Multipliers of Unexpected Increases in Defense Spending: An Empirical Investigation[*]

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Abstract

We show that unexpected increases in defense spending increase total factor productivity (TFP) and output and decrease investment in US quarterly data. Yet, the output multiplier is zero when the TFP response is shut down. We examine various explanations for this phenomenon and find that the rise in TFP is due to the presence of measurement error in quarterly data. Using artificial data generated from an RBC model with measurement error, we demonstrate the suitability of our identification approach for recovering the true output multiplier in the presence of measurement error.

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1 Introduction

According to conventional wisdom, and many textbook analyses, fiscal policy is mostly stimulating demand. Since Keynes advocated a fiscal stimulus during the Great Depression, many governments have implemented fiscal expansions during recessions as a means of stimulating demand. On the other hand, standard business cycle models, both of the Keynesian or the RBC tradition, offer little support for significant demand stimulus from fiscal policy and a lot of recent research aims at developing models that increase the size of the fiscal multiplier (see, e.g., Gali et al. (2007), Christiano et al. (2011), and Erceg and Linde (2013) among others). Hence, understanding the propagation mechanism and effects of fiscal expansions is crucial for both academic and policy analysis.

In this paper we investigate the macroeconomic implications of unexpected defense spending shocks. Following the work of Ramey (2011) most researchers would agree that large increases in defense spending are anticipated several quarters before they actually occur. Still, the traditional unanticipated fiscal shock can be potentially important, and, most importantly, the majority of the theoretical models in the literature study the effects of unexpected rather than expected increases in fiscal policy. For that reason, we focus on unexpected changes in defense spending, identifying these shocks as innovations in defense spending within a VAR that includes various real and nominal macroeconomic variables as well as the Ramey (2011) news series.

We show that unexpected increases in defense spending increase total factor productivity (TFP) and output and decrease investment on impact. Since unexpected increases in defense spending increase TFP, the positive output effect of the fiscal shock might be due to the positive responses of the TFP. Indeed, when we force the fiscal shocks to be orthogonal contemporaneously to TFP movements, we find that the output multiplier is zero, with investment declining more strongly and with the consumption response becoming significantly negative as opposed to being insignificant in the unrestricted case. Thus, our analysis confirms the results of Ramey and Shapiro (1998): unexpected increases in defense spending do not seem to generate any significant demand effects.

What is the mechanism that makes unexpected increases in defense spending increase TFP? We argue that correlated measurement errors present in aggregate quarterly data on defense spending, TFP, and output are driving the positive TFP-defense shock relation.[1] We base our argument on three facts. First, the positive correlation between TFP and the unanticipated defense shock only holds for quarterly data and is entirely eliminated when using a TFP measure that is constructed from annual data. Second, when we use the measurement-error free GDP measure put forward by Aruoba et al. (2013) we also find a zero multiplier in response to the unanticipated defense shock, consistent with our measurement-error based interpretation of the results. This suggests that the positive TFP-defense shock relation is spurious and orthogonalizing the defense shock with respect to TFP essentially strips away the measurement error component from the defense shock. Third, we provide some direct evidence on there being a correlation between the measurement error in defense spending, output, and TFP by showing that the unanticipated defense spending shock significantly raises on impact the "statistical discrepancy", which is the difference between Gross Domestic Product (GDP) and Gross Domestic Income (GDI).[2] This effect, however, is halved once the TFP response is shut down. Moreover, since our TFP measure is constructed from business sector output data that is based on data sources that are also used for constructing GDP, it is reasonable to ascertain that TFP is also contaminated by this output measurement error; consistent with this assessment, we found a correlation of 0.37 between TFP growth and the first difference of the ratio of the statistical discrepancy variable to GDP.

We also provide evidence that rules out other plausible economic explanations for the TFP-defense shock relation. First, as conjectured by Nekarda and Ramey (2011), a fiscal shock may raise aggregate productivity by increasing factor inputs in durable goods industries more that in non-durable ones. This, coupled with the observation that returns to scale are higher in durable goods industries than in non-durable industries (see, e.g., Basu and Fernald (1997) and Nekarda and Ramey (2011)), can generate a rise in TFP in response to a fiscal shock. Nevertheless, we provide evidence against this conjecture by showing that TFP positively responds not only to defense investment shocks but also to defense consumption shocks. To examine if other plausible

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[1] The notion of a common measurement error in aggregate quarterly data is not new; both Ireland (2004) and Malley and Woitek (2010) have formalized this notion by incorporating correlated measurement errors in macroeconomic aggregates in a standard DSGE model.

[2] The statistical discrepancy represents the net sum of all of the measurement errors in estimating the respective components of GDP and GDI. See Rassier (2012) for details on the sources of this measurement error.

economic explanations can account for the evidence, we have investigated whether the TFP-defense shock relation can be accounted for by (a) increases in public capital; b) changes in consumers' confidence; and (c) changes in R&D. None of these other explanations seems to account for the responses we obtain. Hence, it seems that the effects of unanticipated defense spending shocks are solely triggered by measurement errors.

To show that our identification approach is capable of picking up the true output multiplier in the presence of measurement error in quarterly data, we simulate data from an RBC model that includes a common measurement error in TFP, defense spending, and output, and employ our proposed identification scheme on the simulated data. The evidence from this Monte Carlo exercise indicates that our methodology works considerably well. The orthogonalization restriction with respect to TFP enables the proper identification of the true effects of the defense shock on output and the other macroeconomic variables.

Contrary to the effects of unexpected increases in defense spending, anticipated defense spending shocks have sizeable demand effects as shown in Ben Zeev and Pappa (2013) when they are identified as shocks that best explain future movements in defense spending over a five-year horizon and are orthogonal to current defense spending. However, we show that the identified anticipated defense spending shocks do not suffer from the presence of measurement error in quarterly data. Our results suggest that the predictions of the standard RBC model reasonably describe the responses of the US economy to unexpected increases in government spending. Yet, more theory is needed to jointly explain the behavior of the economy after expected and unexpected changes in defense spending.

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 present the Monte Carlo exercise. Section 5 examines the sensitivity of our results to changes in the model's specification. In Section 6 we test different economic explanations for the responses of TFP to unexpected defense shocks and in Section 7 we present evidence on the effects of anticipated defense spending shocks. Section 8 concludes.

2 Identifying Unanticipated Defense Shocks

Let y_t be a kx1 vector of observables and let the VAR in the observables be given by

$$y_t = B_1 y_{t-1} + B_2 y_{t-2} + ... + B_p y_{t-p} + B_c + u_t \tag{1}$$

where B_i are kxk matrices, p denotes the number of lags, B_c is a kx1 vector of constants, and u_t is the kx1 vector of reduced-form innovations with variance-covariance matrix Σ. For future reference, let the $(kp+1)$xk $B = [B_1, ..., B_p, B_c]'$ matrix represent the reduced form VAR coefficient matrix.

It is assumed that there exists a linear mapping between the reduced-form innovations and economic shocks, v_t, given by

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

with $E(v_t) = \mathit{0}$ and $var(v_t) = I$, where I is the identity matrix. The impact matrix A must satisfy $AA' = \Sigma$. There are, however, an infinite number of impact matrices that solve the system. In particular, for some arbitrary orthogonalization, C (e.g the Cholesky factor of Σ), the entire space of permissible impact matrices can be written as CD, where D is a k x k orthonormal matrix ($D' = D^{-1}$, which entails $D'D = DD' = I$).

We place the government defense spending variable in the first position in the VAR and identify the unanticipated defense shock as the unrestricted VAR innovation in defense spending. The idea behind this simple identification strategy is based on the reasonable notion that the unanticipated defense shock is the only shock which has a contemporaneous effect on defense spending, which is valid also in models that assume the presence of defense news shocks, i.e., shocks that have a delayed effect on future defense spending.

Leeper et al. (2013) have demonstrated how the presence of fiscal foresight can create a wedge between economic shocks and VAR innovations and, thus, limit the ability of VAR's to attain shock identification. This wedge, which is a direct result of the econometrician's inability to observe the news component of fiscal policy, can limit one's ability to identify not only anticipated but also unanticipated shocks. To address the potential problem of non-invertiblity that may arise from the presence of news shocks, we include in our VAR the Ramey (2011) news series (which should proxy, at least to some extent, for news shocks). In Ben Zeev and Pappa (2013), we demonstrate that the Ramey (2011) news series is an imperfect measure of defense news shocks; that said, this series still captures essential information concerning large changes in future defense expenditures and is therefore important to have in the VAR. We follow the conventional Bayesian approach to estimation and inference by assuming a diffuse normal-inverse Wishart prior distribution for the reduced-form VAR parameters.[3]

3 Empirical Evidence

3.1 Data

The data covers the period from 1947:Q1 to 2008:Q4. We measure defense spending, output, hours, consumption, and investment in real per capita terms. We also include in the VAR the Ramey (2011) news series, the real manufacturing wage, the Barro and Redlick (2011) average marginal tax rate, the interest rate on 3 month T-bills, CPI inflation, and TFP.

For the TFP series, we employ the real-time, quarterly series on total factor productivity (TFP) for the U.S. business sector, adjusted for variations in factor utilization (labor effort and capital's workweek), constructed by Fernald (2012) and available on his website.[4] Apart from the TFP series, we downloaded all of the data from Ramey's website.[5]

3.2 Impulse responses

Figure 1 depicts the median and 84th and 16th percentiles of the posterior distribution of impulse responses to a positive one standard deviation unanticipated defense shock in the benchmark VAR. The posterior distribution was constructed by taking 2000 draws from the posterior distribution of the VAR parameters. The unanticipated defense shock generates a median impact output multiplier of 0.94. Specifically, a one standard deviation unexpected shock in defense spending raises output by 0.15% on impact after which this effect declines and falls to zero after one year; defense spending exhibits a persistent response with an initial impact of 2.11% , peaking at 2.87% after one year. Moreover, investment significantly declines following the shock with a peak absolute response of

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[3] We have also confirmed the robustness of our results to undertaking classical estimation and inference.

[4] http://www.frbsf.org/economics/economists/staff.php?jfernald

[5] http://weber.ucsd.edu/ vramey/

0.88% after one year. The shock does not significantly affect hours while it increases the real wage moderately (by roughly 0.2% after one year). Consumption and interest rates fall and inflation rises, but all of these responses are economically small and those for consumption and inflation are also statistically insignificant. The response of the average marginal income tax rate is also small and largely insignificant, having a peak increase of only 0.06 percentage points after three quarters.

One seemingly puzzling aspect that emerges from the figure is the positive response of the Ramey news series to the unanticipated shock. It is worth noting that this response, albeit statistically significant, reflects a very small median impact contribution of less than 3% to the forecast error variance of the Ramey news series. This result is consistent with the evidence in Ben Zeev and Pappa (2013) that the Ramey (2011) news series is an imperfect measure of true news. Ramey (2011) acknowledges that the narrative approach might leave some information about anticipated shocks uncaptured (see page 34 in her article); Ben Zeev and Pappa (2013) find evidence that reinforces this by identifying defense news shocks as the shocks that maximally explain defense spending over a five year horizon and that are orthogonal to current defense spending and matching the component of their shock series that is orthognal to Ramey's shocks to historical defense news events not captured by Ramey (2011). That the unanticipated defense shocks raises the Ramey news series is simply another dimension along which the Ramey news series proves to be an imperfect measure of true news. What we show here indicates that this news series contains unanticipated events in addition to anticipated events. That said, this portion of unanticipated events in the Ramey (2011) news series does not seem to be too significant.

Interestingly, TFP significantly rises following the shock with a 0.23% rise on impact. This increase in TFP is quite persistent and only dies out after two years. The immediate significant jump in TFP following the shock is an indication that the mechanism which governs the relation between defense spending and TFP operates contemporaneously. Overall, apart from defense spending, output, investment, and TFP, the responses of the other variables are small and insignificant. Hence, the shock seems to generate a positive multiplier that it is smaller than one due to the crowding out of private investment. But how do the responses of the economy look like when TFP is constrained to be unaffected by the shock?

3.3 Shutting Down the TFP Response

Figure 2 presents the median and 84th and 16th percentiles of the posterior distribution of impulse responses to a positive one standard deviation unanticipated defense shock orthogonalized with respect to current TFP. It is apparent that output does not change resulting in a zero multiplier. In fact, after about three years the response of output becomes significantly negative, indicating that striping away the TFP-induced effect leads to a contractionary fiscal expansion. Whereas the response of consumption in the benchmark case was insignificant, when the TFP channel is shut down the spending shock generates a moderate crowding out of private consumption, which has a significant response now with a peak decline of 0.15% after three quarters. Furthermore, the investment decline is more persistent as well as moderately stronger compared to the benchmark case with a peak absolute response of 0.94% (compared to the benchmark response of 0.88%). Hence, in accordance with the predictions of the standard RBC model the unanticipated government expansion generates a complete crowding out of the private sector.

3.4 Why Does TFP Rise Following an Unanticipated Defense Shock?

It is crucial to understand the central mechanism underlying the positive TFP-defense shock relation that we find in the data in order to properly interpret and understand our findings. In this section, we show that the only explanation that is consistent with the data is that measurement errors present in quarterly aggregate data are driving the positive TFP-defense shock relation. We defer the analysis of other plausible economic explanations for the rise in TFP, e.g., such as sectoral reallocation, complementarily between government spending and innovation, and reverse causality from technology to defense spending to Section 6.

The findings presented thus far suggest that the unanticipated component of defense spending is positively correlated with quarterly TFP. Hence, under the premise that this positive relation is induced by an economic mechanism rather than just some measurement error present in quarterly data, we should also observe a similar positive correlation between the annualized defense shock and a TFP measure constructed from annual data. Table 1 presents the correlation between the growth rate of the utilization-adjusted Solow residual constructed in Basu et al. (2006) from annual data and the annualized defense shock series which simply consists of annual averages of the corresponding quarterly observations. For comparison purposes, the correlation for the corresponding quarterly series is also reported in the table where quarterly TFP is measured by the utilization-adjusted TFP measure constructed in Fernald (2012). It is apparent from the table that the positive relation between the quarterly series is driven by the frequency with which the TFP data is constructed; more specifically, in annual data the positive correlation between the unanticipated defense shock and TFP growth is entirely eliminated.[6]

The results of Table 1 clearly demonstrate that the positive relation between TFP and the unanticipated defense shock is an artifact of the frequency of the data used to construct the TFP measure. In other words, there seems to be a correlation between the measurement errors present in quarterly defense spending data and output data which is responsible for the positive relation between the unanticipated defense shock and TFP.

To formally test the measurement-error hypothesis, we use the new measurement-error free measure of U.S. GDP of Aruoba et al. (2013) which they obtain by applying optimal signal-extraction techniques to the noisy expenditure-side and income-side estimates of GDP.[7] Their new GDP estimate is cleansed of measurement error and can thus be utilized to construct a measure of TFP that is uncontaminated by measurement errors present in quarterly output. To construct such a measurement-error free TFP measure, we follow the same methodology used by Fernald (2012) with only two differences: first, we use as the output measure the GDP measure of Aruoba et al. (2013) instead of business output and, second, we use total hours in the economy instead of business sector hours. If our measurement-error based conjecture is indeed correct we should get an impact output multiplier of zero in response to the unanticipated defense shock as well as a zero impact response of TFP. Effectively, we test our hypothesis by identifying the unanticipated defense shock using our benchmark identification procedure in a VAR that differs from the benchmark one only in that it replaces the standard GDP measure with that of Aruoba et al. (2013) and uses the measurement-error free TFP measure. The sample runs from 1959:Q4 to 2008:Q4, where the starting period is

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[6] Note that the two TFP measures constructed in Basu et al. (2006) and Fernald (2012) differ only along the dimension of the frequency of the data that underlies their TFP measures; this is also true with regard to the utilization component estimated by the two papers which follows the same estimation procedure put forward in Basu et al. (2006).

