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# Multipliers of Unexpected Increases in Military Spending: An Empirical Investigation \*

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## Abstract

We show that unexpected increases in defense and total government 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. Anticipated increases in military spending are not affected by the presence of measurement error and induce sizeable multipliers.

*JEL classification:* E32, E62

*Key words:* Defense Spending, Unanticipated Defense Shocks, Total Factor Productivity

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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. [Ramey \(2011\)](#) constructs two measures of government spending shocks. The first uses narrative evidence to construct an estimate of the change in the expected present value of government spending relying on readings of the Business Week, as well as several newspaper sources. 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. 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. We identify such changes as positive shocks to defense spending that are orthogonal to Ramey’s narrative-based news series about fiscal shocks.

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. These results also hold when we look at

unexpected increases in total government spending. Thus, in agreement with [Ramey and Shapiro \(1998\)](#), unexpected increases in defense spending do not seem to generate any significant demand effects.

What, then, is the mechanism that makes unexpected increases in defense spending increase TFP? We argue that measurement errors present in aggregate quarterly data on government spending and output data are driving the positive TFP-defense shock relation. We base our argument on the fact that the positive correlation between TFP and the unanticipated defense shock only holds for quarterly data and is entirely eliminated by using a TFP measure that is constructed from annual data. Moreover, 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.

We have also provided evidence that rules out various economic explanation 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 than 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 economic explanations can account for the evidence, we have investigated whether unexpected increases in defense spending could be related with (a) increases in patriotism, mirrored in increases in work effort during such episodes; (b) with changes in consumers' confidence; and (c) with 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.

Contrary to the effects of unexpected increases in military 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. Moreover, we show here that, unlike unanticipated defense spending shocks, these 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 government 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 examine their sensitivity to changes in the model specification. In Section 5 we test different economic explanations for the responses of TFP to unexpected defense shocks and in Section 6 we present evidence on the effects of anticipated defense spending shocks. Section 7 concludes.

## 2 Identifying Unanticipated Defense Shocks

We assume that defense spending is driven by two shocks: an unanticipated component which impacts the level of spending in the same period and an anticipated shock which agents observe in advance and impacts on the level of defense spending in the future. We refer to the latter as the defense news shock. For example, a process that incorporates both unanticipated and defense news shocks is:

$$\epsilon_t = \kappa\epsilon_{t-1} + e_{t-1} + \eta_t \tag{1}$$

where  $\epsilon_t$  denotes the log-deviation of defense spending from its steady state, parameter  $0 \leq \kappa < 1$  describes the persistence of the process,  $\eta_t$  is an *iid* unanticipated defense shock, and  $e_t$  is an *iid* defense news shock. Given the timing assumption, the news shock has no immediate impact on the level of defense spending but portends changes in it. We now turn to explaining how we intend to identify the unanticipated defense shock  $\eta_t$ .

In Equation 1,  $\eta_t$  is the only shock that has a contemporaneous effect on defense spending. To obtain it we consider a VAR that includes government defense spending, the Ramey (2011) news series (which should proxy for  $e_{t-1}$ ), real aggregates, the real wages, the Barro and Redlick

(2011) average marginal tax rate, interest rates, inflation, and total factor productivity (TFP). The unanticipated defense shock is identified as the VAR innovation in defense spending orthogonalized with respect to the Ramey (2011) news series.

Leeper et al. (2013) have demonstrated how the presence of fiscal foresight can create a wedge between economic shocks and VAR innovation 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. The inclusion of the Ramey (2011) measure of defense news into our VAR is intended to address this potential non-invertibility issue (see also Sims (2012)). Furthermore, the orthogonalization restriction is imposed to ensure that our identified unanticipated defense shock is unrelated to the Ramey (2011) news shocks.

Let  $y_t$  be a  $k \times 1$  vector of observables and let the VAR in the observables be given as

$$y_t = B_1 y_{t-1} + B_2 y_{t-2} + \dots + B_p y_{t-p} + B_c + u_t \quad (2)$$

where  $B_i$  are  $k \times k$  matrices,  $p$  denotes the number of lags,  $B_c$  is a  $k \times 1$  vector of constants, and  $u_t$  is the  $k \times 1$  vector of reduced-form innovations with variance-covariance matrix  $\Sigma$ . For future reference, let the  $(kp + 1) \times k$   $B = [B_1, \dots, B_p, B_c]'$  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,  $e_t$ , given as

$$u_t = A v_t \quad (3)$$

with  $E(v_t) = 0$  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  $\Sigma$ ), the entire space of permissible impact matrices can be written as  $CD$ , where  $D$  is a  $k \times k$  orthonormal matrix ( $D' = D^{-1}$ , which entails  $D'D = DD' = I$ ). We place the Ramey (2011) news series and government defense spending variable in the first and second positions in the VAR, respectively, and employ a recursive identification strategy where the unanticipated defense shock is identified via the second column of the Cholesky factor of  $\Sigma$ .<sup>1</sup>

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<sup>1</sup>The recursive identification strategy effectively imposes on the first two columns of the orthonormal

## 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.<sup>2</sup> Apart from the TFP series, we downloaded all of the data from Ramey's website.<sup>3</sup>

### 3.2 Time Series of Identified Shocks

Figure 1 shows the unanticipated defense shock series we obtain and compares it with the [Ramey \(2011\)](#) news series. To make the figure more readable, we present the one year backward looking moving average of the shock series. The shaded areas represent the major war periods of the sample.

