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**CHRONICLE OF A WAR FORETOLD:  
THE MACROECONOMIC EFFECTS OF  
ANTICIPATED DEFENSE SPENDING  
SHOCKS**

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# **CHRONICLE OF A WAR FORETOLD: THE MACROECONOMIC EFFECTS OF ANTICIPATED DEFENSE SPENDING SHOCKS**

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## ABSTRACT

### Chronicle of a War Foretold: The Macroeconomic Effects of Anticipated Defense Spending Shocks\*

We identify US defense news shocks as shocks that best explain future movements in defense spending over a five-year horizon and are orthogonal to current defense spending. Our identified shocks are strongly correlated with the Ramey (2011) news shocks, but explain a larger share of macroeconomic fluctuations and have significant demand effects. Fiscal news induces significant and persistent increases in output, consumption, investment, hours and the interest rate. Standard DSGE models fail to produce such a pattern. We propose a sticky price model with distortionary taxation, variable capital utilization, capital adjustment costs and rule-of-thumb consumers that replicates the empirical findings.

JEL Classification: E62, E65 and H30

Keywords: defense spending news, DSGE model, maximum forecast error variance and SVAR

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# 1 Introduction

As Horace (65 BC-8 BC) explains "Life is largely a matter of expectation." After the seminal works of [Beaudry and Portier \(2007\)](#) and [Jaimovich and Rebelo \(2009\)](#), economists seem to agree that macroeconomic fluctuations may be driven by changes in expectations rather than current economic conditions and that agents react to changes in exogenous fundamentals before such changes materialize. [Schmitt-Grohé and Uribe \(2012\)](#) show that anticipated shocks account for about half of aggregate fluctuations in the US.

It is usually difficult to measure news but in some cases researchers were able to identify news by using the timing of specific events. Such strategy is available when trying to identify fiscal changes.<sup>1</sup> [Ramey \(2011\)](#) constructs two measures of news about changes in military spending. The first uses narrative evidence (based on information in the Business Week and other newspapers) to construct an estimate of the change in the expected present value of government spending. The second is constructed using the Survey of Professional Forecasters, and estimated changes in government spending are measured as the difference between actual government spending growth and the forecast of government growth made one quarter earlier. [Ramey \(2011\)](#) shows that VAR shocks incorrectly capture the timing of the news. Thus, inference about dynamic fiscal multipliers,<sup>2</sup> or the effects of fiscal news in the macroeconomy are likely to be biased.

In this paper, we propose an alternative methodology to identify fiscal news in the data which is easier to implement and can be used in situations where narrative evidence is unavailable: Defense news shocks are the shocks that best explain future movements in defense spending over a horizon of five years and that are orthogonal to current defense spending, as in [Barsky and Sims \(2011\)](#).<sup>3</sup> Our

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<sup>1</sup>[Mertens and Ravn \(2012\)](#) also categorize tax changes in the US as anticipated or unanticipated depending on the difference of the announcement and implementation date using narrative evidence of tax changes provided by [Romer and Romer \(2010\)](#).

<sup>2</sup>Along these lines, [Forni and Gambetti \(2011\)](#), [Leeper et al. \(2012\)](#), and [Leeper et al. \(2013\)](#) have shown that, because of the existence of legislative and implementation lags, private agents receive signals about future changes in governments spending before these changes take actually place, thus casting doubts on the evidence of previous SVAR literature on fiscal shocks as VAR representations are likely to be non-fundamental.

<sup>3</sup>[Barsky and Sims \(2011\)](#) used this identification approach to identify news shocks about future total factor productivity.

identified defense news shocks are strongly correlated with the [Ramey \(2011\)](#) news shocks, but they explain a much larger fraction of the variability in all real variables at business cycle frequencies. Also, they have a significant and more positive effect in the economy. In particular, anticipated fiscal shocks induce a significant and persistent increase in output, consumption, investment, hours and the interest rate. Hence, the component of the shock identified using the maximum forecast error variance methodology (henceforth MFEV) that is independent of the Ramey shock series contains important information on future defense spending.

Standard models seem to be incapable of generating responses which are compatible with the data. In fact, in these models consumption falls after a news shock and output reacts less strongly. We have experimented with various alternatives in order to identify the mechanism that would propagate the effects of news shocks in a way compatible with the data. We find that (a) distortionary income taxation, (b) variable capital utilization and capital adjustment costs, and (c) rule of thumb consumers are necessary to have responses that look like those in the data.

Several other studies analyze the macroeconomic effects of anticipated government spending shocks. [Mertens and Ravn \(2010\)](#), for example, use a DSGE model to derive a fiscal SVAR estimator that is applicable when shocks are permanent and anticipated and use it with US data. Our framework is less restrictive since it can deal with temporary fiscal shocks and uses medium-run rather than long-run constraints to identify them. [Leeper et al. \(2012\)](#) identify two types of fiscal news concerning government spending and tax policies. They identify government spending news using the Survey of Professional Forecasters and map the reduced-form estimates of news into a DSGE framework. They find that fiscal news is a time-varying process and incorrectly assuming time-invariant processes to model news might be misleading. [Gambetti \(2012\)](#) assesses the information content of government spending news constructed as the difference between the forecast of government spending growth over the next three quarters made by the agents at time  $t$  (measured with the Survey of Professional Forecasters) and the forecast of the same variable made at time  $t - 1$ . He finds that the identified government spending news shock in a VAR generates Keynesian type of effects, increasing output and consumption and real wages before the actual

increase in spending but crowding out private investment.

The remainder of the paper is organized as follows. Section 2 describes the econometric framework. Section 3 presents the main empirical results and in section 4 we examine their sensitivity to changes in the model specification. In Section 5 we present the standard model and introduce the necessary modifications to match the model and data responses and Section 6 concludes.

## 2 Econometric Strategy

### 2.1 Data

The data covers the period from 1947:Q1 to 2008:Q4. Recent work by [Leeper et al. \(2013\)](#) and [Ramey \(2011\)](#) has discussed the issue of missing information with respect to defense news events and how it can undermine identification in SVAR's. One efficient way to address this problem is by directly adding more information to the VAR, as in [Sims \(2012\)](#) and [Forni and Gambetti \(2011\)](#). Thus, together with real per capita defense spending, we also include in the VAR the [Ramey \(2011\)](#) measure of defense news shocks. Apart from enabling us to alleviate the missing information problem, the inclusion of this series allows us to check how the news series we extract correlates with the latter series and to compare the effects of our shock with the effects of Ramey's news shock.

In addition to the defense spending variable and the [Ramey \(2011\)](#) news series, we also include in the VAR output, hours, consumption, and investment, all in real per capita terms, as well as the real manufacturing wage, the [Barro and Redlick \(2011\)](#) average marginal tax rate, the interest rate on 3 month T-bills, and CPI inflation. The data comes from Ramey's website.<sup>4</sup>

### 2.2 Identifying Defense News Shocks

The defense news shock is identified as the shock that best explains future movements in defense spending over a horizon of five years and that is orthogonal to current defense spending. To

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<sup>4</sup><http://weber.ucsd.edu/~vramey/>

obtain such shock we need to find the linear combination of VAR innovations contemporaneously uncorrelated with current defense spending which maximally contributes to defense spending's future forecast error variance as in [Barsky and Sims \(2011\)](#). The orthogonality restriction relative to defense spending is important since it requires the identified shock to have no contemporaneous effect on defense spending.

Let  $y_t$  be a  $k \times 1$  vector of observables of length  $T$ . Let the reduced form moving average representation in the levels of the observables be:

$$y_t = B(L)u_t \tag{1}$$

where  $B(L)$  is a  $k \times k$  matrix polynomial in the lag operator,  $L$ , and  $u_t$  is the  $k \times 1$  vector of reduced-form innovations. We assume that reduced-form innovations and structural shocks,  $\varepsilon_t$ , are linked by

$$u_t = A\varepsilon_t \tag{2}$$

Equations (1) and (2) imply

$$y_t = C(L)\varepsilon_t \tag{3}$$

where  $C(L) = B(L)A$  and  $\varepsilon_t = A^{-1}u_t$ . The matrix  $A$  must satisfy  $AA' = \Sigma$ , where  $\Sigma$  is the variance-covariance matrix of reduced-form innovations. There are, however, an infinite number of  $A$ 's that satisfy the restriction. For some arbitrary orthogonalization,  $\tilde{A}$  (for example, the Choleski decomposition), the space of permissible impact matrices can be written as  $\tilde{A}D$ , where  $D$  is a  $k \times k$  orthonormal matrix ( $D' = D^{-1}$ , which entails  $D'D = DD' = I$ ).

The  $h$  step ahead forecast error is

$$y_{t+h} - E_t y_{t+h} = \sum_{\tau=0}^h B_\tau \tilde{A} D \varepsilon_{t+h-\tau} \tag{4}$$

where  $B_\tau$  is the matrix of moving average coefficients at horizon  $\tau$ . The contribution to the forecast error variance of variable  $i$  attributable to structural shock  $j$  at horizon  $h$  is

$$\Omega_{i,j} = \sum_{\tau=0}^h B_{i,\tau} \tilde{A} \gamma \gamma' \tilde{A}' B'_{i,\tau} \quad (5)$$

where  $\gamma$  is the  $j$ th column of  $D$ ,  $\tilde{A}\gamma$  is a  $k \times 1$  vector corresponding with the  $j$ th column of a possible orthogonalization, and  $B_{i,\tau}$  represents the  $i$ th row of the matrix of moving average coefficients at horizon  $\tau$ . We put defense spending in the first position in the system, and index the defense news shock as 1. Our identification procedure requires finding the  $\gamma$  which maximizes the sum of contributions to the forecast error variance of defense spending from horizon 0 to horizon  $H$  (the truncation horizon), subject to the restriction that these shocks have no contemporaneous effect on defense spending. Formally, we need to solve the following optimization problem

$$\gamma^* = \underset{\gamma}{\operatorname{argmax}} \sum_{h=0}^H \Omega_{1,1}(h) = \sum_{h=0}^H \sum_{\tau=0}^h B_{1,\tau} \tilde{A} \gamma \gamma' \tilde{A}' B'_{1,\tau} \quad (6)$$

$$\text{subject to} \quad \tilde{A}(1, j) = 0 \quad \forall j > 1 \quad (7)$$

$$\gamma(1, 1) = 0 \quad (8)$$

$$\gamma' \gamma = 1 \quad (9)$$

The first two constraints impose on the identified news shock to have no contemporaneous effect on defense spending. The third restriction ensures that  $\gamma$  is a column vector belonging to an orthonormal matrix. This normalization implies that the identified shocks have unit variance.

In the benchmark set up  $H=20$  quarters. Hence, the defense news shock we identify is the shock that is orthogonal to defense spending and which maximally explains future variation in defense spending over a horizon of five years. The lag of the model is set to 4 which is a midway between what standard criteria suggest (The Akaike criteria favors six lags, the Hannan-Quinn information and Schwartz criteria favor two lags, and the likelihood ratio test statistic chooses eight lags). We examine the robustness of our results to alternative lag lengths and alternative  $H$  in Section 4.