[7] We downloaded their GDP series from http://www.philadelphiafed.org/research-and-data/real-time-center/gdpplus/

restricted by that of the Aruoba et al. (2013) GDP series.

The results from this exercise are presented in Figure 3c, where, for comparison purposes, we also present in Figures 3a and 3b the impulse responses to an unanticipated defense shock from the benchmark VAR using the smaller sample period 1959:4-2008:4 for both the unrestricted TFP case and the restricted TFP case, respectively; for the sake of consistency, the TFP measure underlying Figures 3a and 3b is computed from using the conventional GDP measure and total hours. To make the figures readable, we only present here the responses to defense spending, output, consumption, investment, and TFP. The results confirm our measurement-error based conjecture: while the output and TFP measures that contain measurement errors continue to rise following the defense shock, the identified defense shock from Figure 3c has essentially no impact effect on the measurement-error free measures of output and TFP. Moreover, note that the results from the measurement-error free VAR are similar to those obtained from the VAR where the TFP impact response is shut down.[8] In sum, we can deduce that the positive response of TFP to our unanticipated defense shock is spurious; it is merely an artifact of the measurement error in quarterly data. Our exercise shows that once the measurement error in output is eliminated, the results become similar to those obtained from orthogonalizing the defense shock with respect to TFP. That is, the orthogonalization restriction with respect to TFP produces a measurement-error free defense shock series which is found to no longer have any effect on output.[9]

Finally, we provide some direct evidence for the presence of a common measurement error in defense spending, output, and TFP. A common measure for the measurement error in output data is the "statistical discrepancy" component published by the BEA,[10] which represents the difference between GDP and GDI. If measurement error were not present, GDP and GDI would be equal as they are identical from an accounting perspective. Figures 4a and 4b show the impulse responses

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[8] Note that TFP exhibits a statistically significant delayed rise in the measurement-error free VAR (i.e., Figure 3c) that peaks at 0.13% after one year. We address the potential concerns arising from this delayed response of TFP in Section 5.4.

[9] It is worth noting that John Fernald has communicated to us upon reading this paper that he has recently constructed a revised TFP series that should remove substantially the presence of measurement error; indeed, we found that his new and revised series had a much weaker relation to our defense spending shock, consistent with the story we put forward in this paper that it is measurement error that is driving the spurious relation between TFP and defense spending.

[10] See Rassier (2012) and references therein for a discussion on the sources of this measurement error.

from the benchmark model augmented with the ratio of the statistical discrepancy variable to nominal GDP (i.e., $\frac{GDP-GDI}{GDP}$ when the TFP response is left unrestricted and when it is shut down, respectively. It is clear that the defense spending shock contains a measurement error that is related to that in output as it raises the statistical discrepancy measure on impact in a significant manner by 0.08%. As figure 4b shows, this response is halved to 0.04% once the TFP response is shut down to zero. While this 0.04% is still significantly different from zero, the 0.16 percentile response is 0.015% which is economically indistinguishable from zero. Since our TFP measure is constructed from business sector output data that is based on data sources that are also used for constructing GDP, we naturally deduce that TFP must also be contaminated by this output measurement error. Indeed, TFP and the statistical discrepancy variable are strongly correlated in the data: the correlation between TFP growth and the first difference of the statistical discrepancy variable equals 0.37.

4 Monte Carlo Exercise

In order to show that our identification approach is capable of picking up the true output multiplier in the presence of measurement error in quarterly data, we simulate data from an RBC model with a common measurement error in TFP, defense spending, output, consumption, and investment, and employ our proposed identification scheme on the simulated data. The model we use is pretty standard and we present below its main building blocks.

4.1 Model Used for Simulations

We model defense spending as a waste. There are five agents in the economy: a representative household, a final good firm, a continuum of monopolistically competitive intermediate good firms, a monetary and a fiscal authority.

Households Households derive utility from private consumption, C_t and leisure, $1-N_t$. Their preferences are defined by:

$$E_0 \sum_{t=0}^{\infty} \beta^t u(C_t, N_t) = E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \frac{C_t^{1-\sigma}}{1-\sigma} + \frac{(1-N_t)^{\zeta}}{1-\zeta} \right\} \tag{3}$$

where ζ, $\sigma > 0$ are preference parameters and $0 < \beta < 1$ is the subjective discount factor.

Available time is normalized to unity each period. Households have access to a complete set of nominal state-contingent claims and maximize their objective function subject to an intertemporal budget constraint that is given by:

$$P_t(C_t + I_t) + B_{t+1}R_t^{-1} \leq (1 - \tau_t^l)P_t w_t N_t + [r_t - \tau_t^k(r_t - \delta)]P_t K_t + D_t + B_t - T_t P_t + \Xi_t \tag{4}$$

Current income consists of after tax nominal labor income, $(1 - \tau_t^l)P_t w_t N_t$; after tax nominal capital income (allowing for depreciation), $[r_t - \tau_t^k(r_t - \delta^p)]P_t K_t^p$; the net cash inflow from participating in state contingent securities at time t, denoted by D_t; the dividends derived from the imperfect competitive intermediate good firms Ξ_t, minus nominal lump-sum taxes, $T_t P_t$. Households hold their financial wealth in terms of government bonds, B_t. Total income can be used for private consumption C_t and investment I_t. Private capital accumulates according to:

$$K_{t+1} = I_t + (1 - \delta(U_t))K_t - \xi\left(\frac{K_{t+1}}{K_t}\right)K_t \tag{5}$$

where $\delta(U_t)$ is the depreciation rate which depends on the utilization of capital U_t according to:

$$\delta(U_t) = \overline{\delta}U_t^{\phi}, \phi > 0$$

and $\xi\left(\frac{K_{t+1}}{K_t}\right) = \frac{b}{2}\left[\frac{K_{t+1}-(1-\delta)K_t}{K_t} - \delta\right]^2$, where b determines the size of the adjustment costs. Since households own and supply capital to the firms, they bear the adjustment costs.

Production A competitive firm produces output according to:

$$Y_t = (A_t N_t)^{1-\alpha}(U_t K_t)^{\alpha} \tag{6}$$

where $U_t K_t$ and N_t are private effective capital and labor inputs. A_t stands for TFP.

Fiscal Policy Government's income consists of tax revenues and the proceeds from new debt issue; expenditures are exogenous and consist of defense spending, G_t^D and repayment of debt. The government budget constraint is:

$$P_t G_t^D - \tau_t^l w_t P_t N_t - \tau_t^k(r_t - \delta)P_t K_t - P_t T_t + B_t = R_t^{-1}B_{t+1} \tag{7}$$

We 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.

In order to ensure determinacy of equilibrium and a non-explosive solution for debt (see e.g., Leeper (1991)), we assume a debt targeting rule of the form:

$$\tau_t^l = \overline{\tau}^l \exp(\zeta_b(b_t - \overline{b})) \tag{8}$$

where $\overline{b}$ is the steady state level of $b_t = \frac{B_t}{Y_t}$.[11]

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

$$R_t = \overline{R} \exp(\zeta_\pi \pi_t) \tag{9}$$

where π_t measures inflation in deviation from the steady state.

Closing the model Aggregate production must equal private and public demand:

$$Y_t = C_t + I_t + G_t^D \tag{10}$$

We solve the model by approximating the equilibrium conditions around the non-stochastic steady state. The parameterizations is summarized in the Table 2. The debt coefficient is set to guarantee a determined solution. 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 sample. The rest of the parameter values are pretty standard.

Common Measurement Error Let lowercase variables a_t, g_t, y_t denote the log-deviations from steady state of TFP, defense spending, and output, respectively; furthermore, let $\tilde{a}_t, \tilde{g}_t, \tilde{y}_t$ denote the measured values of these variables. We assume that a common measurement error m_t is affecting the measurement of these variables, that is, denoting by x_t the stacked 3×1 vector

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[11] In exercises we do not present here for economy of space we have also considered the case of non distortionary (lump-sum) and distortionary capital taxation as an instrument for adjustment to debt deviations. As long as we assume rules for which distortionary taxation does not rise significantly in responses to changes in debt and for a given persistence of the government spending shock process, results look similar for the different fiscal rules considered.

comprising of the true values of the variables and by $\tilde{x}_t$ the stacked 3×1 vector comprising of the measured values of the variables, we have that

$$\tilde{x}_t = x_t + m_t \tag{11}$$

where measurement error m_t is assumed to be normally distributed and serially correlated:

$$m_t = \rho m_{t-1} + \lambda_t \tag{12}$$

where $0 < \rho < 1$ and λ_t is a normally distributed white noise shock.[12] The idea of auto-correlated measurement errors goes back at least to Sargent (1989), who both modelled and estimated a serially correlated process for measurement errors in output, consumption, and investment, finding evidence for quite persistent measurement errors. Moreover, both Ireland (2004) and Malley and Woitek (2010) provide evidence from a DSGE model that having serial and cross correlation in the measurement errors generates a significantly better fit compared to the standard specification where separate and uncorrelated errors are assumed for the variables.

4.2 Simulation Results

We simulate 1000 sets of data with 248 observations each from the above model. For each simulation, we estimate the median impulse response from a Bayesian VAR based on 1000 draws from the posterior distribution of the VAR parameters; we include in the Monte Carlo VAR the same variables that we used in the empirical exercise. The only difference in our Monte Carlo exercise relative to the empirical VAR is that we do not include a narrative-based news measure because our theoretical model does not contain a natural counterpart to the Ramey (2011) news series. Also note that, to keep things simple, our model does not include defense news shocks or any other structural shock apart from the unanticipated defense shock; adding such news shocks would not change our results as these shocks affect defense spending only with a delay. In general, our identification method would perform well as long as no other shock significantly affects defense spending

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[12] Generalizing our setting to heterogonous persistence parameters would not change the results but would complicate the exposition; moreover, assuming no serial correlation in the common measurement error would also not alter our main takeaway from the Monte Carlo exercise. We opted to allow for serial correlation as the alternative would generate TFP responses that are short-lived which is inconsistent with our empirical results.

on impact, which is a reasonable assumption since it is sensible to view defense spending as an exogenous variable.

We draw the unanticipated defense shock from the normal distribution. The common measurement error in TFP, defense spending, and output, λ_t, is drawn as well from the normal distribution; to avoid singularity, we also attach eight additional idiosyncratic measurement errors to all variables in the model apart from defense spending, all of which are drawn from normal distributions as well. The standard deviations of the structural shock and the common and idiosyncratic measurement errors, along with the persistence parameter of the common measurement error process, are presented in Table 3.

Figure 5a depicts both the theoretical and estimated median impulse responses averaged over the simulations to an unexpected defense shock. The theoretical responses are represented by the solid lines and the average estimated median responses over the simulations are depicted by the dashed lines, with the dotted lines depicting the 2.5th and 97.5th percentiles of the distribution of estimated median impulse responses. The shock is estimated to have positive and significant effects on output, hours, investment, and inflation but negative effects on consumption. Notice that the estimated responses for TFP are positive while in the true model they are nil. The comparison between estimated and actual impulse responses reveals that when there is a common measurement error component in TFP, defense spending, and output, using the unrestricted VAR innovation in defense spending to identify an unexpected spending shock will lead to erroneous conclusions similar to the ones obtained in the corresponding empirical exercise.

Instead, when we orthogonalize the identified shocks with respect to movements in TFP, as shown in Figure 5b, we can recover responses that are very close to the true ones. Hence, this exercise suggests that the orthogonalization restriction with respect to TFP enables us to properly identify the true effects of the unexpected defense shock on output and the other macroeconomic variables.

5 Robustness

The results of the previous section are challenging since they seem to suggest that the stimulative effects of defense spending are due to the presence of a common measurement error in output, defense spending, and TFP. In this section we provide results from a number of sensitivity checks we have run to establish the robustness of our findings in section 3. To make the analysis more concise, we only plot the responses of defense spending, output, consumption, investment, and TFP.

5.1 VAR Specification

We have confirmed that our results are unchanged when we consider a different number of lags, a sample that excludes the Korean war period, and a post-1983 sub-sample for which results are less likely to suffer from potential heteroscedasticity and/or coefficient instability (e.g., Stock and Watson (2007)). Figures 6a and 6b show the median impulse responses for all the tested lag lengths, from 4 to 6, to the benchmark unanticipated shock and the shock orthogonalized with respect to TFP, respectively;[13] Figures 7a and 7b correspond to Figures 1 and 2, respectively, with the only difference being that now the VAR is estimated using the smaller sample period of 1955:Q1-2008:Q4 which excludes the Korean war; and Figures 8a and 8b also correspond to Figures 1 and 2, respectively, where the VAR is now estimated using the smaller sample period of 1984:Q1-2008:Q4. As evident, in all specifications TFP rises following the unanticipated defense shock and shutting down the TFP response also shuts down the output response and thus diminishes the multiplier to zero.[14]

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[13] We are not considering models with a smaller number of lags because the VAR residuals from such models failed to pass various white noise tests.

[14] We have conducted a number of additional robustness checks with respect to the VAR specification which we do not present here to save on space. Two such checks are worth noting: *i*) we confirmed that excluding TFP from the VAR does not alter the results with respect to the unrestricted defense shock; and *ii*) we have used a standard Solow residual which does not account for changes in utilization of factor inputs instead of the Fernald (2012) utilization-adjusted TFP measure and obtained similar results.

5.2 State-Dependent Impulse Responses

An important question that one can raise in light of this paper's findings is whether the benchmark results are robust to accounting for the possibility that impulse responses to defense shocks vary depending on the state of the business cycle. Several papers have recently estimated state-dependent impulse responses to fiscal shocks where a distinction between expansionary regimes and recessionary regimes has been made (e.g Auerbach and Gorodnichenko (2012, 2013) and Owyang et al. (2013)). We follow the econometric framework employed in Auerbach and Gorodnichenko (2013) and Owyang et al. (2013) which uses the local projection technique developed in Jorda (2005) to calculate impulse responses. This method allows for state-dependent effects in a straightforward manner while involving estimation by simple regression techniques. Moreover, it is more robust to misspecification than a non-linear VAR.[15]

In particular, we estimate the impulse responses directly by projecting a variable of interest on current values and lags of defense spending and lags of the Ramey (2011) variable, output, and TFP. For example, when we use output (y_t) as the dependent variable, the response of output at horizon h is estimated from the following regression:

$$\begin{aligned} y_{t+h} = I_{t-1}[\Phi_{A,h}(L)fds_t + \Xi_{A,h}(L)news_t + \Gamma_{A,h}(L)y_{t-1} + \Upsilon_{A,h}(L)tfp_{t-1} + \alpha_{A,h}] + \\ (1 - I_{t-1})[\Phi_{B,h}(L)fds_t + \Xi_{B,h}(L)news_t + \Gamma_{B,h}(L)y_{t-1} + \Upsilon_{B,h}(L)tfp_{t-1} + \alpha_{B,h}] + u_{t+h} \end{aligned} \quad (13)$$

where fds_t stands for federal defense spending, $news_t$ represents the Ramey (2011) news variable, and all the coefficients vary according to whether we are in state "A", i.e., a recession, or state "B", i.e., an expansion. I is a dummy variable that takes the value of one when the unemployment rate is above a threshold. We follow Owyang et al. (2013) and assume that a recessionary state occurs when the unemployment rate is above 6.5%. This threshold dictates that 22% of the time the economy is in a recessionary state, a number that is consistent with the duration of recessions in the US post-war period according to NBER business cycle dates (21 percent of the time). The impulse responses to the defense shock for the two recessionary and expansionary states at horizon

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[15] We have also estimated a non-linear VAR along the lines of Bachmann and Sims (2012) and Auerbach and Gorodnichenko (2012) to estimate the effects of the defense shock conditioned on the state of the business cycle. However, even in parsimonious models that included only defense spending, the Ramey (2011) news series, output, and TFP, the results obtained were uninformative as the resulting confidence intervals were very large, especially for the recessionary regime for which there are fewer observations.

h are simply $\widehat{\Phi}_{A,h}$ and $\widehat{\Phi}_{B,h}$, respectively. To obtain the estimated impulse responses for the case in which the TFP impact response is shut down, we add the current value of TFP to the regressions. The shock is normalized so that the impact response of defense spending is one percent. The confidence bands are 95 percent bands and are based on Newey-West standard errors that account for the serial correlation induced in the regressions when $h > 0$.