The identified unanticipated defense shock series is related to war periods. In general, sizeable positive realizations take place during war periods followed by negative realizations after the ending of the wars. Most apparent is the Vietnam war, in which positive realizations (with a magnitude of 1.5 standard deviation) occurred during the war followed by negative realizations (of nearly -1 standard deviation magnitude). Moreover, the shock captures well the significant military budget reductions that took place during the 1990s.

The shock series we extract and the [Ramey \(2011\)](#) news shock series, which are orthogonal by construction, have different time patterns, apart from the second gulf war. Moreover, the largest defense news event took place in the beginning of the Korean War, while the largest unexpected increase in defense spending is associated with the Vietnam War. Some unexpected increases in

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matrix  $D$  to have one element equal to one in the first and second rows, respectively, and zeros in all other elements.

<sup>2</sup><http://www.frbsf.org/economics/economists/staff.php?jferald>

<sup>3</sup><http://weber.ucsd.edu/~vramey/>

defense spending took place in the mid-1980s, of which some were related to the news series of Ramey and some were not. There is also an apparent disconnect between the two series at the end of the 1980's following the fall of the Berlin Wall. While this significant event induced very large negative news shocks, the unanticipated shock realizations during this time were quite positive perhaps reflecting the fact that defense expenditures were very high by historical standards in the late 1980's and only began to significantly decline in the early 1990's. Overall, unexpected changes in defense spending occur both during war and peace times, being generally positive during wars and negative in their immediate aftermath.

### 3.3 Impulse responses

Figure 2 depicts the estimated impulse responses of all the endogenous variables to a positive one standard deviation unanticipated defense shock in the benchmark VAR, with the dashed lines representing 2.5th and 97.5th percentile confidence bands, respectively, constructed with a bootstrap procedure, repeated 2000 times.<sup>4</sup>

The unanticipated defense shock generates an impact output multiplier of 0.87. 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 2.25% , peaking at 2.6% after one year. Moreover, investment significantly declines following the shock with a peak absolute response of 0.84% after one year. The shock does not seem to affect the labor market and both hours and real wage responses are insignificant. Consumption demand is not affected by the shock either. The same holds true for the responses of the interest rate and inflation and the shock appears to be uncorrelated with changes in the average marginal income tax rate.

Interestingly, TFP significantly rises following the shock with a 0.24% 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,

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<sup>4</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 \(1999\)](#).



output, investment, and TFP, the responses of the other variables are small and insignificant. Hence, the shock seems to generate a positive multiplier that is smaller than one due to the crowding out of private investment. But how do responses of the economy look like when TFP is constrained to be unaffected by the shock?

### 3.4 Shutting Down the TFP Response

Figure 3 presents the estimated impulse responses of all the variables to a positive one standard deviation unanticipated defense shock orthogonalized with respect to current TFP. This amounts to placing TFP in the first position in the VAR, the Ramey (2011) news series in the second position, and defense spending in the third position, whereby the unanticipated defense shock is now identified via the third column of the Cholesky factor of the VAR variance covariance matrix.

It is apparent that output now essentially does not change resulting in a zero multiplier. Whereas the response of consumption in the benchmark case was essentially zero, when the TFP channel is shut down the spending shocks seems to moderately crowd out private consumption. Furthermore, investment declines more compared to the benchmark case with a peak absolute response of 0.92% (compared to the benchmark response of 0.84%). Hence, in accordance with the predictions of the standard RBC model the unanticipated government expansion generates a complete crowding out of the private sector.

### 3.5 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.<sup>5</sup>

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

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<sup>5</sup>Naturally, our initial focus was on a number of plausible economic explanations for the rise in TFP, e.g., sectoral reallocation, complementarity between government spending and innovation, reverse causality from technology to defense spending, among others. Yet, in Section 5, we provide evidence that rules out all of these possible explanations.

is induced by an economic mechanism rather than just some measurement error, 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, when annual data underlies the TFP measure the positive correlation between the unanticipated defense shock and TFP growth is entirely eliminated.<sup>6</sup>

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 validity of our measurement-error based argument, we use the new and superior 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.<sup>7</sup> 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

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<sup>6</sup>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).

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

is indeed correct we should get an impact output multiplier of zero in response to the unanticipated defense shock as well as a zero 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 restricted by that of the [Aruoba et al. \(2013\)](#) GDP series.

The results from this exercise are presented in Figure 4c, where, for comparison purposes, we also present in Figures 4a and 4b 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. To make the figures readable, we only present here the responses to output, consumption, investment, and TFP.<sup>8</sup> The results are consistent with our measurement-error based argument: while the output and TFP measures that contain measurement errors continue to rise following the defense shock, the identified defense shock from Figure 4c has no 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.<sup>9</sup> 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.

## 4 Robustness

The results of the previous section are challenging since they seem to suggest that the stimulative effects of government spending are due to the positive contemporaneous relationship between defense spending and TFP. In this section we provide results from a number of sensitivity checks we

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<sup>8</sup>The results with the entire set of impulse responses are available upon request from the authors.

<sup>9</sup>Note that TFP moderately rises after about a year in the restricted TFP VAR (i.e., Figure 4b); however, this rise is not economically significant peaking at only 0.13% after 7 quarters.

run to establish the robustness of our findings in section 3.

