a]	[b]	0.52	0.38	0.67	0.63	0.49	0.77	0.68	0.54	0.82	0.8
Stabilizer θ_g^m	Gamma	0.20	0.05	0.17	0.10	0.24	0.15	0.09	0.23	0.15	0.11	0.19	1.1
Stabilizer θ_g^y	Gamma	0.07	0.05	0.07	0.00	0.16	0.07	0.00	0.15	0.07	0.00	0.15	1.0
Stabilizer θ_τ^y	Gamma	0.20	0.28	0.28	0.07	0.50	0.36	0.12	0.61	0.17	0.07	0.28	0.8
Stabilizer θ_k^y	Gamma	1.00	0.30	1.23	0.60	1.92	1.44	0.79	2.13	1.08	0.57	1.64	0.9
Stabilizer θ_n^y	Gamma	0.50	0.25	0.46	0.08	0.92	0.52	0.19	0.87	0.10	0.02	0.19	0.9
Stabilizer θ_g^b	Gamma	0.40	0.20	0.11	0.04	0.19	0.03	0.01	0.04	0.03	0.01	0.04	4.3
Stabilizer θ_τ^b	Gamma	0.40	0.20	0.03	0.01	0.05	0.03	0.01	0.04	0.01	0.00	0.01	0.9
Stabilizer θ_k^b	Gamma	0.40	0.20	0.12	0.03	0.22	0.11	0.06	0.15	0.03	0.01	0.06	1.1
Stabilizer θ_n^b	Gamma	0.40	0.20	0.07	0.02	0.12	0.03	0.01	0.05	0.01	0.01	0.02	2.1
SD σ_z	Inverse Gamma	0.05	0.02	0.036	0.023	0.050	0.016	0.013	0.019	0.023	0.018	0.028	2.2
SD σ_m	Inverse Gamma	[c]	[d]	0.091	0.067	0.117	0.003	0.003	0.004	0.036	0.029	0.045	26.7
SD σ_{war}	Gamma	0.05	0.02	0.042	0.014	0.073	0.003	0.002	0.005	0.023	0.010	0.036	12.4
SD σ_g	Inverse Gamma	[c]	[d]	0.010	0.008	0.013	0.004	0.003	0.004	0.005	0.004	0.006	3.0
SD σ_τ	Inverse Gamma	[c]	[d]	0.008	0.006	0.010	0.004	0.003	0.005	0.005	0.004	0.006	1.8
SD σ_k	Inverse Gamma	[c]	[d]	0.061	0.047	0.076	0.015	0.013	0.017	0.036	0.031	0.042	4.0
SD σ_n	Inverse Gamma	[c]	[d]	0.017	0.013	0.022	0.007	0.006	0.008	0.010	0.009	0.012	2.5

Notes. [a] Uses the OLS estimate of the corresponding coefficient in the policy rule. [b] Uses 0.15×OLS estimate of the corresponding coefficient in the policy rule. [c] Uses the standard deviation of the residual from the estimated policy rule. [d] Uses 0.15×SD of the residual from the estimated policy rule.

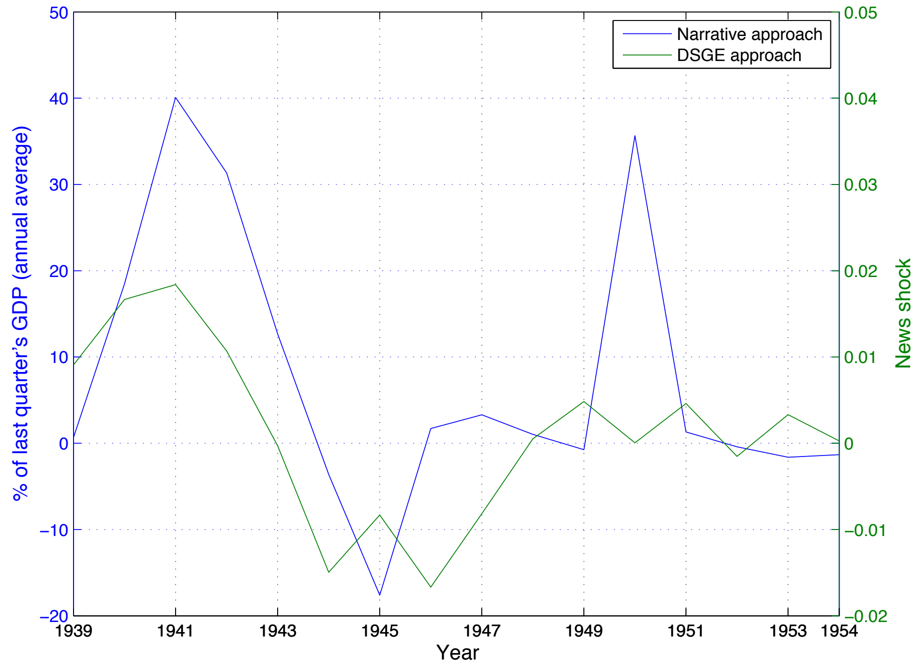

Figure 3: News of war, narrative vs. DSGE approaches (1939-1954 sample).