Figure 9a shows the state-dependent responses of defense spending, the Ramey (2011) news variable, output, and TFP to the unanticipated defense shock whereas Figure 9b presents the state-dependent responses to the defense shock that is orthogonalized with respect to current TFP.[16] It is apparent that the main result of the paper continues to hold in a manner that is robust to the state of the business cycle: TFP continues to rise in response to the defense shock in both states with output rising as well, while orthogonalizing the shock with respect to TFP shuts down the output response.

5.3 Exogenizing the Ramey (2011) News Series

Thus far, we let the Ramey (2011) news series depend on its lags as well as the lags of the other variables. One may argue that this news variable is exogenous and hence should be modelled accordingly. This modelling approach was pursued in recent work by Zubairy (2009) where, apart from exogenizing the Ramey (2011) news series and excluding TFP from the VAR, a similar empirical framework to ours was implemented to identify and explain the effects of unexpected government spending shocks. The results we obtain when TFP is left unrestricted (i.e., Figure 1) are broadly consistent with what Zubairy (2009) finds; the major difference between our paper and hers is that we show that the expansionary effect of the defense shock on output is due to measurement errors present in quarterly data. The purpose of this section is to show that our results are robust to using the estimation framework used in Zubairy (2009), i.e., one in which the Ramey (2011) news series is exogenized. Effectively, this implies that the identified defense shock has no effect on the Ramey (2011) news series both contemporaneously and also at no future horizon.

Figures 10a and 10b correspond to Figures 1 and 2, respectively, with the only difference being

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[16] We also estimated the linear analogue of Model (13) and obtained similar results that are available upon request.

that now the Ramey (2011) news series constitutes an exogenous variable in the VAR as in Zubairy (2009).[17] It is apparent from both figures that by and large the results are qualitatively unchanged and the defense shock and TFP relation continues to be significant. Moreover, orthogonalizing the unanticipated shock with respect to TFP continues to generate a multiplier of zero with complete crowding out of the private sector.

5.4 Restricting the Future Response of TFP

Our broad set of robustness checks indicates that reducing the sample size and/or increasing the number of lags in our model generally induces a significant delayed response of TFP to our orthogonalized defense shock. Moreover, as seen in Figure 3c), although the measurement-error free TFP measure does not move on impact, it does rise in a significant manner with a delay in response to the non-orthogonalized defense shock. The delayed response of TFP can be potentially troublesome since it might imply that our identification method is erroneously picking up positive TFP news shocks, rather than just the true defense shock.

To ensure that TFP news shocks are not driving our results, we have developed an estimation algorithm that effectively removes any potential delayed effect that the identified unanticipated defense shock may have on TFP. Our extended estimation algorithm is based on the notion that an equivalent way to identify our benchmark orthogonalized defense shock is to utilize the Maximum Forecast Error Variance (MFEV) identification approach put forward by Uhlig (2003) and identify the unanticipated defense shock as the shock that maximally explains the impact variation in defense spending and is orthogonal to TFP.[18] Therefore, a natural extension that incorporates restrictions

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[17] We apply here the Bayesian estimation algorithm for strong block recursive VAR models put forward by Zha (1999), where the likelihood function is broken into the different recursive blocks. In our case, we only have two blocks, where the first consists of a single equation in which the Ramey (2011) news series is equal to itself, since as in Zubairy (2009) we are not letting the Ramey (2011) news series depend on its own lags, and the second block contains a ten equation VAR for the remaining variables in which the Ramey (2011) news series enters the right hand side of these equations both contemporaneously and in lagged form. As shown in Zha (1999), this kind of block separation along with the standard assumption of a normal-inverse Wishart prior leads to a normal-inverse Wishart posterior distribution for the block recursive VAR parameters.

[18] The reason for this is that the VAR innovation in defense spending orthogonalized with respect to TFP is the only shock other than the TFP innovation that has an impact effect on defense spending. We have also confirmed the equivalence between the MFEV-based identification method and the benchmark orthogonalization-based method by applying both on the same data, finding a correlation of one between the two identified shock series as well as identical impulse responses.

on the future effect of the defense shock on TFP would be to solve an extended optimization problem in which the unanticipated defense shocks is identified as the shock that maximally explains the difference between the contribution to the impact defense spending variation and the sum of contributions to to the variation in TFP over some finite horizon H.

Specifically, as in Section 2, let y_t be a kx1 vector of observables of length T. Let the reduced form moving average representation in the levels of the observables be given by

$$y_t = F(L)u_t \tag{14}$$

where $F(L)$ is a kxk matrix polynomial in the lag operator, L, of moving average coefficients; and u_t is the kx1 vector of reduced-form innovations, which has variance-covariance matrix Σ and is linearly related to the white noise vector of economic shocks, v_t, as follows:

$$u_t = Av_t \tag{15}$$

where impact matrix A must satisfy $AA' = \Sigma$ and the entire space of permissible impact matrices can be written as CD, where C is the Cholesky factor of Σ and D is a k x k orthonormal matrix. The h step ahead forecast error is

$$y_{t+h} - E_t y_{t+h} = \sum_{\tau=0}^{h} F_\tau C D v_{t+h-\tau} \tag{16}$$

where F_τ is the matrix of moving average coefficients at horizon τ. The contribution to the forecast error variance of variable i attributable to structural shock j at horizon h is then given as

$$\Omega_{i,j} = \sum_{\tau=0}^{h} F_{i,\tau} C\gamma\gamma' C A' F'_{i,\tau} \tag{17}$$

where γ is the jth column of D, $C\gamma$ is a kx1 vector corresponding with the jth column of a possible orthogonalization, and $F_{i,\tau}$ represents the ith row of the matrix of moving average coefficients at horizon τ. We put TFP and defense spending in the first and second positions in the system, respectively, and index the unanticipated defense shock as 1. We let ξ be the first column of D, which corresponds to the unanticipated defense shock. Then, the estimation of ξ requires the solution to the following constrained maximization problem:

$$\max_{\xi}\left(\Omega_{2,1}(0)-\sum_{h=0}^{H}\Omega_{1,1}(h)\right) = \max_{\xi}\left[F_{2,0}C\xi\xi'C'F_{2,0}'-\sum_{h=0}^{H}\sum_{\tau=0}^{h}F_{1,\tau}C\xi\xi'C'F_{1,\tau}'\right] \tag{18}$$

$$\text{subject to } \xi(1) = 0 \tag{19}$$

$$\xi'\xi = 1 \tag{20}$$

where Restriction (19) ensures that the identified shock is orthogonal to current TFP and Restriction (20) ensures that the identified ξ is a unit vector. We choose $H = 20$ and implement the estimation of ξ by solving the constrained maximization problem in (18)-(20). Since this problem can no longer be reduced to an eigenvalue-eigenvector problem as in Uhlig (2003), we resort to using a numerical optimization procedure where 10^5 draws of unit vectors are randomly drawn for each draw from the posterior distribution of reduced form VAR parameters $p(B, \Sigma \mid data)$,[19] from which the vector that maximizes the objective function (18) is picked. The specific steps are as follows: First, randomly draw a $(k-1)$x1 vector of NID(0,1) random variables and divide this vector by its norm to obtain a unit vector ξ. Second, we add a zero to the the first element of ξ and use the resulting vector to compute the value of the objective function. Third, we repeat steps 1 and 2 10^5 times. Fourth, we pick the maximal value obtained from step 2; the vector ξ that corresponds to this maximal value contains the identified column vector from which we compute the impulse responses and forecast error variance shares.

Figures 11a, 11b, 12a, and 12b depict the median and 84th and 16th percentiles of the posterior distribution of impulse responses to a positive one standard deviation unanticipated defense shock identified from the above estimation algorithm, for the following four selected models: five lags model, six lags model, post-1959 model, and the measurement-error free model.[20] The posterior distribution for all figures was constructed by taking 2000 draws from the posterior distribution of the VAR parameters. To save on space, we are only showing results for one sub-sample model. Although the TFP response to the orthogonalized shock in the post-1959 VAR is insignificant (see Figure 3b), we focus on this period for comparison purposes because it corresponds to the sample

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[19] Note that B here represent the stacked $(kp+1)$xk reduced form VAR coefficient matrix, i.e., $B = [B_1, ..., B_p, B_c]'$.

[20] We have also applied the extended identification procedure to all of the other models considered in our paper and found similar results.

for which the measurement-error free GDP measure of Aruoba et al. (2013) is available and, thus, is a very important model for comparison purposes with respect to the measurement-error free model, in which TFP exhibits a significant delayed response (see Figure 3c).[21]

It is evident that TFP news shocks are not the driver of our results: the identified defense shock generates impulse responses that are similar to the benchmark case, inducing a zero output multiplier and a decline in investment. The only difference concerns the TFP response, which is now much weaker and insignificant with all median responses always lower than 0.04%. Thus, we feel comfortable rejecting the possibility that TFP news shocks are driving the results of our paper.

5.5 Cross-Correlations with Other Structural Disturbances

An additional concern that may arise from the benchmark results is that the identified unanticipated defense shock is correlated with other structural disturbances. If so, it would be these structural shocks that are actually driving the positive TFP impact response. To address this concern, we computed the correlation between the set of 2000 identified defense shock series and up to four lags and leads of the Romer and Romer (2004) monetary policy shock measure, Romer and Romer (2010) tax shock measure, a shock to the real price of oil, 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. All shocks were constructed as the residuals of univariate regressions of each of the four variables on four lags.

The results are presented in Figure 13 where the median correlation between the defense shocks and up to four lags and leads of each of the other four shocks are shown, along the corresponding 16% and 84% percentiles of the posterior distribution of correlations. The results indicate that the cross-correlations are small and insignificant, with all the contemporaneous correlations being lower than 9% in absolute value. The fact that the monetary policy shocks seem to have no relation to current and future values of our identified shock is especially important given the previous findings of Hall (1988), Mankiw (1989), and Evans (1992) on a relation between lagged values of interest

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[21] Note that, since the identified shock in the measurement-error free model is not orthogonalzied with respect to TFP, we had to slightly modify the above estimation algorithm so as to be consistent with the benchmark estimation method underlying the measurement-error free VAR and its corresponding Figure 3c. In particular, this modification merely amounts to removing Restriction (19) from the optimization problem and drawing a kx1 vector ξ without restricting its first element to be zero.

rates and money measures and current TFP. In sum, we can be quite confident that the main results of the paper are not driven by other structural shocks.

6 Ruling Out Various Economic Explanations for the TFP-Defense Shock Relation

We have provided evidence in favor of the notion that the increase in TFP following the defense shock is a result of measurement error in quarterly aggregate data. To further strengthen the reliability of this finding, in this section we provide evidence that rules out various plausible economic explanations for our findings on the relation between unanticipated defense shocks and TFP.

6.1 Sectoral Reallocation

Using annual industry-level data, Nekarda and Ramey (2011) find that government spending shocks slightly reduce labor productivity. As discussed in that paper, a plausible explanation for the difference between the aggregate relation between government spending and productivity and the industry-level relation is the sectoral reallocation effects that take place following a government spending shock. Specifically, Basu and Fernald (1997) have shown that aggregate TFP growth (ΔTFP_t) can be written as the sum of technological growth and a reallocation term:

$$\Delta TFP_t \quad = \quad \Delta a_t + \sum_i \omega_i (\gamma_i - \bar{\gamma}) \Delta x_{it} \tag{21}$$

where Δa_t is the growth rate of aggregate technology, Δx_{it} represents the cost share weighted sum of the growth rates of factor inputs in industry i, $\bar{\gamma}$ is the weighted average returns to scale across industries, γ_i is returns to scale in industry i, and ω_i is the share of industry i in total output. The last term represents reallocation of inputs across industries and will be non zero as long as different industries have different returns to scale.

Nekarda and Ramey (2011) argue that a plausible explanation for the rise in aggregate productivity following a government spending shock is that factor inputs rise more in durable goods industries than in non-durable goods industries, which would in turn result to higher aggregate productivity due to the higher returns to scale in the durable goods industries (see, e.g., Basu and Fernald (1997) and Nekarda and Ramey (2011)). A testable implication of this conjecture is that

TFP should rise in response to an unexpected increase in defense spending on durable goods while it should not move in response to defense spending on non-durable goods. To test this, we use data on real defense consumption expenditures and real defense investment expenditures, taken from the BEA, to correspondingly identify unanticipated defense consumption and defense investment shocks. Specifically, we identify the two shocks by estimating two sperate VARs that differ from the benchmark VAR only with respect to the measure of defense spending: one VAR replaces total defense spending with defense consumption spending while the other VAR replaces total defense spending with defense investment spending.[22]

Figures 14a and 14b present the impulse responses to the defense consumption shock and defense investment shocks, respectively. It is clear that the sectoral reallocation based explanation for the positive TFP-defense spending relation is rejected: both types of shocks raise TFP and, if anything, it is the defense consumption shock that has a more significant effect on TFP. Thus, it seems unlikely that what is causing the rise in TFP is a sectoral reallocation mechanism whereby factor inputs in durable goods manufacturing rise more that those in the non-durable industries.

6.2 Public Capital

Defense spending could be viewed as public investment, I_t^g. If the production function is given by: $Y_t = F(A_t, K_t, N_t, K_t^g)$ where A_t is TFP, K_t and N_t are private capital and labor, respectively, and K_t^g is public capital and the accumulation of public capital is determined by: $K_{t+1}^g = I_t^g + (1-\delta)K_t^g$. Then defense spending could affect TFP. However, in such an environment the effect of the shock in defense spending on TFP could not be contemporaneous as we observe in the data, since it takes time for public capital to accumulate.

6.3 Consumer Confidence

A widespread belief among economists and policy-makers is that the confidence of households and firms is a critical component of the transmission of fiscal policy shocks into economic activity (e.g., Bachmann and Sims (2012)). If unexpected increases in defense spending increase firms and

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[22] The two identified shocks were found to be uncorrelated with a negative median correlation that is lower in absolute terms than 0.06.

consumers confidence this could be reflected in the determination of TFP.