## 3 Empirical Evidence

### 3.1 Identified News Shocks and Ramey News Shocks

Figure 1 shows the time series of identified (MFEV) news and the Ramey news shocks. The Ramey news shock is identified as the innovation in the Ramey news variable orthogonalized with respect to current defense spending.<sup>5</sup> To make the figure more readable, we present a one year backward looking average of the shock series. Shaded areas represent the war periods.

The two shock series are highly correlated with a contemporaneous correlation of 0.85. It is apparent that our news shock series captures important defense news events, such as the Korean war, Vietnam war, the Carter-Reagan buildup that began in the early 1980's, and the fall of the Berlin wall at the end of the 1980's. All of these events are also accounted for in the series of Ramey (2011). However, as we shall see in the next section, while strongly correlated, these two series have significantly different impacts on macroeconomic variables.

### 3.2 Impulse Responses

Figure 2a shows the estimated impulse responses of all the variables to a positive one standard deviation defense news shock from the benchmark VAR, with the dashed lines representing 2.5st and 97.5th percentile confidence bands. These bands are constructed from a residual based bootstrap procedure repeated 2000 times.<sup>6</sup>

Following a positive defense news shock, defense spending does not change on impact, by construction, and then grows gradually peaking after 7 quarters at 3.9%. Output, investment, consumption, and hours all increase on impact, with the responses being statistically significant at 0.35%, 0.82%, 0.32%, 0.32%, respectively. The peak response of output occurs after 3 quarters

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<sup>5</sup>It is important to add this orthogonalization restriction since its omission implies that the Ramey news shock has a significant impact effect on defense spending.

<sup>6</sup>We use the Hall confidence interval (see Hall (1992)) which attains the nominal confidence content, at least asymptotically, under general conditions and has relatively good small sample properties as shown by Kilian (1999).

reaching 0.59%, reflecting a multiplier of 4.27.<sup>7</sup> Output and hours have a hump-shaped response that dies off after three years; consumption and investment responses return to zero after a year and a half.

It is also apparent that the real wage declines significantly following the news shock. Given that the real wage is measured as the product wage in the manufacturing sector rather than the consumption wage, this result can be interpreted along the lines of [Ramey and Shapiro \(1998\)](#) who showed that the relative price of manufactured goods rises significantly during a defense buildup and, thus, product wages in these industries can fall at the same time that the consumption wage is unchanged or rising. The news shock also raises the average marginal income tax rate, inflation and interest rates. Note that the tax rate increases in a gradual manner reflecting the notion that defense news shocks foretell future increases in both defense spending and tax rates.

Figure [2b](#) shows the estimated impulse responses to a positive one standard deviation shock to the Ramey news variable. Two important differences stand out. First, our identified news shock has a larger effect on defense spending: the peak response of spending following the Ramey news shock is 3.3% compared to 3.9% following our news shock. Second, the responses of all the macro variables are significantly weaker. For example, the peak response of output occurs after 5 quarters, generating a multiplier of 1.13. On the other hand, the responses of hours are insignificant at all horizons. Furthermore, the responses of investment, consumption, and interest rates, though not significant, have signs which are the opposite of those obtained with our news series.

### 3.3 Forecast Error Variance Decomposition

Figure [3](#) shows the share of the forecast error variance of the endogenous variables attributable to our defense news shocks and the Ramey news shock. In general, our news shock explains a larger share of the forecast error variance of all variables. For example, it explains 54% of the variation in defense spending at the three year horizon compared to 38% for the Ramey news

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<sup>7</sup>The multiplier is computed as the product of the ratio of the impulse responses of output and defense spending at the 3 quarter horizon and the average ratio of nominal GDP to nominal defense spending over the sample period.

shock. Moreover, our news shock explains 70% of the variation in the Ramey news variable on impact. This indicates that our identified news shock is strongly related to Ramey's news shock though it appears to contain more information about future defense spending.

In addition to the defense spending variable, our MFEV news shock accounts for a much larger share of the forecast error variance of all other variables: It explains 23% and 28% of output and hours variation at the one year horizon, respectively, compared to 2% and 0% explained by Ramey's news shock; and a much bigger share of the variation in the nominal variables and the [Barro and Redlick \(2011\)](#) average marginal tax rate. In particular, our news shocks explains 21% of the variation in inflation at the three quarter horizon and 22% of the variation in the tax rate at the two year horizon, compared to 9% and 4% of the Ramey news shock, respectively. Furthermore, our news shock explains 13% of the variation in interest rates at the two year horizon, compared to zero in the case of Ramey's news shock.

To examine whether the differences between the contributions of the MFEV news shock and the Ramey news shock to the variables' variation are statistically significant, we estimated for all variables the p-value for the null hypothesis that the difference between the contribution the MFEV news shock and the Ramey news does not exceed zero. Each estimated p-value was obtained as the proportion of bootstrap values of the contribution difference of the two shocks not exceeding zero.<sup>8</sup> Our estimated p-values indicate that the differences are generally significant. [Table 2](#) presents these results. To be concise, we focus on the horizon for which the point estimate of the contribution difference is maximal. P-values are sufficiently low for most variables: The contribution differences for defense spending, output, hours, the [Barro and Redlick \(2011\)](#) average marginal tax rate, and investment appear to be highly significant with p-values of 0%, 2.2%, 1.1%, 3.2%, and 6.1%, respectively, and those corresponding to inflation and consumption are moderately significant with p-values of 10.6% and 12.5%, respectively. The zero p-value for the null hypothesis that the difference between the contribution of our news shock and the Ramey news shock to the defense spending variation is not positive strongly indicates that our news shock contains relatively more

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<sup>8</sup>As noted in [Lutkepohl \(2005\)](#) on p. 712, this estimation procedure will yield p-value estimates that are consistent under general assumptions.

information about future defense spending.

## 4 Robustness

This section addresses five potentially important issues regarding the analysis undertaken in the previous section. The first is the concern that assuming different lag specifications or alternative truncation horizons for the MFEV optimization problem may produce different results. The second issue pertains to the potential effect that altering the sample period, such that either the World War II period is included or the Korean War period is excluded, may have on the benchmark results. The third issue we examine is whether our shock is correlated with the identified defense shock of [Fisher and Peters \(2011\)](#) which corresponds to the innovation to the accumulated excess returns of large US military contractors. Finally, we confirm that our results are not driven by a positive correlation of our identified shock with other structural disturbances that are identified in the literature as potential drivers of business cycle fluctuations.<sup>9</sup>

### 4.1 VAR Lags and the Truncation Horizon

Figure [4a](#) shows the impulse responses obtained with lag lengths, from 3 to 6. As evident, the impulse responses to all of the variables are in general similar both qualitatively and quantitatively. The only noticeable difference is in the response of the [Barro and Redlick \(2011\)](#) income tax rate which is weaker and negative on impact for the model with 6 lags. Figure [4b](#) displays the responses for four separate horizons,  $H = 10, 20$  (benchmark), 30, and 40. The results are similar for all horizons.

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<sup>9</sup>We have also tried a battery of sensitivity tests regarding the number of variables in the VAR and their ordering: Our results are insensitive to such changes and we do not present them here for economy of space.

## 4.2 Changing the Sample

Figures 5a and 5b correspond to Figures 2a and 2b with the only difference being that now the VAR is estimated using the larger sample period of 1939:Q2-2008:Q4. Including the World War II period introduces additional large fiscal events that are relatively much larger in magnitude (See also Ramey (2011)).

It is apparent that, by and large, the results are qualitatively unchanged for both news shocks, with the exception of the responses of investment which falls after our news shock in the extended sample. While the point estimate impact effect on investment is still positive, investment starts to decline much sooner as compared to the benchmark sample though the decline becomes significant only after 6 quarters.

Quantitatively responses are stronger than in the previous section and the MFEV news shock still generates much stronger responses than the Ramey news shock. The peak effects on output and hours are twice as large as before and the peak response of defense spending is 5.7% following our news shock compared to 2.9% following the Ramey news shock. These differences are most likely related to the very large fiscal news events that took place in the World War II period and are seen to have a noticeable effect on the responses of output and hours.

Perotti (2007) argues that the Korean War was unusually large and it should be excluded from the analysis of the effects of government spending. Figures 6a and 6b present responses estimated using the smaller sample period of 1955:Q1-2008:Q4. The results are unchanged: our news shock continues to generate significant demand effects that are stronger than the Ramey news shock effects.

## 4.3 Relation of News Shocks to the Fisher and Peters (2011) Defense Shock Series

Fisher and Peters (2011) have recently identified government spending shocks as the innovations to the accumulated excess returns of large US military contractors. Figures 7a and 7b plot the

responses of the economy to a news shocks identified with our and Ramey’s approach, when the VAR includes the [Fisher and Peters \(2011\)](#) excess return series.

The main results are robust to adding the excess return series to the VAR. Yet, an interesting result emerges with respect to the added excess returns variable. While our news shock significantly increases the excess returns of large defense contractors, the Ramey news shock has an insignificant effect on this variable. Thus, our methodology might recover shocks which contain more information about future fiscal policy relative to the Ramey news series.

#### 4.4 Cross-Correlations with Other Structural Disturbances

An additional concern that may arise from the benchmark results is that the identified MFEV news shock is correlated with other structural disturbances. To address this concern, we computed the correlation between the identified MFEV news shock and up to four lags and leads of the [Romer and Romer \(2004\)](#) monetary policy shock measure, [Romer and Romer \(2010\)](#) tax shock measure, shock to the real price of oil, the TFP news shock from [Barsky and Sims \(2011\)](#), and the shock to uncertainty used in [Bloom \(2009\)](#) which is based on stock market volatility. Apart from the [Barsky and Sims \(2011\)](#) TFP news shock series which was used in its raw form, all other shocks were constructed as the residuals of univariate regressions of each of the four variables on four lags.

In [Figure 8](#) we plot contemporaneous and lead and lag correlations between the MFEV news shocks and the other five shocks we consider, together with the corresponding 95% asymptotic confidence interval. The results indicate that the cross-correlations are small and insignificant, with all correlations being lower than 19% in absolute value. Thus, the fact that our shock is well identified and it has significant effects on output, consumption, investment, and hours relative to Ramey’s news cannot be driven by mixing disturbances when using our identification approach. .

# 5 Are the Responses Consistent with Standard Theory?

We begin by exploring what standard DSGE models predict concerning the effects of anticipated shocks. The model we present in this section is pretty standard and we briefly discuss its main ingredients.