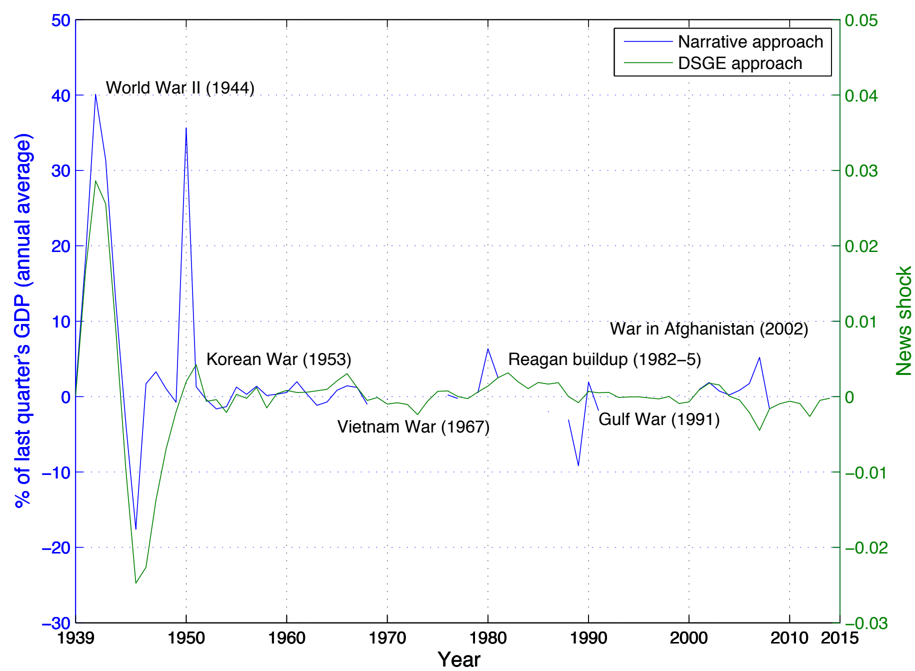

Figure 4: News of war, narrative vs. DSGE approaches (full sample).

spending g_{t+1}. However, given the tax rules, families discount tax burden increases that may spread across a long horizon—due to the possibility of war. As public debt is expected to rise, the real interest rate rises as well while investment falls. The net aggregate effect is an immediate contraction in output. In the second period, output reacts positively to the fiscal news (reaching

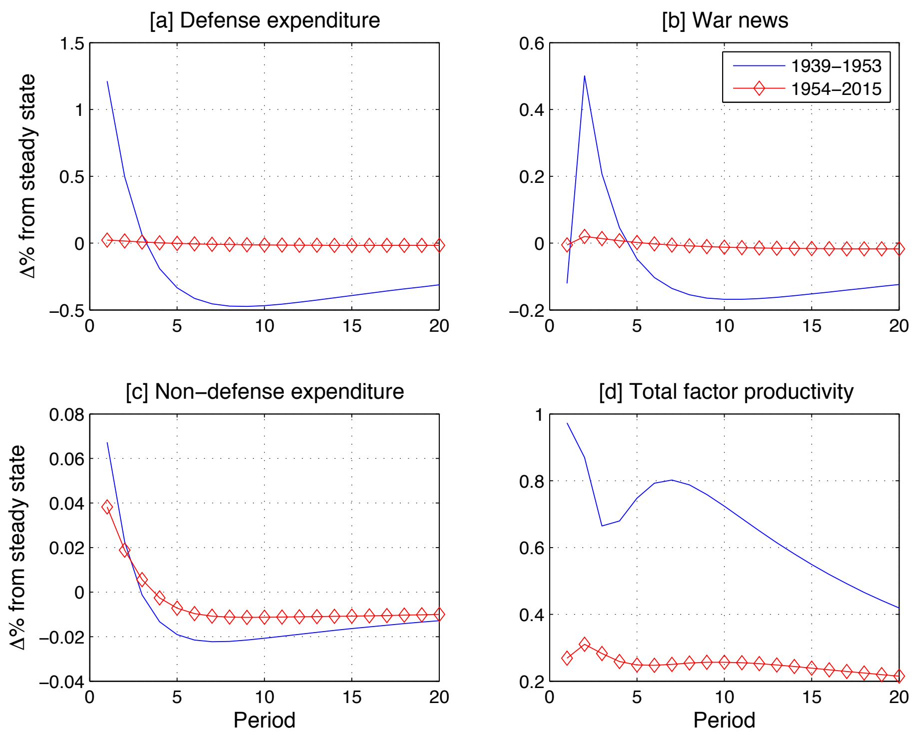

Figure 5: Model impulse-response functions (expenditure and TFP).

a peak), as the negative wealth effect causes households to demand less leisure or to work more hours, although private consumption and investment continue to fall. Past the fourth period, the net response of output to the anticipated fiscal expansion becomes negative.[11]

5.4 Business cycle implications

We now compare the business cycle facts observed for the series with those moments implied from the model simulation. In Table 6 we compile a selection of statistical moments for the U.S., using annual data from 1939 to 2014. Panel [a] presents the volatility of detrended series. The standard deviations of the data indicate a drastic moderation in all series, which reduces volatility by a factor ranging from 2 (consumption) to 14 (defense spending). There are also remarkable changes in the correlation coefficients for all cases, as shown in panel [b]. For instance, the correlation of output with consumption increases during the second sample, and the output-investment correlation shifts from counter- to procyclical, which could reflect a crowding-out effect from fiscal expansions during the first sample. While the correlation of non-defense spending with output changes from negative to positive between samples, that of defense spending does the opposite. In both cases, the correlation is weak in the second period. Finally, the negative correlations of debt and prices strengthen in the second sample.