We investigate this hypothesis by including consumer confidence data from the Michigan Survey of Consumers in our benchmark VAR. This confidence series summarizes responses to a forward-looking question concerning aggregate expectations over a five year horizon and is available from 1960:Q1. The results from this extended VAR are shown in Figure 15. The response of consumers confidence to our identified shock is not significant, while that of TFP is significantly positive, indicating that confidence changes is the wrong channel to look at as a potential explanation for our findings.[23]

6.4 R&D Transmission

Finally, many analysts and some economists would agree that defense spending affects innovative, high-tech defense projects that can potentially increase the economy-wide R&D. A recent New York Times article[24] found that the Pentagon spends about 12 percent of its budget on research and development, or about $81.4 billion during the most recent fiscal years. That amount, the Times found, is roughly 55 percent of all federal spending on research and development. Hence, unexpected increases in defense spending could affect the R&D of the economy, and eventually TFP measures. Nevertheless, such effect cannot be contemporaneous as it takes time for R&D to build up and change TFP. However, the reaction of TFP to the identified shock is positive and significant on impact.[25]

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[23] While Bachmann and Sims (2012) have provided evidence in favor of a positive response of consumer confidence to government spending shocks during economic slack, the evidence in that paper suggests that there is even a slightly negative response of consumer confidence during expansions. We confirmed these results using the state-dependent model of Section 5.2 while also finding that the positive confidence response is quite delayed. Hence, given that most of the time the economy is in a state of expansion, it is reasonable to conclude that it is not a consumer confidence channel that is driving the positive TFP-defense spending relation.

[24] A Shrinking Defense Budget May Take Neighbors With It, January 6, 2012, by Binyamin Appelbaum. New York Times

[25] In fact, we have not even found evidence for R&D effects of our defense shock at low frequencies. Specifically, we looked at the correlation between the growth rate in annual private R&D, covering the period 1954-2002, and our annualized defense shock series. The median correlation from this exercise is only 5%, indicating that it is unlikely that there is a transmission from the defense shocks to private R&D.

7 Anticipated Defense Spending Shocks

So far, we have established that the effects of unexpected increases in defense spending, in accordance with the predictions of the standard RBC model, involve a crowding out of the private sector and a zero multiplier. This could sound like bad news for policymakers, especially nowadays that the need of stimulus is demanded in many economies in the aftermath of the Great Recession. Yet, in an accompanying paper (Ben Zeev and Pappa (2013)), we show that fiscal news have sizeable and significant demand effects when extracted as shocks that maximally explain the defense spending variability over a five-year horizon and are orthogonal to defense spending contemporaneously. In this section we analyze whether the results obtained in Ben Zeev and Pappa (2013) are contaminated by measurement error problems. To this end, we identify via our benchmark VAR the Ben Zeev and Pappa (2013) defense news shocks. The identification strategy employed in Ben Zeev and Pappa (2013) is essentially an application of the general news shock identification approach put forward by Barsky and Sims (2011) to the identification of defense spending news shocks.

Impulse responses to the anticipated fiscal shock are depicted in Figure 16. The results suggest that the presence of the TFP series does not alter the effects of anticipated defense spending shocks in the economy and it is apparent that the identified news shock has no effect on TFP at all horizons.[26,27] Thus, we conclude that the measurement error issue related to the unexpected shock is not an issue for the anticipated component of defense spending.

We view this as positive news for both academics and policymakers. For policymakers because it is still possible to affect demand and stimulate the economy by fiscal news and for academics because it opens a new direction for research on fiscal policy where more emphasis should be put on explaining the effects of anticipated shocks versus the unexpected ones and because it poses a challenge to writing models that can jointly generate significant demand effects from anticipated

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[26] Note that since the contemporaneous response of TFP to the defense news shocks is essentially zero, imposing the restriction that the news shock be orthogonal to current TFP would have no effect on the results.

[27] We have also examined the impulse responses to a shock to the Ramey (2011) news series itself, along the lines of what was done in Ramey (2011) in a VAR without TFP. Our TFP-augmented VAR produced a non-zero multiplier for this narrative-based news shock, consistent with the results in Ramey (2011), while the shock was found to have only a moderate delayed effect on TFP. These results are available upon request from the authors.

defense spending shocks and at the same time zero multipliers with respect to unexpected ones. In any case, the standard RBC model is a good point of departure since it matches, at least, pretty well the responses of the economy to unexpected increases in defense spending.

8 Conclusion

Most economists would agree that unexpected increases in defense spending increase output and decrease investment significantly on impact, while disagreements would arise on the impact of such increases on consumption, hours worked and the real wage. In this paper we show that the Keynesian multiplier associated with unexpected increases in defense spending is dead. Defense spending per se cannot stimulate additional private spending. This result is robust and survives a battery of sensitivity tests we have performed.

Our results are very important for directing future research in fiscal policy issues since they render the efforts of many economists to build models that produce high output multipliers in response to unexpected fiscal spending increases unsuitable. Unexpected increases in defense spending shocks do not involve significant demand effects and our findings bring us back to square one: the RBC model.

A word of caution is, however, at place, since other types of unexpected expenditure shocks, other than defense spending, can be quite or more important for stimulating economic activity. Unfortunately, we cannot apply our approach to such spending components. While defense spending is clearly exogenous, the non-defense spending component of government spending is most likely endogenous and, thus, renders our empirical approach ineffective for recovering its unanticipated shock. We view our work as a call for papers for more empirical work on this. We also conclude by inviting theoretical work that can explain jointly the zero output effects of unexpected increases in defense spending and the significant effects of defense spending news shocks.

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Table 1: **Correlation between TFP and Unanticipated Defense Shock: Quarterly Frequency versus Annual Frequency.**

	Annual Frequency	Quarterly Frequency
Correlation	-0.13	0.25

Notes: This table presents the median correlation between the growth rate of the utilization-adjusted TFP measure constructed in Basu et al. (2006) from annual data and the annualized defense shock series which simply consists of annual averages of the corresponding quarterly observations of the quarterly benchmark defense shock series. For comparison purposes, the median correlation for the corresponding quarterly series is also reported in the table where quarterly TFP is measured by the utilization-adjusted TFP measure constructed in Fernald (2012).

Table 2: **Monte Carlo Experiment: Model Parameterization**.

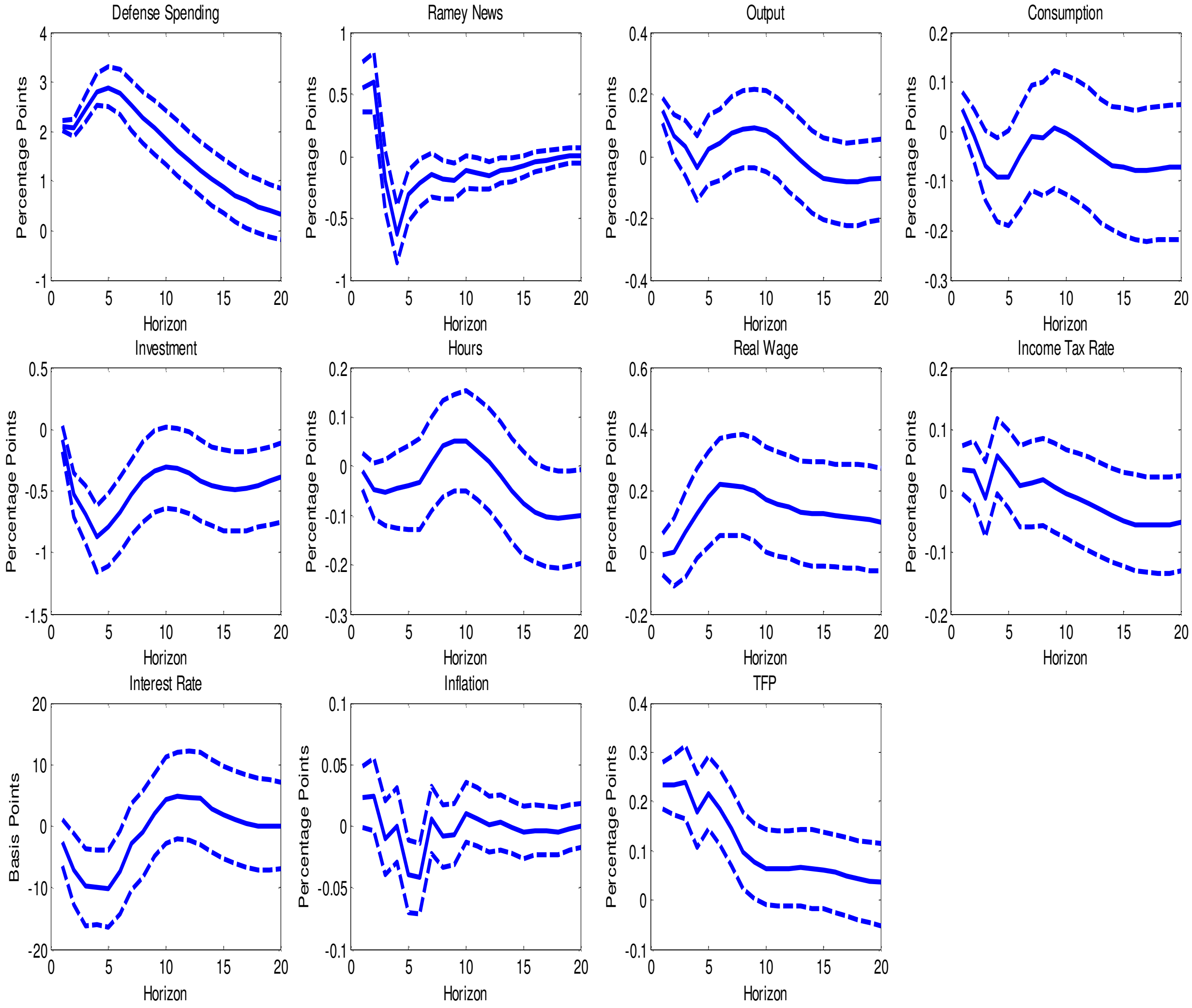
σ	Risk Aversion Coefficient	2
β	Discount Factor	0.99
$1/\zeta$	Elasticity of labor supply	0.5
b	Adjustment Cost Parameter	11.2
$\overline{\delta}$	Steady State Capital Depreciation Rate	0.025
ϕ	Elasticity of Depreciation to Changes in Utilization	1.40
α	Capital Share	0.36
B/Y	Debt to GDP Ratio	0.55
τ^l	Average labor Tax Rate	0.25
τ^k	Average Capital Tax Rate	0.25
G^D/Y	Steady State C^g/Y Ratio	0.07
ζ_b	Coefficient on Debt Rule	0.05
ζ_π	Coefficient of Inflation in Interest Rate Rule	1.1
ϱ_g	Persistence of Fiscal Shock	0.8

Table 3: **Monte Carlo Experiment: DSGE Model Shock Standard Deviations and Common Measurement Error Persistence**.

	Parameter Value
Unanticipated Defense Shock (std)	0.02
Common Measurement Error (std)	0.006
Idiosyncratic Measurement Errors (std)	0.003
Persistence parameter of Common Measurement Error (ρ)	0.7

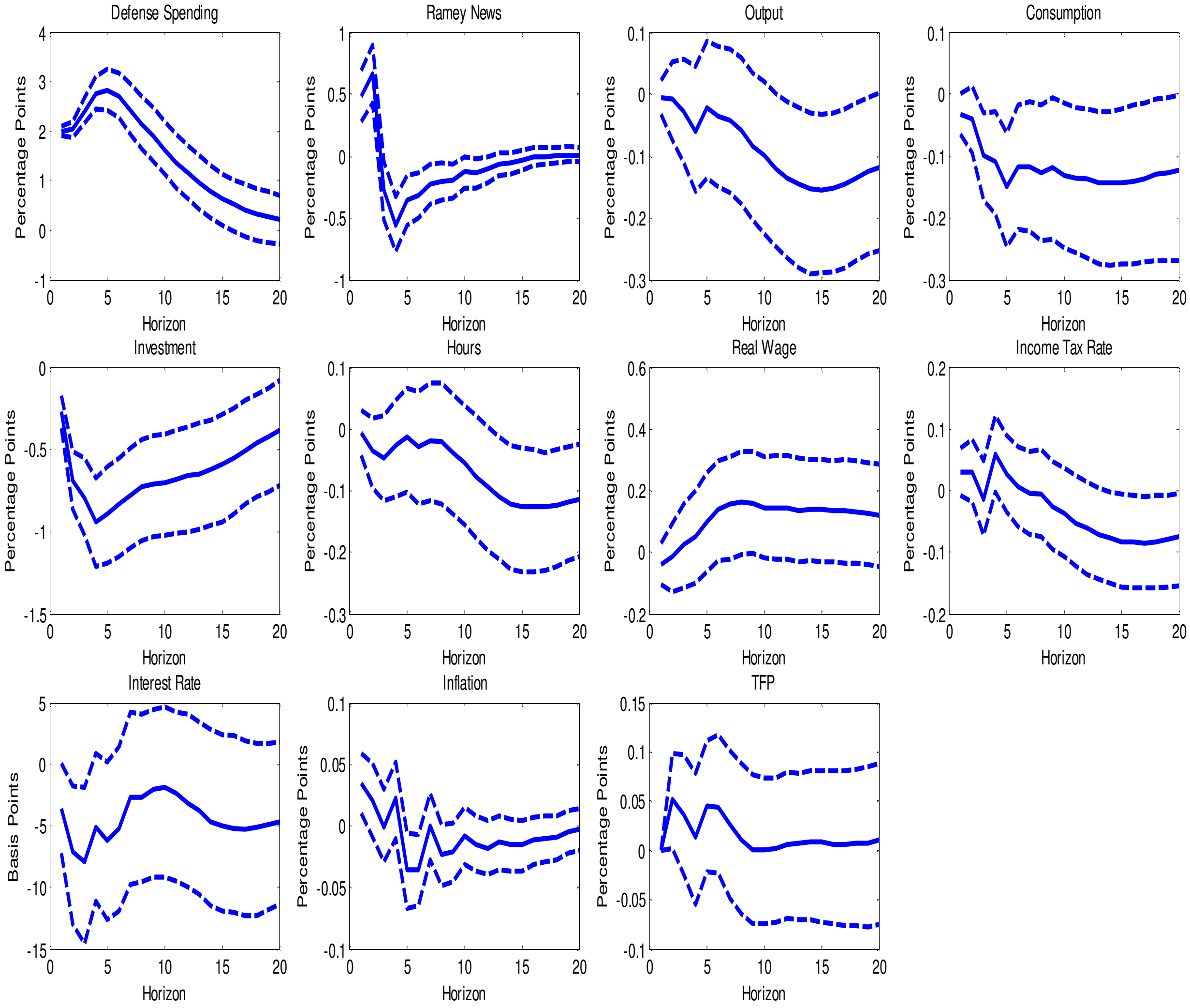
Notes: This table reports the standard deviations of the shocks used to generate the data in the Monte Carlo experiment of Section 4, along with the persistence parameter of the common measurement error process. The idiosyncratic measurement errors are simply white noise errors attached to all variables in the model apart from defense spending, whose purpose is to avoid singularity.

Figure 1: **Impulse Responses to a One Standard Deviation Unanticipated Defense Shock from the Benchmark VAR (solid lines)**.



