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How Does the US Government Finance Fiscal Shocks?

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How does the U.S. government finance fiscal shocks?

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We develop a method for identifying and quantifying the fiscal channels that help finance government spending shocks. We define fiscal shocks as surprises in defense spending and show that they are more precisely identified when defense stock data are used in addition to aggregate macroeconomic data. Our results show that in the postwar period, about 9% of the U.S. government's unanticipated spending needs were financed by a reduction in the market value of debt and more than 70% by an increase in primary surpluses. Additionally, we find that long-term debt is more effective at absorbing fiscal risk than short-term debt.
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In this paper we explore the dynamic adjustment of the U.S. government's fiscal balances to expenditure shocks. We identify the different fiscal adjustment channels that help stabilize the U.S. government's balances and develop a method for quantifying the use of each channel in the postwar era. To do so, we make use of the government's intertemporal budget constraint. The government's budget constraint dictates that surprise increases in spending must be financed through either an increase in primary surpluses or a reduction in returns on the government's bond portfolio. We refer to the first channel of adjustment as the surplus channel and the second as the debt valuation channel.

The surplus channel operates through an increase in contemporaneous and expected future surplus growth when the news about higher expenditures are revealed whereas the debt valuation channel operates through a decline in contemporaneous and expected future debt returns. In normative models of fiscal policy, adjustments through the debt valuation channel are referred to as "fiscal insurance". Standard models in this literature feature a benevolent government that minimizes the excess burden of taxation by varying its debt returns. The extent to which it can do this is determined by the asset market structure it faces. In complete-market models, a decline in debt returns absorbs the surprise increase

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in spending needs, allowing the government to maintain a constant excess burden of taxation. In incomplete-market models, however, interstate financing of fiscal shocks, hence fiscal insurance through bond markets, is limited.[1]

Several authors have used the implications of these normative models and the empirical behavior of tax rates and debt levels to assess the incompleteness of debt markets.[2] The empirical evidence uncovered and documented in these papers suggests that debt markets are incomplete and hence do not provide *full* insurance against fiscal shocks. However, the prior literature does not quantify how much fiscal insurance the government does achieve through bond markets in practice.[3] Our main contribution is to develop a framework that not only identifies fiscal adjustment channels, but more importantly, provides quantitative estimates of fiscal insurance. This is accomplished by using the intertemporal budget constraint of the government only, and hence without taking an a priori stance on market incompleteness or government preferences.

To quantify the degree of fiscal adjustment through each channel, we proceed in three steps. The first step involves a particular log-linearization of the government's budget constraint which permits a tractable decomposition of the response to fiscal shocks into news about current and future surplus growth and news about current and future debt returns. Motivated by Valerie A. Ramey (2011)'s discussion that defense spending accounts for almost all of the volatility of government spending, we identify fiscal shocks as news to current and future defense spending growth.

In the second step, we carefully construct holding returns on government debt and estimate unstructured VARs to obtain empirical measures of the news variables. There is potentially an important caveat associated with using only aggregate macroeconomic data to estimate these news variables, particularly the news to current and future defense spending growth. As documented by Ramey (2011), the problem is the possible failure of aggregate data to respond to defense spending surprises in a timely manner. Our second contribution is to propose a novel approach that addresses this issue within the VAR framework. Specifically, we include information embedded in the stock returns of companies in the defense industry as additional explanatory variables. Our logic is straightforward. In so far as defense companies' profits and dividends are tied to defense spending, defense stock return variables should respond contemporaneously to news about future defense spending growth. The results from a VAR augmented with defense stock returns confirm our intuition: defense spending growth is indeed predicted more precisely compared to a VAR that includes only aggregate macroeconomic data.

In the third step, we utilize the constructed news variables to estimate the fiscal

[1]See Section I.B for references and a more thorough discussion of normative models.

[2]See, inter alia, Robert J. Barro (1979), Pierre-Olivier Gourinchas and Helen Rey (2007), Andrew Scott (2007) and Albert Marcet and Andrew Scott (2009).

[3]One exception is Elisa Faraglia, Albert Marcet and Andrew Scott (2008), who report covariances between deficit shocks and value of debt for a select group of OECD countries between 1970 and 2000.

adjustment betas that describe the response of expected surpluses and of expected returns to fiscal shocks. The budget constraint decomposition we use maps these fiscal adjustment betas directly into the fraction of fiscal shocks financed through the surplus and debt valuation channels. In the postwar era, most of the fiscal adjustment following fiscal shocks is provided by the surplus channel. Depending on the particular VAR lag specification, the fraction of fiscal risk absorbed by the surplus channel is between 72% and 94%. The amount of fiscal risk absorbed through the debt valuation channel is about 9%, and is robust to different VAR lag lengths used. This estimate for the debt valuation channel is associated with a fiscal adjustment beta of about -0.35, which implies that innovations to real returns on government debt decrease by roughly 35 basis points when innovations to defense spending growth increase by one percent. These results indicate that the U.S. government has achieved a limited, but non-negligible degree of fiscal insurance through the bond markets since 1946.

The debt valuation channel has two components: (i) return variations that are contemporaneous with fiscal news and the focus of much of the normative literature on fiscal policy, and (ii) variations in future returns following fiscal news. We find that only about 2%, roughly 20% of the fiscal adjustment through the debt valuation channel, is achieved through variation in current returns. Variations in future bonds returns, on the other hand, have absorbed over 7% of the fiscal risk in the postwar era. This latter result does not have an analogue in the normative literature, but it is a robust feature of the data.

The debt valuation channel estimates reflect the response of value weighted returns on the government debt portfolio to fiscal shocks. This leads to the question of whether debt of different maturities is equally effective at delivering fiscal insurance. The third contribution of our paper is to provide empirical evidence that long-term debt, mainly through adjustments to future returns, is more effective in absorbing fiscal shocks than short-term debt.[4] Using the augmented VAR, we show that the fraction of fiscal risk absorbed by debt of 1-year maturity is about 7.5%, whereas this fraction is more than double of that amount at 17% for debt of 20-year maturity. The total amount of fiscal insurance depends on the actual maturity composition of government debt. The value weighted maturity of government debt in the postwar period is 3.1 years, delivering an overall fiscal insurance of about 9% as previously stated. While our framework is not designed to provide a policy recommendation on the maturity structure of government debt, the relationship between debt maturity and fiscal insurance we uncover is relevant for models of optimal debt management.

[4]In the normative fiscal literature, two papers display the use of long-term debt to absorb fiscal shocks. One is Hanno Lustig, Christopher Sleet and Sevin Yeltekin (2008), who show that the long-term debt helps the government smooth distortions from costly unanticipated inflation in a dynamic model of optimal fiscal and monetary policy with nominal rigidities, and nominal non-contingent debt of various maturities. The other is Goerge M. Angeletos (2002), who argues that if the maturity structure of public debt is carefully chosen ex ante, the ex post variation in the market value of outstanding long-term debt may offset the contemporaneous variation in the level of fiscal expenditures.

The paper proceeds as follows. Section I log-linearizes and decomposes the budget constraint, and formally defines fiscal shocks and our fiscal adjustment channels. Section II describes the data and reports the empirical results from a benchmark VAR. Section III introduces the VAR model augmented with defense stock variables, presents the associated results and provides a variety of robustness checks. In Section IV, we take a closer look at the composition of government debt and identify the maturities that are more effective in delivering fiscal insurance. Section V concludes.

I. Government Budget Constraint and Fiscal Adjustment

In this section we explore the implications of the government's intertemporal budget constraint and identify the fiscal adjustment channels that help finance expenditure shocks. The dynamic period-by-period version of the government's budget constraint is given by:

$$B_{t+1} = R^b_{t+1} \left(B_t - S_t \right),$$

where B_t denotes the time-t real market value of government debt outstanding at the beginning of the period. S_t denotes the federal government's real primary surplus. It is equal to receipts T_t, inclusive of seignorage revenue, less expenditures G_t. R^b_{t+1} denotes the gross real return paid on the government's bond portfolio between t and $t+1$. This equation can be re-arranged to yield the following expression for the growth rate of government debt as a function of the return on this debt and the primary surplus to debt ratio:

$$\frac{B_{t+1}}{B_t} = R^b_{t+1} \left(1 - \frac{S_t}{B_t} \right). \tag{1}$$

Our goal is to measure the impact of *news* about current and future spending on the budget constraint. In other words, to what extent is this impact offset by contemporaneous and subsequent declines in the market value of outstanding debt and increases in future primary surpluses? To accomplish this task, we first separate the various components of the budget constraint by log-linearizing Equation (1). The log-linearization of the government's budget constraint follows a similar procedure to the log-linearization of the household budget constraint in John Y. Campbell (1993) and the country external budget constraint of Gourinchas and Rey (2007). Campbell's focus is asset pricing, whereas Gourinchas and Rey's is international adjustment to large trade or asset imbalances. Our main focus on the other hand is on the channels that stabilize the U.S. fiscal balance following expenditure shocks.

A. Log-linearizing the budget constraint

Campbell's linearization of the household budget constraint treats labor income as the return on human capital and, hence, part of the return on the household's overall portfolio. The constraint is then re-expressed as a function of household wealth (inclusive of human capital) and consumption, both of which are taken to be positive. In contrast, we treat government income from taxation as a part of the surplus flow rather than as a return on a government asset. The fact that the surplus may be either positive or negative creates difficulties for the log-linearization of (1). We circumvent these issues by expanding around both the average log receipts to debt and log spending to debt ratios and then constructing a weighted log primary surplus.

The log-linearization procedure is valid under the following assumptions regarding spending, receipt and surplus to debt ratios. First, we assume that for all t, the market value of outstanding government debt, B_t, is positive and larger than the primary surplus, S_t. Second, we assume that the logarithm of the receipts to debt ratio, $\log(T_t/B_t)$, and the logarithm of the spending to debt ratio, $\log(G_t/B_t)$, are stationary around their average values $\overline{\tau b}$ and $\overline{gb}$, respectively. Lastly, we suppose that $\exp(\overline{\tau b}) - \exp(\overline{gb})$ lies between 0 and 1.

We have verified that our assumptions are supported by the data for our sample period of 1946.I to 2008.III. Figure 1 displays the time series of $\log(T_t/B_t)$ and $\log(G_t/B_t)$.[5] Optimizing the Bayesian Information Criterion (BIC) proposed by Gideon Schwarz (1978), we find an optimal lag length of one for both time series.[6] The associated Augmented Dickey-Fuller test statistics reveal that the unit-root hypothesis can be rejected for both $\log(T_t/B_t)$ and for $\log(G_t/B_t)$ at the 5% level.[7]

Throughout, our notational convention is to use lower cases to denote log variables and Δ to denote a difference, so that $b_t = \log B_t$, $\Delta b_{t+1} = \log B_{t+1} - \log B_t$, and so on. Let ns_t denote the *weighted log primary surplus*:

$$ns_t = \mu_\tau \tau_t - \mu_g g_t. \tag{2}$$

The weights are derived from the log-linearization of Equation (1) detailed in Appendix A, and are given by

$$\mu_\tau = \frac{\mu_{\tau b}}{\mu_{\tau b} - \mu_{gb}} \qquad \text{and} \qquad \mu_g = \frac{\mu_{gb}}{\mu_{\tau b} - \mu_{gb}}, \tag{3}$$

[5] Details of the fiscal data used to construct T and G can be found in the appendix.

[6] The Akaike Information Criterion (AIC), based on Hirotsugu Akaike (1974), penalizes the number of parameters less severely and as a result suggests that including two ($\log(T_t/B_t)$) or five ($\log(G_t/B_t)$) lags is optimal. In any case, the AIC test statistics were fairly flat for one to ten lags, for both time series.

[7] The ADF(0) test statistic is -3.0879 for $\log(T_t/B_t)$ and -3.1182 for $\log(G_t/B_t)$, each with a 5% critical value of -2.8418. See Said E. Said and David A. Dickey (1984) for details.