## 5.1 A Benchmark DSGE Model

### Households

Households derive utility from private consumption,  $C_t$  and leisure,  $1 - N_t$ . At time 0 households choose sequences for consumption, labor supply, capital to be used next period  $K_{t+1}$ , nominal state-contingent bonds,  $D_{t+1}$  and government bonds,  $B_{t+1}$  to maximize the expected discounted utility:

$$E_0 \sum_{t=0}^{\infty} \beta^t u(C_t, N_t) = E_0 \sum_{t=0}^{\infty} \beta^t \frac{[C_t(1 - N_t)^{1-\phi}]^{1-\sigma} - 1}{1 - \sigma} \quad (10)$$

where  $0 < \beta < 1$ , and  $\sigma > 0$ . Here  $\beta$  is the subjective discount factor and  $\sigma$  a risk aversion parameter. Available time each period is normalized at unity. We assume that  $C_t = \left[ \int_0^1 C_{it}(i)^{\frac{\varepsilon-1}{\varepsilon}} di \right]^{\frac{\varepsilon}{\varepsilon-1}}$ , where  $C_{it}$  stands for consumption of product  $i$  and  $\varepsilon$  is the elasticity of substitution between different varieties of goods. The household maximizes utility subject to the sequence of budget constraints:

$$P_t(C_t + I_t) + E_t\{Q_{t,t+1}D_{t+1}\} + R_t^{-1}B_{t+1} \leq (1 - \tau^l)P_t w_t N_t + [r_t - \tau^k(r_t - \delta)]P_t K_t + D_t + B_t - T_t P_t + \Xi_t \quad (11)$$

where  $(1 - \tau^l)P_t w_t N_t$ , is the after tax nominal labor income,  $[r_t - \tau^k(r_t - \delta)]P_t K_t$  is the after tax nominal capital income (allowing for depreciation),  $\Xi_t$ , are nominal profits from the firms (which are owned by consumers), and  $T_t$  are lump-sum taxes. We assume complete private financial markets:  $D_{t+1}$  is the holdings of the state-contingent nominal bond that pays one unit of currency in period

$t + 1$  if a specified state is realized and  $Q_{t,t+1}$  is the period- $t$  price of such bonds, and  $R_t$  the gross return of a government bond  $B_t$ . Private capital accumulates according to:

$$K_{t+1} = I_t + (1 - \delta)K_t - \nu\left(\frac{K_{t+1}}{K_t}\right)K_t \quad (12)$$

where  $\delta$  is a constant depreciation rate and the function  $\nu(\cdot)$  is parameterized as

$$\nu\left(\frac{K_{t+1}}{K_t}\right) = \frac{b}{2} \left[ \frac{K_{t+1} - (1 - \delta)K_t}{K_t} - \delta \right]^2 \quad (13)$$

where  $b$  determines the size of the adjustment costs. Since households own and supply capital to the firms, they bear the adjustment costs.

## Firms

Firm  $j$  produces output according to:

$$Y_t(j) = (Z_t N_t(j))^{1-\alpha} K_t(j)^\alpha \quad (14)$$

where  $K_t(j)$  and  $N_t(j)$  are private capital and labor inputs hired by firm  $j$ , and  $Z_t$  is an aggregate technology shock. We assume that firms are perfectly competitive in the input markets: they minimize costs by choosing private inputs, taking wages and the rental rate of capital as given. Since firms are identical, they all choose the same amount of inputs and cost minimization implies

$$\frac{K_t}{N_t} = \frac{\alpha}{(1 - \alpha)} \frac{w_t}{r_t} \quad (15)$$

Equation (15) and the production function imply that the common (nominal) marginal costs is given by:

$$MC_t = \frac{1}{\Upsilon} Z_t^{\alpha-1} w_t^{1-\alpha} r_t^\alpha P_t \quad (16)$$

where  $\Upsilon = \alpha^\alpha (1 - \alpha)^{1-\alpha}$ .



In the goods market firms are monopolistic competitors. The strategy firms use to set prices depends on whether prices are sticky or flexible. In the former case we use the standard [Calvo \(1983\)](#) setting. That is, at each point in time each domestic producer is allowed to reset her price with a constant probability,  $(1 - \gamma)$ , independently of the time elapsed since the last adjustment. When a producer receives a signal to change her price, she chooses her new price,  $P_t^*$ , to maximize:

$$\max_{P_t^*(j)} E_t \sum_{k=0}^{\infty} \gamma^k Q_{t+k+1,t+k} (P_t^* - MC_{t+k}) Y_{t+k}(j) \quad (17)$$

Optimization implies

$$\sum_{k=0}^{\infty} \gamma^k E_t \{ Q_{t+k+1,t+k} Y_{t+k}(j) (P_t^* - \frac{\varepsilon}{\varepsilon - 1} \frac{1}{1 - \tau^\varepsilon} MC_{t+k}) \} = 0 \quad (18)$$

where  $\tau^\varepsilon = -(\varepsilon - 1)^{-1}$  is a subsidy that, in equilibrium, eliminates the monopolistic competitive distortion. Given the Calvo pricing assumption, the evolution of the aggregate price index is:

$$P_t = [\gamma P_{t-1}^{1-\varepsilon} + (1 - \gamma) P_t^{*1-\varepsilon}]^{\frac{1}{1-\varepsilon}} \quad (19)$$

When prices are flexible, the fraction of firms that can reset the price at each  $t$  is equal to one. Hence, prices are determined by:

$$P_t = \frac{\varepsilon}{\varepsilon - 1} \frac{1}{1 - \tau^\varepsilon} MC_t, \quad \forall t \quad (20)$$

## Fiscal and Monetary Policy

Government's income consists of tax revenues minus the subsidies to the firms and the proceeds from new debt issue; expenditures consist of government purchases and repayment of debt. The government budget constraint is:

$$P_t G_t - \tau^\varepsilon P_t Y_t - \tau^l w_t P_t N_t - \tau^k (r_t - \delta) P_t K_t - P_t T_t + B_t = R_t^{-1} B_{t+1} \quad (21)$$

We also assume that the government takes market prices, private hours and private capital as given, and that  $B_t$  endogenously adjusts to ensure that the budget constraint is satisfied. To ensure determinacy of equilibria and a non-explosive solution for debt (see, e.g., [Leeper \(1991\)](#)), we assume a debt targeting rule of the form:

$$T_t = \bar{T} \exp(\zeta_b(b_t - \bar{b})) \quad (22)$$

where  $b_t = \frac{B_t}{GDP_t}$  and  $\zeta_b$  measures the degree of aversion of fiscal policy to debt deviations from target,  $\bar{b}$ . When  $\zeta_b$  is very high, the model delivers results which are similar to those obtained in a model where the government balances its budget every period.

Finally, there is an independent monetary authority which sets the nominal interest rate as a function of current inflation according to the rule:

$$R_t = \bar{R} \exp(\zeta_\pi \pi_t + \epsilon_t^R) \quad (23)$$

where  $\epsilon_t^R$  is a monetary policy shock.

## Resource Constraint

Aggregate production must equal the demand for goods from the private and public sector:

$$Y_t = C_t + I_t + G_t \quad (24)$$

## 5.2 Introducing Anticipated Government Spending Shocks

The government spending shock is driven by anticipated innovations. Given the results of Section 3, we will study a formulation with 6-quarter anticipated shocks. Thus, government spending in

log deviations from steady state evolves according to:

$$g_t = \rho g_{t-1} + \varepsilon_{g,t-j} + \varepsilon_{g0,t} \quad (25)$$

$$\varepsilon_{g,t} = \rho_g \varepsilon_{g,t-1} \quad (26)$$

Here  $\varepsilon_{g,t}$  denotes the anticipated portion of the news and  $\varepsilon_{g0,t}$  is the unanticipated portion of the news.  $j \geq 1$  represents the anticipation lag, i.e. the delay between the announcement of news and the period in which the future spending change is expected to occur. We set  $\rho = 0$ ,  $\rho_g = 0.5$ , and  $j = 6$  in our quantitative exercise.

### 5.3 Parametrization

We solve the model by approximating the equilibrium conditions around the flexible price non-stochastic steady state. The parameterization we use is standard and is summarized in Table 1. The size of the steady state government spending to GDP ratio is set to match the average value of military spending to GDP in our sample. The Taylor rule and debt coefficients are set to guarantee a determined solution for all the different models we consider.<sup>10</sup> We assume equal tax rates for capital and labor in the economy and the debt to GDP ratio is set to match the average debt to GDP ratio in the US in our sample. The rest of the parameter values are pretty standard. By varying parameter,  $\gamma$ , the degree of price stickiness, we can study whether the results differ depending on whether flexible or sticky prices are assumed.

### 5.4 Responses of the Benchmark Model

Figure 9 presents the impulse responses of the flexible and the sticky price model to an anticipated increase in government spending. The responses of the variables to a fiscal news shocks in the standard sticky price model (dashed lines) are different from the ones depicted in Figure 2a both qualitatively and quantitatively. Although output, hours and investment increase after the shock,

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<sup>10</sup>Note that the indeterminacy of equilibria is a very common phenomenon in economies with news shocks.

their responses are much less persistent than in the data. Moreover, the response of consumption is negative. In the flexible price version of the model (continuous lines) consumption falls even more persistently after the fiscal news shock. The responses of output, hours and investment are qualitatively more in line with the responses of Figure 2a, but they are very small. The maximum output multiplier the model generates is around 0.9, which is significantly lower than those obtained in the data. Thus, both models fail to match qualitatively and quantitatively the responses present in the data.

Clearly we are not the first to face difficulties in inducing positive responses of consumption after government spending shocks nor the first to have difficulties in replicating the propagating process for news shocks in the literature. Various theoretical models have been suggested for generating increases in consumption after a fiscal expansion. These mechanisms include: (a) consumption and hours' complementarity in the utility function (see [Monacelli and Perotti \(2008\)](#), [Hall \(2009\)](#), [Christiano et al. \(2011\)](#) and [Nakamura and Steinsson \(2011\)](#)); (b) a lax monetary policy (see [Canova and Pappa \(2011\)](#), [Christiano et al. \(2011\)](#) and [Erceg and Linde \(2013\)](#)); (c) rule-of-thumb consumers (see [Gali et al. \(2007\)](#)); (d) deep habits (see [Mertens and Ravn \(2012\)](#)); (e) spending reversals (see [Muller et al. \(2009\)](#)) and (g) home production (see [Gnocchi \(2013\)](#)). On the other hand, the 'News Driven Business Cycles' literature has focused on the problem of generating intuitive news driven business cycles. Several modifications of the standard model have been suggested for propagating TFP news shocks:<sup>11</sup> (a) making consumption or leisure an inferior good (see, [Eusepi and Preston \(2009\)](#)); (b) using wealth in the utility function ([Karnizova \(2012\)](#)); (c) allowing for sticky prices and accommodative monetary policy (see [Christiano et al. \(2010\)](#), [Khan and Tsoukalas \(2012\)](#), [Blanchard et al. \(2009\)](#) among others); (d) adopting a multi-sector structure (see, [Beaudry and Portier \(2007\)](#)); (e) introducing investment adjustment costs and variable capital utilization (see [Jaimovich and Rebelo \(2009\)](#)) and (f) introducing search and matching frictions (see, [Den Haan and Kaltenbrunner \(2009\)](#)). Next we investigate which modification is able to simultaneously produce considerable output responses and positive comovements in the macro

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<sup>11</sup>[Beaudry and Portier \(2013\)](#) provide an extensive literature review on the topic.

variables in response to fiscal news.