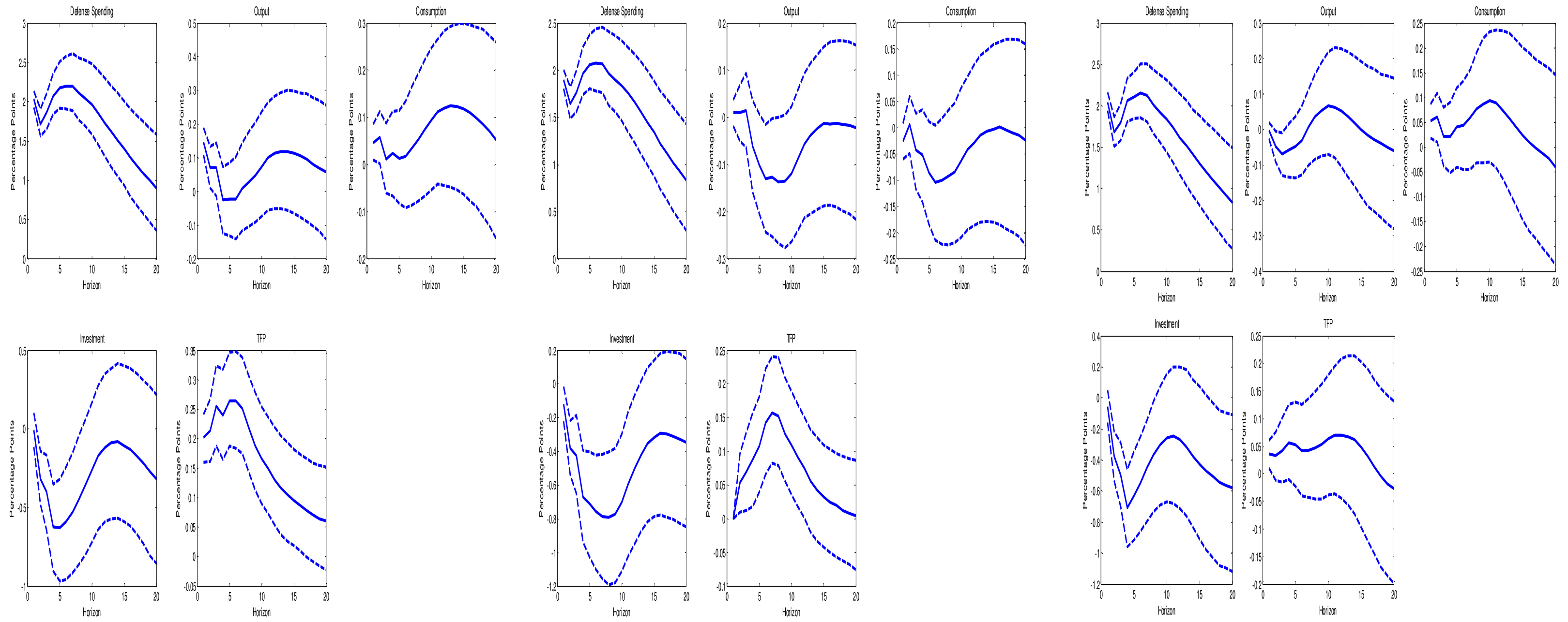
Notes: The unanticipated defense spending shock is identified as the VAR innovation in defense spending. Solid line and dashed lines are the median and 16th and 84th percentiles of the posterior distribution of impulse responses, respectively, based on 2000 draws taken from the posterior distribution of the VAR parameters. Horizon is in quarters.

Figure 2: **TFP Response Shut Down: Impulse Responses to a One Standard Deviation Unanticipated Defense Shock from the Benchmark VAR (solid lines)**.



Notes: The unanticipated defense spending shock is identified as the VAR innovation in defense spending orthogonalized with respect to TFP. Solid line and dashed lines are the median and 16th and 84th percentiles of the posterior distribution of impulse responses, respectively, based on 2000 draws taken from the posterior distribution of the VAR parameters. Horizon is in quarters.

Figure 3: **Measurement-Error Free Measures of Output and TFP: (a) Benchmark VAR with Measurement Errors (Unrestricted TFP); (b) Benchmark VAR with Measurement Errors (TFP Response Shut Down); (c) VAR with Measurement-Error Free Measures of Output and TFP**.



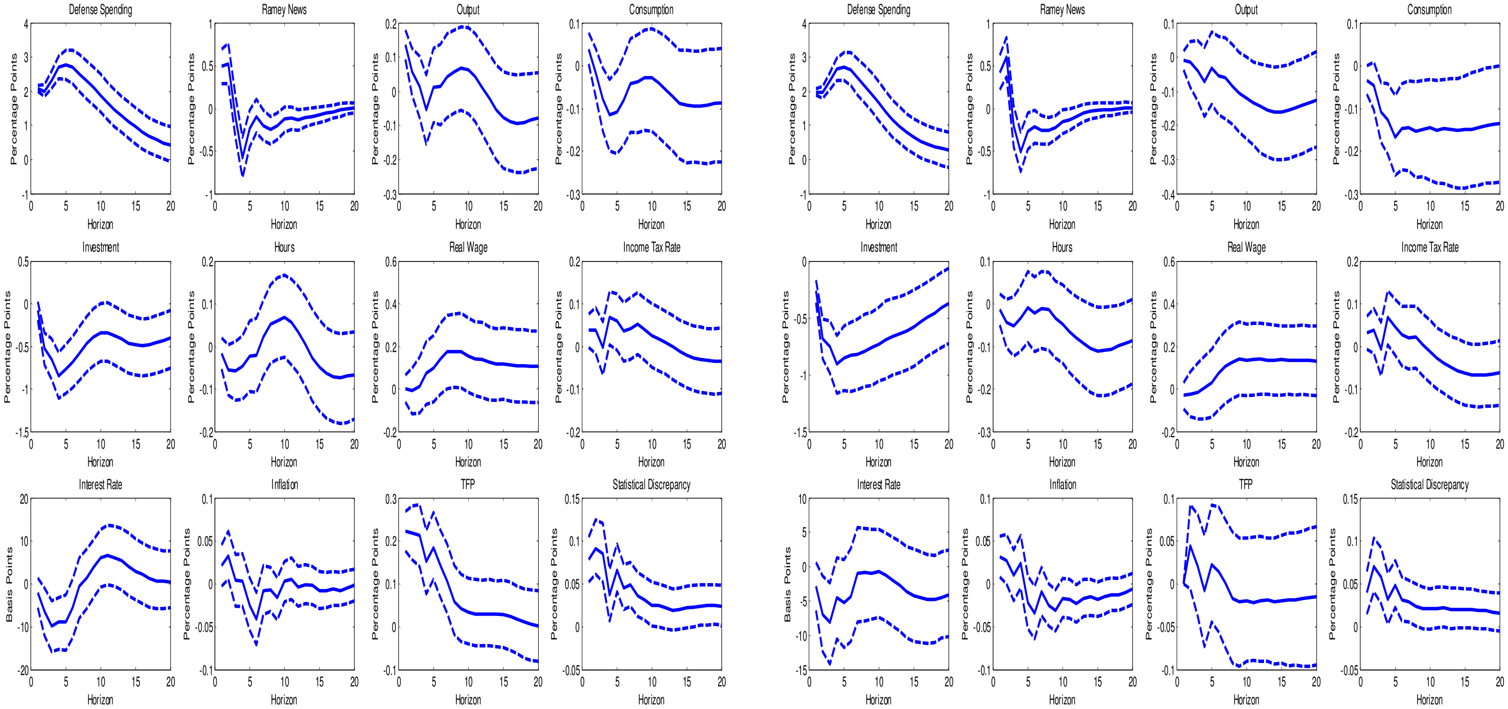
(a) Impulse Responses to a One Standard Deviation Unanticipated Defense Shock (Unrestricted TFP).

(b) Impulse Responses to a One Standard Deviation Unanticipated Defense Shock (TFP Response Shut Down).

(c) Impulse Responses to a One Standard Deviation Unanticipated Defense Shock (Measurement-Error Free Measures of Output and TFP).

Notes: Panel (a): The unanticipated defense spending shock is identified as the VAR innovation in defense spending where the sample period is 1959:4-2008:4. Solid line and dashed lines are the median and 16th and 84th percentiles of the posterior distribution of impulse responses, respectively, based on 2000 draws taken from the posterior distribution of the VAR parameters. Horizon is in quarters. Panel (b): The unanticipated defense spending shock is identified as the VAR innovation in defense spending orthogonalized with respect to TFP where the sample period is 1959:4-2008:4. Panel (c): The unanticipated defense spending shock is identified as the VAR innovation in defense spending from a VAR that replaces the standard GDP measure with the measurement-error free GDP measure of Aruoba et al. (2013) and uses the measurement-error free TFP measure whose construction is based on the Aruoba et al. (2013) GDP measure. The sample period for this VAR is 1959:Q4-2008:Q4.

Figure 4: **VAR with the Statistical Discrepancy Variable: (a) Unrestricted TFP; (b) TFP Response Shut Down**.

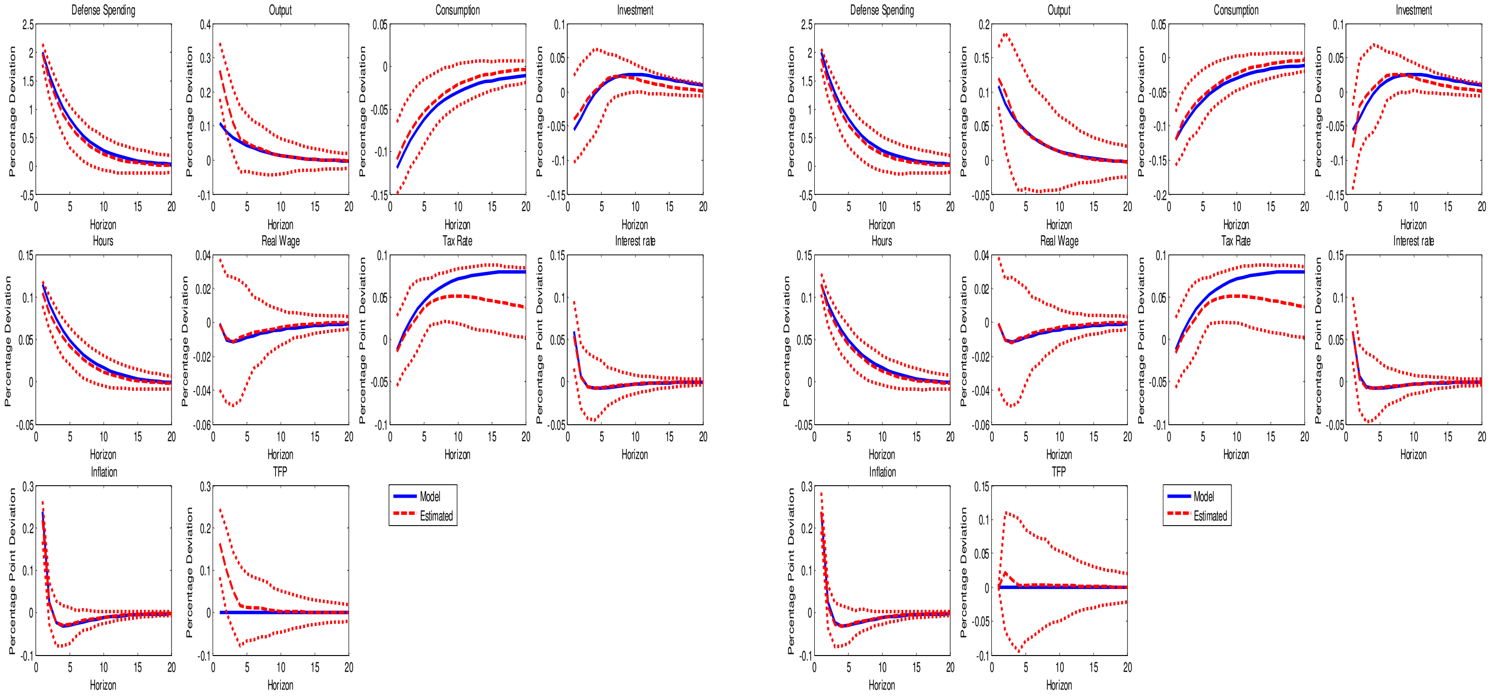


(a) Impulse Responses to a One Standard Deviation Unanticipated Defense Spending Shock (Unrestricted TFP).

(b) Impulse Responses to a One Standard Deviation Unanticipated Defense Spending Shock (TFP Response Shut Down).

Notes: Panel (a): The unanticipated defense spending shock is identified as the VAR innovation from the benchmark model augmented with the statistical discrepancy variable, which is the ratio of the difference between GDP and GDI to GDP. Solid line and dashed lines are the median and 16th and 84th percentiles of the posterior distribution of impulse responses, respectively, based on 2000 draws taken from the posterior distribution of the VAR parameters. Horizon is in quarters. Panel (b): The unanticipated defense spending shock is identified as the VAR innovation orthogonalized with respect to TFP from the benchmark model augmented with the statistical discrepancy variable, which is the ratio of the difference between GDP and GDI to GDP. Solid line and dashed lines are the median and 16th and 84th percentiles of the posterior distribution of impulse responses, respectively, based on 2000 draws taken from the posterior distribution of the VAR parameters. Horizon is in quarters.

Figure 5: **Monte Carlo Evidence (Estimated Impulse Responses): Unrestricted TFP; (b) Restricted TFP**.

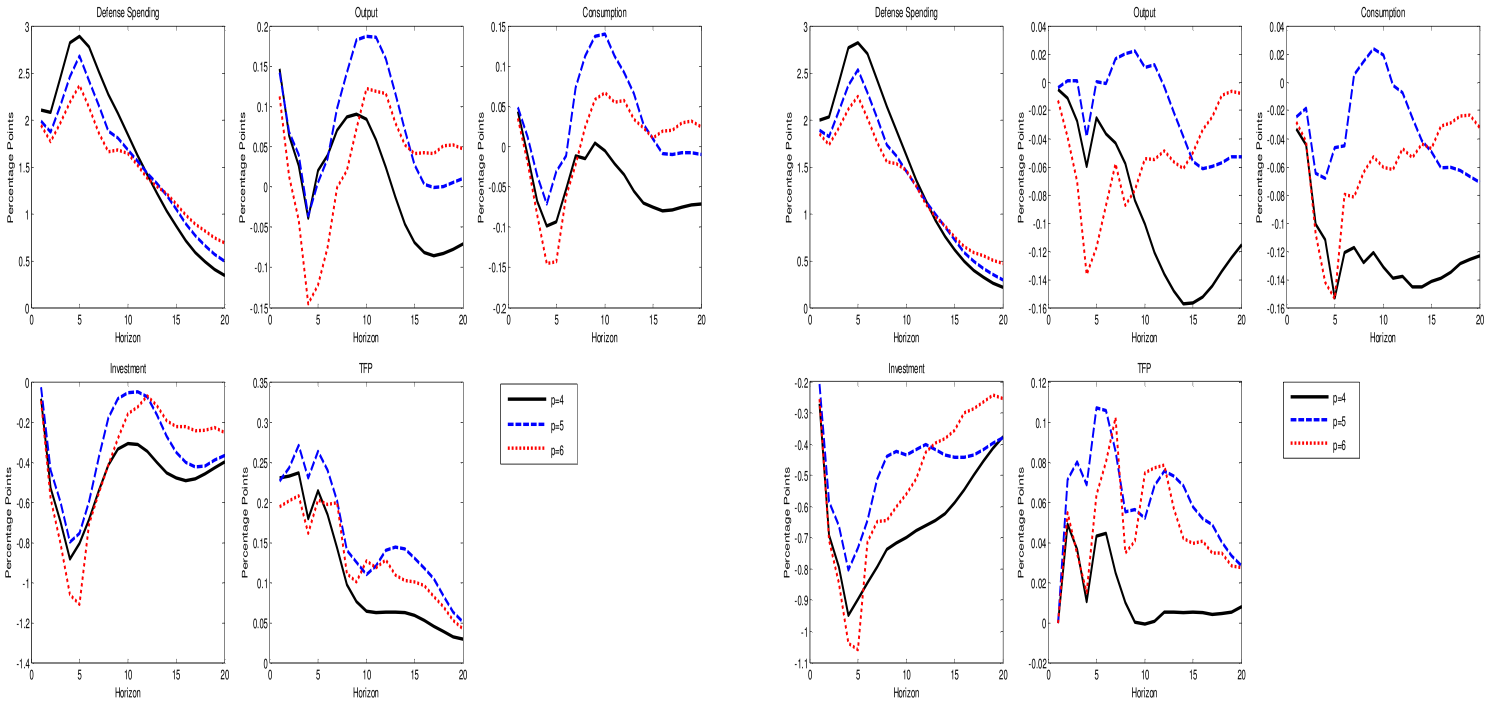


(a) The Estimated Mean and 97.5th and 2.5th percentile Median Impulse Responses and the True Impulse Responses.