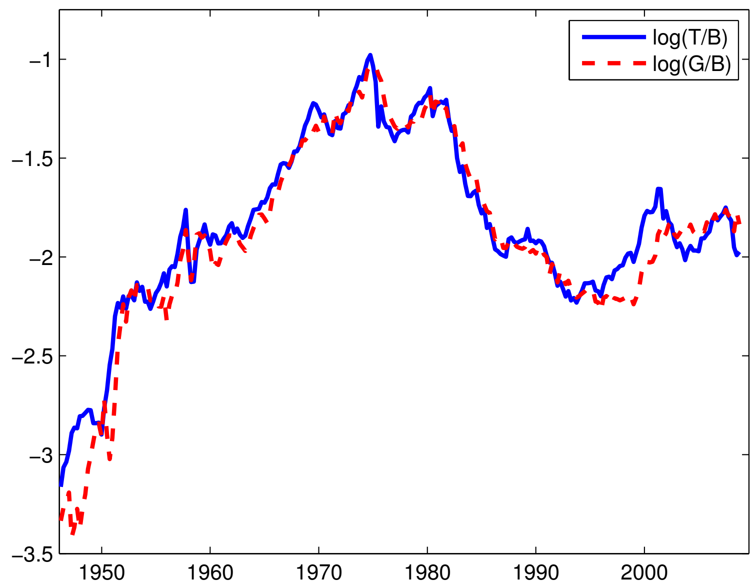

Figure 1. Government Receipts and Spending

Note: This plot shows the logarithm of the receipts to debt ratio, $\log(T_t/B_t)$, and the logarithm of the spending to debt ratio, $\log(G_t/B_t)$. The sample period is 1946.I-2008.III.

where $\mu_{\tau b} = \exp(\overline{\tau b})$ and $\mu_{gb} = \exp(\overline{gb})$. In Appendix A, we also show that under the above assumptions, and ignoring unimportant constants, the log-linearization yields the following approximation for the law of motion for debt:

$$\Delta b_{t+1} = r^b_{t+1} + \left(1 - \frac{1}{\rho}\right)(ns_t - b_t), \tag{4}$$

where $\mu_{sb} = \mu_{\tau b} - \mu_{gb}$ and $\rho = (1 - \mu_{sb}) \in (0, 1)$.

Equation (4) implies the first-order difference equation:

$$ns_t - b_t = \rho r^b_{t+1} - \rho \Delta ns_{t+1} + \rho(ns_{t+1} - b_{t+1}). \tag{5}$$

Solving (5) forward and imposing the tail condition $\lim_{j\to\infty} E_t \rho^j (ns_{t+j} - b_{t+j}) = 0$, we obtain the following expression for the *weighted log surplus to debt ratio*, $ns_t - b_t$:

$$ns_t - b_t = E_t \sum_{j=1}^{\infty} \rho^j \left(r^b_{t+j} - \Delta ns_{t+j}\right). \tag{6}$$

The expression in (6) implies that if the log surplus to debt ratio fluctuates, it has to be due to either a change in expected future returns on outstanding debt, or a change in expected surplus growth. The log surplus to debt ratio reveals deviations from the long-run relationship between surpluses and debt. If it is negative, the surplus is small relative to the market value of debt. In this case, we expect low future returns on government debt or high future surplus growth. If the log surplus to debt ratio is positive, we anticipate high future returns on debt or low future surplus growth.

In a related paper, Chryssi Giannitsarou and Andrew Scott (2006), by following Gourinchas and Rey (2007), derive a log-linearized budget constraint similar to Equation (6) to assess fiscal sustainability in a number of countries.[8] Giannitsarou and Scott use a variance-covariance decomposition of a weighted log deficit to total government liabilities ratio to examine the channels through which governments achieve fiscal sustainability. Our focus on the other hand, is on adjustments to exogenous fiscal shocks. Temporal variations in $ns_t - b_t$ may or may not be anticipated and hence cannot be used to measure shocks. Therefore, we do not base our estimation strategy on Equation (6), but transform it into a relationship between *innovations* to the variables in the budget constraint. This allows us to directly quantify fiscal insurance.

To express Equation (6) in terms of innovations, we compute the difference between expectations at time $t+1$ in (6) minus those at time t, and move $b_{t+1} - E_t b_{t+1} = r^b_{t+1} - E_t r^b_{t+1}$ to the right-hand side. This yields the following expression:

$$ns_{t+1} - E_t ns_{t+1} = (E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j r^b_{t+j+1} - (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j \Delta ns_{t+j+1}.$$

Since $ns_{t+1} - E_t ns_{t+1} = (E_{t+1} - E_t)\Delta ns_{t+1}$, we have:

$$(E_{t+1} - E_t)\Delta ns_{t+1} = (E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j r^b_{t+j+1} - (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j \Delta ns_{t+j+1}. \quad (7)$$

In what follows, we refer to $(E_{t+1} - E_t)X_{t+1}$ as innovations, news, shocks to X_{t+1} for any process X. Equation (7) then states that a positive shock to the (weighted log) surplus growth must correspond either to a positive shock to returns on government debt or to a negative shock to surplus growth. As a corollary, we can infer news about surplus growth from news about returns on government debt.

Ultimately, we are interested in finding out how much the government uses each of the two channels, lower bond returns or higher future surpluses, to finance its unanticipated spending needs. Therefore, we decompose Equation (7) further to isolate the component of the government's budget that we identify with

[8] A recent paper related to Giannitsarou and Scott (2006) is Hess Chung and Eric M. Leeper (2009), which imposes a version of Equation (6) on an identified VAR to study its implications for fiscal financing.

expenditure shocks.

B. Fiscal shocks and fiscal adjustment channels

The presence of active fiscal policy and its associated implementation lags complicate the timing and extraction of news to government expenditures from aggregate government spending data. Ramey (2011) advocates using defense spending data to identify fiscal shocks. She argues that fluctuations in defense spending account for almost all of the fluctuations in total government spending relative to its trend and that non-defense spending accounts for most of the trend in government spending. Ramey also shows evidence that suggests most non-defense spending is done by state and local governments rather than the federal government, undermining the ability of empirical estimations relying on aggregate expenditure data to capture unanticipated changes to government spending.

Motivated by Ramey, we define exogenous shocks to government spending, i.e. fiscal shocks, as innovations to defense spending growth. We do not argue that all defense spending is exogenous, but rather that *innovations* to defense spending are a measure of shocks to government expenditures. To identify these fiscal shocks, we first separate government spending into defense and non-defense components. We then re-derive the log-linearization of the budget constraint in Appendix A by expanding $\log(1 + S_t/B_t)$ in (A2) around three components: the average log receipt to debt ratio, $\overline{\tau b}$, the average log non-defense spending to debt ratio, $\overline{gb}^{ndef}$, and the average log defense to debt ratio, $\overline{gb}^{def}$. We can then redefine ns_t as:

$$ns_t = \mu_\tau \tau_t - \mu_g^{ndef} g_t^{ndef} - \mu_g^{def} g_t^{def}, \tag{8}$$

where

$$\mu_g^{ndef} = \frac{\mu_{gb}^{ndef}}{\mu_{\tau b} - \mu_{gb}^{ndef} - \mu_{gb}^{def}} \quad \text{and} \quad \mu_g^{def} = \frac{\mu_{gb}^{def}}{\mu_{\tau b} - \mu_{gb}^{ndef} - \mu_{gb}^{def}}, \tag{9}$$

with $\mu_{gb}^{ndef} = \exp\left(\overline{gb}^{ndef}\right)$, $\mu_{gb}^{def} = \exp\left(\overline{gb}^{def}\right)$ and $\mu_\tau = 1 + \mu_g^{ndef} + \mu_g^{def}$. We denote the weighted log surplus excluding defense spending with $ns_t^{ndef} = \mu_\tau \tau_t - \mu_g^{ndef} g_t^{ndef}$. This implies that:

$$\Delta ns_{t+1} = \Delta ns_{t+1}^{ndef} - \mu_g^{def} \Delta g_{t+1}^{def},$$

where Δg_{t+1}^{def} denotes the growth in defense spending. Substituting the last equation into (7), and rearranging produces the following relation between news about defense spending growth, news about government debt returns and news about non-defense surplus growth:

$$
\begin{aligned}
(E_{t+1}-E_t)\sum_{j=0}^{\infty}\rho^j\Delta g^{def}_{t+j+1} \quad = \quad & -\frac{1}{\mu_g^{def}}\left((E_{t+1}-E_t)\sum_{j=0}^{\infty}\rho^j r^b_{t+j+1}\right) \\
& +\frac{1}{\mu_g^{def}}\left((E_{t+1}-E_t)\sum_{j=0}^{\infty}\rho^j\Delta ns^{ndef}_{t+j+1}\right),
\end{aligned} \tag{10}
$$

where ρ is now computed as $1-\left(\mu_{\tau b}-\mu_{gb}^{ndef}-\mu_{gb}^{def}\right)$.

Equation (10) is central to our analysis and guides our empirical strategy. It identifies two main channels for stabilizing the government's fiscal balances following a defense spending shock. It implies that a positive shock to defense expenditure growth has to coincide with one of two things: a negative shock to returns on debt, and/or a positive shock to non-defense surplus growth. We refer to the first of these adjustments as the *debt valuation channel*, and the second as the *surplus channel*. To quantify the relative importance of each of these channels, we first develop a framework to construct these news variables and then measure the empirical relationship between them.

The normative fiscal theory refers to the debt valuation channel, specifically the current return component of the debt valuation channel, as *fiscal insurance*. Standard models in the normative literature feature a benevolent government that minimizes the welfare losses arising from variation in marginal tax rates over time and states. If the tax system is sufficiently constrained, then the government will wish to smooth inter-state marginal tax rates and the excess burden of taxation by varying the return it pays on its debt.[9] The extent to which it can do this is determined by the asset market structure it faces.

In complete market models, there are no restrictions on the government's ability to insure against shocks through return variations.[10] At the other extreme, if the government can trade only one period real non-contingent debt, then optimal policy entails intertemporal rather than interstate smoothing of taxes and the excess burden.[11] Intermediate cases in which fiscal insurance is possible, but costly, deliver intermediate results. In these scenarios, the government optimally

[9] If the government has access to lump sum taxation, then Ricardian Equivalence implies that it need make no recourse to bond markets. If it can tax private assets without inducing any contemporaneous distortion, then asset taxation can substitute for variations in debt returns. Lastly, if the government can flexibly adjust both consumption and income tax rates in response to shocks, then again debt is redundant as a fiscal insurance mechanism (see Isabel H. Correia, Juan P. Nicolini and Pedro Teles (2008)). On the other hand, if the tax system is sticky or if the government is constrained to adjust income tax rates in the aftermath of shocks, then debt's essential role as a fiscal insurance instrument is reinstated.

[10] Scott (2007) shows that when markets are complete, the government maintains the excess burden of taxation—the shadow value of the future primary surplus stream—at a constant level. Labor tax rates still vary to the extent that the compensated labor supply elasticity varies. However, these variations are typically dampened relative to an incomplete-market setting.

[11] See Barro (1979) and S. Rao Aiyagari, Albert Marcet, Thomas J. Sargent and Juha Seppala (2002).

responds to shocks with a mixture of interstate and intertemporal smoothing of taxes and the excess burden.[12]

Several contributors, beginning with Barro (1979), have used normative models of the sort described above to assess fiscal policy empirically. Early analysis found evidence of persistence in tax rates consistent with incomplete-market models.[13] More recent work by Scott (2007) and Marcet and Scott (2009) has obtained and empirically assessed the implications of complete and incomplete markets optimal policy models. These two papers provide further evidence of persistence in debt levels and tax rates relative to allocations, suggestive of incomplete-market models and hence limited access to fiscal insurance through bond markets. We, on the other hand, do not take any ex-ante stance on the degree of market completeness or on the preferences of the government. That is, we do not distinguish between the government's inability or unwillingness to engage in fiscal insurance. Our framework relies only on the intertemporal budget constraint of the government, which is consistent with all dynamic fiscal models. Our goal is to develop a method for quantifying fiscal adjustments to fiscal shocks, and apply this method to postwar U.S. data. More specific theoretical mechanisms can be introduced into our framework and tested as restrictions. However, they will have to be consistent with the two channels of adjustment and their relative quantitative importance. Our findings can provide useful information to guide the theoretical fiscal management literature.

We now describe how we use Equation (10) to quantify the debt valuation and surplus adjustments to fiscal shocks.

C. *Quantifying fiscal adjustments*

The debt valuation channel operates through a decline in contemporaneous and expected future returns on the government's debt portfolio when news about higher defense spending growth is revealed, whereas the surplus channel operates through an increase in contemporaneous and expected future non-defense surplus growth. When the government is fully insured against fiscal shocks, the negative shock to expected returns completely offsets the surprise increase in expected defense spending growth. If fiscal shocks are not financed through the debt valuation channel fully, then the government will have to run larger surpluses now or in the future. Before we quantify the relative importance of these two channels, we introduce the following pieces of notation. We denote news about current and future defense spending growth, news about current and future returns to

[12] One example is Lustig, Sleet and Yeltekin (2008). There, a government trades nominal non-contingent debt of various maturities. Costly contemporaneous or expected future inflations allow it to hedge fiscal shocks. Another example is Christopher Sleet (2004) who requires fiscal policy to satisfy incentive compatibility restrictions.