## 4.1 VAR lags

Figures 5a and 5b show the impulse responses for all the tested lag lengths, from 4 to 6, to the benchmark unanticipated shock and unanticipated shock orthogonalized with respect to TFP, respectively.<sup>10</sup> To be concise, in these figures as well as the remaining ones in this section we only report responses of defense spending, the Ramey (2011) news series, output, and TFP. As evident, the main result from the benchmark analysis that TFP rises following the unanticipated defense shock is maintained. Moreover, shutting down the TFP response also shuts down the output response and thus diminishes the multiplier to zero.

## 4.2 Identifying Total Government Spending Shocks

Our identification strategy can also easily be used for identifying unanticipated shocks to total government spending. As in Blanchard and Perotti (2002), we assume that total government spending does not respond contemporaneously to other macroeconomic variables and replace defense spending with total government spending in the VAR. Figure 6a presents the responses of the variables to the unanticipated government spending shocks while Figure 6b shows the responses to the unanticipated government spending shock orthogonalized with respect to TFP.

It is evident from both figures that the qualitative nature of the benchmark results generally remains unchanged. The impact response of output is 0.19% which reflects a multiplier of 0.82. TFP rises significantly following the unanticipated government spending shock. Once the unanticipated spending shock is orthogonalized with respect to TFP, the multiplier falls to zero just like in the benchmark case.

## 4.3 Results for the post-Korea Sample

Next we examine the sensitivity of our results to excluding the Korean war from the sample. Figures 7a and 7b correspond to Figures 2 and 3, respectively, with the only difference being that now

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<sup>10</sup>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.

the VAR is estimated using the smaller sample period of 1955:Q1-2008:Q4 which excludes the Korean war. Results are qualitatively unchanged: The significant relation between the unanticipated defense shock and TFP continues to hold and orthogonalizing the unanticipated shock with respect to TFP continues to generate a multiplier of zero with complete crowding out of the private sector.

## 4.4 Results for the post-1983 Sample

One potential concern that arises from applying our identification strategy to the entire post-war sample is that the VAR coefficients may not be stable over the entire sample period. Moreover, the VAR innovations may not be homoscedastic. In this section we apply our methodology on the post-1983 sub-sample since for this sample results are less likely to suffer from potential heteroscedasticity and/or coefficient instability (e.g., [Stock and Watson \(2007\)](#)).

Figures [8a](#) and [8b](#) correspond to Figures [2](#) and [3](#), respectively, where the VAR is now estimated using the smaller sample period of 1983:Q1-2008:Q4. Given the significantly smaller sample size, we estimated a four-variable VAR which includes defense spending, the [Ramey \(2011\)](#) news series, output, and TFP. We can clearly see that the main results are robust to the sample period. The defense shock continues to significantly raise TFP while orthogonalizing the unanticipated shock with respect to TFP continues to generate a multiplier of zero.

## 4.5 Alternative TFP Measure

Although the [Fernald \(2012\)](#) TFP measure arguably represents the state-of-the-art in growth accounting, it still seems worthwhile to confirm that our results are not driven by this particular choice to measure aggregate TFP. Therefore, we examine the robustness of our results to using a standard Solow residual which does not account for changes in utilization of factor inputs. The Solow residual we utilize is the one constructed by [Fernald \(2012\)](#) upon which the utilization-adjusted TFP measure is based. Figures [9a](#) and [9b](#) correspond to Figures [2](#) and [3](#), respectively, with the only difference being that now the VAR is estimated using a standard Solow residual measure.

The results remain unchanged: The unanticipated defense significantly raises the Solow residual and orthogonalizing the unanticipated shock with respect to the Solow residual continues to generate a multiplier of zero with complete crowding out of the private sector. These results indicate that

our results are not dependent upon our choice of measuring TFP, i.e., the utilization adjustment has no bearing on the results.<sup>11</sup>

Furthermore, note that the impact response of the utilization-adjusted TFP measure from Figure 2 is moderately stronger than that of the non-adjusted measure (0.24 percent versus 0.18 percent). This implies that our identified defense shocks is not likely to be generating a positive impact effect on labor effort and capital utilization. We explore in more detail the implications of our defense shock for labor effort in Section 5.4, where we obtain results that are consistent with those obtained in this section, i.e., that the positive TFP-defense spending relation cannot be accounted for by an accompanying positive labor effort response to a defense spending shock.

## 4.6 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.<sup>12</sup>

In particular, we estimate the impulse responses directly by projecting a variable of interest on current values and lags of defense spending and the Ramey (2011) variable and lags of output and TFP. We include the current values of defense spending and the Ramey (2011) news variable to

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<sup>11</sup>We have also confirmed that our defense shock induces similar effects on labor productivity, as measured by the output per hours in the non-farm business sector. These results are available upon request from the authors.

<sup>12</sup>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.

ensure that the defense spending shock has a zero impact on defense news. 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:

$$y_{t+h} = I_{t-1}[\Phi_{A,h}(L)fds_t + \Xi_{A,h}(L)news_t + \Gamma_{A,h}(L)y_{t-1} + \Upsilon_{A,h}(L)tfp_{t-1} + \alpha_{A,h}] + (1 - I_{t-1})[\Phi_{B,h}(L)fds_t + \Xi_{B,h}(L)news_t + \Gamma_{B,h}(L)y_{t-1} + \Upsilon_{B,h}(L)tfp_{t-1} + \alpha_{B,h}] + u_{t+h} \quad (4)$$

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% whereas an expansionary state takes place when the unemployment rate is below 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  $h$  are simply  $\hat{\Phi}_{A,h}$  and  $\hat{\Phi}_{B,h}$ , 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 10a shows the state-dependent responses of defense spending, the [Ramey \(2011\)](#) news variable, output, and TFP to the unanticipated defense shock whereas Figure 10b presents the state-dependent responses to the defense shock that is orthogonalized with respect to current TFP.<sup>13</sup> 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. Overall, the positive response of TFP to the unanticipated defense shock and the result that this output response is shut down when the TFP response is zero are maintained

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<sup>13</sup>We also estimated the linear analogue of Model (4) and obtained similar results to those attained from the benchmark VAR. These results are available upon request from the author.

also when we consider a state-dependent model which allows for different effects in recessions and expansions.