## 5.5 A Modified DSGE Model

We introduce three modifications to the standard sticky price model in order to bring its predictions closer to the data: (a) allowing in the debt rule of (22) distortionary income taxes to react to deviations of debt from target; (b) introducing variable capacity utilization in the production function as in [Jaimovich and Rebelo \(2009\)](#); <sup>12</sup> and (c) introducing rule of thumb consumers, assuming that 30% of the population does not have access to capital markets and simply consumes its disposable income. <sup>13</sup>

Figure 10 presents the responses of the modified economy to anticipated changes in military spending. Continuous circled lines represent the responses of the modified model while dashed lines depict the responses of the standard sticky price model (NK model) to the shock. Relative to the benchmark model, the responses of the modified economy to the anticipated shock are more persistent. Output, consumption and labor increase for more than a year after the news. Investment declines at a slower pace relative to the standard model, while the real wage is not reacting initially and increases after the third quarter steadily until the shock reaches its peak effect. Finally, the nominal interest and inflation (not shown in the picture since its responses are proportional to the responses of the nominal rate) increase persistently after the shock. Thus, apart from the responses of the real wage, the model captures reasonably well the dynamics of the real variables in response to fiscal news. Given that the responses of the real wage in the data changed with the sample, we prefer not to change the model specification in order to change this result.

### 5.5.1 Discussion

In this subsection we investigate the importance of the different assumptions we have incorporated for the transmission of fiscal news shocks. Apart from eliminating an important transmission

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<sup>12</sup>Following [Burnside and Eichenbaum \(1996\)](#) we assume that production depends on effective utilized capital and that capital depreciation depends negatively of the capital utilization rate.

<sup>13</sup>The modified model is presented in Appendix A.

channel, if the debt rule continues to remain as in (22) the effects of fiscal news shocks in the model become very strong, generating output peak multipliers of 10, which is inconsistent with our empirical findings. When distortionary taxes do not vary, the news about future increases in military spending generate a wealth effect that makes optimizers increase their labor supply and decrease their consumption. On the other hand, firms increase their demand for both labor and capital since, with capital adjustment costs and rigid prices, it is optimal for them to react in advance to the announced shock. The result is an increase in tax revenues that decreases deficits and debt and, as a result, an increase in transfers that augments the disposable income of financially constrained agents and boosts aggregate consumption. With labor taxes reacting to the debt target, when optimizers learn that taxes will be raised in the future to control the increased debt resulting from expected increases in military spending, they increase their labor supply even further today, pushing wages down. Thus, tax revenues do not increase as much as in the case of lump sum taxes and the debt falls less. Rule-of-thumb consumers' disposable income still increases but by less relative to the previous case. Hence, the responses of the economy to news about future spending increases are smaller.

In order to obtain increases in private consumption after fiscal news we have introduced a share of financially constrained consumers in the model economy. The behavior of those households is, by definition, insulated from movements in real interest rates. Moreover, since these agents consume their disposable income and since in the presence of sticky prices, their income is increased through the increases in the real wage induced by the increased labor demand and the increase in tax revenues when the shock arrives, those agents will increase consumption after the fiscal news shock. As Figure 11 shows the presence of financially constrained individuals guarantees an increase in consumption on impact after the shock.

In the absence of variable capital utilization and, hence, an additional margin to react to the increased demand generated by the expected shock, firms are constrained to increase more labor demand. This results in higher increases in wages which translates into higher increases in consumption by rule of thumb consumers. At the same time, investment increases also more due

to the absence of effective capital in the model and the demand effects of the shock become even stronger. Yet, the responses to the shock of all variables in Figure 11 are less persistent since the initial increase in demand reduces debt and taxes move less along the transition delivering a quicker recovery of the economy from the news shocks.

The presence of capital adjustment costs is also crucial for generating persistent and moderate responses of investment to news shocks (see diamond-line in Figure 11). In the absence of capital adjustment costs investment bursts when news about future increases in military spending arrive increasing labor demand and wages, and, hence, consumption and output. Responses of all the variables, however, converge fast to the steady state, as tax revenues increase on impact reducing debt and reducing movements in taxation between the announcement and the implementation of the fiscal news reducing the importance of the tax channel through which fiscal news are propagated in the model.

### 5.5.2 Other Assumptions that Help Propagate Fiscal News Shocks

Evans and Karras (1998) suggest that private consumption and military spending are complements and estimate the share of financially constrained individuals to be 30% in the US. We investigate how the assumption of financially constrained individuals coupled with complementarity of military spending and private consumption affect the dynamics of the model economy by introducing spending directly in the utility function. The responses of the modified economy are presented in Figure 11. Assuming complementarity between military and private spending enhances the propagation mechanism of anticipated shocks and helps the model fit better the data.

Finally, many authors have shown (see, e.g., Canova and Pappa (2011)) that the interaction between fiscal and monetary policy is crucial for the propagation of fiscal shocks. We plot responses of the model economy when we assume a lower coefficient for the Taylor rule in (23) - setting  $\zeta_\pi = 1$ . A laxer monetary policy does indeed allow for stronger demand effects of fiscal news shock.

## 6 Conclusion

We show that news about military spending do affect significantly aggregate demand and explain a significant fraction of output fluctuations. In contrast with [Ramey \(2011\)](#), fiscal news generate significant Keynesian type of effects in the economy, increasing persistently output, consumption, investment, hours, the interest rate and inflation.

We propose a DSGE model that can explain some of the facts we have revealed. Standard models fail to generate persistent output responses with respect to fiscal news and positive consumption responses. The introduction of capital adjustment costs coupled with variable capacity utilization makes the responses of the economy to fiscal news more persistent, while the incorporation of financially constrained agents in the economy is crucial for generating positive responses of private consumption to fiscal news shocks. Distortionary taxes help generating realistic responses of the macro variables to anticipated increases in military spending. Finally a laxer monetary policy and complementarity between military spending and private consumption can propagate even further the effects of military spending news.

Our results are useful to both academics and policymakers. First, we propose a new methodology for the identification of news about fiscal policy changes. It is objective and does not require the readings of newspapers sources and, as a result, can be applied for countries with weak or no newspaper archives. Second, we have shown that our approach captures better information about future military spending increases relative to [Ramey \(2011\)](#) approach. Third, we show that the presence of rigidities and financially constrained individuals are key assumptions for matching the empirical findings. Financial frictions matter for aggregate fluctuations, even when the latter are induced by news shocks. Finally, according to our estimates, news about future changes in military spending account for a non-negligible share of output fluctuations at business cycle frequencies. Since anticipation effects are estimated to be significant and economically important, policymakers should be cautious in announcing policy changes that can affect agents' expectations about future government spending. Or reversing this argument, policymakers can use policy announcements as a tool for responding to the cycle when constrained by budgetary or other types of restrictions.



# Appendix A Modified NK Model

In this appendix we present briefly the modifications of the benchmark model that we have considered in Section 5.5. There are two types of households, optimizers and rule of thumb consumers. The problem of the optimizers is given below.

## A.1 Optimizers

There is a share  $1 - \lambda$  of optimizers that derive utility from private consumption,  $C_t^o$  and leisure,  $1 - N_t^o$ . At time 0 they choose sequences for consumption, labor supply, capital to be used next period  $K_{t+1}$ , nominal state-contingent bonds,  $D_{t+1}$  and government bonds,  $B_{t+1}$  to maximize the expected discounted utility in (10). Optimizers maximize utility subject to the sequence of budget constraints:

$$P_t(C_t^o + I_t) + E_t\{Q_{t,t+1}D_{t+1}\} + R_t^{-1}B_{t+1} \leq (1 - \tau_t^l)P_t w_t N_t^o + [r_t - \tau^k(r_t - \delta)]P_t K_t + D_t + B_t + \Xi_t \quad (27)$$

where  $\tau_t^l$  varies to satisfy:

$$\tau_t^l = \bar{\tau}_l \exp(\zeta_b(b_t - \bar{b})) \quad (A2)$$

The capital law of motion is the same as the one of the benchmark model.

## A.2 Financially constrained households

The remaining fraction of households,  $\lambda$ , are financially constrained. Rule-of-thumb households fully consume their current labor income. They cannot smooth their consumption in the face of fluctuations in labor income and intertemporally substitute in response to changes in interest rates. Their period utility is the of the same form as for optimizers and its given by (10). And their budget constrained is given by:

$$P_t C_t^r = (1 - \tau_t^l)P_t w_t N_t^r \quad (28)$$

### A.3 Aggregation

Aggregate consumption and hours are given by a weighted average of the corresponding variables for each consumer type. That is,

$$C_t = (1 - \lambda)C_t^o + \lambda C_t^r \quad (\text{A4})$$

and

$$N_t = (1 - \lambda)N_t^o + \lambda N_t^r \quad (\text{A5})$$

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Table 1: **Parameter values**

$\beta$	discount factor	0.99
$B/Y$	steady state debt to output ratio	0.55
$\sigma$	risk aversion coefficient	2
$\phi$	preference parameter	0.7
$b$	adjustment cost parameter	15
$\delta$	capital depreciation rate	0.025
$\alpha$	capital share	0.36
$\tau^l$	average labor tax rate	0.3
$\tau^k$	average capital tax rate	0.3
$G/Y$	steady state $G/Y$ ratio	0.07
$\zeta_\pi$	Taylor's coefficient	1.1
$\zeta_b$	coefficient on debt rule	2
$\gamma$	degree of price stickiness	0.75
$\frac{\varepsilon}{\varepsilon-1}$	steady state markup	7.88
$\lambda$	rule of thumb consumers	0.3
$\phi_u$	elasticity of depreciation to changes in utilization	1.40

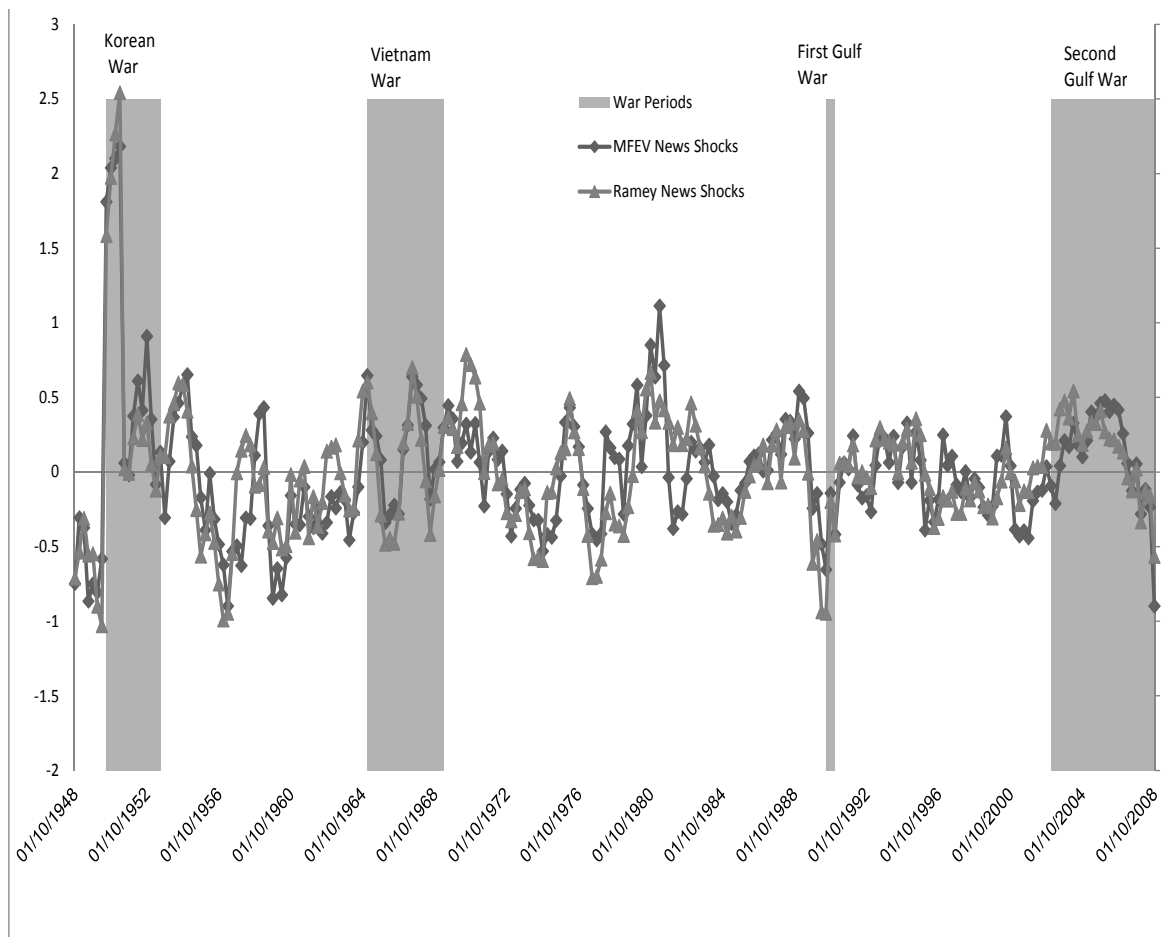
Table 2: **The Difference Between the Forecast Error Variance Contributions of MFEV and Ramey News Shocks: Statistical Significance**