[13] See, for example, Chaipat Sahasakul (1986), David S. Bizer and Steven N. Durlauf (1990) and Gregory D. Hess (1993). However, as Henning Bohn (1998) and Scott (2007) point out, the unit root tests used in this literature have low power against the alternative of optimal policy in an environment with complete markets and persistent shocks.

government debt, and news about current and future non-defense surplus growth by

$$
\begin{aligned}
h_{t+1}(g^{def}) &= (E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j \Delta g^{def}_{t+j+1}, \\
h_{t+1}(r^b) &= (E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j r^b_{t+j+1}, \\
h_{t+1}(ns^{ndef}) &= (E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j \Delta ns^{ndef}_{t+j+1}.
\end{aligned}
$$

With these pieces of notation in place, we can also formally define fiscal insurance in our framework to be a negative covariance between innovations to current and future defense spending growth and innovations to current and future returns:

$$
cov\Big(h_{t+1}(g^{def}), h_{t+1}(r^b)\Big) < 0.
$$

To assess how much of the defense spending shocks is absorbed by debt returns and by future surpluses, we regress both the news about returns and the news about surplus growth on innovations to defense spending growth separately:

$$
\begin{aligned}
h_{t+1}(r^b) &= \beta^r_0 + \beta^r_1 h_{t+1}(g^{def}) + \varepsilon^r_{t+1}, && (11) \\
h_{t+1}(ns^{ndef}) &= \beta^{ns}_0 + \beta^{ns}_1 h_{t+1}(g^{def}) + \varepsilon^{ns}_{t+1}. && (12)
\end{aligned}
$$

If β^r_1 is equal to minus one, the total decline in innovations to current and future debt returns is one percent when the innovations to current and future defense expenditure growth rises by one percent. According to Equation (10), we can map this beta directly into a fraction of total fiscal risk financed by the debt valuation channel. If β^r_1/μ^{def}_g is minus one, the government is obviously fully fiscally insured and does not require any adjustment through the surplus channel. Analogously, if β^{ns}_1/μ^{def}_g is one, the surplus channel fully absorbs the fiscal shocks.

II. Estimating the News Variables

This section provides details on the data and presents our first set of estimation results. We start by setting up an unrestricted VAR to construct innovations to defense spending growth, to government debt returns and to non-defense surplus growth. The state vector of the VAR consists of variables that help estimate the terms in Equation (10), including real holding returns on government debt, non-defense surplus growth and defense spending growth. We use quarterly data that covers the postwar period from 1946.I to 2008.III. We then estimate the fraction of fiscal shocks financed by each adjustment channel using the news variables constructed from the VAR.

A. Government debt returns

Real holding returns on government debt, r_t^b, are central to our analysis and need to be carefully constructed, so that their temporal variation is preserved. Therefore, we do not rely on aggregate fiscal data as in Chung and Leeper (2009), nor on average price and maturity data as in Giannitsarou and Scott (2006) and Faraglia, Marcet and Scott (2008). Instead we employ a multi-step procedure that computes the holding returns for each maturity in order to obtain a value weighted return on total government debt. We start our procedure by employing the Charles R. Nelson and Andrew F. Siegel (1987) technique to extract the time-t nominal zero-coupon yield curve using CRSP Treasury bill and coupon-bond price data.[14] This enables us to compute nominal discount rates, which are converted to real terms using the Consumer Price Index (CPI). Let P_t^k denote the real price of a synthetic zero-coupon government bond that matures at time $t+k$, for $k = 1, \ldots, 120$, where k represents quarters. The time-t real holding return on government debt maturing at $t+k$ can then be computed as $r_t^k = (P_t^{k-1} - P_{t-1}^k)/P_{t-1}^k$. We obtain r_t^b by forming the value weighted average of the quarterly real holding returns r_t^k, across all maturities k:

$$r_t^b \;=\; \sum_{k=1}^{120} w_{t-1}^k r_t^k,$$

where $w_{t-1}^k = s_{t-1}^k P_{t-1}^k / \sum_{l=1}^{120} s_{t-1}^l P_{t-1}^l$ is the time-$(t-1)$ weight for maturity k.

In the definition of w_{t-1}^k, s_t^k denotes the number of time-$(t+k)$ dollars the government has promised to deliver as of time t. The series s_t^k is determined from the CRSP Monthly Treasury database going back to 1960 and from the Treasury Bulletins, the Wall Street Journal and the New York Times for the years 1946 to 1960. These files contain monthly data on the maturity and face value of outstanding publicly held debt, plus coupon-rate data on virtually all negotiable direct obligations of the U.S. Treasury. We unbundle each outstanding bond at time t into its principal and coupon payments, and then construct s_t^k by accumulating, across all bonds, the notional amounts due in k periods.[15] A similar accounting technique is used in George J. Hall and Thomas J. Sargent (1997) for

[14] To facilitate the yield-curve extraction, we clean the price data so that it contains only straight bonds with a maturity of at least one year plus T-bills with 30-days or longer until maturity. We also remove all bonds with 1.5% coupon rates, as they have been documented to contain large spurious errors. For details, see pg. 27 of the CRSP Monthly Treasury U.S. Database Guide.

[15] Note that CRSP does not report the face value of Treasury bills held by the public, and that these data are obtained from table FD-5 of the monthly Treasury Bulletins.

computing the government's real cost of borrowing.[16] Figure 2 shows the times series of r_t^b for our sample period of 1946.I to 2008.III. The average return is close to zero at 0.34%, but the series displays considerable variation with a standard deviation of 2.34%.

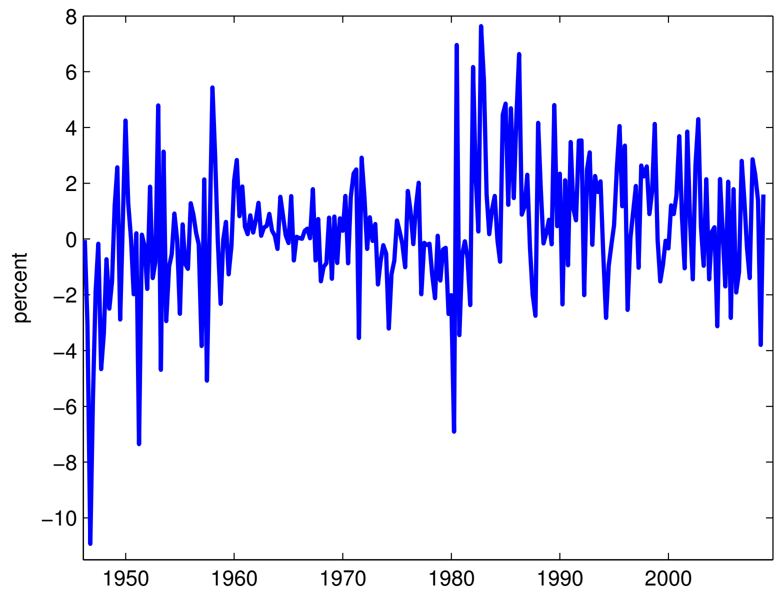

FIGURE 2. REAL HOLDING RETURNS ON GOVERNMENT DEBT

Note: This plot shows the time series of value weighted real holding returns on the government debt portfolio, r_t^b. The sample period is 1946.I-2008.III.

We make the assumption that there are no relevant innovations to slow-moving trends for any of the three variables in Equation (10). This allows us to remove slow-moving trend components, if they exist, of debt returns, non-defense surplus growth and defense spending growth in order to estimate their innovations more precisely. For government debt returns, we do not find any significant trend component. We do, however, observe a sudden upward shift in the average level of returns around 1981.[17] We do not view this increase as part of a slow moving trend but rather as an innovation to government debt returns, which we would

[16]The Treasury reports the interest cost of total government debt, calculated by summing up all the principal and coupon payments the government has promised to deliver at $t + k$ as of time t. The Treasury's methodology makes no distinction between coupon payments and principal payments, and hence mismeasures the cost of funds.

[17]Between 1946 and 1980, real holding returns r_t^b fluctuate around zero, but starting in 1981, the average return level increases to 1.2%.

like to capture. It is possible that this shift in the average returns is related to Volcker disinflation starting in the early 1980's. We therefore include inflation as a state variable in our VAR analysis, but do not detrend r_t^b.

B. Non-defense surplus and defense spending growth

To construct ns_t^{ndef}, we first compute μ_τ, μ_g^{ndef} and μ_g^{def} from the sample averages of the logs of receipts to debt, non-defense spending to debt and defense spending to debt ratios. For our sample period of 1946.I to 2008.III, these weights are $\mu_\tau = 10.877$, $\mu_g^{ndef} = 6.064$ and $\mu_g^{def} = 3.813$. Receipts include current federal tax revenues, contributions for social insurance, income receipts on other assets, current transfer receipts and seignorage revenue. Non-defense spending includes all federal expenditures excluding national defense spending, g^{def}, and excluding interest on debt. Most data are obtained from NIPA tables. The monetary base for calculating the seignorage revenue is obtained from the St. Louis FRED. The computation of the seignorage revenue and the details of the fiscal data are explained further in Appendix B. The debt in question, B_t, measures the time-t real market value of bonds outstanding at the end of $t-1$/beginning of t, and is calculated as:

$$B_t = \sum_{k=1}^{120} s_{t-1}^k P_t^{k-1}.$$

We detrend Δg_t^{def} and Δns_t^{ndef} using a one-sided Robert J. Hodrick and Edward C. Prescott (1997) (HP) filter. The one-sided HP filter uses only past values to estimate the trend and hence preserves the temporal ordering of data. In detrending the two series, we use a smoothing factor of 8330, which tends to cut out frequencies corresponding to periods above 15 years. We choose 15 years as our benchmark because that is the average time between consecutive increases in defense spending, as documented by Ramey (2011) and displayed in Figure 3. The figure includes real defense spending and the Ramey dates for our sample period. The latter are (1941.I,) 1950.III, 1965.I, 1980.I, and 2001.III.[18]

C. Benchmark VAR results

We first estimate a benchmark VAR that includes only aggregate macroeconomic data. The state vector $\mathbf{z_t}$ for this VAR includes real holding returns on government debt, non-defense surplus growth, defense spending growth, as well as two additional variables known to predict real bond returns: quarterly inflation, π_t, computed as the quarterly rate of change of the CPI and the quarterly John H.

[18] In Section III.D, we provide results from a variety of cycles, including the standard cycle length of 9.9 years, employed by the business cycle literature.

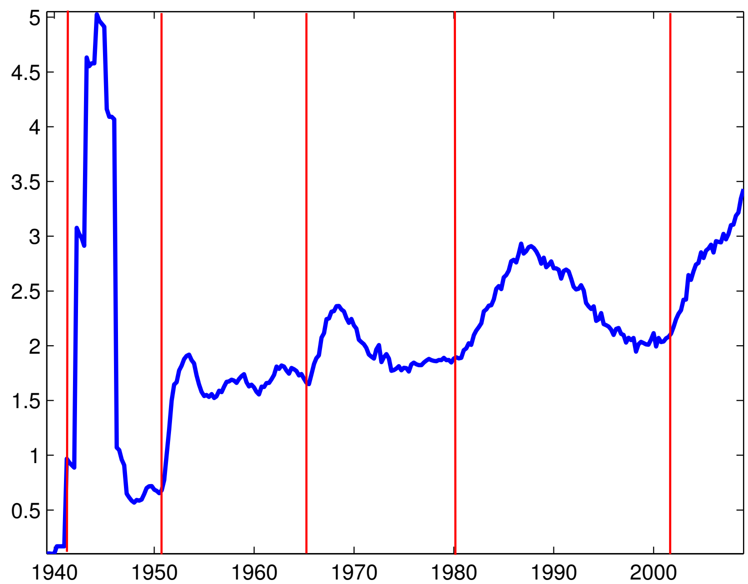

FIGURE 3. REAL DEFENSE SPENDING

Note: This plot shows the time series of real defense spending from 1939 to 2008, as well as the Ramey (2011) defense shock dates (vertical lines).

Cochrane and Monika Piazzesi (2005) risk factor, CP_t. This leaves us with a five-dimensional state vector:

$$\mathbf{z_t} = \begin{pmatrix} r_t^b & \pi_t & \xi_t^{ns,ndef} & CP_t & \xi_t^{g,def} \end{pmatrix},$$

where $\xi_t^{ns,ndef}$ and $\xi_t^{g,ndef}$ are the detrended Δns^{ndef} and Δg^{def} series, respectively. All variables, except inflation and CP, are deflated using the CPI. We demean all the variables and impose a first-order structure on the VAR:

$$\mathbf{z_{t+1}} = \mathbf{A}\mathbf{z_t} + \boldsymbol{\varepsilon}_{\mathbf{t+1}}.$$

Table 1 reports the GMM estimates with their t-statistics.[19] Our results show that this simple specification does reasonably well in predicting the returns on government debt. The R^2 on the return equation is 13.5%, with significant coefficients for CP and inflation. Our results also indicate that, as one would expect, none of the variables are significant in predicting the non-defense surplus growth

[19]We provide robustness checks on the VAR lag length in Section III.D.

or in predicting defense spending growth.