(b) The Estimated Mean and 97.5th and 2.5th percentile Median Impulse Responses and the True Impulse Responses Under Orthogonalization with respect to TFP.

Notes: The figures are based on 1000 Monte Carlo simulations of the model of Section 4 where in each simulation the impulse responses to the defense shock were identified as the median values of impulse responses based on 1000 draws from the posterior distribution of the VAR parameters. Panel (a): The solid line represents the true model impulse responses, the dashed line is the average estimated median impulse response to the defense shock across Monte Carlo replications, and the dotted lines are the 97.5th and 2.5th estimated percentiles of the median impulse response. Panel (b): The solid line represents the true model impulse responses, the dashed line is the average estimated median impulse response to the defense shock across Monte Carlo replications orthogonalized with respect to TFP, and the dotted lines are the 97.5th and 2.5th estimated percentiles of the median impulse response.

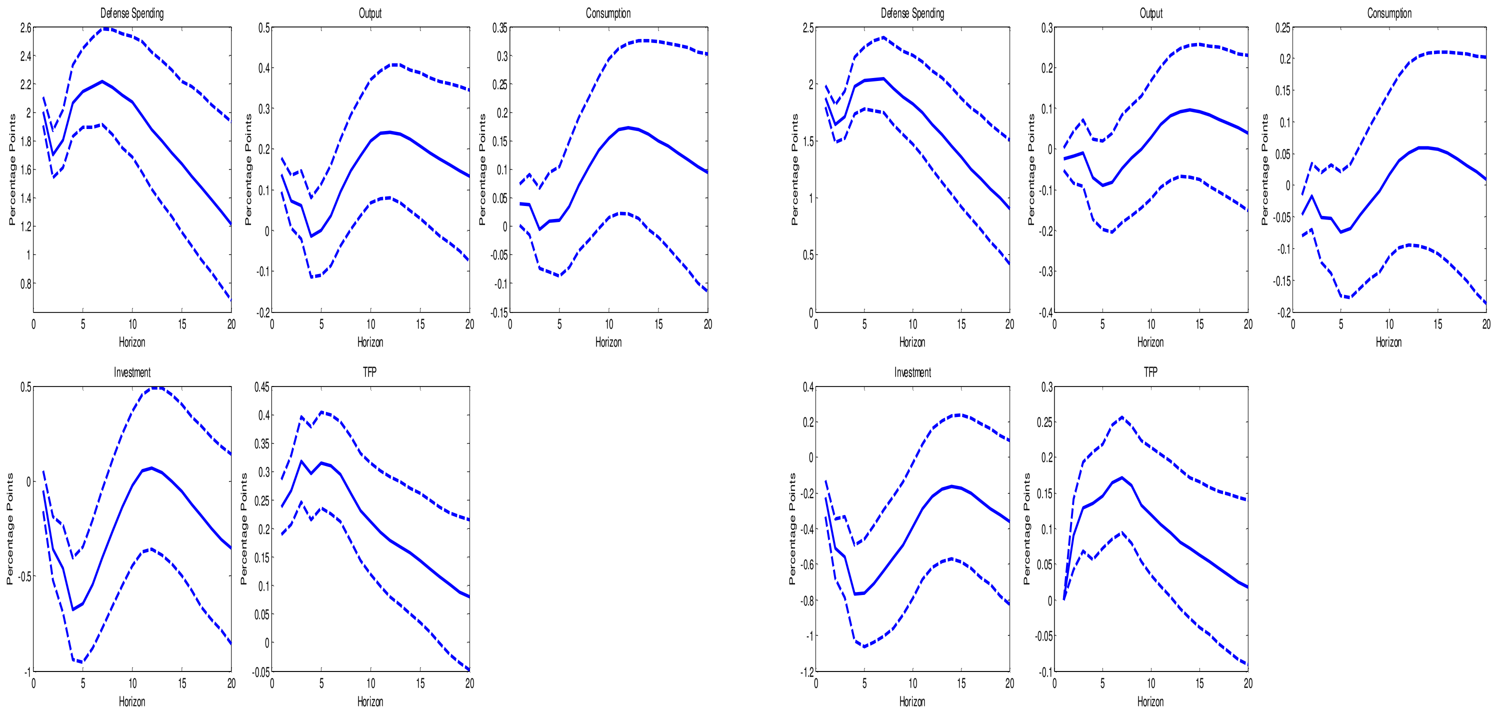
Figure 6: **Robustness to VAR Lags: (a) Unrestricted TFP; (b) TFP Response Shut Down**.



(a) Impulse Responses to a One Standard Deviation Unanticipated Defense Shock (Unrestricted TFP). **(b) Impulse Responses to a One Standard Deviation Unanticipated Defense Shock (TFP Response Shut Down).**

Notes: Panel (a): The solid, dashed, dotted and dash-dotted lines are the estimated median impulse responses to the unanticipated defense shock from a VAR with 4, 5, and 6 lags, respectively, based on 2000 draws taken from the posterior distribution of the VAR parameters. Horizon is in quarters. Panel (b): The solid, dashed, dotted and dash-dotted lines are the estimated impulse responses to the unanticipated defense shock from a VAR with 4, 5, and 6 lags, respectively, based on 2000 draws taken from the posterior distribution of the VAR parameters. The shock is orthogonalized with respect to TFP. Horizon is in quarters.

Figure 7: **Post-Korea Sample (1955-2008): (a) Unrestricted TFP; (b) TFP Response Shut Down**.

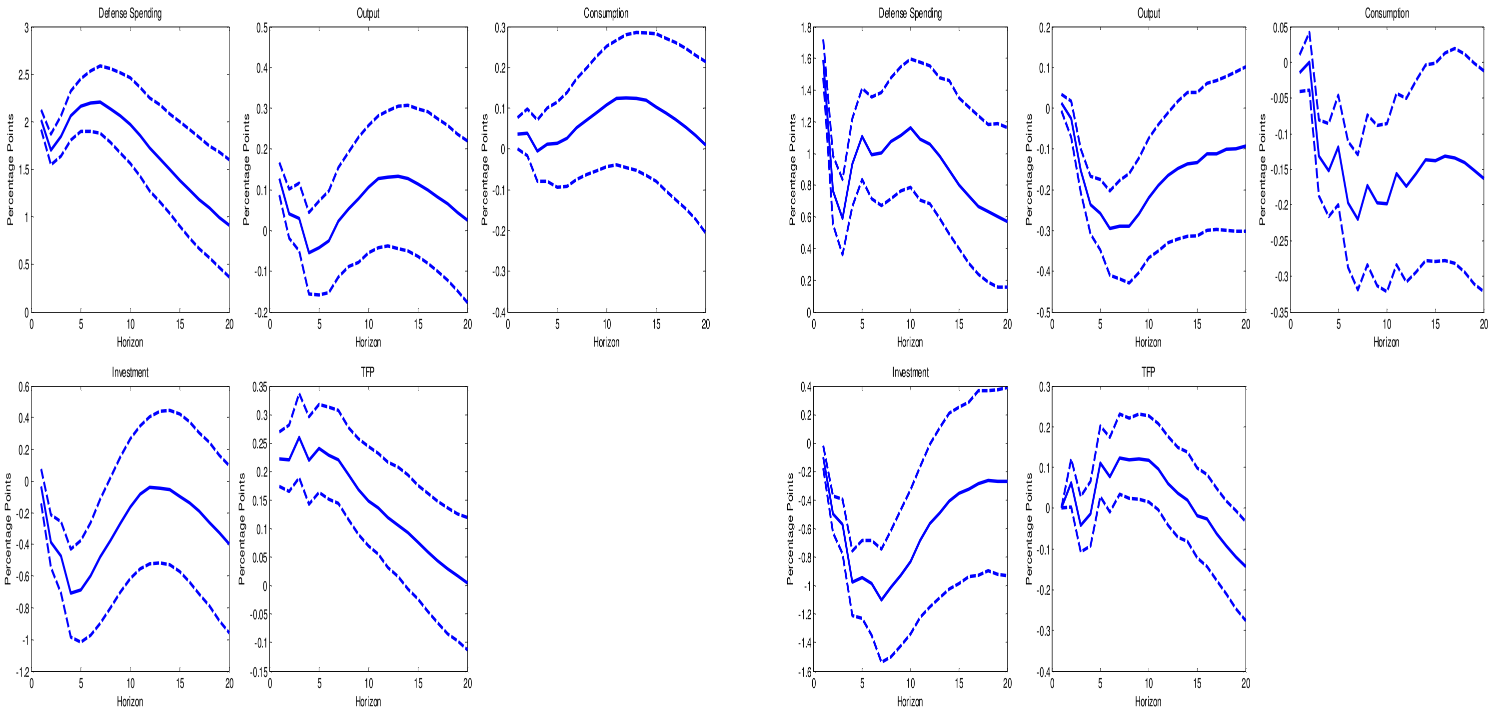


(a) Impulse Responses to a One Standard Deviation Unanticipated Defense Spending Shock (Unrestricted TFP).

(b) Impulse Responses to a One Standard Deviation Unanticipated Defense Spending Shock (TFP Response Shut Down).

Notes: Panel (a): The unanticipated defense spending shock is identified as the VAR innovation using the sample period 1955-2008. Solid line and dashed lines are the median and 16th and 84th percentiles of the posterior distribution of impulse responses, respectively, based on 2000 draws taken from the posterior distribution of the VAR parameters. Horizon is in quarters. Panel (b): The unanticipated defense spending shock is identified as the VAR innovation in defense spending orthogonalized with respect to TFP using the sample period 1955-2008. Solid line and dashed lines are the median and 16th and 84th percentiles of the posterior distribution of impulse responses, respectively, based on 2000 draws taken from the posterior distribution of the VAR parameters. Horizon is in quarters.

Figure 8: **Post-1983 Sample (1984-2008): (a) Unrestricted TFP; (b) TFP Response Shut Down**.

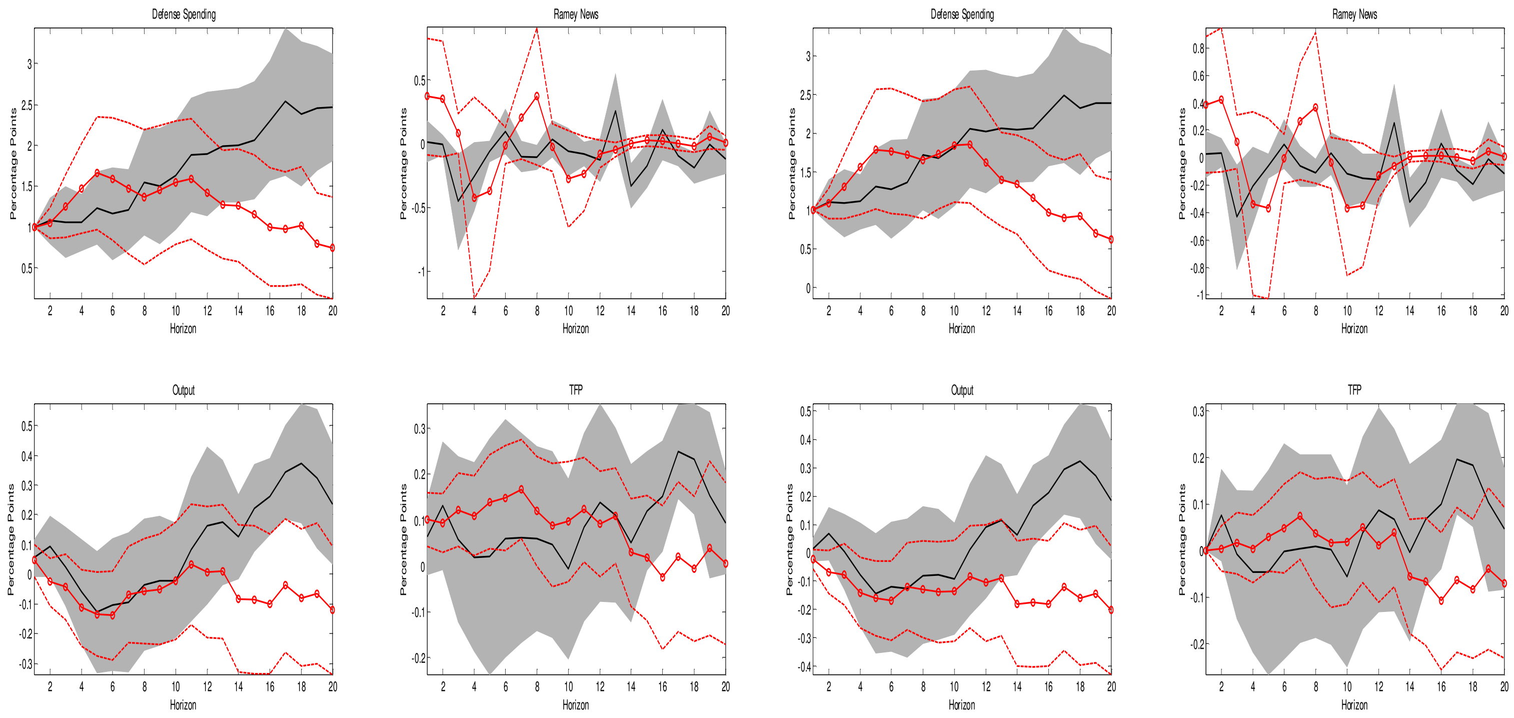


(a) Impulse Responses to a One Standard Deviation Unanticipated Defense Spending Shock (Unrestricted TFP).

(b) Impulse responses to a one standard deviation Unanticipated Defense Spending Shock (TFP Response Shut Down).

Notes: Panel (a): The unanticipated defense spending shock is identified as the VAR innovation in defense spending using the sample period 1984-2008. Solid line and dashed lines are the median and 16th and 84th percentiles of the posterior distribution of impulse responses, respectively, based on 2000 draws taken from the posterior distribution of the VAR parameters. Horizon is in quarters. Panel (b): The unanticipated defense spending shock is identified as the VAR innovation in defense spending orthogonalized with respect to TFP using the sample period 1984-2008. Solid line and dashed lines are the median and 16th and 84th percentiles of the posterior distribution of impulse responses, respectively, based on 2000 draws taken from the posterior distribution of the VAR parameters. Horizon is in quarters.

Figure 9: **State-Dependent Impulse Responses: (a) Unrestricted TFP; (b) TFP Response Shut Down**.