Variable	Contribution Difference (%)	Horizon	P-Value (%)
Defense Spending	16	12	0
Output	21	3	2.2
Consumption	16	1	12.5
Investment	15	1	6.1
Real Wage	5	5	24.6
Tax Rate	17	9	3.2
Hours	28	5	1.1
Interest Rate	13	10	15.4
Inflation	11	3	10.6

*Notes:* This table presents the p-values for the null hypothesis that the difference between the contribution of the MFEV news shock and the Ramey news shock to the corresponding variable's variation is not positive. The horizon for which the p-value is computed is the one at which the point estimate of the contribution difference is maximal. The second column depicts the maximal point estimate difference between the two shocks' contributions to the corresponding variable's variation, and the third column gives the corresponding horizon. Each estimated p-value was obtained as the proportion of bootstrap values of the contribution difference of the two shocks not exceeding zero.

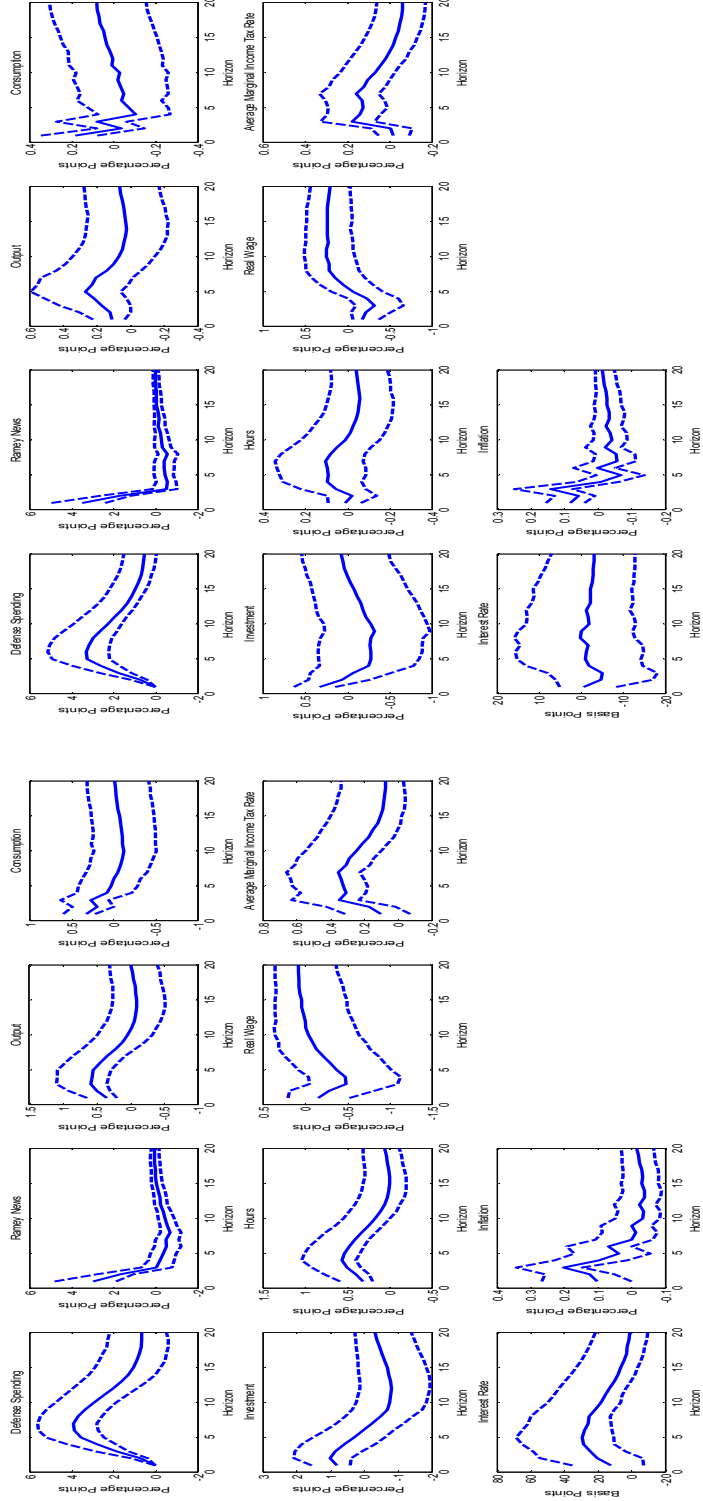


Figure 1: MFEV News Shock and Ramey News Shock Time Series.



Notes: U.S. war periods are represented by the shaded areas. Plotted is a one year backward looking average of the shock series  $\varepsilon_t^s = (\varepsilon_{t-3} + \varepsilon_{t-2} + \varepsilon_{t-1} + \varepsilon_t)/4$ . The series begin in 1948:Q4 and ends in 2008:Q4.

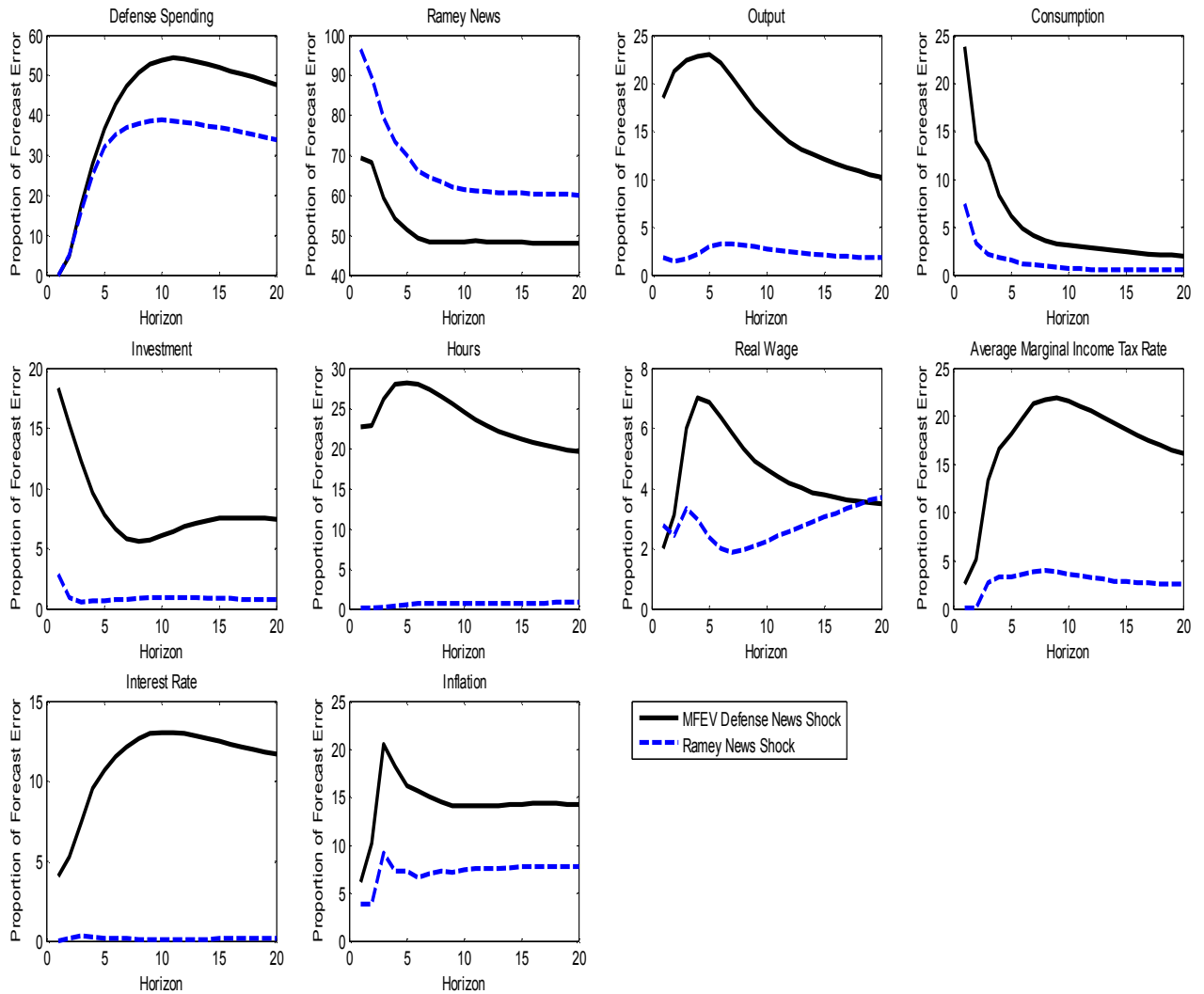
Figure 2: Benchmark VAR: (a) Impulse Responses to MFEV News Shock; (b) Impulse Responses to Ramey News Shock



(a) Impulse responses to a one standard deviation MFEV News Shock. (b) Impulse responses to a one standard deviation Ramey News Shock.