TABLE 1—BENCHMARK VAR ESTIMATES

	r^b_{t-1}	π_{t-1}	$\xi^{ns,ndef}_{t-1}$	CP_{t-1}	$\xi^{g,def}_{t-1}$	R^2
r^b_t	-0.0999	-0.3784	-0.0019	1.9802	-0.0051	0.1353
	(-0.9935)	(-2.1090)	(-0.7394)	(4.5360)	(-0.2569)	
π_t	0.0220	0.5195	0.0019	-0.1504	-0.0031	0.2541
	(0.6618)	(6.1524)	(1.2353)	(-0.8226)	(-0.2749)	
$\xi^{ns,ndef}_t$	0.0557	4.1801	0.0848	-8.3343	-0.3712	0.0196
	(0.0261)	(0.7321)	(0.5727)	(-0.6256)	(-0.6302)	
CP_t	0.0073	0.0221	-0.0002	0.9154	0.0002	0.8763
	(0.8683)	(2.0545)	(-1.3978)	(33.4974)	(0.2663)	
$\xi^{g,def}_t$	-0.0276	0.8138	0.0061	-2.7649	0.0873	0.1260
	(-0.1906)	(1.6801)	(0.5760)	(-1.5209)	(0.4327)	

Note: This table reports the results of the benchmark VAR estimation. The benchmark VAR includes five variables, one lag and uses quarterly data. T-statistics for the GMM estimates are reported in parentheses. We use the Newey-West variance-covariance matrix with four lags as the weighting matrix. The last column reports the R-squared. The sample period is 1946.I-2008.III.

We calculate the news about current and future defense spending growth from the benchmark VAR estimates as:

$$h_{t+1}(g^{def}) = \mathbf{e_5}(\mathbf{I} - \rho\mathbf{A})^{-1}\boldsymbol{\varepsilon}_{\mathbf{t+1}},$$

where $\mathbf{I}$ is the identity matrix, $\mathbf{e_i}$ represents a row vector of dimension five with one in the i'th position and zero everywhere else, and $\boldsymbol{\varepsilon}_{\mathbf{t+1}}$ represent the VAR residuals.[20] We set $\rho = 1 - (\mu_{\tau b} - \mu^{ndef}_{gb} - \mu^{def}_{gb})$ equal to its postwar sample value of 0.9855. We obtain news about current and future government debt returns and news about current and future non-defense surplus growth by:

$$\begin{aligned} h_{t+1}(r^b) &= \mathbf{e_1}(\mathbf{I} - \rho\mathbf{A})^{-1}\boldsymbol{\varepsilon}_{\mathbf{t+1}}, \\ h_{t+1}(ns^{ndef}) &= \mathbf{e_3}(\mathbf{I} - \rho\mathbf{A})^{-1}\boldsymbol{\varepsilon}_{\mathbf{t+1}}. \end{aligned}$$

D. *Benchmark fiscal adjustment results*

This section reports our empirical fiscal adjustment results for the benchmark VAR model.

[20]If Equation (10) were to hold exactly as an equality, constructing all three of the news variables from the same VAR would not be possible because the system would be overidentified. However, Equation (10) is a first-order approximation which allows us to compute the news variables as defined here. We have nevertheless verified our fiscal adjustment results by constructing the relevant news variables from separate VARs that avoid this overidentification problem. These results, which confirm our original estimates, are available from the authors upon request.

Empirical correlations. — Table 2 reports the correlations between the news variables on its off diagonals, and the standard deviations of these variables on the diagonals. We make the following observations. First, news about current and future defense spending growth are strongly negatively correlated with news about current and future returns on government debt (-0.72), providing strong evidence of fiscal insurance in the postwar period. Second, innovations to current and future defense spending growth have twice the volatility of government debt returns. Third, innovations to current and future defense spending growth are positively correlated with innovations to non-defense surplus growth, providing evidence for fiscal adjustment through the surplus channel. The news to non-defense surplus growth is very volatile, with a standard deviation roughly seven times that of news to defense spending growth and 15 times that of news to government debt returns. Finally, there is a moderate negative correlation (-0.42) between news to debt returns and news to non-defense surplus growth, indicating that the interaction between the surplus and the debt valuation channels increases the total amount of fiscal shocks absorbed, rather than counteracting either of the channels.

Table 2—Correlations Between Innovations for Benchmark VAR

	$h_{t+1}(r^b)$	$h_{t+1}(g^{def})$	$h_{t+1}(ns^{ndef})$
$h_{t+1}(r^b)$	0.04		
$h_{t+1}(g^{def})$	-0.72	0.08	
$h_{t+1}(ns^{ndef})$	-0.42	0.40	0.58

Note: This table reports the standard deviations (diagonals) and the correlations (off-diagonals) of the news variables constructed from the benchmark VAR. The sample period is 1946.I-2008.III.

Fiscal adjustment betas. — Table 3 reports the betas from the fiscal adjustment regressions and maps these betas into the fraction of fiscal shocks absorbed by the debt valuation and surplus channels. The fiscal adjustment beta for the debt valuation channel (Line 3) is -0.37, implying that a one-percent shock to defense spending growth induces, on average, a 37 basis points unexpected drop in returns on outstanding public debt. This suggests that a sizable degree of fiscal risk was born by bond holders in the postwar era: 9.61% of defense expenditure shocks were absorbed by an unanticipated decline in current and future bond returns. Over this period, innovations to current and future defense spending growth have accounted for 52% of the total variation in innovations to current and future holding returns on the federal government's outstanding portfolio of bonds.

The fiscal adjustment beta for the surplus channel (Line 4) is 2.80, implying that a one-percent shock to defense spending growth induces, on average, a 2.80 percentage point unexpected increase in current and future non-defense surplus growth. It suggests that the surplus channel has absorbed a significant portion,

Table 3—Fiscal Adjustment Results for Benchmark VAR

	β_0	β_1	R^2	Fraction
$h^c(r^b)$	0.0003	-0.0690	0.0671	0.0181
	(0.2179)	(-2.2625)		
$h^f(r^b)$	0.0017	-0.2973	0.5620	0.0780
	(1.0098)	(-5.2064)		
$h(r^b)$	0.0020	-0.3663	0.5200	0.0961
	(0.8841)	(-4.8947)		
$h(ns^{ndef})$	-0.0001	2.7962	0.1586	0.7334
	(-0.0035)	(5.2112)		

Note: This table reports the results from regressing $h_{t+1}(r^b)$, its components $h^c_{t+1}(r^b)$ and $h^f_{t+1}(r^b)$, and $h_{t+1}(ns^{ndef})$ on $h_{t+1}(g^{def})$, as described in Equations (11) and (12). The first two columns show the intercept and the fiscal adjustment beta, with their t-statistics in parentheses. The third column reports the R-squared, and the final column shows the fraction of fiscal shocks financed by each channel. Innovations are computed from the benchmark VAR. The sample period is 1946.I-2008.III.

73.34%, of fiscal shocks in the postwar era. Over this period, innovations to current and future defense spending growth have accounted for 16% of the total variation in innovations to current and future surplus growth. These results imply that over the sample period, adjustments in bond returns and non-defense surpluses together have financed about 83% of fiscal shocks.[21]

The fiscal adjustment estimates reported in Table 3 are the results of a two-step procedure–in the first step we estimate the VAR and construct the news variables, and in the second step we run fiscal adjustment regressions that treat these news variables as observed data. Although such multi-step procedures yield consistent point estimates and are common practice in the empirical macro and macro-finance literatures, we do provide additional statistics that take into account parameter uncertainty to verify the robustness of our benchmark fiscal adjustment estimates. We do so by computing a Monte Carlo distribution of the betas that takes the benchmark VAR coefficient matrix $\mathbf{A}$ and simulates 10,000 realizations $\{\mathbf{A^{(z)}}\}$ from its asymptotic distribution using the estimated mean and covariance matrix. For each realization $\mathbf{A^{(z)}}$, we compute the innovation variables and re-run the fiscal adjustment regressions to obtain betas $\beta_1^{r,(z)}$ and $\beta_1^{ns,(z)}$. We then simulate 1,000 realizations from the asymptotic distribution of β_1^r and β_1^{ns}, using their respective estimated means and standard deviations to obtain an overall Monte Carlo distribution for each beta. The first, second and third quartile of the $\beta_1^{r,(z)}$ distribution are -0.41, -0.30 and -0.20, translating into 10.84%, 7.84% and 5.20% of fiscal risk absorbed. For the surplus channel, the first, second and third quartile of the $\beta_1^{ns,(z)}$ distribution are 1.51, 2.74 and 4.30, resulting in

[21] The sum of β_1^r/μ_g^{def} and β_1^{ns}/μ_g^{def} can differ from one since Equation (10) is an approximation derived from the intertemporal budget constraint, and hence need not hold with equality. We do not impose any restrictions on the size of the betas, nevertheless our empirical estimates show that their sum is reasonably close to one. This is confirmed by the robustness checks in the next subsection.

39.53%, 71.97% and 112.77% of fiscal risk absorbed. Our reported point estimates for β_1^r and β_1^{ns} are well within these intervals.

Table 3 also reports fiscal adjustment betas for two components of the debt valuation channel: adjustments to current returns and adjustments to future returns. The current fiscal adjustment beta is obtained by regressing the first term in $h_{t+1}(r^b)$, which is $h^c_{t+1}(r^b) = (E_{t+1} - E_t)r^b_{t+1}$, on $h_{t+1}(g^{def})$. According to our estimates, this beta, although statistically significant, is only -0.069. It implies that between 1946 and 2008, only 1.81% of defense spending shocks were absorbed by a surprise decline in contemporaneous debt returns. Most of the adjustment to debt returns after a fiscal shock has come in the form of a decline in future debt returns. The future fiscal adjustment beta, obtained by regressing $h^f_{t+1}(r^b) = (E_{t+1} - E_t)\sum_{j=1}^{\infty} \rho^j r^b_{t+j+1}$, on $h_{t+1}(g^{def})$, is -0.30, which corresponds to 7.80% of the fiscal shocks financed. The normative literature on fiscal policy emphasizes the role of contemporaneous adjustment to returns in providing fiscal insurance. Our results show that adjustments to future returns play an important role and help absorb more of the fiscal shocks. This suggests an additional fiscal adjustment channel for normative models to explore.

III. Defense Shocks and Defense Stocks

For our measures of the debt valuation and surplus channels to be precise, it is important that we estimate innovations to defense spending growth well. These innovations represent any changes to the information set expectations are conditioned on. These changes stem from previously expected but eventually unrealized movements in defense spending growth, and/or from previously unanticipated yet realized movements in defense spending growth. Two factors potentially complicate the extraction of such forecasts from macroeconomic data. First, agents may learn about political and/or military events driving future defense spending growth in advance of this growth occurring or affecting other aggregate variables. Second, macroeconomic data may dilute the new information on defense spending growth during aggregation. Thus, VARs relying exclusively on such aggregate data may fail to identify the true date of the shock.[22] We propose a novel VAR specification that addresses these issues. More specifically, we augment our benchmark VAR specification with information embedded in the stock returns of companies in the defense industry. Our logic is straightforward. In so far as defense companies' profits and dividends are tied to defense spending, defense stock return variables should immediately capture any new information about defense spending growth. If our intuition is correct, then defense stock returns will help identify fiscal shocks more precisely.[23]

[22]See Ramey (2011) for a discussion of the causes and implications of mis-timing shocks when using the VAR approach.