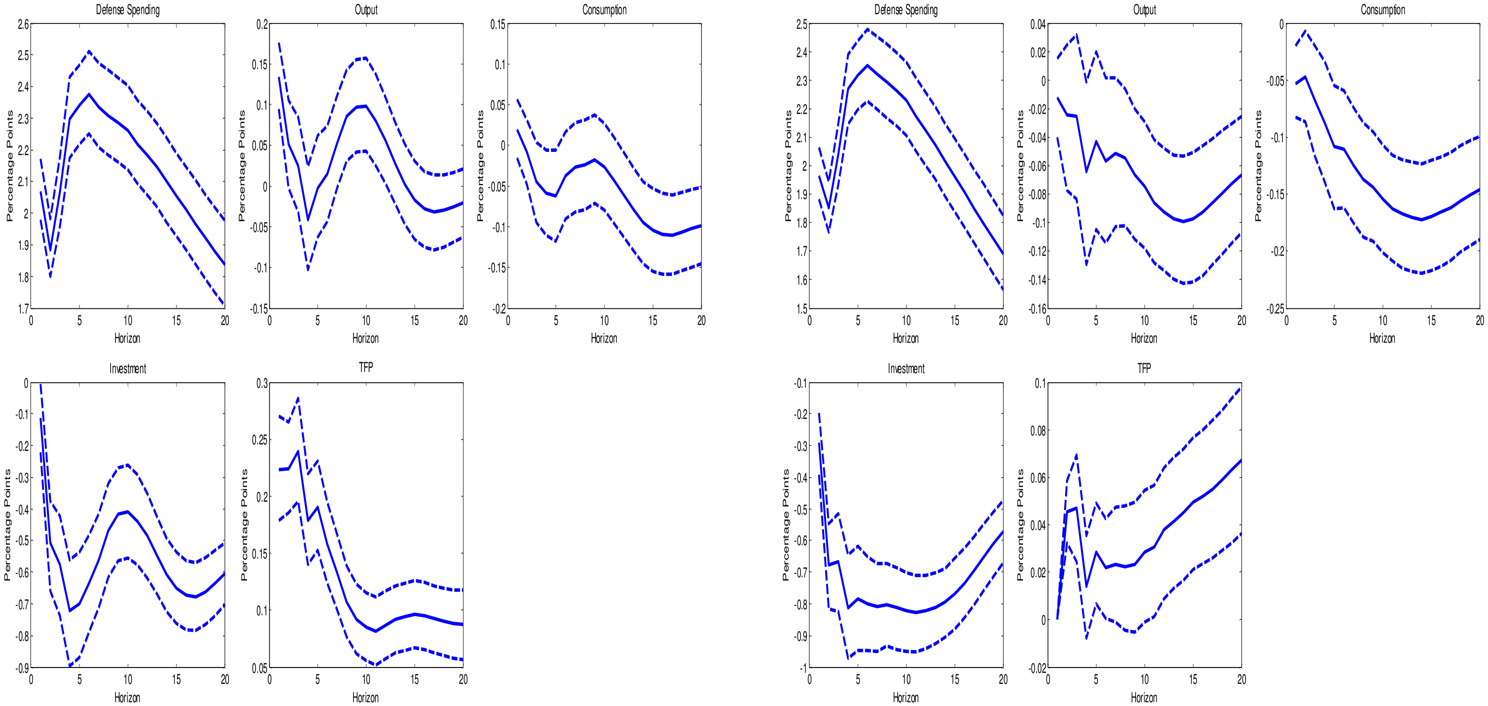


(a) Impulse responses to an Unanticipated Defense Spending Shock (Unrestricted TFP).

(b) Impulse responses to an Unanticipated Defense Spending Shock (TFP Response Shut Down).

Notes: Panel (a): Solid lines are responses in the high unemployment state. 95% confidence intervals are shown. The defense shock is normalized such that defense spending rises by 1% on impact. Horizon is in quarters. Panel (b): lines with circles are responses in the low unemployment state. 95% confidence intervals are shown. The defense shock is orthogonalized with respect to TFP and is normalized such that defense spending rises by 1% on impact. Horizon is in quarters.

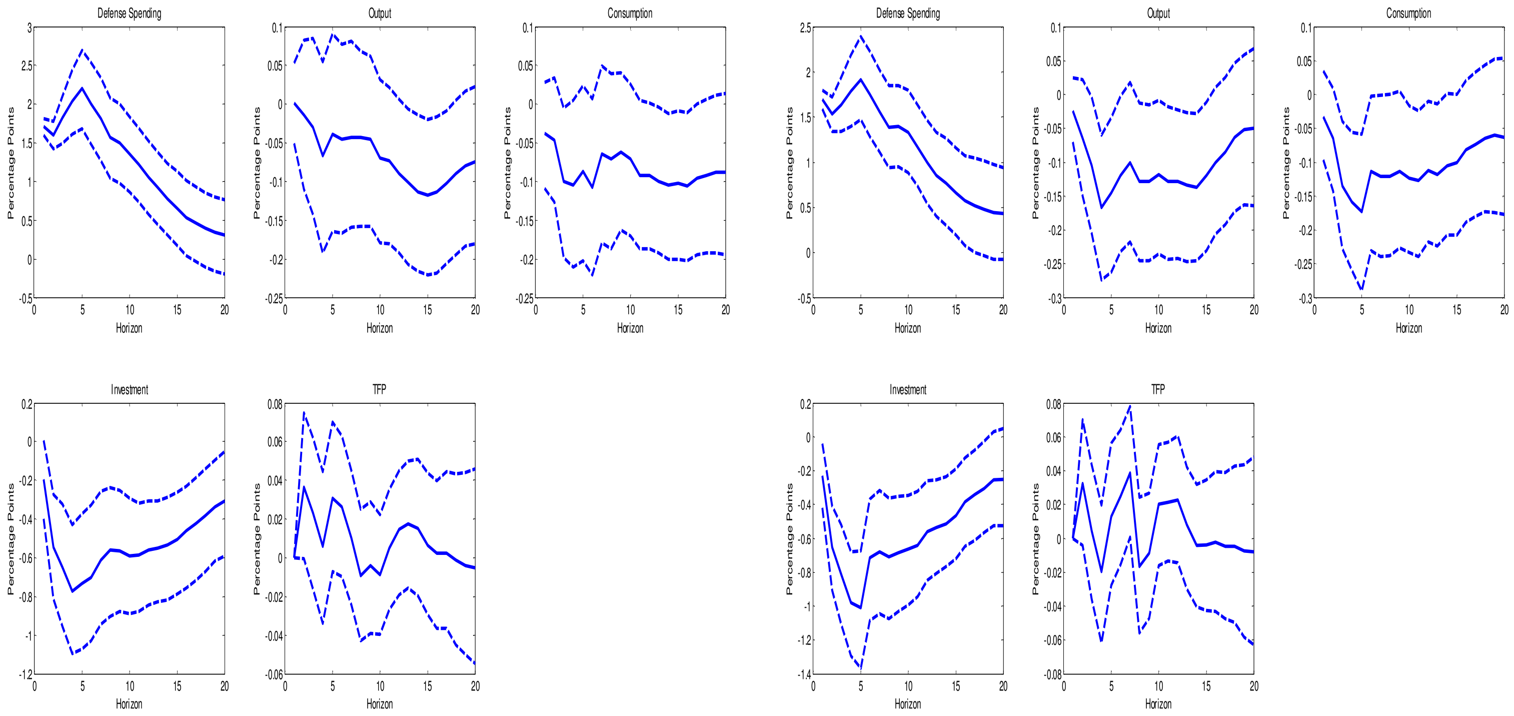
Figure 10: **Exogenizing the Ramey (2011) News Series: (a) Unrestricted TFP; (b) TFP Response Shut Down**



(a) Impulse responses to an Unanticipated Defense Spending Shock (Unrestricted TFP). **(b) Impulse responses to an Unanticipated Defense Spending Shock (TFP Response Shut Down).**

Notes: Panel (a): The unanticipated defense spending shocks is identified as the VAR innovation in defense spending, where now the Ramey (2011) news series is only allowed to depend upon its own lags. Solid line and dashed lines are the median and 16th and 84th percentiles of the posterior distribution of impulse responses, respectively, based on 2000 draws taken from the posterior distribution of the VAR parameters. Horizon is in quarters. Panel (b): The unanticipated defense spending shocks is identified as the VAR innovation in defense spending orthogonalized with respect to TFP, where the Ramey (2011) news series is now only allowed to depend upon its own lags. Solid line and dashed lines are the median and 16th and 84th percentiles of the posterior distribution of impulse responses, respectively, based on 2000 draws taken from the posterior distribution of the VAR parameters. Horizon is in quarters.

Figure 11: **Results from Extended Estimation Procedure: (a) Five Lags VAR (Benchmark Sample Period 1947-2008); (b) Six Lags VAR (Benchmark Sample Period 1947-2008)**.

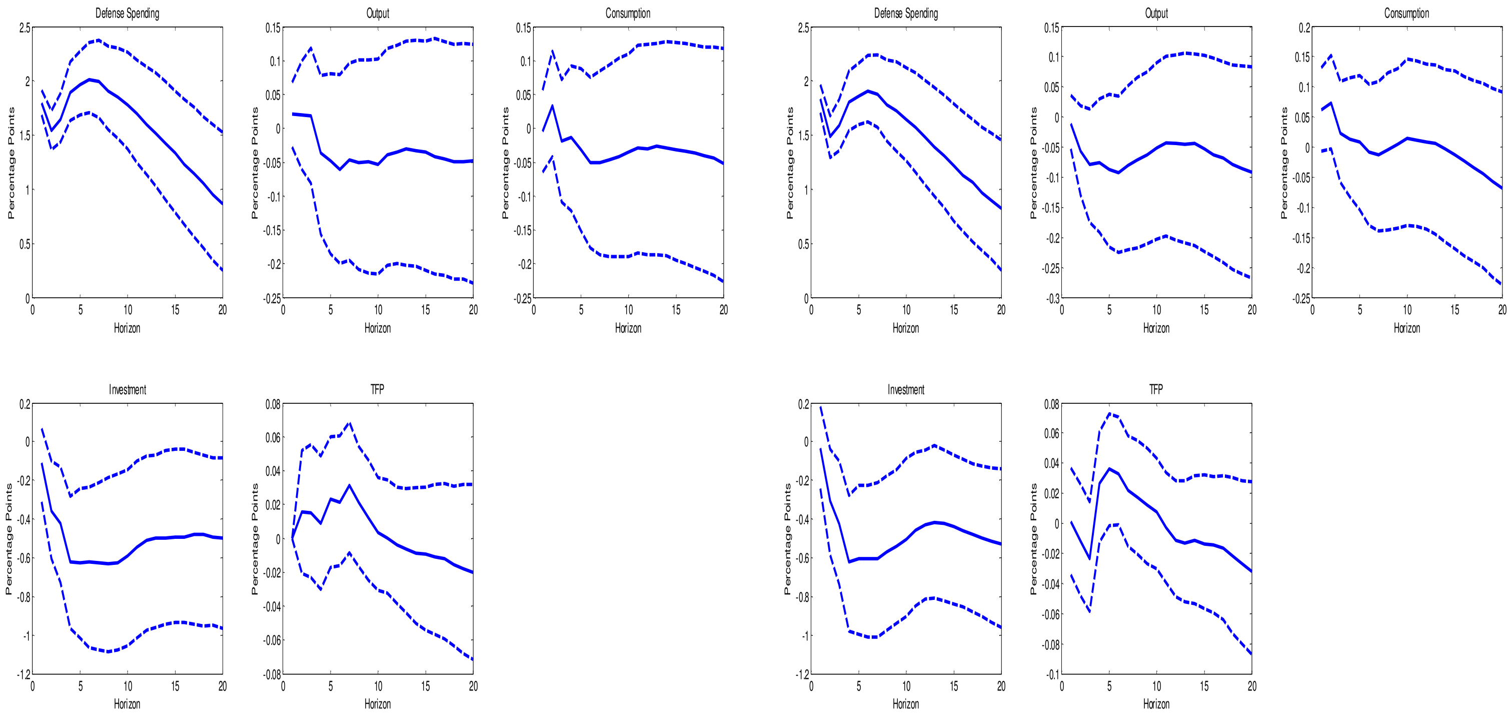


(a) Impulse Responses to a One Standard Deviation Unanticipated Defense Shock from Extended Estimation Procedure (Five Lags VAR).

(b) Impulse Responses to a One Standard Deviation Unanticipated Defense Shock from Extended Estimation Procedure (Six Lags VAR).

Notes: Panel (a): The unanticipated defense spending shock is identified as the shock that maximally explains the difference between the contribution to the impact defense spending variation and the sum of contributions to to the variation in TFP over a five year horizon, assuming a five lag specification in the VAR. Solid line and dashed lines are the median and 16th and 84th percentiles of the posterior distribution of impulse responses, respectively, based on 2000 draws taken from the posterior distribution of the VAR parameters. Panel (b): The unanticipated defense spending shock is identified as the shock that maximally explains the difference between the contribution to the impact defense spending variation and the sum of contributions to to the variation in TFP over a five year horizon, assuming a six lag specification in the VAR. Solid line and dashed lines are the median and 16th and 84th percentiles of the posterior distribution of impulse responses, respectively, based on 2000 draws taken from the posterior distribution of the VAR parameters. Horizon is in quarters.

Figure 12: **Results from Extended Estimation Procedure: (a) Post-1959 Benchmark VAR; (b) Measurement-Error Free VAR**.

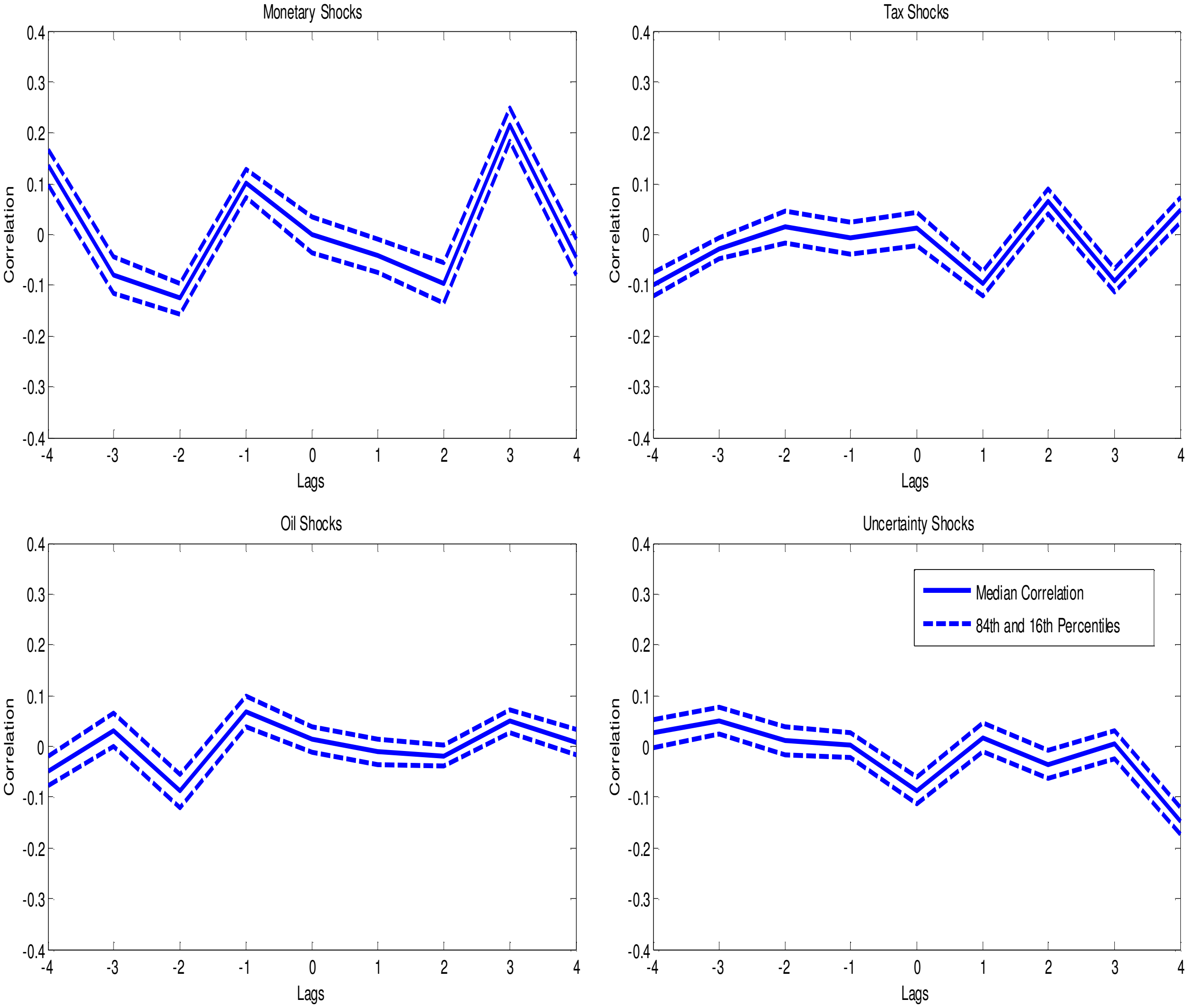


(a) **Impulse Responses to a One Standard Deviation Unanticipated Defense Shock from Extended Estimation Procedure (Post-1959 Benchmark VAR).**