Finally, panel [c] presents the correlations of detrended non-defense spending and investment with lags and leads of detrended defense spending. Reported correlations confirm that both out-

[11] Ramey (2011) finds a positive immediate response of output and services consumption to the defense news, which is contrary to our findings. To the extent that the participation of services on private consumption has been growing over time in the U.S., this suggests that her work underestimates the negative wealth effects associated with the shock.

Table 6: Business cycle facts of U.S. aggregate variables, 1939-2014.

Variable	[a] Standard deviations (%)			[b] Correlation with output		
	1939-2014	1939-1954	1955-2014	1939-2014	1939-1954	1955-2014
GDP	2.9	6.0	1.3	1.00	1.00	1.00
Consumption	1.0	1.5	0.8	0.53	0.42	0.90
Investment	7.6	14.9	4.1	-0.52	-0.88	0.94
Non-defense spending	2.3	4.7	1.1	-0.50	-0.62	0.11
Defense spending	17.0	37.7	2.7	0.76	0.86	-0.18
Debt	4.0	8.4	1.5	-0.18	-0.14	-0.42

[c] Correlations of non-defense spending and investment with defense spending

1939-2014	-2	-1	0	1	2
$\text{corr}(g_t, m_{t+j})$	-0.52	-0.62	-0.52	-0.10	0.35
$\text{corr}(x_t, m_{t+j})$	-0.08	-0.62	-0.63	-0.14	0.12
1939-1954	-2	-1	0	1	2
$\text{corr}(g_t, m_{t+j})$	-0.58	-0.68	-0.58	-0.12	0.38
$\text{corr}(x_t, m_{t+j})$	-0.12	-0.71	-0.70	-0.15	0.13
1955-2014	-2	-1	0	1	2
$\text{corr}(g_t, m_{t+j})$	-0.13	-0.12	-0.03	0.09	0.25
$\text{corr}(x_t, m_{t+j})$	0.22	-0.11	-0.38	-0.29	0.01

Notes. The series have been HP-filtered using a parameter $\lambda = 6.25$, as recommended by Ravn and Uhlig (2002) for annual-frequency data.

lays are contemporaneously negatively correlated and that military spending behaves as a leading indicator for non-defense spending.

Table 7 reports model-based moments to be compared with those shown in Table 6. For the simulation, we use the posterior means from Tables 2 through 7. Comparing with Table 6, we conclude that the model can reproduce the moderation occurring after the Korean War. Yet the adjustment factor in this moderation is not always of the same magnitude observed in the data. For instance, the model underestimates the moderation for output. The model also underpredicts the volatility of defense spending variables, mainly for the first sample. In the model, debt is five times more volatile than its sample analogue in Table 6 (46.8 vs. 8.4).

Regarding the correlations with output, the simulated correlations tend to meet the observed correlations reported in Table 6, with the exception of investment during the first sample. The simulated correlation between output and investment is positive (0.78, Table 7) while the observed one is negative (-0.88, Table 6), this being a consequence of the smaller variability that our parameter estimates associate to defense spending. Also, the model-based correlation between output and defense spending drops from 0.21 in the first sample to 0 in the second one. In Section 3, we saw that the slope of expression (3.1) can be interpreted as an estimate of the fiscal multiplier: $m_Y = \text{cov}(\Delta Y_t/Y_t, \Delta M_t/Y_t)/\text{var}(\Delta M_t/Y_t)$. Hence, it follows that the model can account for the downturn in the slope coefficient m_Y for the second sample, as reported in Figure 2.

Finally, the simulated correlations of non-defense spending and investment with leads and lags of defense spending replicate the leading indicator feature of defense spending from Table 6. Defense spending is a leading indicator of investment in the first sample, yet the model implies an orthogonal relation between investment and defense spending at all leads and lags in the second sample.

Table 7: Simulated moments for U.S. aggregate variables, 1939-2014.

Variable	[a] Standard deviations (%)			[b] Correlation with output		
	1939-2014	1939-1954	1955-2014	1939-2014	1939-1954	1955-2014
GDP	2.1	3.7	1.5	1.00	1.00	1.00
Consumption	1.8	2.4	0.8	0.95	0.71	0.96
Investment	3.8	8.3	3.3	0.96	0.78	0.97
Non-defense spending	3.0	15.3	2.4	0.63	0.75	0.88
Defense spending	6.4	13.8	0.8	0.08	0.21	0.00
Debt	58.4	46.8	26.3	-0.82	-0.83	-0.95