[23]Ramey (2011) and Alan J. Auerbach and Yuriy Gorodnichenko (2010) investigate the predictive power of government spending forecasts provided by the Fed's Greenbook and the Survey of Professional Forecasters for VAR-implied spending shocks and find evidence that these forecasts do indeed have

A. Defense stocks: Excess returns

First, we consider augmenting the benchmark VAR with excess returns on defense stocks, r_t^{def}, relative to the market return, r_t^m, and their price to dividend ratios as additional forecasting variables. Defense stocks are identified as firms with SIC codes between 3760-3769 (Guided missiles and space vehicles), 3795-3795 (Tanks and tank components) and 3480-3489 (Ordnance & accessories). This is identical to the Fama-French definition of the "Guns" industry in their 49 industry portfolios.[24] We use CRSP cum-dividend returns for all defense stocks to compute quarterly value weighted portfolio returns for the defense industry. In addition, we also compute price dividend ratios at the portfolio level, using CRSP data on dividend cash amount (data item DIVAMT). The market return is measured as the return on the value weighted CRSP market portfolio. The inclusion of these additional variables is motivated by the John Y. Campbell and Robert J. Shiller (1988) expression for the dividend to price ratio:

$$d_t - p_t = E_t \sum_{j=1}^{\infty} \rho^j \left(r_{t+j}^s - \Delta d_{t+j} \right),$$

where d is the log dividend, p is the log price, r^s is the holding return and Δd is the dividend growth rate of a stock. All variables are in real terms. Campbell and Shiller argue that a high log dividend to price ratio implies high expected future holding returns or low expected future dividend growth. For our case, this means that excess returns and dividend to price ratios on defense stocks may contain information about current and future dividend growth in the defense industry and hence information on current and future defense spending growth. The state vector for the augmented VAR is:

$$\mathbf{z_t} = \begin{pmatrix} r_t^b & \pi_t & \xi_t^{ns,ndef} & CP_t & \xi_t^{g^{def}} & r_t^{def,excess} \end{pmatrix}, \tag{13}$$

where $r_t^{def,excess} = r_t^{def} - r_t^m$.[25]

Table 4 reports the estimation results using the VAR specification (13). Our results indicate that the excess returns on defense stocks help predict future defense spending growth; the coefficient of excess returns in the defense spending equation is positive and significant. This provides empirical evidence that defense stock returns do indeed contain new information about future defense spending

predictive power. They suggest including these forecasts as additional explanatory variables in the VAR. We have verified that these forecasts do not have any predictive power for our defense spending shocks largely because by extracting deviations from trend, $\xi^{g,def}$, from g^{def} prior to the VAR analysis, we remove these forecastable components from defense spending growth.

[24]For details, see Kenneth French's online data library.

[25]A preliminary analysis of the VAR augmented with these two variables revealed that the dividend to price ratio did not contribute to or alter any of our results. Therefore we omit it from our subsequent estimations and report results from the VAR augmented only with excess returns on defense stocks.

growth. The variation in defense spending growth is explained better compared to our benchmark VAR: the R^2 improves to 13.5%. Additionally, (13) proves to be a slightly better specification for explaining the variation in real holding returns on government debt—the R^2 moves up to 14.2%.

Table 4—Augmented VAR Estimates: Excess Returns on Defense Stocks

	r^b_{t-1}	π_{t-1}	$\xi^{ns,ndef}_{t-1}$	CP_{t-1}	$\xi^{g,def}_{t-1}$	$r^{def,excess}_{t-1}$	R^2
r^b_t	-0.1100	-0.3874	-0.0018	1.9822	-0.0039	0.0213	0.1416
	(-1.1188)	(-2.1251)	(-0.7148)	(4.4558)	(-0.1893)	(1.3103)	
π_t	0.0248	0.5220	0.0019	-0.1509	-0.0035	-0.0060	0.2563
	(0.7289)	(6.0505)	(1.1931)	(-0.8042)	(-0.3017)	(-0.6843)	
$\xi^{ns,ndef}_t$	-0.1391	4.0050	0.0855	-8.2952	-0.3476	0.4101	0.0249
	(-0.0656)	(0.6784)	(0.5684)	(-0.6141)	(-0.5756)	(1.1291)	
CP_t	0.0072	0.0220	-0.0002	0.9154	0.0002	0.0002	0.8763
	(0.8425)	(1.9985)	(-1.3566)	(32.6842)	(0.2749)	(0.2376)	
$\xi^{g,def}_t$	-0.0541	0.7900	0.0062	-2.7595	0.0905	0.0558	0.1348
	(-0.3655)	(1.6001)	(0.5830)	(-1.4908)	(0.4399)	(2.0732)	
$r^{def,excess}_t$	-0.2368	-0.5145	-0.0003	2.0267	0.1312	0.0565	0.0266
	(-0.6912)	(-0.7083)	(-0.0220)	(1.4655)	(2.6914)	(0.7673)	

Note: This table reports the results of the augmented VAR estimation. The augmented VAR includes the five variables from the benchmark VAR plus the excess returns on the Fama and French "Guns" portfolio, $r^{def,excess}$. It has one lag and uses quarterly data. T-statistics for the GMM estimates are reported in parentheses. We use the Newey-West variance-covariance matrix with four lags as the weighting matrix. The last column reports the R-squared. The sample period is 1946.I-2008.III.

Table 5 reports the fiscal adjustment betas and the fraction of fiscal risk absorbed through the debt valuation and the surplus channels, using the innovations estimated by our augmented model. All of the estimated beta coefficients are significant at the five percent level and quantitatively very close to our estimates from the benchmark model. The debt valuation beta is -0.36, implying that a one percent increase in innovations to defense spending growth leads to a 36 basis points decrease in innovations to returns and hence to 9.54% of fiscal shocks absorbed through the debt valuation channel. Of that, only 1.84 percentage points are financed by a drop in current bond returns and the remaining 7.70 percentage points by a decline in future bond returns. The surplus beta is 2.81. It implies that 73.68% of the fiscal risk were absorbed by the surplus channel in the postwar years.

As in the benchmark case, we also compute the Monte Carlo distribution of the betas reported in Table 5. The first, second and third quartile of the $\beta_1^{r,(z)}$ distribution are -0.41, -0.29, and -0.20 and translating into 10.79%, 7.73% and 5.13% of fiscal risk absorbed. For the surplus channel, the first, second and third quartile of the $\beta_1^{ns,(z)}$ distribution are 1.53, 2.79 and 4.39, resulting in 40.14%, 73.29% and 115.05% of fiscal risk absorbed. Our reported point estimates for β_1^r

Table 5—Fiscal Adjustment Results for Augmented VAR: Excess Returns on Defense Stocks

	β_0	β_1	R^2	Fraction
$h^c(r^b)$	0.0003	-0.0702	0.0704	0.0184
	(0.2351)	(-2.3066)		
$h^f(r^b)$	0.0018	-0.2934	0.5480	0.0770
	(1.0169)	(-5.1858)		
$h(r^b)$	0.0021	-0.3636	0.5158	0.0954
	(0.9090)	(-4.9286)		
$h(ns^{ndef})$	0.0002	2.8089	0.1604	0.7368
	(0.0046)	(5.3221)		

Note: This table reports the results from regressing $h_{t+1}(r^b)$, its components $h^c_{t+1}(r^b)$ and $h^f_{t+1}(r^b)$, and $h_{t+1}(ns^{ndef})$ on $h_{t+1}(g^{def})$, as described in Equations (11) and (12). The first two columns show the intercept and the fiscal adjustment beta, with their t-statistics in parentheses. The third column reports the R-squared, and the final column shows the fraction of fiscal shocks financed by each channel. Innovations are computed from the augmented VAR in Table 4. The sample period is 1946.I-2008.III.

and β_1^{ns} are well within these intervals.

B. Defense stocks: Abnormal returns

The excess returns used in the VAR specification (13), $r_t^{def,excess}$, measure movements in defense returns in excess of overall market returns. They may, however, still be correlated with the market return or other systematic risk factors that affect stock returns. We explore the extent to which the industry-specific component of defense stock returns helps predict defense spending growth. Therefore, we replace $r_t^{def,excess}$ with abnormal returns that control for the known systematic stock market factors.

Abnormal returns on defense stocks are constructed by regressing the difference between the returns, r_t^{def}, and the three-month riskfree rate, r_t^{RF}, on the following four factors: the excess return on the market portfolio, MKT, the Eugene F. Fama and Kenneth R. French (1993) size and book-to-market factors, SMB and HML, and the Narasimhan Jegadeesh and Sheridan Titman (1993) momentum factor, UMD. Specifically, we estimate abnormal returns on defense stocks using rolling regressions on moving windows of three years. That is, at time t we only use information from the last three years, and hence exclude observations that are not in the agent's information set.[26] Our model for the returns on the defense industry is:

$$\begin{aligned} r_t^{def} - r_t^{RF} &= \alpha + \beta_{MKT}\mathrm{MKT}_t + \beta_{SMB}\mathrm{SMB}_t + \beta_{HML}\mathrm{HML}_t \\ &\quad + \beta_{UMD}\mathrm{UMD}_t + \varepsilon_t^{def}. \end{aligned} \tag{14}$$

[26] As an alternative, one could use all prior information to estimate abnormal returns as of time t, but this would imply putting less and less weight on recent observations. A moving window of fixed size assigns equal weight to the last three years.

The model is estimated using quarterly data. We refer to the residuals in regression (14) as the abnormal defense stock returns, and denote them by $r_t^{def,abn}$. The new state vector for the VAR is:

$$\mathbf{z_t} = \begin{pmatrix} r_t^b & \pi_t & \xi_t^{ns,ndef} & CP_t & \xi_t^{g,def} & r_t^{def,abn} \end{pmatrix}. \tag{15}$$

Table 6 reports our estimation results using the alternative augmented VAR specification (15). The variation in defense spending growth explained moves up from our benchmark estimate of 12.6% to 15.4%. A one standard deviation increase in abnormal returns increases future defense spending growth by 0.88%, while a one standard deviation increase in excess returns results in a smaller increase of 0.49%. This is computed from multiplying the sample standard deviations for abnormal returns (5.15%) and excess returns (8.84%) with their respective coefficient estimates. In Table 6, the coefficient associated with abnormal returns in the defense spending equation is positive and significant at the ten percent level. We interpret it as providing additional empirical evidence that defense stock returns do indeed contain new information about future defense spending growth. Once again, the augmented model proves to be a slightly better specification for explaining the variation in real holding returns on government debt—the R^2 is 14.2%. Table 7 shows that the fraction of fiscal risk absorbed through the debt valuation and the surplus channels remain virtually unchanged at 9.40% and 72.15%, respectively.

Table 6—Augmented VAR Estimates: Abnormal Returns on Defense Stocks

	r_{t-1}^b	π_{t-1}	$\xi_{t-1}^{ns,ndef}$	CP_{t-1}	$\xi_{t-1}^{g,def}$	$r_{t-1}^{def,abn}$	R^2
r_t^b	-0.0963	-0.3604	-0.0014	1.9695	-0.0064	0.0380	0.1421
	(-0.9465)	(-1.9834)	(-0.5538)	(4.3969)	(-0.3057)	(1.2780)	
π_t	0.0210	0.5143	0.0018	-0.1473	-0.0027	-0.0110	0.2566
	(0.6055)	(6.0028)	(1.1241)	(-0.7954)	(-0.2350)	(-0.6824)	
$\xi_t^{ns,ndef}$	0.0487	4.1453	0.0839	-8.3137	-0.3686	-0.0737	0.0197
	(0.0221)	(0.7249)	(0.5356)	(-0.6048)	(-0.6021)	(-0.1027)	
CP_t	0.0073	0.0222	-0.0002	0.9153	0.0002	0.0003	0.8763
	(0.8498)	(1.9988)	(-1.3200)	(32.4777)	(0.2428)	(0.1768)	
$\xi_t^{g,def}$	-0.0114	0.8944	0.0081	-2.8125	0.0815	0.1706	0.1540
	(-0.0801)	(1.8818)	(0.8119)	(-1.5296)	(0.4100)	(1.9671)	
$r_t^{def,abn}$	-0.2935	-0.1915	0.0004	1.0532	0.1178	0.0288	0.0580
	(-1.8407)	(-0.4259)	(0.0554)	(1.2770)	(4.1135)	(0.3958)	

Note: This table reports the results of the augmented VAR estimation. The augmented VAR includes the five variables from the benchmark VAR plus the abnormal returns on the Fama and French "Guns" portfolio, $r^{def,abn}$. It has one lag and uses quarterly data. T-statistics for the GMM estimates are reported in parentheses. We use the Newey-West variance-covariance matrix with four lags as the weighting matrix. The last column reports the R-squared. The sample period is 1946.I-2008.III.

Table 7—Fiscal Adjustment Results for Augmented VAR: Abnormal Returns on Defense Stocks

	β_0	β_1	R^2	Fraction
$h^c(r^b)$	0.0003	-0.0736	0.0793	0.0193
	(0.2390)	(-2.4640)		
$h^f(r^b)$	0.0017	-0.2846	0.5329	0.0746
	(0.9969)	(-5.1066)		
$h(r^b)$	0.0020	-0.3582	0.5205	0.0940
	(0.9077)	(-4.9918)		
$h(ns^{ndef})$	-0.0003	2.7509	0.1588	0.7215
	(-0.0079)	(5.6460)		

Note: This table reports the results from regressing $h_{t+1}(r^b)$, its components $h^c_{t+1}(r^b)$ and $h^f_{t+1}(r^b)$, and $h_{t+1}(ns^{ndef})$ on $h_{t+1}(g^{def})$, as described in Equations (11) and (12). The first two columns show the intercept and the fiscal adjustment beta, with their t-statistics in parentheses. The third column reports the R-squared, and the final column shows the fraction of fiscal shocks financed by each channel. Innovations are computed from the augmented VAR in Table 6. The sample period is 1946.I-2008.III.