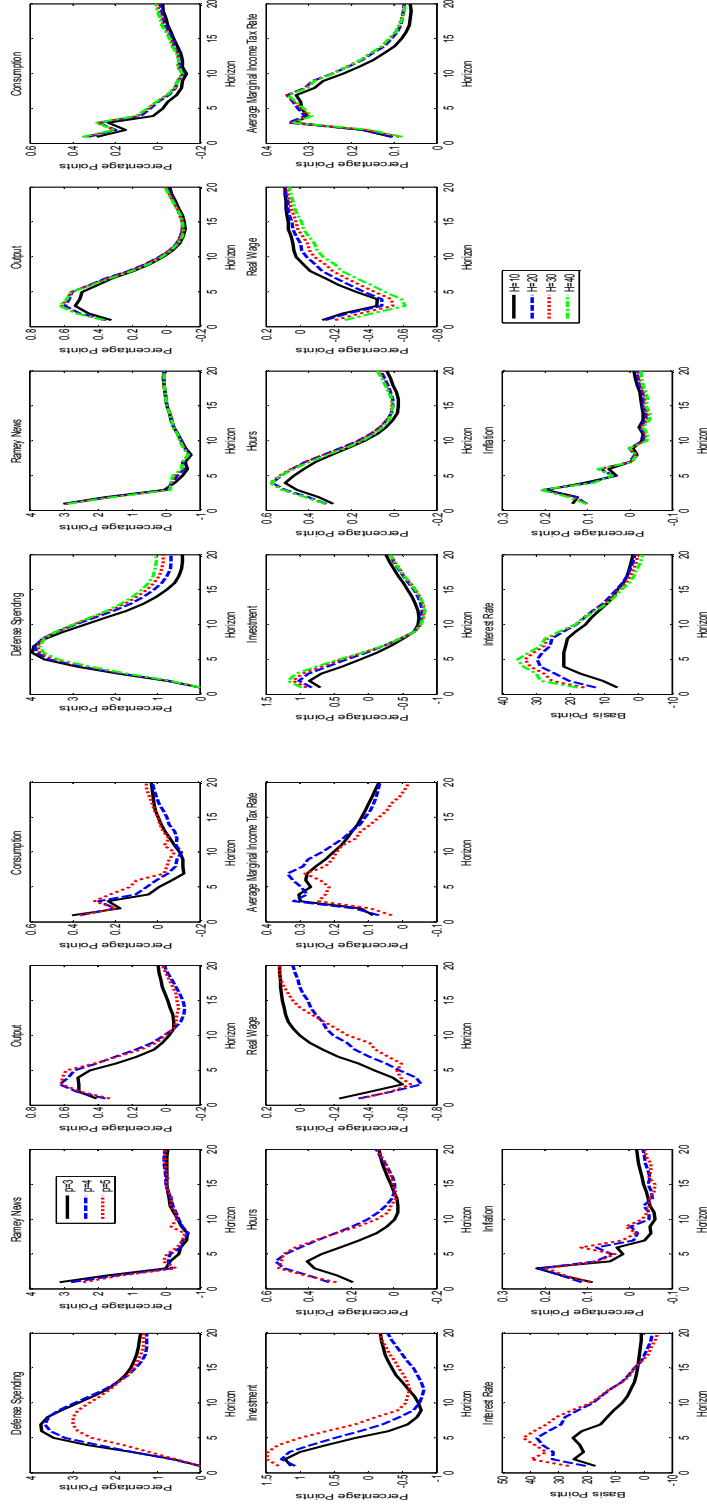
Notes: Panel (a): The impulse responses were obtained from applying the MFEV method explained in section 2 on the benchmark VAR. Dashed lines represent 2.5th and 97.5th percentile Hall (1992) confidence bands generated from a residual based bootstrap procedure repeated 2000 times. Panel (b): The impulse response are with respect to the shock to the Ramey news variable orthogonalized with respect to current defense spending. Dashed lines represent 2.5th and 97.5th percentile Hall (1992) confidence bands generated from a residual based bootstrap procedure repeated 2000 times.

Figure 3: The Share of Forecast Error Variance Attributable to MFEV News Shocks and Ramey's News Shocks.



Notes: The MFEV news shock corresponds to that from figure 2a whereas the Ramey news shock corresponds to that from figure 2b.

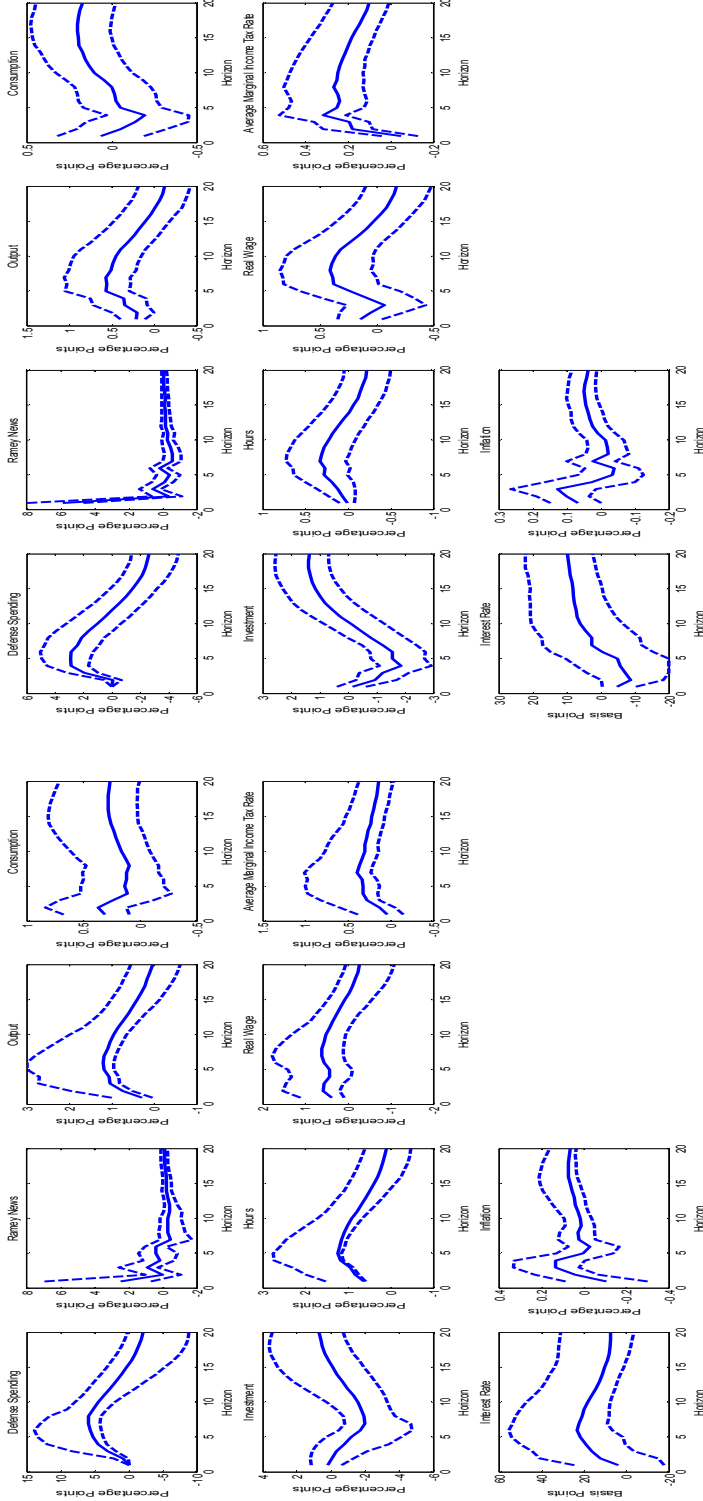
Figure 4: Robustness: (a) VAR lags; (b) Truncation horizon



(a) Impulse responses to a one standard deviation Defense News Shock: robustness to different lag structures. (b) Impulse responses to a one standard deviation Defense News Shock: robustness to different truncation horizons.

Notes: Panel (a): The solid, dashed, dotted and dash-dotted lines are the estimated impulse responses to the defense news shock from a VAR with 3, 4, 5, and 6 lags, respectively. Panel (b): The solid, dashed, dotted and dash-dotted lines are the estimated impulse responses to the defense news shock from a VAR with a truncation horizon,  $H$ , equal to 10, 20, 30, and 40 periods, respectively.

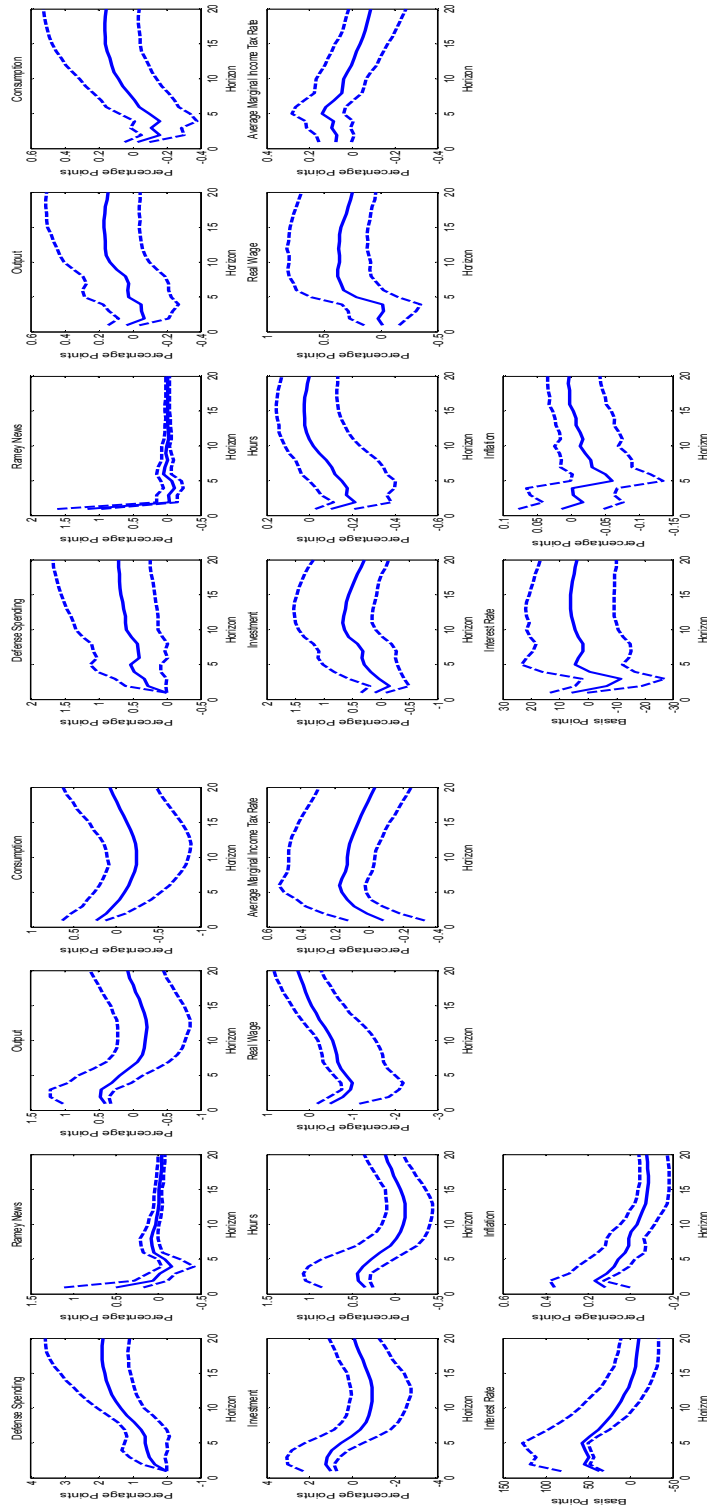
Figure 5: Larger Sample (1939-2008): (a) Impulse Responses to MFEV News Shock; (b) Impulse Responses to Ramey News Shock



(a) Impulse responses to a one standard deviation MFEV (b) Impulse responses to a one standard deviation Ramey News Shock.