[c] Correlations of non-defense spending and investment with defense spending					
1939-2014	-2	-1	0	1	2
corr(g_t, m_{t+j})	-0.40	-0.46	-0.47	-0.34	-0.25
corr(x_t, m_{t+j})	-0.15	-0.15	-0.14	-0.11	-0.08
1939-1954	-2	-1	0	1	2
corr(g_t, m_{t+j})	-0.37	-0.37	-0.34	-0.24	-0.16
corr(x_t, m_{t+j})	-0.40	-0.42	-0.38	-0.27	-0.19
1955-2014	-2	-1	0	1	2
corr(g_t, m_{t+j})	-0.16	-0.16	-0.15	-0.12	-0.10
corr(x_t, m_{t+j})	-0.01	-0.01	-0.01	-0.01	-0.01

5.5 Variance decomposition

Table 8 shows the decomposition of variances for the main aggregate variables. Since we work with annual series, we present an analysis of conditional variances on impact ($j = 0$) and an horizon up to 4 years for both samples.

In the first sample, defense fiscal shocks have an important effect on output, accounting for 53% of output variance on impact and 28% five years ahead. Pure fiscal shocks from discretionary non-defense policies (ε_{gt}) have a negligible impact. Together with fiscal shocks, TFP shocks account for virtually all output variability; however, the bulk in the variability of consumption, investment, and hours worked is mostly accounted by TFP shocks. Unanticipated defense spending shocks, together with those to capital tax rate and the labor tax rate, account for nearly all of the short run variability of debt. In the long term, the variance of debt can be explained by the TFP shock. However, the war news shock plays a minor role in the variability of model variables.

In the second sample, output, consumption, investment, government debt, and hours worked variability is mostly accounted by TFP shocks. Expenditure shocks (including news) are negligible across the board, though tax shocks matter for government debt. Since the variance of defense expenditure falls considerably in the second sample, the unanticipated defense shock reduces its importance for non-defense spending. The war news shock matters for defense spending, accounting for 46% of its variance; the role of this shock on the remaining variables is basically zero.

These results are contrary to those of Ben Zeev and Pappa (2017), who use quarterly data from 1948:I to 2007:IV and find that news shocks account for 9% and 13% of variation in output and hours at a one year horizon. The equivalent figures in our analysis are 5% and 2% for the first sample (at a 4-year horizon) and zero in the second sample.[12]

[12] Ramey (2011) uses a sample similar to the one in Ben Zeev and Pappa (2017) and finds that these shares are

Table 8: Decomposition of simulated conditional variances.

Variable	Year	1939-1954								1955-2014							
		ε_z	ε_m	ε_{war}	ε_g	ε_τ	ε_k	ε_n	ε_c	ε_z	ε_m	ε_{war}	ε_g	ε_τ	ε_k	ε_n	ε_c
Output	0	0.45	0.53	0.00	0.00	0.00	0.00	0.01	0.00	0.94	0.00	0.00	0.02	0.00	0.00	0.04	0.00
	4	0.66	0.28	0.05	0.00	0.00	0.00	0.01	0.00	0.97	0.00	0.00	0.00	0.00	0.00	0.03	0.00
Consumption	0	0.86	0.11	0.01	0.00	0.00	0.00	0.02	0.00	0.94	0.00	0.00	0.00	0.00	0.00	0.06	0.00
	4	0.63	0.28	0.06	0.00	0.00	0.00	0.02	0.00	0.92	0.00	0.00	0.00	0.00	0.00	0.07	0.01
Investment	0	0.84	0.14	0.01	0.00	0.00	0.01	0.01	0.00	0.96	0.00	0.00	0.00	0.00	0.00	0.03	0.00
	4	0.67	0.27	0.05	0.00	0.00	0.00	0.00	0.00	0.97	0.00	0.00	0.00	0.00	0.00	0.02	0.00
Debt	0	0.01	0.43	0.00	0.00	0.00	0.18	0.36	0.01	0.02	0.00	0.00	0.01	0.00	0.07	0.88	0.03
	4	0.91	0.06	0.00	0.00	0.00	0.01	0.01	0.00	0.92	0.00	0.00	0.00	0.00	0.01	0.06	0.01
Defense spending	0	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
	4	0.00	0.83	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.54	0.46	0.00	0.00	0.00	0.00	0.00
Non-defense spending	0	0.00	0.68	0.00	0.32	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.98	0.00	0.00	0.00	0.00
	4	0.23	0.62	0.09	0.04	0.00	0.01	0.01	0.00	0.08	0.12	0.08	0.67	0.00	0.00	0.04	0.00
Hours worked	0	0.90	0.09	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	4	0.87	0.10	0.02	0.00	0.00	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00

5.6 Expenditure multipliers

As we show below, the definition of the multiplier is critical for its magnitude. We distinguish between present-value multipliers (Mountford and Uhlig 2009) and peak impact multipliers (Blanchard and Perotti 2002 and many others). We find that the former definition cannot yield multipliers above unity, but the latter can.[13]

Present value multipliers Following Mountford and Uhlig (2009), we now display present-value multipliers. Let Δy_{t+i} and Δgs_{t+i} denote the impulse-responses of output and government spending (here $gs = \{g, m\}$) with respect to fiscal shock ε_{gt} or ε_{mt}. The present value multiplier generated by a change in the present value of government spending gs over a j-period horizon is

$$PV^{y}_{gs}(j) = \frac{\sum_{i=0}^{j} \Delta y_{t+i} \times \prod_{i=0}^{j} r^{-1}_{b,t+i}}{\sum_{i=0}^{j} \Delta gs_{t+i} \times \prod_{i=0}^{j} r^{-1}_{b,t+i}} \cdot \frac{y}{gs}, \tag{5.1}$$

where $r_{b,t+i}$ represents the impulse-response for the bond yield. The multipliers for consumption, investment, non-defense, and defense expenditure are defined accordingly.