## 4.7 Exogenizing the Ramey (2011) news series

Thus far, we let the 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 2) 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 and only allowed to depend on its own lags.

Figures 11a and 11b correspond to Figures 2 and 3, respectively, with the only difference being that now the Ramey (2011) news series constitutes an exogenous variable in the VAR which only depends on its own lags. 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.

## 4.8 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 identified defense 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, 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 12 where the correlation between the defense shocks and up to four lags and leads of each of the other four shocks are shown, along the corresponding 95% asymptotic confidence interval. The results indicate that the cross-correlations are small and insignificant, with all the contemporaneous correlations being lower than 9% in absolute value and none of the other shocks having any relation to the future value of the identified defense shock. 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 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.<sup>14</sup>

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

We have provided evidence in favor of the notion that the TFP increase 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 economic explanations for our finding on the relation between unanticipated defense shocks and TFP.

### 5.1 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

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<sup>14</sup>We have also tried another battery of sensitivity tests regarding the number of variables in the VAR and found that our results are insensitive to such changes that we do not present here for economy of space.

( $\Delta TFP_t$ ) can be written as the sum of technological growth and a reallocation term:

$$\Delta TFP_t = \Delta a_t + \sum_i \omega_i (\gamma_i - \bar{\gamma}) \Delta x_{it} \quad (5)$$

where  $\Delta a_t$  is the growth rate of aggregate technology,  $\Delta x_{it}$  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,  $\gamma_i$  is returns to scale in industry  $i$ , and  $\omega_i$  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.<sup>15</sup>

Figures [13a](#) and [13b](#) 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.

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<sup>15</sup>The two identified shocks were found to be uncorrelated with a negative correlation that is lower in absolute terms than 0.06.

## 5.2 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.

## 5.3 Reverse Causality

We have also examined the possibility of reverse causality, that is, that technology is actually driving defense spending, by computing the correlation between the [Basu et al. \(2006\)](#) purified annual aggregate technology measure and our annualized defense shock. We obtained evidence that is inconsistent with the reverse causality conjecture, finding a negative albeit statistically insignificant correlation of -0.16. If the reverse causality conjecture were true, we would expect to see that the unanticipated component of defense spending is positively correlated with technological innovations, which is not the case.

## 5.4 Patriotism and Working Effort

Unexpected shocks in defense spending might signal that the economy is in danger raising the sense of patriotism and making workers exert more effort at work to contribute to the strengthening of the country. For example, during World War II, propaganda was used to increase support for the war and commitment. Using a vast array of media, propagandists urged greater public effort for war production and victory, persuaded people to save so that more material could be used for the war effort, and sold war bonds. Patriotism became the central theme of advertising throughout the war, as large scale campaigns were launched to sell war bonds, promote efficiency in factories and maintain civilian morale.<sup>16</sup> Hence, increases in patriotism following unexpected increases in defense spending could increase unobservable labor effort and hence TFP.

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<sup>16</sup>See Wikipedia, American propaganda during World War II.

To examine such a scenario we took annual data from the PSID from 1967 to 2008 on absences from work due to vacation taken (in weeks) and examined their correlation with our identified unanticipated shock. The correlation is positive in the data and equal to 0.32 and the response of absences to the identified shock in an annual two-variable VAR is positive but insignificant,<sup>17</sup> suggesting that increases in working effort in all sectors cannot be the explanation for the pattern of TFP responses to the fiscal shock we see in the data since, if anything, patriotism should induce a negative correlation between absences and the defense shock.

## 5.5 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 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 14. 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.<sup>18</sup>

## 5.6 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

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<sup>17</sup>These results are available upon request from the authors.

<sup>18</sup>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 4.6 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.

York Times article<sup>19</sup> 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 the TFP to the identified shock is positive and significant on impact.

Yet, we have tried to investigate this alternative hypothesis by running an annual VAR that includes our annualized defense shock series and private sector R&D series, which was taken from the Industrial Research and Development Information System (IRIS) and is available from 1953 to 2002. Figure 15 presents the response of the growth rate of private sector R&D to our annualized shock. Evidently, the response is insignificant indicating that it is unlikely that there is a transmission from the defense shocks to private R&D.<sup>20</sup>

## 6 Anticipated defense spending shocks

So far, we have established that the effects of unexpected increases in government spending, in accordance with the predictions of the standard RBC model, involve a crowding out of the private sector and an almost 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 explain most of the defense spending variability in a five-year horizon that are orthogonal to defense spending contemporaneously.<sup>21</sup> 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

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<sup>19</sup>A Shrinking Defense Budget May Take Neighbors With It, January 6, 2012, by Binyamin Appelbaum. New York Times

<sup>20</sup>We also found no significant positive effects of the defense shock on neither total R&D nor federal government R&D. These results are available upon request from the authors.