The Monte Carlo distributions for the betas reported in Table 7 are as follows. The first, second and third quartile of the $\beta_1^{r,(z)}$ distribution are -0.40, -0.29 and -0.19, translating into 10.59%, 7.61% and 5.08% of fiscal risk absorbed. For the surplus channel, the first, second and third quartile of the $\beta_1^{ns,(z)}$ distribution are 1.46, 2.70 and 4.27, resulting in 38.39%, 70.69% and 118.90% of fiscal risk absorbed. Once again, our reported point estimates for β_1^r and β_1^{ns} are well within these intervals.

C. *The surplus channel: Receipts vs. non-defense spending*

Our empirical results show that the surplus channel has played a predominant role in absorbing fiscal risk in the U.S. postwar era. An interesting question is how much of this absorption can be attributed to innovations in receipts and how much of it to innovations in non-defense spending. To answer this question, we decompose Equation (10) further to isolate the two components of the surplus channel:

$$\begin{aligned}(E_{t+1}-E_t)\sum_{j=0}^{\infty}\rho^j\Delta g^{def}_{t+j+1} \quad = \quad & -\frac{1}{\mu_g^{def}}\left((E_{t+1}-E_t)\sum_{j=0}^{\infty}\rho^j r^b_{t+j+1}\right)\\ & +\frac{\mu_\tau}{\mu_g^{def}}\left((E_{t+1}-E_t)\sum_{j=0}^{\infty}\rho^j\Delta\tau_{t+j+1}\right)\\ & -\frac{\mu_g^{ndef}}{\mu_g^{def}}\left((E_{t+1}-E_t)\sum_{j=0}^{\infty}\rho^j\Delta g^{ndef}_{t+j+1}\right),\end{aligned}$$

where $\Delta\tau$ and Δg^{ndef} are the growth rates of receipts and non-defense spending, respectively.

To estimate the innovations to receipt growth and non-defense spending growth, we modify our augmented VAR by replacing ns^{ndef} with τ and g^{ndef}. The new VAR state vector is:

$$\mathbf{z_t} = \begin{pmatrix} r_t^b & \pi_t & \xi_t^\tau & \xi_t^{g,ndef} & CP_t & \xi_t^{g,def} & r_t^{def,*} \end{pmatrix},$$

where $\xi_t^{\tau,ndef}$ and $\xi_t^{g,ndef}$ are the detrended $\Delta\tau$ and Δg^{ndef} series, respectively, and $r_t^{def,*} \in \{r_t^{def,excess}, r_t^{def,abn}\}$. We then estimate a first-order VAR to construct the innovations to current and future receipt growth, $h_{t+1}(\tau)$, and the innovations to current and future non-defense spending growth, $h_{t+1}(g^{ndef})$. These news variables are subsequently used in our fiscal adjustment regressions and the results are reported in Table 8. The debt valuation channel beta is now about -0.35 for both excess and abnormal defense stock return cases. This corresponds to 9.1-9.2% of the shocks financed, with adjustments to future returns again constituting a larger part, 7.49% for excess returns and 7.24% for abnormal returns. The fiscal adjustment beta that measures the response of innovations to receipt growth to innovations to defense spending growth is positive and highly significant, with a value of 0.14 for both excess and abnormal returns cases. This suggests that about 39% of the innovations to defense spending growth are absorbed by current and future receipt growth. The fiscal adjustment betas for the non-defense spending is negative and highly significant with values of -0.24 (excess returns) and -0.23 (abnormal returns). These translate into to 37.90% (excess returns) and 36.57% (abnormal returns) of the fiscal risk absorbed by non-defense spending.[27]

The results above also shed some light on why using total government spending, as opposed to defense spending, in assessing fiscal shocks and fiscal insurance can be problematic. If one were to observe an unanticipated change in total spending, it would not be clear what the source of the shock is: defense or possibly non-defense. In our framework, the non-defense part of government spending is itself a *fiscal adjustment* channel for defense spending shocks. Because of this endogeneity problem, we do not use total spending to identify fiscal shocks.

D. Robustness checks

Having shown that the inclusion of defense stock returns improves the fit of our model, we now proceed to perform robustness checks on the augmented VAR. In particular, we investigate the sensitivity of our results to the detrending parameter, and to the VAR lag length. The tables report results from both the VAR

[27]These fractions were calculated by dividing the relevant betas with $(-\mu_\tau/\mu_g^{def})$ for receipt growth and $(-\mu_g^{ndef}/\mu_g^{def})$ for non-defense surplus growth.

TABLE 8—FISCAL ADJUSTMENT RESULTS FOR AUGMENTED VAR: RECEIPTS VS. NON-DEFENSE SPENDING

	Excess Returns				Abnormal Returns			
	β_0	β_1	R^2	Fraction	β_0	β_1	R^2	Fraction
$h^c(r^b)$	0.0003	-0.0656	0.0630	0.0172	0.0003	-0.0690	0.0717	0.0181
	(0.2204)	(-2.1873)			(0.2245)	(-2.3362)		
$h^f(r^b)$	0.0017	-0.2856	0.5379	0.0749	0.0017	-0.2761	0.5204	0.0724
	(1.0247)	(-5.2397)			(1.0024)	(-5.1492)		
$h(r^b)$	0.0020	-0.3512	0.4986	0.0921	0.0020	-0.3451	0.5011	0.0905
	(0.9041)	(-4.8601)			(-0.9023)	(-4.8999)		
$h(\tau)$	-0.0000	0.1382	0.1090	0.3942	-0.0001	0.1383	0.1121	0.3945
	(-0.0178)	(3.3465)			(-0.0393)	(3.3762)		
$h(g^{ndef})$	-0.0001	-0.2383	0.1395	0.3790	-0.0001	-0.2299	0.1348	0.3657
	(-0.0262)	(-3.9979)			(-0.0257)	(-4.1415)		

Note: This table reports the results from regressing $h_{t+1}(r^b)$, its components $h^c_{t+1}(r^b)$ and $h^f_{t+1}(r^b)$, as well as $h_{t+1}(\tau)$ and $h_{t+1}(g^{ndef})$ on $h_{t+1}(g^{def})$. The left panel shows the results with innovations computed from the VAR augmented with excess returns on defense stocks, and the right panel reports the results for the VAR augmented with abnormal returns. In each panel, the first two columns show the intercept and the fiscal adjustment beta, with their t-statistics in parentheses. The third column reports the R-squared, and the final column shows the fraction of fiscal shocks financed by each channel. The sample period is 1946.I-2008.III.

augmented with excess returns and with abnormal returns on defense stocks, but for brevity we discuss only the latter in the text. The results for excess returns are qualitatively identical and quantitatively very close to those for abnormal returns.

DETRENDING. — The fiscal adjustment estimates reported in Tables 5 and 7 are sensitive to the smoothing parameter we use in our HP filter. Our benchmark smoothing factor is 8330, corresponding to 15-year cycles. In Table 9, we report fiscal adjustment betas and the fraction of fiscal risk absorbed by the debt valuation and surplus channels for a variety of smoothing parameters corresponding to shorter and longer cycles, for the augmented VAR specifications. Our findings suggest that as the cycle length increases, the fraction of fiscal shocks financed by the debt valuation channel decreases, while the opposite is true for the surplus channel. The intuition for these results is as follows. As the length of the trend cycle increases, the volatility of filtered defense spending growth rises. Hence the volatility of defense spending news increases relative to that of bond return news. This in turn leads to a decrease in the fiscal adjustment beta.

For the surplus channel, the trend cycle choice affects both the defense spending and the non-defense surplus growth. In particular, as the cycle length increases, the HP filter converges to a linear filter, leaving almost all of the volatility in defense spending growth and non-defense surplus growth in the filtered data. If these two series have nonlinear trend components that are correlated, a very high HP smoothing factor will not filter them out. As a result, these trend components,

Table 9—Fiscal Adjustment Betas for Augmented VAR for a Variety of HP Smoothing Parameters

		Excess Returns			Abnormal Returns		
HP cycle		β_1	R^2	Fraction	β_1	R^2	Fraction
9.9-year*	β_1^r	-0.4290	0.4887	0.1125	-0.4210	0.4871	0.1104
		(-4.2704)			(-4.2539)		
	β_1^{ns}	2.1450	0.0804	0.5626	2.1007	0.0792	0.5510
		(4.9594)			(5.1619)		
15-year	β_1^r	-0.3636	0.5158	0.0954	-0.3582	0.5205	0.0940
		(-4.9286)			(-4.9918)		
	β_1^{ns}	2.8089	0.1604	0.7368	2.7509	0.1588	0.7215
		(5.3221)			(5.6460)		
20-year	β_1^r	-0.3079	0.5594	0.0808	-0.3061	0.5698	0.0803
		(-5.8604)			(-5.9820)		
	β_1^{ns}	3.3832	0.2812	0.8874	3.3279	0.2783	0.8729
		(7.5580)			(7.9734)		
30-year	β_1^r	-0.2463	0.5818	0.0646	-0.2465	0.5958	0.0647
		(-6.7762)			(-6.9505)		
	β_1^{ns}	3.9004	0.4430	1.0231	3.8605	0.4401	1.0126
		(12.3670)			(13.0463)		
50-year	β_1^r	-0.2186	0.5906	0.0573	-0.2189	0.6045	0.0574
		(-7.2490)			(-7.4353)		
	β_1^{ns}	4.1504	0.5261	1.0886	4.1199	0.5240	1.0806
		(16.2031)			(17.1316)		

Note: This table reports the results from regressing $h_{t+1}(r^b)$ and $h_{t+1}(ns^{ndef})$ on $h_{t+1}(g^{def})$, as described in Equations (11) and (12). The left panel shows the results with innovations computed from the VAR augmented with excess returns on defense stocks, and the right panel reports the results for the VAR augmented with abnormal returns. In each panel, the first column shows the fiscal adjustment betas, with their t-statistics in parentheses. The second column reports the R-squared, and the final column shows the fraction of fiscal shocks financed by each channel. We report results for several smoothing parameters for the HP filter. The sample period is 1946.I-2008.III.
*This cycle is actually 9.93 years, corresponding to a HP filter smoothing factor of 1600, the smoothing factor used in business cycle analysis.

which can be anticipated (such as the increases in surpluses to reduce debt and decreases in defense spending following the end of WWII), will be retained in these two series. This induces a higher correlation between the news variables which in turn leads to higher surplus channel betas. For our benchmark cycle length of 15 years, nonlinear trend components are removed whereas extreme cycle lengths such as 50 years fail to do this. In any case, these robustness checks indicate that regardless of the cycle length, the U.S. government has achieved some degree of fiscal insurance through the bond markets during the postwar era.

Lag length. — The fiscal adjustment results reported in the earlier sections are obtained for a first-order VAR. We choose a first-order VAR so that the number of parameters to be estimated relative to the size of the sample is not too large.

As a robustness check, we do, however, perform standard lag length tests that compare the VAR(1) and VAR(2) specifications. The test results are displayed in Table 10 and show that the BIC supports our choice of using one lag. The AIC penalizes the number of parameters less severely, and as a result suggests that a lag length of two is better than one. In this section, we investigate if any of our fiscal adjustment results are sensitive to the lag choice.

Table 10—AIC and BIC Test Statistics for Augmented VAR

Lags	Excess Returns		Abnormal Returns	
	AIC	BIC	AIC	BIC
1	-42.52	-42.02	-43.67	-43.16
2	-42.88	-41.87	-44.02	-43.00

Note: The left panel of this table reports the AIC and BIC test statistics for one and two lags in the VAR augmented with excess returns on defense stocks, and the right panel reports these statistics for the VAR augmented with abnormal returns. The sample period is 1946.I-2008.III. We include data from 1945.IV for VAR(2) to keep the number of observations in the estimations constant.

We find that our estimates for the debt valuation channel are robust to changing the lag length from one to two. With VAR(1), the debt valuation channel absorbs 9.40% (abnormal returns) of the fiscal risk. With VAR(2), this number is only slightly lower 8.97%. The relative contribution of the current and future returns to total fiscal insurance stays virtually the same for both lag length specifications.[28] The debt valuation channel estimates for different HP smoothing parameters are also robust to moving from one to two lags. As the cycle length increases from 9.9 years to 50 years, total fiscal insurance moves from above 11% to under 6% for both lag lengths.