Table 9 shows the present value multipliers implied by our model, where we look at both samples and an horizon up to 4 years. For time horizon $j = 0$, the multiplier is measured on impact. As these multipliers are calculated using the impulse-response functions derived from our structural DSGE model, the estimate of the multiplier cannot be contaminated by an identification bias. When considering the multiplier implied by defense spending, $gs = m$, the fiscal adjustment taking place within government budget (parameter θ^m_g in equation [4.10]) is internalized into the model: a positive fiscal shock ε_{mt} boosts defense spending over its steady value m, prompting the government to adjust non-defense spending by $-\theta^m_g$.

From Table 9 we draw three conclusions. First, the output present-value multipliers are always below unity and the consumption and investment multipliers are negative, consistent with crowding out.[14] Moreover, there are not substantial differences between both periods. The multiplier of non-defense spending has a modest increase and the defense spending multiplier has a modest decrease. Second, non-defense multipliers are slightly higher than defense ones, a result from the asymmetric budgetary adjustment motivated by θ^m_g. The values of PV^g_m show that a change in military spending is not a free lunch in terms of non-defense outlays, especially during the second sample. Finally, the value of the multiplier decreases as the time horizon increases.

The posterior distributions in Table 3 show three key parameters that change in the second sample: the Frisch elasticity of labor supply $1/\chi$ (falls), the habit persistence parameter μ, and the capital adjustment cost κ (both increase). These changes can moderate the response of output when affected by fiscal shocks: a more inelastic labor supply cushions the change in hours worked when the household observes a negative income effect due to higher government spending. Similarly, the other two parameters induce a higher real rigidity in both consumption (when μ increases, households smooth consumption plans), and investment (when κ increases, firms find costlier adjusting capital). However, the multipliers reported in Table 9 indicate that these changes are rather small.

Finally, changes in the fiscal rule volatilities, as shown in Table 5, are unlikely to have altered fiscal multipliers. The moderation in the structural standard deviations are neutral according to (5.1), given that they increase its numerator and denominator by same scale.[15]

2% (ouptut) and 4% (hours).

[13] This issue has also been raised by Zubairy (2014) and Ramey and Zubairy (2018).

[14] The inability of the neoclassical framework to produce large multipliers has been highlighted by Dyrda and Ríos-Rull (2012) and Ríos-Rull and Huo (2013), who suggest introducing other frictions to motivate higher multipliers.

[15] For the rest of fiscal parameters in Table 5, it is not straightforward to infer the effects they produce on the

Table 9: Present value multipliers.

Sample/Year	Output		Consumption		Investment		Non-defense		Defense	
	PV_g^y	PV_m^y	PV_g^c	PV_m^c	PV_g^x	PV_m^x	PV_g^g	PV_m^g	PV_g^m	PV_m^m
1939-2014										
$j = 0$	0.75	0.59	-0.14	-0.12	-0.11	-0.10	1.00	-0.19	0.00	1.00
1	0.64	0.46	-0.19	-0.16	-0.17	-0.14	1.00	-0.24	0.00	1.00
2	0.54	0.37	-0.24	-0.18	-0.22	-0.17	1.00	-0.28	0.00	1.00
3	0.45	0.29	-0.27	-0.20	-0.28	-0.20	1.00	-0.31	0.00	1.00
4	0.37	0.23	-0.30	-0.21	-0.33	-0.23	1.00	-0.33	0.00	1.00
1939-1954										
$j = 0$	0.74	0.67	-0.13	-0.12	-0.13	-0.12	1.00	-0.09	0.00	1.00
1	0.61	0.53	-0.19	-0.16	-0.20	-0.18	1.00	-0.13	0.00	1.00
2	0.49	0.41	-0.24	-0.20	-0.27	-0.23	1.00	-0.16	0.00	1.00
3	0.39	0.31	-0.28	-0.22	-0.33	-0.27	1.00	-0.19	0.00	1.00
4	0.29	0.23	-0.32	-0.25	-0.39	-0.31	1.00	-0.22	0.00	1.00
1955-2014										
$j = 0$	0.81	0.62	-0.06	-0.03	-0.13	-0.07	1.00	-0.29	0.00	1.00
1	0.70	0.46	-0.09	-0.04	-0.21	-0.09	1.00	-0.41	0.00	1.00
2	0.59	0.34	-0.12	-0.04	-0.29	-0.11	1.00	-0.51	0.00	1.00
3	0.49	0.24	-0.15	-0.04	-0.36	-0.12	1.00	-0.60	0.00	1.00
4	0.40	0.16	-0.17	-0.04	-0.43	-0.12	1.00	-0.68	0.00	1.00

Peak impulse multipliers Alternatively, the fiscal multiplier can be calculated from the impulse-response function in the following manner:

$$PI_{gs}^{y}(j) = \Delta y_{t+j} \cdot \frac{y}{gs}. \tag{5.2}$$

In the above, Δy_{t+j} normally takes the peak response value of output, which in our case coincides with the value on impact; the multipliers for consumption, investment, non-defense, and defense expenditure are defined accordingly. Table 10 shows the multiplier values using this procedure.