<sup>21</sup>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, where we include in the VAR the narrative-based defense news series of Ramey (2011) so as to attain better identification.

benchmark VAR the [Ben Zeev and Pappa \(2013\)](#) news shocks by using the same identification strategies employed in that paper. 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.<sup>22,23</sup> Thus, we can 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 government 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 military spending.

## 7 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 government spending is dead. Government 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

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<sup>22</sup>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.

<sup>23</sup>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 a only a moderate delayed effect on TFP. These results are available upon request from the authors.

render the efforts of many economists to build models that produce high output multipliers in response to unexpected government spending increases unsuitable. Unexpected increases in government spending shocks do not involve significant demand effects and our findings bring us back to square one: the RBC model.

We view our work as a call for papers that can account both for the zero effects of unexpected increases in spending and significant demand effects of fiscal news.

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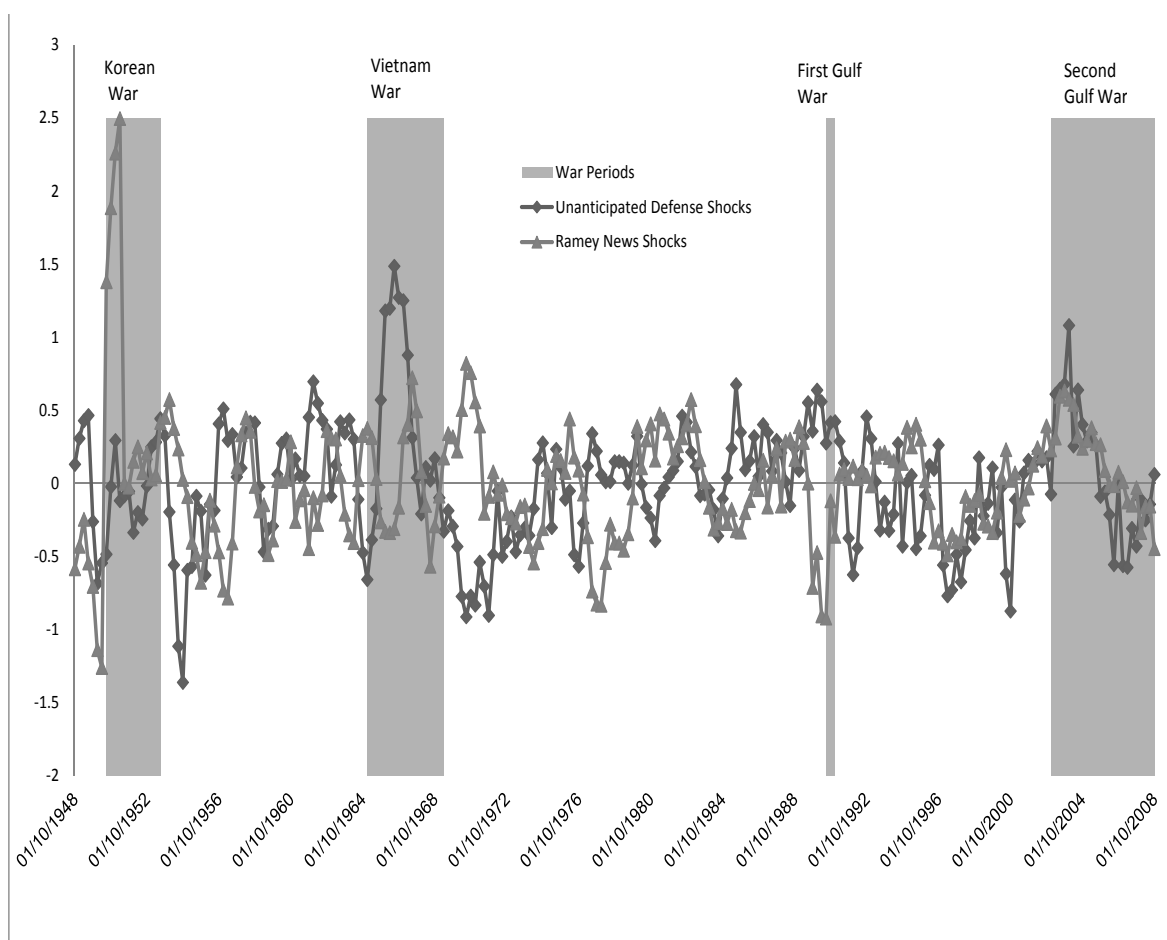
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Table 1: **Correlation between TFP and Unanticipated Defense Shock: Quarterly Frequency versus Annual Frequency.**