Notes: Panel (a): The impulse responses were obtained from applying the MFEV method explained in section 2 on the benchmark VAR using the sample period 1939:Q2-2008:Q4. Dashed lines represent 2.5st and 97.5th percentile Hall (1992) confidence bands generated from a residual based bootstrap procedure repeated 2000 times. Panel (b): The impulse response are with respect to the shock to the Ramey news variable orthogonalized with respect to current defense spending, using the sample period of 1939:Q2-2008:Q1. Dashed lines represent 2.5st and 97.5th percentile Hall (1992) confidence bands generated from a residual based bootstrap procedure repeated 2000 times.

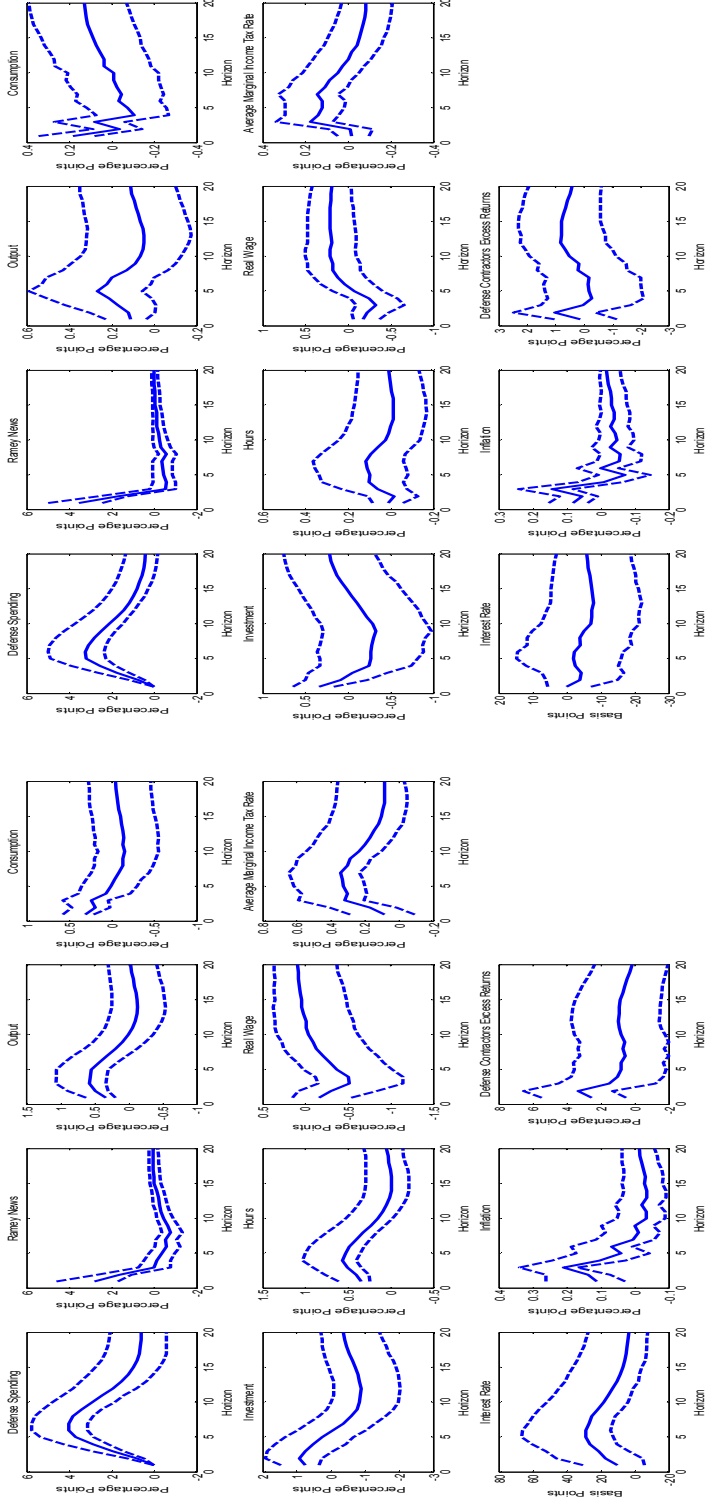
Figure 6: Post-Korean War Sample (1955-2008): (a) Impulse Responses to MFEV News Shock; (b) Impulse Responses to Ramey News Shock



(a) Impulse responses to a one standard deviation MFEV News Shock. (b) Impulse responses to a one standard deviation Ramey News Shock.

*Notes:* Panel (a): The impulse responses were obtained from applying the MFEV method explained in section 2 on the benchmark VAR using the sample period 1955:Q1-2008:Q4. Dashed lines represent 2.5st and 97.5th percentile Hall (1992) confidence bands generated from a residual based bootstrap procedure repeated 2000 times. Panel (b): The impulse response are with respect to the shock to the Ramey news variable orthogonalized with respect to current defense spending, using the sample period of 1955:Q1-2008:Q1. Dashed lines represent 2.5st and 97.5th percentile Hall (1992) confidence bands generated from a residual based bootstrap procedure repeated 2000 times.

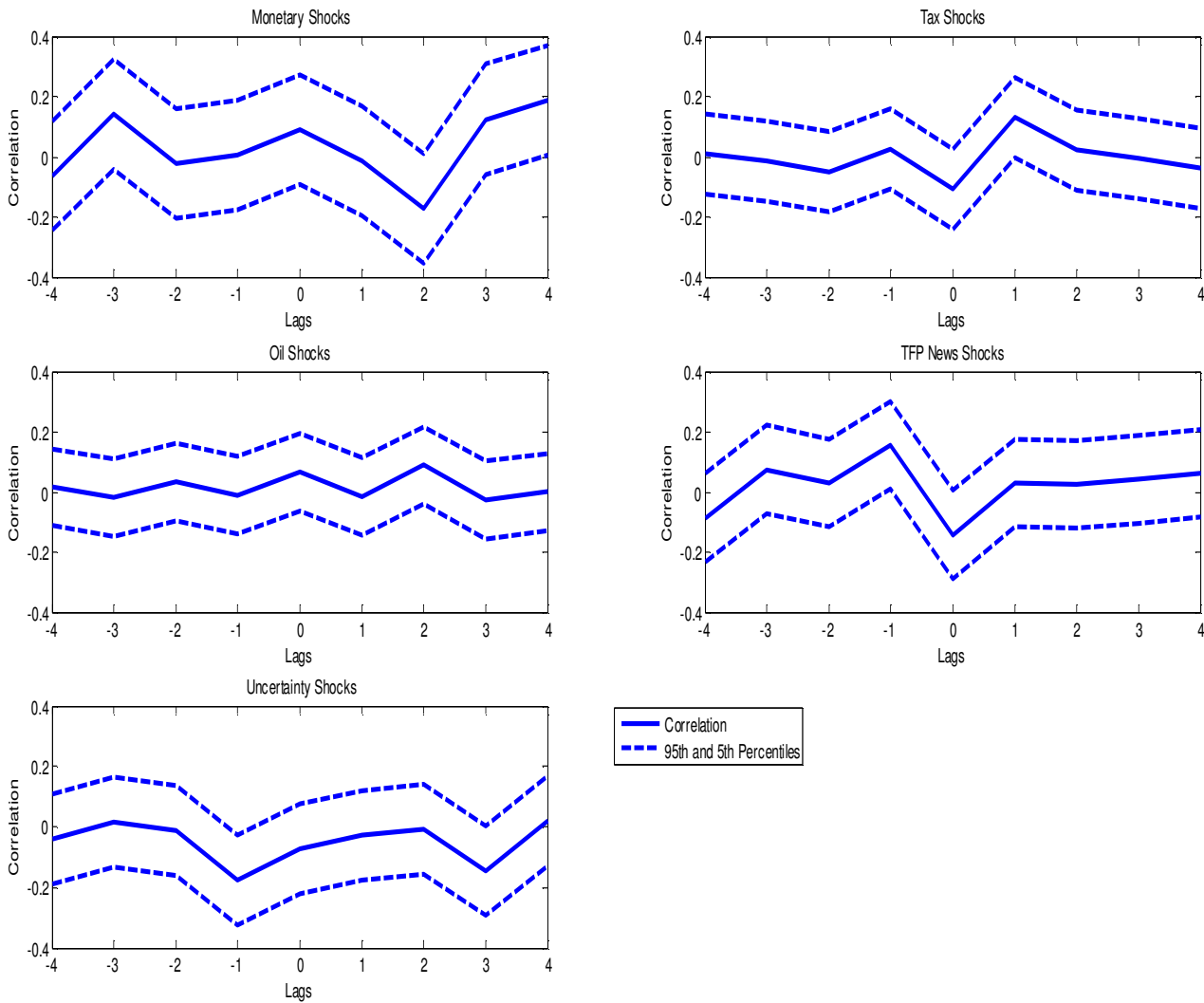
Figure 7: VAR with the Fisher and Peters (2011) Defense Shock Series: (a) Impulse Responses to MFEV News Shock; (b) Impulse Responses to Ramey News Shock



(a) Impulse responses to a one standard deviation MFEV News Shock. (b) Impulse responses to a one standard deviation Ramey News Shock.

Notes: Panel (a): The impulse responses were obtained from applying the MFEV method explained in section 2 on a VAR that includes the Fisher and Peters (2011) Defense Shock Series. Dashed lines represent 2.5st and 97.5th percentile Hall (1992) confidence bands generated from a residual based bootstrap procedure repeated 2000 times. Panel (b): The impulse response are with respect to the shock to the Ramey news variable orthogonalized with respect to current defense spending, via a VAR that includes the Fisher and Peters (2011) Defense Shock Series. Dashed lines represent 2.5st and 97.5th percentile Hall (1992) confidence bands generated from a residual based bootstrap procedure repeated 2000 times.