For the complete sample, the multiplier is 0.39 for non-defense spending, and 2.19 for defense spending. Interestingly, when the sample is split, the multiplier for non-defense spending is 0.77 in the first sample and 0.28 in the second one. For defense spending, the multiplier is 6.11 on impact during the first sample, and 0.21 in the second one. The definition in (5.2) produces multiplier values that depend on the standard deviation of the structural shocks σ_m and σ_g—which declined after the Korean War, as shown in Table 6—a fact that is irrelevant for the present-value multipliers defined in (5.1). Hence, fiscal multiplier above unity can be attained whenever the structural parameters estimated over the whole sample are incorporated. Ramey (2011, p. 30), who uses a definition similar to (5.2), finds a defense spending multiplier of 1.1 using peak responses and quarterly observations. Analogously, Auerbach and Gorodnichenko (2012, Table 1) calculate a peak impulse defense spending multiplier of 1.16, while Ben Zeev and Pappa (2017, p. 1574) find a cumulative multiplier (over 6 quarters) of 2.14.

multipliers.

Table 10: Peak impulse multipliers.

Sample/Year	Output		Consumption		Investment		Non-defense		Defense	
	PI_g^y	PI_m^y	PI_g^c	PI_m^c	PI_g^x	PI_m^x	PI_g^g	PI_m^g	PI_g^m	PI_m^m
1939-2014										
$j = 0$	0.39	2.19	-0.07	-0.46	-0.06	-0.37	0.52	-0.69	0.00	3.70
1	0.10	0.76	-0.08	-0.55	-0.07	-0.52	0.25	-0.87	0.00	2.70
2	-0.02	0.08	-0.06	-0.51	-0.07	-0.56	0.12	-0.81	0.00	1.96
3	-0.06	-0.25	-0.05	-0.43	-0.07	-0.55	0.05	-0.70	0.00	1.43
4	-0.08	-0.40	-0.04	-0.35	-0.06	-0.52	0.02	-0.57	0.00	1.04
1939-1954										
$j = 0$	0.77	6.11	-0.14	-1.07	-0.14	-1.09	1.05	-0.79	0.00	9.06
1	0.26	2.00	-0.19	-1.45	-0.21	-1.64	0.66	-1.19	0.00	6.27
2	-0.01	-0.16	-0.19	-1.44	-0.23	-1.80	0.41	-1.27	0.00	4.34
3	-0.15	-1.23	-0.17	-1.25	-0.23	-1.74	0.24	-1.25	0.00	3.01
4	-0.22	-1.73	-0.14	-1.03	-0.21	-1.59	0.13	-1.19	0.00	2.08
1955-2014										
$j = 0$	0.28	0.21	-0.02	-0.01	-0.05	-0.02	0.34	-0.10	0.00	0.34
1	0.14	0.07	-0.03	-0.01	-0.08	-0.04	0.25	-0.16	0.00	0.28
2	0.04	0.00	-0.04	-0.01	-0.10	-0.04	0.18	-0.19	0.00	0.23
3	-0.02	-0.04	-0.04	-0.01	-0.11	-0.03	0.13	-0.20	0.00	0.19
4	-0.05	-0.06	-0.04	-0.01	-0.11	-0.02	0.10	-0.19	0.00	0.16

6 Concluding remarks

In this paper, we have explored the role of military spending as a valid instrument to quantify the effects of fiscal policies on output, consumption and investment. For this purpose, and guided by Ramey's (2011) findings, we split our dataset into two samples, before and after the Korean War, and work upon a DSGE model that incorporates news of forthcoming military spending increases. The model parameters have been estimated using Bayesian techniques. We use the posterior distribution to simulate the model and infer several conclusions.

We show that our DSGE model does a good job in capturing anticipated changes in defense spending, the war news shock, relative to those reported by Ramey (2011). However, under the lens of a structural model (not an SVAR), these shocks generate small effect on the variability of model variables in both samples. Ramey (2011) shows that for an SVAR, using the narrative-approach defense news is a valid instrument that can disentangle anticipated movements in fiscal variables from pure fiscal shocks. It's all in the timing. However, in a structural model, the role of war news is ancillary.

We offer evidence that defense and non-defense spending shocks generate present value multipliers of output between 0.6 and 0.8 in the short run, and that these values barely change between samples. Moreover, the model produces a simulated correlogram that replicates key observed moments: a downturn in the correlation of output and defense spending, a counter-cyclical relation between the two fiscal outlays (defense and non-defense), and the leading indicator role of defense spending over investment and output.