	Annual Frequency	Quarterly Frequency
Correlation	-0.13	0.25

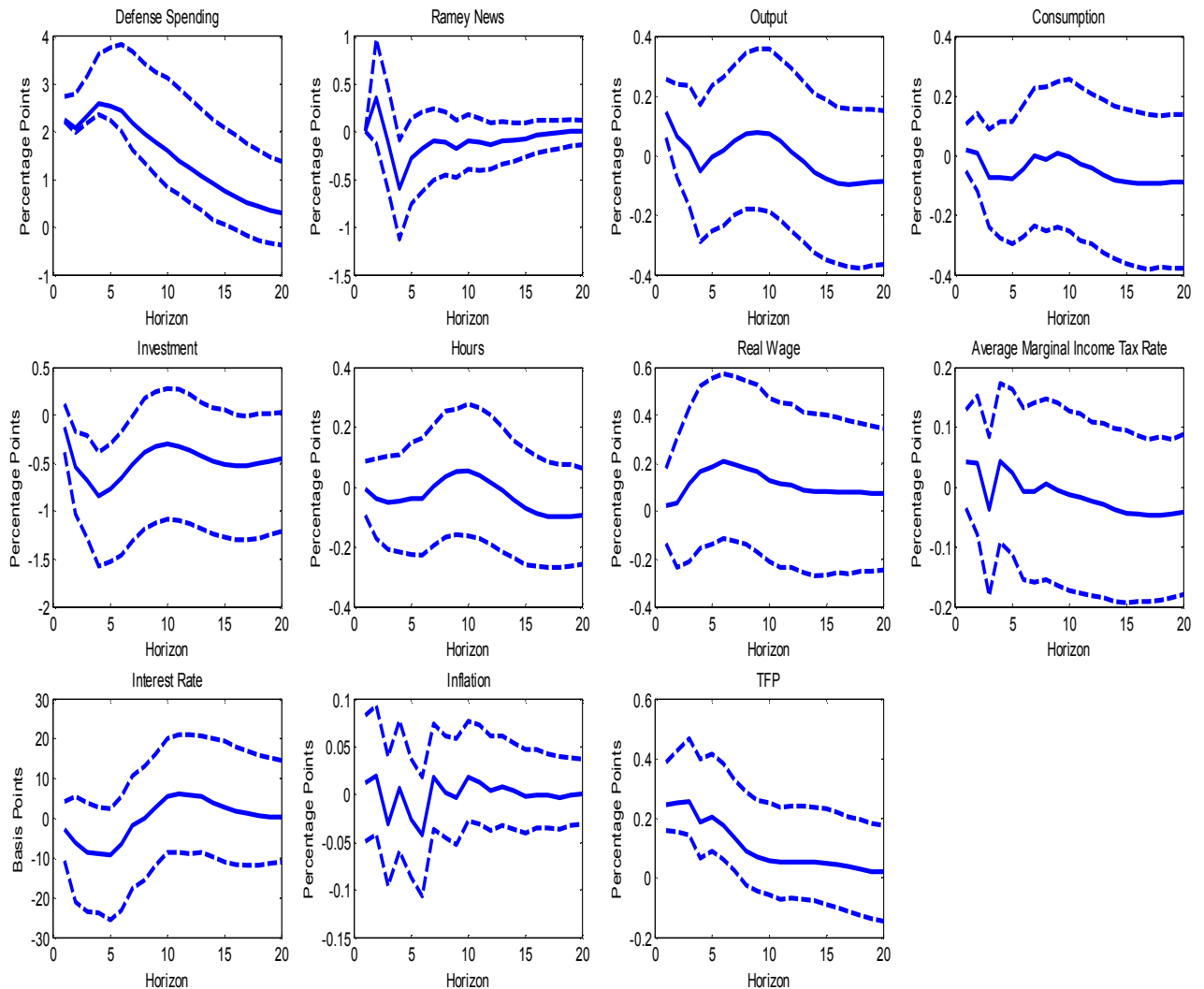
*Notes:* This table presents the correlation between the growth rate of the utilization-adjusted TFP measure constructed in [Basu et al. \(2006\)](#) from annual data and the annualized defense shock series which simply consists of annual averages of the corresponding quarterly observations of the quarterly benchmark defense shock series. For comparison purposes, the 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 \(2012\)](#).

Figure 1: Identified Unanticipated Defense Shock and Ramey (2011) News Shock Time Series (smoothed).