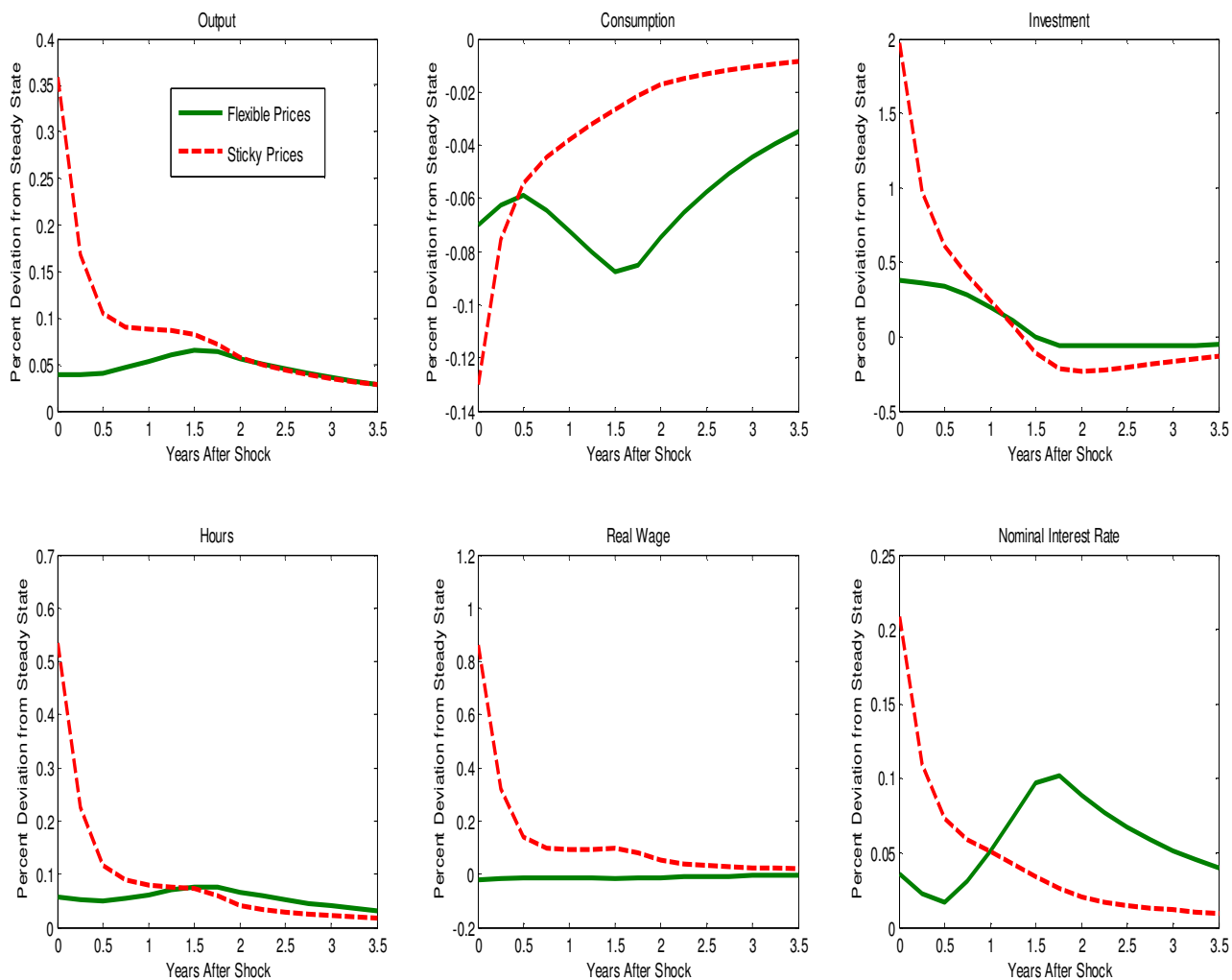
Figure 8: **The Cross-Correlation between the MFEV News Shock and Lags/Leads of Other Structural Shocks.**



*Notes:* The solid line is the cross-correlation and the dashed lines represent the 95% asymptotic confidence interval. The other shocks are the [Romer and Romer \(2004\)](#) monetary policy shock measure, [Romer and Romer \(2010\)](#) tax shock measure, shock to the real price of oil, the TFP news shock from [Barsky and Sims \(2011\)](#), and the shock to the uncertainty measure used in [Bloom \(2009\)](#) which is based on stock market volatility and corresponds to Figure 1 in his paper. Apart from the [Barsky and Sims \(2011\)](#) TFP news shock series which was used in its raw form, all other shocks were constructed as the residuals of univariate regressions of each of the four variables on four lags.

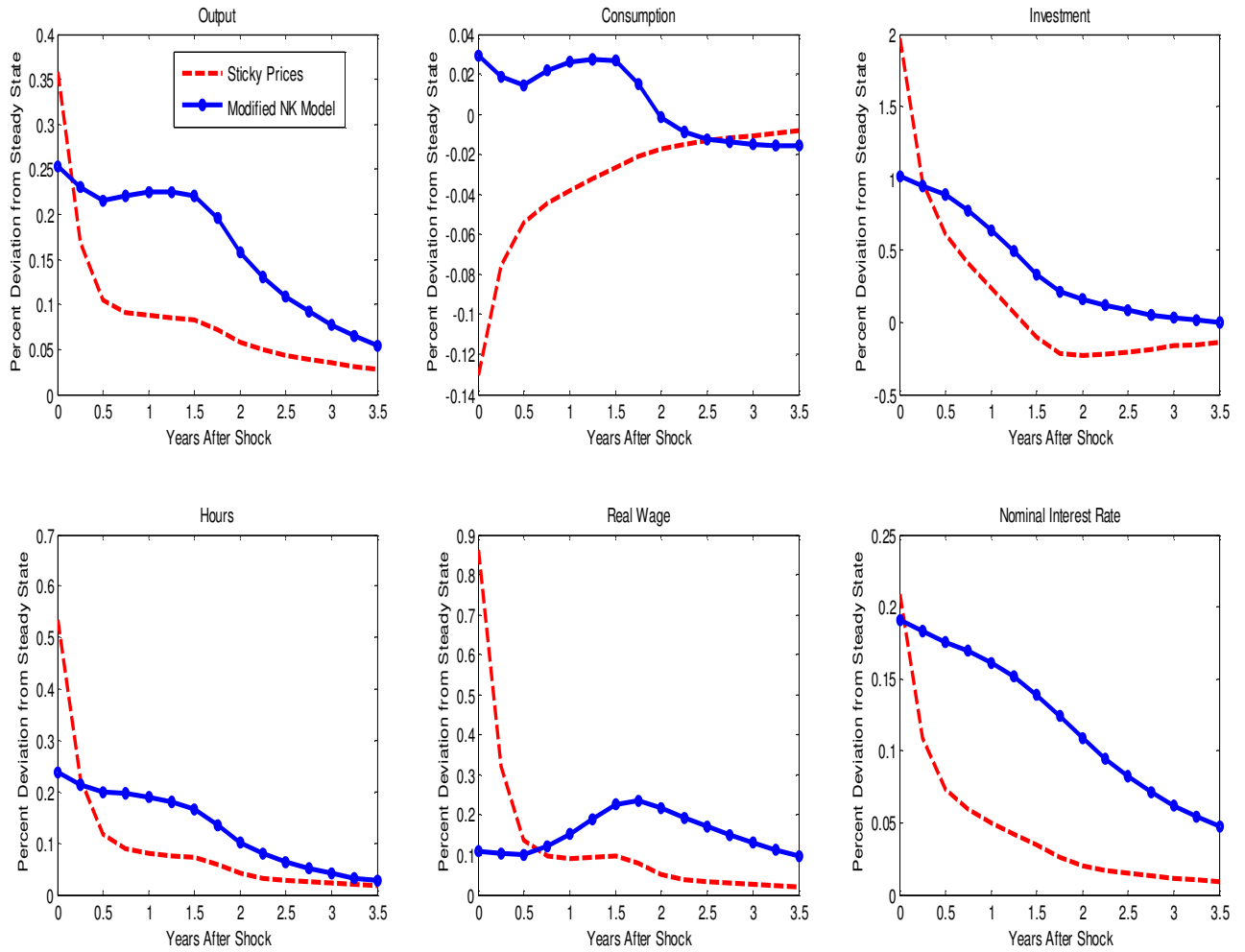


Figure 9: Benchmark DSGE Model: Responses to an Anticipated Shock.



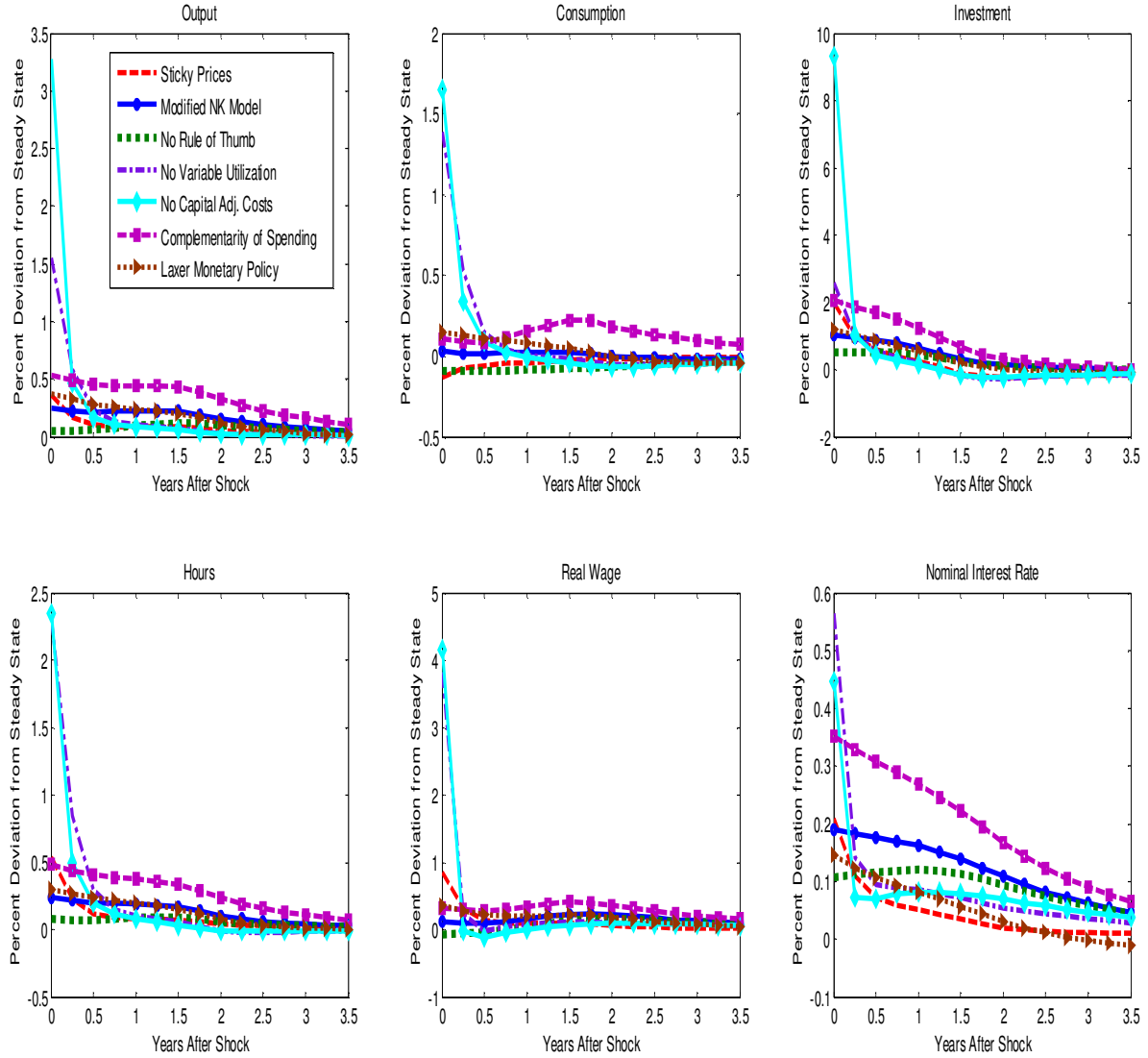
*Notes:* The Responses were obtained from the model of Section 5.1, where the solid lines correspond to the sticky price model and the dashed lines correspond to the flexible price version of the model.

Figure 10: Modified DSGE Model: Responses to an Anticipated Shock.



*Notes:* The Responses were obtained from the model of Section 5.5, where the solid lines correspond to the sticky price model and the circled lines correspond to the modified sticky price version of the model.

Figure 11: Modified DSGE Model: Quantification of the Propagation Mechanisms.



Notes: The Responses were obtained from the model of Section 5.5, where each line corresponds to a model in which the relevant feature is absent from the model.