Our main conclusion is that obtaining fiscal multipliers above unity largely depends on (i) how one defines a multiplier and (ii) the variance of the structural fiscal shocks. Using the peak of the impulse-response functions, we have shown that multipliers above unity can be generated in our model, but only if data before the Korean War are included. The effect resulting from adding or subtracting these years follows the large moderation that took place after WWII and the Korean War, particularly affecting military spending. Hence, multipliers that include data from these years are to a large extent influenced by these observations. Once we get rid of these data points, the model is unable to produce multipliers above unity, regardless of the definition adopted. For this reason, we recommend using the concept of present value multiplier proposed by Mountford and Uhlig (2009), given that it is neutral with respect to the variance of the structural fiscal shocks. As we claim in the title of our paper, it's all in the variances.

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A Data appendix

Aggregate series come from the Bureau of Economic Analysis (BEA). Given our interest to incorporate observations that include WWII, our analysis is limited to annual series, as quarterly series are only provided by the BEA from 1947 to present. Nominal series are transformed into real series by dividing by the GDP implicit deflator (line 1 Table 1.1.4).

Consumption Consumption C is defined as the sum of non durable goods consumption plus services consumption, $CNonDur + CServ$ (lines 5 and 6 at Table 1.1.5).

Investment Investment X is defined as the sum of durable goods consumption plus gross private domestic investment, $CDur + GPDI$ (lines 4 and 7 at Table 1.1.5).

Government expenditure Total government expenditure is divided into non-defense government expenditure G and defense government expenditure M. Non-defense expenditure consists of federal spending plus state and local public expenditure (Table 1.1.5, lines 25 and 26). Defense government expenditure M is retrieved from Table 1.1.5, line 24. The series of defense government expenditures spans from 1929 through 2014. Table 1.1.6 uses different deflators for government spendings: from 1929 to 1947, from 1942 to 1962, from 1962 to 1982, from 1982 to 2002, and from 2000 to 2014. For the overlapping years, we take the average of the two measures of the two changes (Hall 2009).

Tax rates We follow the methodology proposed by Mendoza, Razin, and Tesar (1994), who derive aggregate estimates for effective tax rates using national accounts.

The consumption tax rate is computed as the sum of Excise taxes, $ExcT$, Customs duties, $CustDut$, and Sales taxes, $SalesT$, divided by the sum of Personal consumption expenditures C and total government expenditures $G + M$ (lines 5, 6, and 7 from Table 3.2 and Lines 2 and 22 from Table 1.1.5):

$$\tau_c = \frac{ExcT + CustDut + SalesT}{C + (G + M)}.$$

The income tax rate is calculated as the ratio of Income tax revenues $IncT$ (federal, state, and local, Lines 3 and 9 in Table 3.4) over the sum of Proprietors' income with inventory valuation and capital consumption adjustments (PI, Line 9 in Table 2.1), Rental income of persons with capital consumption adjustment ($RICCA$, Line 12 in Table 2.1), Personal income receipts on assets ($PIRA$, Line 13 in Table 2.1), Wages and salaries (W) and Supplements to wages and salaries (SW) (Lines 3 and 6 in Table 2.1):

$$\tau_Y = \frac{IncT}{PI + RICCA + PIRA + (W + SW)}.$$

Using the calculated tax rate on income τ_Y, the tax rate on labor income τ_n is derived as

$$\tau_n = \left(\tau_Y + \frac{GSI}{W + SW}\right)\frac{W + SW}{CE}.$$

where GSI denotes Contributions for government social insurance (Line 7 in Table 3.1), and CE denotes Compensation of employees (Line 2 in Table 2.1).

The tax rate on capital income is computed as follows:

$$\tau_k = \frac{\tau_Y\,(PI + RICCA + PIRA) + PT + TCI}{PI + PIRA + IRA},$$

where PT denotes Property taxes (Line 11 in Table 3.4), TCI denotes taxes on corporate income (Lines 7 and 10 in Table 3.2), and IRA denotes Income receipts on assets (Line 9 in Table 4.1).

Figure 6 presents our estimates for the [a] labor, [b] capital, and [c] consumption tax rates as well as [d] the debt-to-output ratio. Both Leeper et al. (2010) and Fernández-Villaverde et al. (2015) use tax rates using a similar strategy. The tax rates and the debt reflect the fiscal expansions resulting from war, primarily WWII.

Ohanian (1997) finds that WWII and the Korean War were financed differently in the U.S.: WWII was financed via debt, holding the tax burden constant, while the Korean War was financed with higher taxation, keeping a balanced budget. By contrast, our estimates reflect increases—as early as in 1940—for the capital income tax or the labor income tax. During the Korean War, these tax rates remained stable relative to the levels reached during the previous years. Yet, the debt-output ratio reached a value of 1.2 at the end of WWII. The ratio decreased afterward, reaching a trough by the end of the 1970s and then growing, alongside the Reagan military buildup. After the Great Recession of 2009, debt accounted for nearly 100% of U.S. GDP, while government spending (in GDP terms) remained stable (see Figure 1).