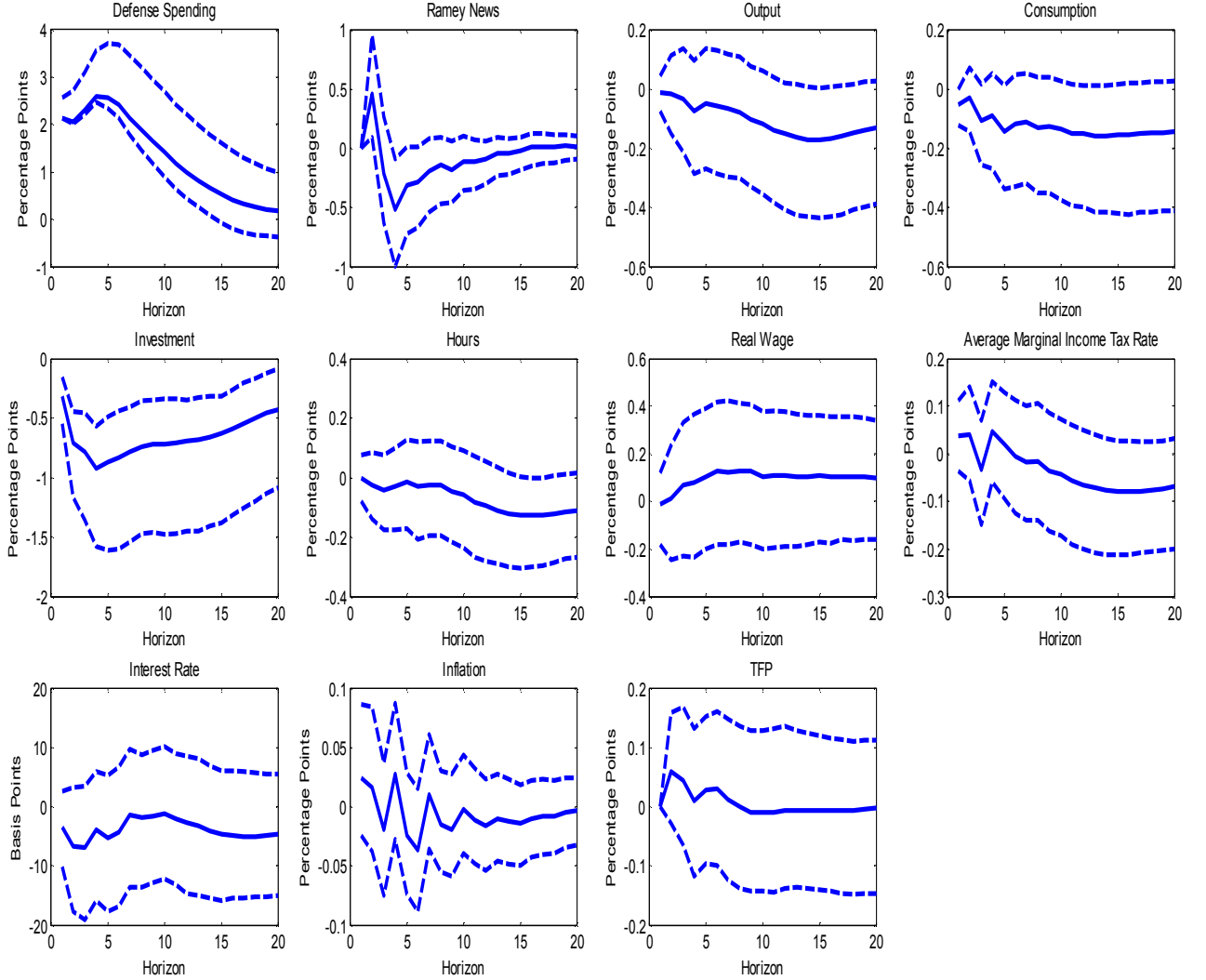
*Notes:* The war periods are represented by the shaded areas. So as to render the figure more readable, the plotted identified shock series is smoothed using a one year moving average. Specifically, it is calculated as  $\varepsilon_t^s = (\varepsilon_{t-3} + \varepsilon_{t-2} + \varepsilon_{t-1} + \varepsilon_t)/4$ , where  $\varepsilon_t$  is the identified shock series. The plotted series begins in 1948:Q4 and ends in 2008:Q1.

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



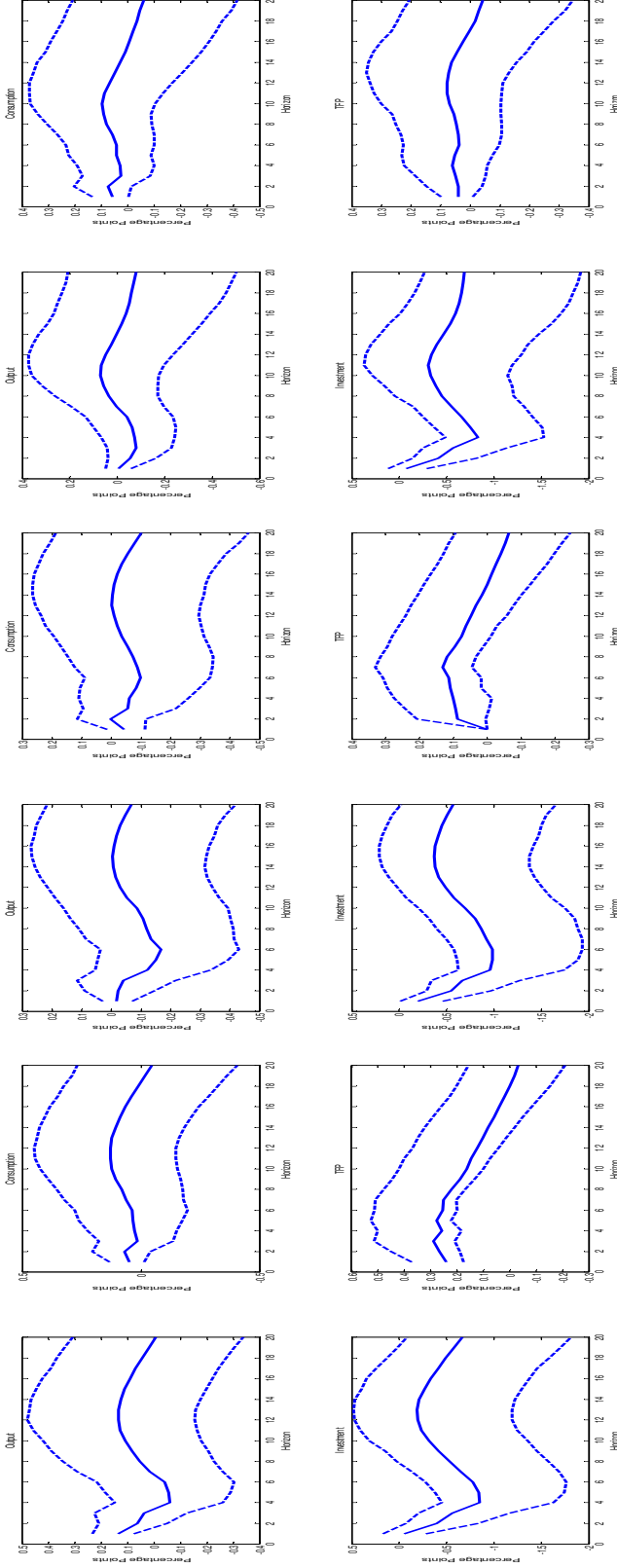
*Notes:* The unanticipated defense spending shock is identified as the VAR innovation in defense spending orthogonalized with respect to the [Ramey \(2011\)](#) news series. Dashed lines represent 2.5th and 97.5th percentile [Hall \(1992\)](#) confidence bands generated from a residual based bootstrap procedure repeated 2000 times. Horizon is in quarters.