We do, however, find that the estimates for the fraction of fiscal risk absorbed through the surplus channel are indeed sensitive to the lag length. This estimate is 72.15% when obtained from the augmented VAR(1) and 94.13% when two lags are used. To further explore where this change is coming from, we decompose the surplus channel into adjustments that stem from non-defense spending growth and adjustments from receipt growth. We find that the amount of fiscal risk absorbed by non-defense spending growth changes little. It decreases from 36.57% for VAR(1) to 33.03% for VAR(2). The amount of fiscal risk absorbed by receipt growth, on the other hand, changes more significantly. It increases from 39.45% for VAR(1) to 69.20% for VAR(2). While the VAR(2) specification (available in the online appendix) delivers a significantly more precise estimate of the receipt growth innovations by incorporating the delayed response of receipt growth to changes in defense spending growth, it does so at the expense of additional parameters. These additional parameters may lead to overfitting in sample; the AIC and BIC test statistics are inconclusive in determining whether VAR(1) or

[28]The fiscal insurance estimates obtained from the benchmark VAR are similarly robust to changing the lag length from one to two.

VAR(2) represents a better specification.

To summarize, government receipt growth is the only fiscal adjustment channel that is sensitive to the lag length. The sensitivity of the surplus channel to the lag length stems from this changing response of its receipt component. It is important to emphasize, however, that the fiscal insurance results, i.e. the debt valuation channel estimates, are robust across VAR(1) and VAR(2) specifications. The full set of VAR(2) results can be found in the online appendix.

IV. Debt Maturity and Fiscal Insurance

The previous sections documented that in the postwar era, the U.S. government financed part of its surprise spending needs through the bond markets. The normative fiscal theory proposes two ways to deliver fiscal insurance in the absence of real state-contingent debt. One is through surprise increases in inflation in the presence of nominal non-contingent debt (e.g., Henning Bohn (1988)), the other is by a careful choice of the maturity structure when only real non-contingent debt is available (e.g., Angeletos (2002)). The latter suggests that the composition of the government's debt portfolio plays an important role in the degree of financing through the debt valuation channel.[29] In this section, we take a closer look at the composition of government debt and identify the maturities that are more effective in delivering fiscal insurance. We begin by showing some summary statistics. Table 11 displays the average quarterly real holding return and its standard deviation for bonds of different maturities.

Table 11—Real Bond Holding Returns by Maturity

Maturity	1	5	10	15	20
Mean (%)	0.30	0.43	0.48	0.46	0.38
Std dev (%)	(1.52)	(3.58)	(5.74)	(9.78)	(18.05)

Note: This table reports the average quarterly real holding returns (in percentage terms) on bonds of different maturities (in years). Standard deviations are reported in parentheses. Zero-coupon yield curves are constructed from CRSP data. The sample period is 1946.I-2008.III.

Table 11 shows that real holding returns on long-term debt are significantly more volatile than returns on short-term debt. The higher volatility of long-term debt returns has led to arguments for shortening the maturity structure, both in the normative tax literature and in other related work. John Y. Campbell (1995) argues that a cost-minimizing government should respond to a steeply sloped nominal yield curve by shortening the maturity structure since high yield spreads tend to predict high expected bond returns in the future. Robert J. Barro (1997) emphasizes tax smoothing considerations and calls for shortening the maturity

[29] Inflation is included in our VAR state vector. Hence our fiscal insurance estimates represent adjustments to *real returns* after controlling for inflation.

structure when the inflation process becomes more volatile and persistent to help governments reduce their risk exposure and better smooth taxes.

While our framework is not designed to provide a policy recommendation on the maturity structure of government debt, it can be used to uncover some stylized facts about the relationship between debt maturity and fiscal insurance. In particular, it allows us to quantitatively assess the effectiveness of different maturities of debt in financing fiscal shocks. We proceed by modifying our augmented VAR to include the real holding returns on zero-coupon bonds of k-year maturity, r_t^k for each $k \in \{1,\ 5,\ 10,\ 15,\ 20\}$, in addition to all the other variables. The new VAR is:

$$\mathbf{z^k_{t+1}} = \mathbf{A^k}\mathbf{z^k_t} + \boldsymbol{\varepsilon}^{\mathbf{k}}_{\mathbf{t+1}}, \qquad \text{for } k = 1, 5, 10, 15, 20. \tag{16}$$

The state vector now includes seven variables:

$$\mathbf{z^k_t} = \begin{pmatrix} r_t^b & \pi_t & \xi_t^{ns,ndef} & CP_t & \xi_t^{g,def} & r_t^{def,*} & r_t^k \end{pmatrix},$$

where $r_t^{def,*} \in \{r_t^{def,excess}, r_t^{def,abn}\}$.

For each maturity k, we re-estimate Equation (16) and compute the news about current and future government returns, $h_{t+1}(r^k)$, by

$$h_{t+1}(r^k) = \mathbf{e_7}(\mathbf{I} - \rho\mathbf{A^k})^{-1}\boldsymbol{\varepsilon}^{\mathbf{k}}_{\mathbf{t+1}},$$

where $\mathbf{e_7}$ is now a row vector of dimension seven. As before, we then regress the news variable $h_{t+1}(r^k)$ on innovations to current and future defense spending growth, $h_{t+1}(g^{def})$, for each k. The resulting fiscal adjustment beta estimates, $\beta_1^{r,k}$, are reported in Table 12.

The top panel shows the fiscal adjustment betas on, and the fraction of fiscal shocks absorbed by, current and future returns on debt with maturities of 1, 5, 10, 15 and 20 years. All of the estimated betas are significantly negative at the five percent level. The beta for 20-year debt, -0.66, is more than double of the beta for 1-year debt, -0.29. Correspondingly, the fraction of fiscal shocks financed increases with maturity, from 7.49% to 17.22%. The sizable increase in the estimated betas suggests that long-term debt is more effective in absorbing fiscal shocks than short-term debt. However, the decline in the associated t-statistics reported in the Table 12 prevents us from rejecting the null of constant betas across maturities.

In earlier results (see Tables 5 and 7), we document that the fiscal adjustment beta for the debt valuation channel is more precisely estimated for future returns than for current returns. This suggests that future returns may be more suitable for finding a significant link between maturity of debt and absorption of fiscal risk. We therefore estimate the betas using only innovations to future returns and report them for each maturity in the middle panel of Table 12. All of the betas

Table 12—Fiscal Adjustment Betas for Augmented VAR for Each Maturity

Mat	Excess Returns β_0	$\beta_1^{r,k}$	R^2	Fraction	Abnormal Returns β_0	$\beta_1^{r,k}$	R^2	Fraction
		$h(r^b)$				$h(r^b)$		
1	0.0016	-0.2903	0.5660	0.0762	0.0016	-0.2857	0.5683	0.0749
	(0.9619)	(-5.6387)			(0.96411)	(-5.7426)		
5	0.0024	-0.4171	0.4176	0.1094	0.0024	-0.4124	0.4261	0.1082
	(0.7945)	(-4.4024)			(0.7961)	(-4.4595)		
10	0.0030	-0.4839	0.2907	0.1269	0.0030	-0.4800	0.3000	0.1259
	(0.7096)	(-3.4204)			(0.7088)	(-3.4672)		
15	0.0034	-0.5552	0.1814	0.1456	0.0034	-0.5502	0.1855	0.1443
	(0.5400)	(-2.6656)			(0.53417)	(-2.6944)		
20	0.0038	-0.6644	0.0958	0.1743	0.0037	-0.6563	0.0964	0.1722
	(0.3405)	(-2.0408)			(0.3324)	(-2.0473)		
		$h^f(r^b)$				$h^f(r^b)$		
1	0.0013	-0.2138	0.5631	0.0561	0.0012	-0.2075	0.5466	0.0544
	(1.0187)	(-5.2921)			(0.9984)	(-5.2240)		
5	0.0021	-0.3433	0.5606	0.0900	0.0020	-0.3311	0.5392	0.0869
	(1.0126)	(-5.7269)			(0.9842)	(-5.5982)		
10	0.0029	-0.4689	0.5112	0.1230	0.0028	-0.45133	0.4911	0.1184
	(0.9993)	(-5.1305)			(0.9704)	(-5.0221)		
15	0.0034	-0.5571	0.4929	0.1409	0.0033	-0.5182	0.4727	0.1359
	(0.9816)	(-5.2674)			(0.9523)	(-5.1660)		
20	0.0030	-0.4778	0.4464	0.1253	0.0029	-0.4579	0.4201	0.1201
	(0.9228)	(-5.5869)			(0.8932)	(-5.3650)		
		$h^c(r^b)$				$h^c(r^b)$		
1	0.0003	-0.0765	0.2072	0.0201	0.0003	-0.0782	0.2227	0.0205
	(0.4024)	(-4.3019)			(0.4092)	(-4.5561)		
5	0.0003	-0.0738	0.0324	0.0193	0.003	-0.0812	0.0405	0.0213
	(0.1461)	(-1.3483)			(0.1539)	(-1.5254)		
10	0.0001	-0.0150	0.0005	0.0039	0.0001	-0.0286	0.0019	0.0075
	(0.0335)	(-0.1713)			(0.0431)	(-0.3347)		
15	0.0001	-0.0183	0.0002	0.0048	0.0001	-0.0320	0.0008	0.0084
	(0.0229)	(-0.1190)			(0.0254)	(-0.2142)		
20	0.0008	-0.1865	0.0077	0.0489	0.0007	-0.1985	0.0089	0.0521
	(0.0702)	(-0.6378)			(0.0685)	(-0.6906)		

Note: The top panel of this table reports the results from regressing $h_{t+1}(r^k)$ on $h_{t+1}(g^{def})$, maturity by maturity (in years). The first two columns show the intercept and the beta, with their t-statistics in parentheses. The third and fourth columns report the R-squared and the fraction of fiscal shocks financed. The middle and bottom panels report similar results for innovations to future returns and to current returns. Innovations are computed from the VAR augmented with excess returns on defense stocks (left panel) or abnormal returns on defense stocks (right panel), and with r_t^k, $k = 1, 5, 10, 15, 20$. The sample period is 1946.I-2008.III.

are significantly negative and, as anticipated, they are more precisely estimated compared to the betas reported in the top panel. With the confidence intervals used in this paper, the null hypothesis of constant betas across maturities would be rejected.

Our results show that long-term debt, through adjustments to future returns, is more effective in absorbing fiscal shocks than short-term debt. To the best of our knowledge, this is the first empirical documentation of the role of long-term debt as an effective fiscal insurance instrument for the government. The relationship between debt maturity and fiscal insurance that we uncover has important implications for modeling optimal debt management. In particular, our results can help mitigate concerns raised by Campbell (1995) and Barro (1997) about the costs of using long-term debt and support the findings of Lustig, Sleet and Yeltekin (2008). The latter analyze the structure of optimal debt management in an environment with non-contingent nominal debt of various maturities. They show that when costly contemporaneous or expected future inflations allow the government to hedge fiscal shocks, optimal debt management calls for issuing long-term debt only. In their setting, the volatility of long-term debt returns, which we report in Table 11, is deliberate and managed so as to hedge the fiscal risk the government faces. The risk premium on this debt resembles an insurance premium paid by the government; it provides a motive for lengthening the maturity structure.

We also report the fiscal adjustment betas using innovations to current returns for each maturity in the bottom panel of Table 12. These betas are generally not significant, with one exception: the beta for 1-year debt. It absorbs 2.05% of the total 7.49% fiscal insurance provided by debt of 1-year maturity.

Lastly, we verify the robustness of these maturity results for our augmented VAR with two lags. The amount of fiscal insurance estimated using the two lag specification and different maturities shows patterns identical to the one lag case. The fiscal adjustment beta for the debt valuation channel more than doubles from -0.27 at the 1-year maturity to -0.64 at the 20-year maturity. This translates into 7.16% and 16.76% fiscal risk absorbed by 1-year debt and 20-year debt, respectively. For VAR(2), we have also estimated the betas using only innovations to future returns and confirmed that long-term debt, mainly through adjustments to future returns, provides significantly better fiscal insurance relative to short-term debt.

A. *Actual maturity structure of government debt*

The right panel of Table 12 shows that the fraction of fiscal adjustment provided by value weighted returns, 9.40%, falls between the fraction of fiscal risk absorbed by 1-year bonds, 7.49% and 5-year bonds, 10.82%. This suggests that the value weighted maturity of U.S. government debt over the sample period is somewhere between 1 and 5 years. Figure 4 displays the face value weighted and market value weighted maturity structure of U.S. government debt between 1939.I and 2008.III. Both maturity series fluctuate substantially at low frequencies. At the end of the WWII, the value weighted maturity was around eight years, declining to less than two years by the mid-seventies. The face value weighted maturity shows a similar pattern, rising above 8.5 years after WWII and declining to 2.5 years in the mid-seventies. Both maturity series start to increase again in the eighties and stay close to or above three years for the value weighted and above four years for the face value weighted maturity until the end of the sample. Since we use value weighted returns to quantify the debt valuation channel, we focus on the market value weighted maturity. As anticipated, the average value of this series for our regression sample period, between 1946.I and 2008.III, is 3.1 years. This average, combined with the maturity by maturity fiscal insurance results in Table 12, is consistent with our results for the debt valuation channel.