B First-order and steady state conditions

Given the model economy described in Section 4, let λ_t denote the Lagrange multiplier on the budget constraint that results from merging (4.2) and (4.3) and ξ_t be the multiplier associated with

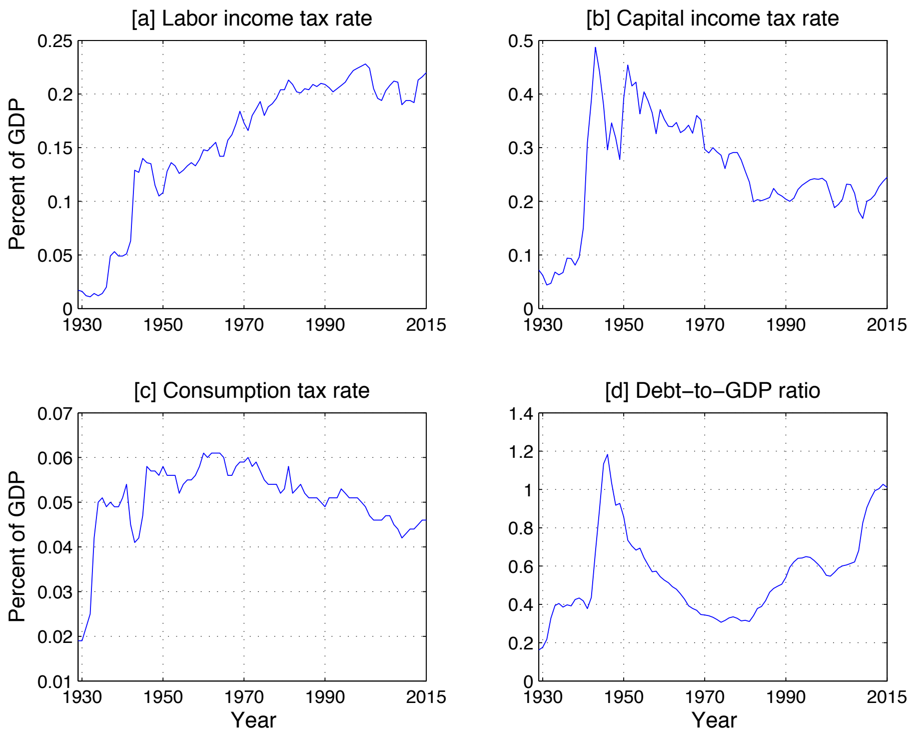

Figure 6: Selected fiscal variables, 1930-2015.

the law of motion for capital (4.4). Then, the first-order conditions that characterize household equilibrium are given by the derivatives of the household Lagrangian with respect to consumption, investment, hours worked, utilization, capital, and bonds

$$\begin{aligned}
\lambda_t(1+\tau_{ct}) &= q_t^{-1} - \beta\mu E_t q_{t+1}^{-1} \\
\lambda_t &= \xi_t - \xi_t\left[S'\left(\frac{x_t}{x_{t-1}}\right)\frac{x_t}{x_{t-1}} + S\left(\frac{x_t}{x_{t-1}}\right)\right] + \beta E_t\xi_{t+1}S'\left(\frac{x_{t+1}}{x_t}\right)\left(\frac{x_{t+1}}{x_t}\right)^2 \\
\lambda_t(1-\tau_{nt})w_t &= \phi n_t^{\chi} \\
\lambda_t(1-\tau_{kt})r_t &= \xi_t\delta'(u_t) \\
\xi_t &= \beta E_t\lambda_{t+1}[(1-\tau_{k,t+1})r_{t+1}u_{t+1} + \delta_0\tau_{k,t+1}] + \beta E_t\xi_{t+1}(1-\delta(u_{t+1})) \\
\lambda_t &= \beta E_t\lambda_{t+1}r_{t+1}^b,
\end{aligned}$$

where $q_t \equiv c_t - \mu c_{t-1}$. To the equations above we add the budget constraint (4.2), the tax equation (4.3), and the law of motion for capital (4.4). For the firm, we provide a definition for output y_t and take the derivatives of the profit function with respect to capital and labor inputs:

$$\begin{aligned}
y_t &= Az_tK_{Ft}^{\alpha}n_{Ft}^{1-\alpha} \\
\alpha y_t &= r_tK_{Ft} \\
(1-\alpha)y_t &= w_tn_{Ft}
\end{aligned}$$

Finally, the government needs to satisfy its budget constraint (4.8) and the fiscal rules (4.9)-(4.14). Note that combining the household and government budget constraints we get the aggregate feasibility constraint (4.15) and that in an equilibrium, $K_{Ft} = u_tk_t$ and $n_{Ft} = n_t$.

In the steady state, we let $y = u = z = 1$. The equilibrium conditions become

$$\begin{aligned}
\lambda(1+\tau_c) &= (1-\beta\mu)q^{-1} \\
\lambda &= \xi \\
\lambda(1-\tau_n)w &= \phi n^{\chi} \\
\lambda(1-\tau_k)r &= \xi\delta_1 \\
\xi &= \beta\lambda[(1-\tau_k)r + \delta_0\tau_k] + \beta\xi(1-\delta_0) \\
1 &= \beta r^b \\
1 &= c + x + g + m \\
k &= (1-\delta_0)k + x \\
q &= (1-\mu)c \\
1 &= Ak^{\alpha}n^{1-\alpha} \\
\alpha &= rk \\
(1-\alpha) &= wn.
\end{aligned}$$