(b) **Impulse Responses to a One Standard Deviation Unanticipated Defense Shock from Extended Estimation Procedure (Measurement-Error Free VAR).**

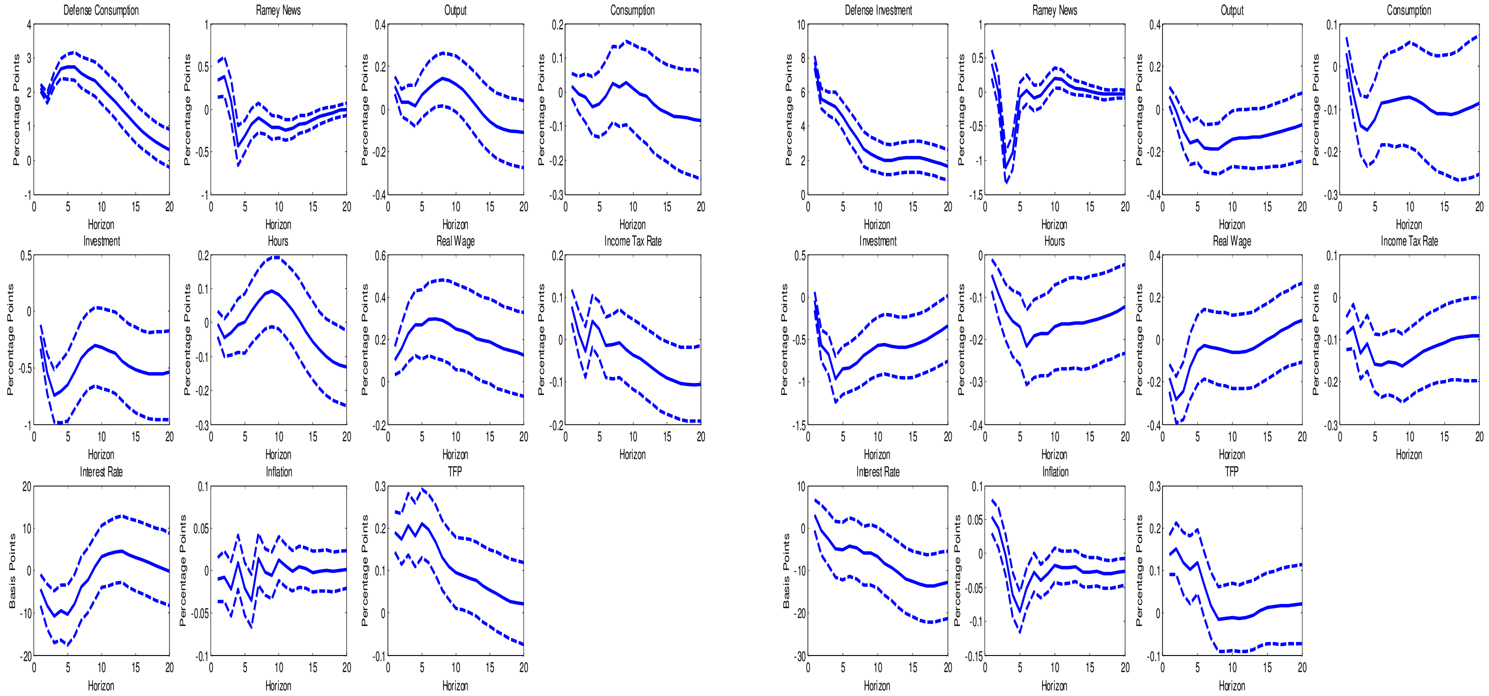
Notes: Panel (a): The unanticipated defense spending shock is identified as the shock that maximally explains the difference between the contribution to the impact defense spending variation and the sum of contributions to to the variation in TFP over a five year horizon, using a post-1959 sample period. Solid line and dashed lines are the median and 16th and 84th percentiles of the posterior distribution of impulse responses, respectively, based on 2000 draws taken from the posterior distribution of the VAR parameters. Horizon is in quarters. Panel (b): The unanticipated defense spending shock is identified as the shock that maximally explains the difference between the contribution to the impact defense spending variation and the sum of contributions to to the variation in TFP over a five year horizon, using the VAR from Figure 3c which includes measurement-error free measures of GDP and TFP. Solid line and dashed lines are the median and 16th and 84th percentiles of the posterior distribution of impulse responses, respectively, based on 2000 draws taken from the posterior distribution of the VAR parameters. Horizon is in quarters.

Figure 13: **The Cross-Correlation between the Unanticipated Defense Shock and Lags/Leads of Other Structural Shocks**.



Notes: The solid line and dashed lines are the median and 16th and 84th percentiles of the posterior distribution of cross-correlations between the unanticipated defense shock and the four considered macroeconomic shocks, based on 2000 draws taken from the posterior distribution of the VAR parameters used to construct the 2000 shock series. The other shocks include the Romer and Romer (2004) monetary policy shock measure, Romer and Romer (2010) tax shock measure, shock to the real price of oil, 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. All shocks were constructed as the residuals of univariate regressions of each of the four variables on four lags.

Figure 14: **Impulse Responses to Consumption and Investment Defense Shocks: (a) Defense Consumption; (b) Defense Investment**

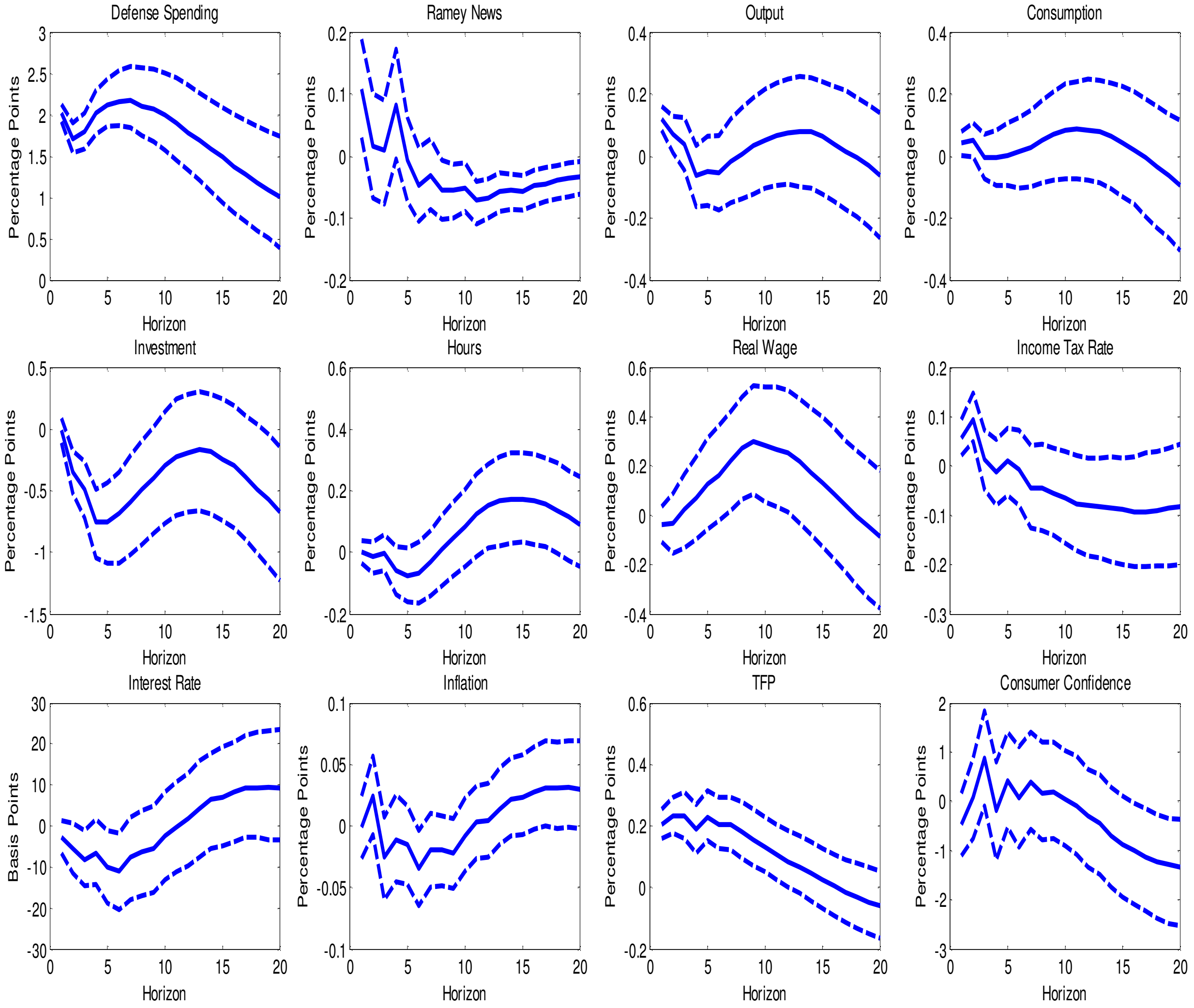


(a) Impulse responses to an Unanticipated Defense Consumption Shock.

(b) Impulse responses to an Unanticipated Defense Investment Shock.

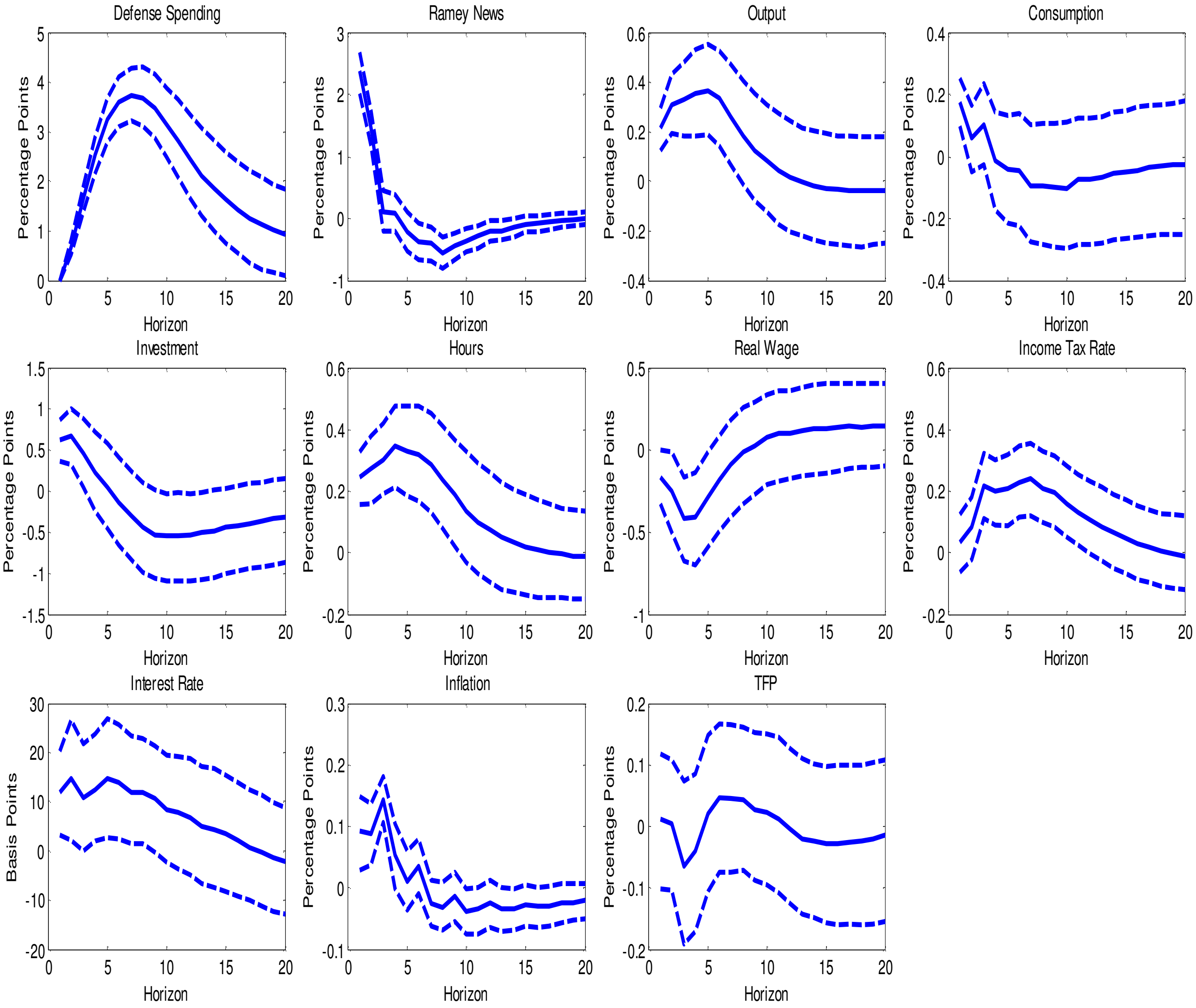
Notes: Panel (a): The unanticipated defense consumption shock is identified as the VAR innovation in defense consumption spending. Solid line and dashed lines are the median and 16th and 84th percentiles of the posterior distribution of impulse responses, respectively, based on 2000 draws taken from the posterior distribution of the VAR parameters. Horizon is in quarters. Panel (b): The unanticipated defense investment shock is identified as the VAR innovation in defense investment spending. Solid line and dashed lines are the median and 16th and 84th percentiles of the posterior distribution of impulse responses, respectively, based on 2000 draws taken from the posterior distribution of the VAR parameters. Horizon is in quarters.

Figure 15: **Impulse Responses to a One Standard Deviation Unanticipated Defense Shock (VAR with Consumer Confidence)**.



Notes: The unanticipated defense spending shocks is identified as the VAR innovation in defense spending from a VAR that includes consumer confidence. Solid line and dashed lines are the median and 16th and 84th percentiles of the posterior distribution of impulse responses, respectively, based on 2000 draws taken from the posterior distribution of the VAR parameters. Horizon is in quarters.

Figure 16: **Impulse responses to a One Standard Deviation Defense News Shock from the Benchmark VAR (solid lines).**



Notes: The impulse responses were obtained from applying the identification method used in Ben Zeev and Pappa (2013), where the news shock is identified as the shock that is orthogonal to current defense spending and that best explains future movements in defense spending over a five year horizon. Solid line and dashed lines are the median and 16th and 84th percentiles of the posterior distribution of impulse responses, respectively, based on 2000 draws taken from the posterior distribution of the VAR parameters. Horizon is in quarters.