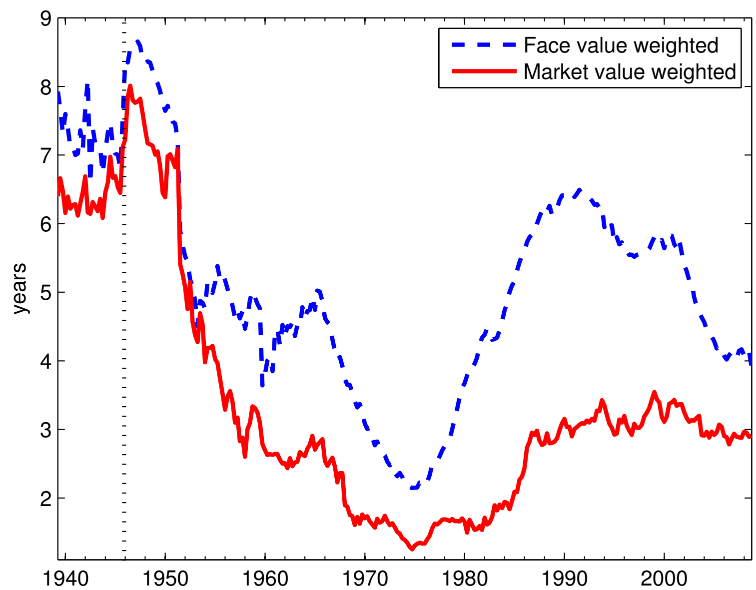

Figure 4. Maturity Structure of Publicly Held Debt

Note: This plot shows the face value weighted and market value weighted maturity (in years) of publicly held debt between 1939.I-2008.III. The vertical dotted line marks 1946.I, the beginning of the sample period for our empirical analysis.

In a related paper, Faraglia, Marcet and Scott (2008) investigate the role of debt management in providing fiscal insurance. They assess the quality of debt management in OECD countries for the sample period 1970 to 2000. The authors perform a cross-country regression of their fiscal insurance measure on debt composition and find that the degree of fiscal insurance achieved is not well connected to *cross-country* variations in debt issuance patterns. We, on the other hand, are able to show empirically that long-term debt is more effective at absorbing fiscal risk than short-term debt. There are multiple key differences between our approach and theirs. First, Faraglia, Marcet and Scott (2008) quantify fiscal insurance by the negative covariance between deficit shocks and the current market value of debt, whereas we measure fiscal insurance by estimating fiscal adjustment betas and mapping them into the fraction of fiscal risk absorbed by current and future return variations. This allows us to use time series data more effectively by including not only the current response of returns, but also the response of *future* returns to fiscal shocks. Second, the authors approximate the market value of debt from average coupon and maturity numbers whereas we unbundle, price and rebundle every outstanding bond to construct this value, preserving not only the volatility of the market value of debt, but more importantly the volatility of holding returns at each maturity. These differences in volatility across maturities are central to our results that link debt maturity to the amount of fiscal insurance. Finally, our sample period extends further back to 1946.

V. Conclusion

The U.S. government's finances, especially in times of high spending such as wars, have been and continue to be a topic of importance for researchers, policy-makers and the tax-paying public. There is, however, limited empirical work on quantifying the adjustment channels that help stabilize the government's balances following fiscal shocks. Our main contribution is to develop a novel framework that links innovations to government spending to innovations to debt returns and innovations to surpluses, and provides a direct measure of fiscal insurance. This framework does not rely on any particular fiscal model, nor does it require taking a stance on asset market completeness or government preferences. We make use of the government's intertemporal budget constraint only, a common feature of all dynamic fiscal models. We show that our log-linearized version of the government's intertemporal budget constraint implies the following. Surprise defense spending needs must be financed either through surprise increases in primary non-defense surpluses or through a surprise decline in current and future bond returns. Our estimates show that in the postwar era, the U.S. government has financed at least 70% of its surprise defense spending needs by running primary non-defense surpluses and about 9% by delivering real capital losses to bond holders. The latter result indicates that the U.S. government was able to achieve a limited, but non-negligible degree of fiscal insurance through bond markets.

Our second contribution is a novel VAR specification that estimates fiscal shocks more precisely and helps resolve the "timing" issue associated with using only aggregate data to identify these shocks. In this novel specification, we include returns on defense stocks as an additional explanatory variable. Defense stock returns respond contemporaneously to news about defense spending growth and hence predict future defense spending growth. Our approach has already been adopted by Jonas D. M. Fisher and Ryan H. Peters (2010), who use similar defense stock variables in their VAR to identify government spending shocks and estimate the response of consumption, real wages, hours and other real macroeconomic variables to such shocks. Our emphasis is on fiscal adjustment channels. The augmented VAR specification confirms our earlier results: the U.S. government has made some use of bond markets to finance its surprise defense spending needs in the postwar era. About 9% of fiscal shocks were absorbed by a drop in current and future returns.

Our third contribution concerns the link between debt maturity and the degree of fiscal insurance. We provide empirical evidence that long-term debt, mainly through adjustment to future returns, is a better instrument for absorbing fiscal risk compared to short-term debt. We show that the fraction of fiscal risk absorbed by debt of 1-year maturity is over 7%, whereas this fraction is more than double of that amount at about 17% for debt of 20-year maturity. These results have important implications for models concerning active management of government debt. Specifically, the effectiveness of long-term debt in absorbing fiscal shocks may help mitigate concerns about the costs of using such debt.

Our analysis separates the responses of bond returns from the response of surpluses to defense spending shocks. We then pursue a further decomposition and estimate the contributions of the responses of non-defense spending and receipts to fiscal shocks. Depending on the particular VAR lag specification, the results indicate that 33% to 38% of fiscal risk is absorbed by a decrease in non-defense spending growth, and between 39% and 69% by an increase in receipt growth. The implications of these different channels of government financing on the rest of the economy, especially on output, consumption, employment and investment, can be quite different depending on the economic environment assumed. We leave the investigation of this to future research.

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Appendix A: Log-linearization of the Government Budget Constraint

We start with the dynamic budget constraint of the government. All variables are expressed in real terms. Let B_t denotes the time-t real market value of government debt outstanding at the beginning of the period. The government budget constraint is given by:

$$B_{t+1} \quad = \quad R^b_{t+1}\left(B_t - S_t\right),$$

where R^b_{t+1} is the gross real return on government debt between t and $t+1$. The government's real primary surplus, $S_t = T_t - G_t$, is computed as the difference between receipts T_t and expenditures G_t. T_t also includes seignorage revenue. The growth rate of government debt can be stated simply as the gross return times one minus the primary surplus to debt ratio:

$$\frac{B_{t+1}}{B_t} \quad = \quad R^b_{t+1}\left(1 - \frac{S_t}{B_t}\right). \tag{A1}$$

We assume that $B_t > 0$ and $B_t > S_t$, for all t. Additionally, we assume that the log receipts to debt ratio, $\log(T_t/B_t)$, and the log spending to debt ratio,

$\log(G_t/B_t)$, are stationary around their respective average values $\overline{\tau b}$ and $\overline{gb}$, and that $\exp(\overline{\tau b})-\exp(\overline{gb})$ is between 0 and 1. Using lower case letters to denote logs, Equation (A1) may be rewritten as:

$$\Delta b_{t+1} = \begin{cases} r^b_{t+1} + \log(1-\exp(s_t - b_t)), & \text{if } S_t > 0 \\ r^b_{t+1} + \log(1+\exp(d_t - b_t)), & \text{if } D_t = -S_t > 0, \end{cases}$$

where we distinguish between the case in which the government is running surpluses and the case in which it is running deficits. If the government only ran surpluses, then we could expand the right-hand side of the log budget constraint as a function of $s_t - b_t$ around $\overline{sb} = \overline{\log SB}$:

$$\log(1-\exp(s_t-b_t)) \quad \approx \quad \log(1-\exp(\overline{sb})) - \frac{\exp(\overline{sb})}{1-\exp(\overline{sb})}\left[(s_t-b_t)-\overline{sb}\right].$$

Since governments do run deficits, an alternative expansion is required. We rewrite $\log(1-S_t/B_t)$ as $\log(1-\exp(\tau_t-b_t)+\exp(g_t-b_t))$ and expand around $(\overline{\tau b}, \overline{gb})$. We obtain:

$$\begin{aligned} \log\left(1-\frac{S_t}{B_t}\right) \quad &\approx \quad \log(1-\exp(\overline{\tau b})+\exp(\overline{gb})) \\ &\quad - \frac{\mu_{sb}}{1-\mu_{sb}}\left(\frac{\mu_{\tau b}\left(\tau_t - b_t - \overline{\tau b}\right) - \mu_{gb}\left(g_t - b_t - \overline{gb}\right)}{\mu_{sb}}\right) \\ &= \quad K - \frac{\mu_{sb}}{1-\mu_{sb}}\left(\frac{\mu_{\tau b}}{\mu_{\tau b}-\mu_{gb}}\tau_t - \frac{\mu_{gb}}{\mu_{\tau b}-\mu_{gb}} g_t - b_t\right), \end{aligned} \tag{A2}$$

where K absorbs unimportant constants. The weights are defined as $\mu_{sb} = \mu_{\tau b} - \mu_{gb}$, with $\mu_{\tau b} = \exp(\overline{\tau b})$ and $\mu_{gb} = \exp(\overline{gb})$.

The approximation in (A2) implies the following law of motion for debt:

$$\Delta b_{t+1} \quad = \quad r^b_{t+1} + \left(1 - \frac{1}{\rho}\right)(ns_t - b_t),$$

where $\rho = 1 - \mu_{sb}$. Rearranging terms produces:

$$ns_t - b_t \quad = \quad \rho r^b_{t+1} - \rho \Delta ns_{t+1} + \rho\left(ns_{t+1} - b_{t+1}\right).$$

This is a first-order difference equation that can be solved by repeated substitution for the weighted log surplus to debt ratio. Taking conditional expectations and imposing the tail condition $\lim_{j\to\infty} E_t\rho^j(ns_{t+j} - b_{t+j}) = 0$, we obtain:

$$ns_t - b_t = E_t \sum_{j=1}^{\infty} \rho^j \left(r^b_{t+j} - \Delta ns_{t+j} \right). \tag{A3}$$

Equation (A3) implies:

$$\begin{aligned} ns_{t+1} - b_{t+1} - E_t(ns_{t+1} - b_{t+1}) &= (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j r^b_{t+j+1} \\ &\quad - (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j \Delta ns_{t+j+1}. \end{aligned}$$

Substituting $r^b_{t+1} - E_t r^b_{t+1}$ for $b_{t+1} - E_t b_{t+1}$ yields:

$$ns_{t+1} - E_t ns_{t+1} = (E_{t+1} - E_t) \sum_{j=0}^{\infty} \rho^j r^b_{t+j+1} - (E_{t+1} - E_t) \sum_{j=1}^{\infty} \rho^j \Delta ns_{t+j+1}.$$

Appendix B: Fiscal Data

The source for most of our fiscal budget data is NIPA Table 3.2, Government Current Receipts and Expenditures, seasonally adjusted and measured in billions of dollars. Government expenditures G include current expenditures (Line 41), gross government investment (Line 42), and capital transfer payments (Line 43). We subtract consumption of fixed capital (Line 45) and debt interest payments (Line 29) from current expenditures. We separate total government expenditure into two components: defense spending, G^{def} and non-defense spending, G^{ndef}. National defense spending data are from NIPA Table 3.9.5., Line 11 (national defense expenditures). They are seasonally adjusted and measured in billions of dollars. We adjust G^{def} by subtracting the proportion of consumption of fixed capital that's attributable to defense spending (as a percentage of total spending). We compute G^{ndef} by subtracting G^{def} from total expenditures G.

We calculate government receipts, T, by taking total receipts (Line 37 of NIPA Table 3.2), which includes current tax receipts, contributions for social insurance, income receipts on other assets and current transfer receipts, and adding on seignorage revenue. We compute seignorage revenue at time t as $(M_t - M_{t-1})/CPI_t$, where M_t is the monetary base at time t and CPI_t is the price level defined by the consumer price index at t. Therefore real seignorage revenue includes the "inflation tax", the resources generated from adjusting the real value of the existing monetary base, and the real value of revenues from a change in the monetary base. The monetary base data are the St. Louis Adjusted Monetary Base (AMBSL) series, seasonally adjusted and measured in billions of dollars.