Figure 3: **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 the [Ramey \(2011\)](#) news series and TFP. Dashed lines represent 2.5th and 97.5th percentile [Hall \(1992\)](#) confidence bands generated from a residual based bootstrap procedure repeated 2000 times. Horizon is in quarters.

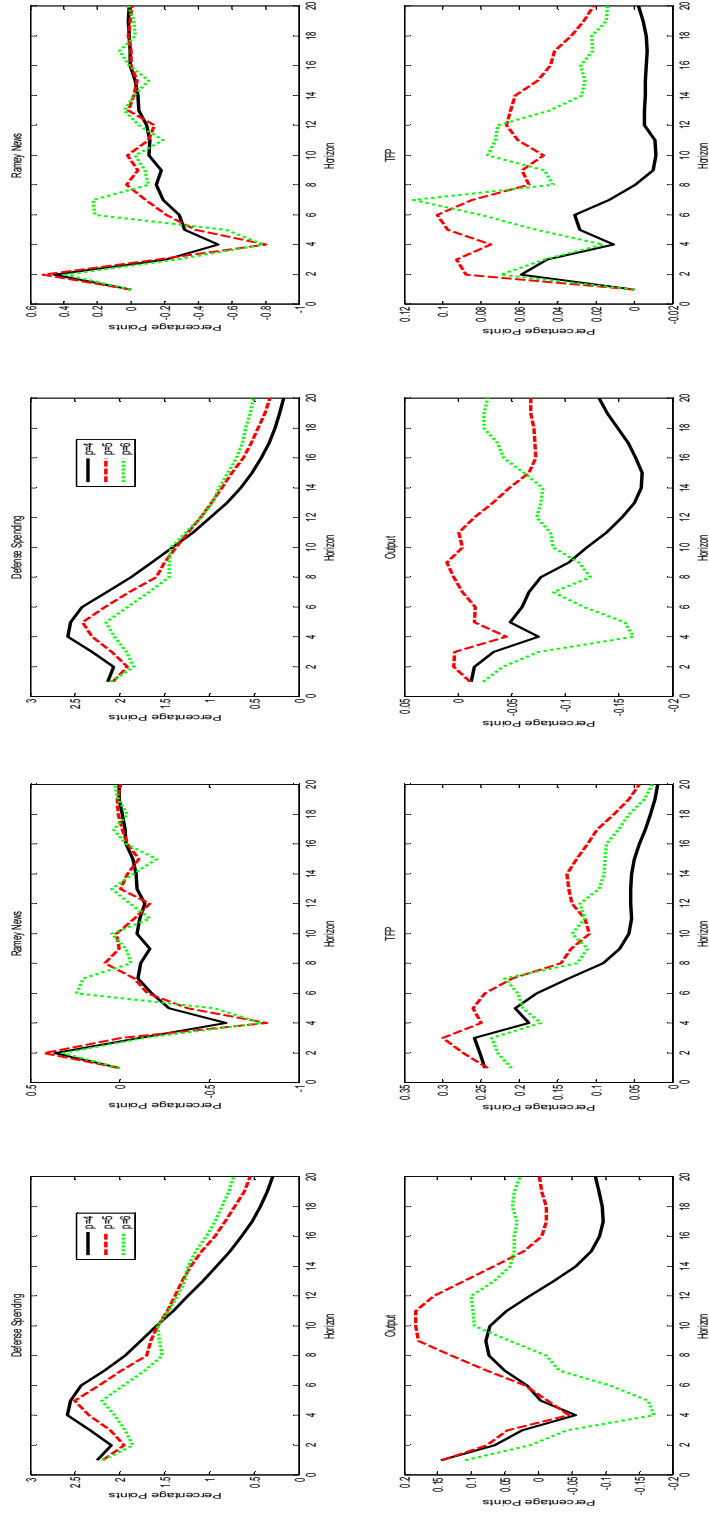
Figure 4: Measurement-Error Free Measures of Output and TFP: (a) Benchmark VAR with Measurement Errors (Unrestricted TFP); (b) Benchmark VAR with Measurement Errors (TFP Response Shut Down); (c) VAR with Measurement-Error Free Measures of Output and TFP



(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 orthogonalized with respect to the Ramey (2011) news series where the sample period is 1959:4-2008:4. Dashed lines represent 2.5th and 97.5th percentile Hall (1992) confidence bands generated from a residual based bootstrap procedure repeated 2000 times. Horizon is in quarters. Panel (b): The unanticipated defense spending shock is identified as the VAR innovation in defense spending orthogonalized with respect to the Ramey (2011) news series and 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 orthogonalized with respect to the Ramey (2011) news series 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 5: Robustness to VAR Lags: (a) Unrestricted TFP; (b) TFP Response Shut Down

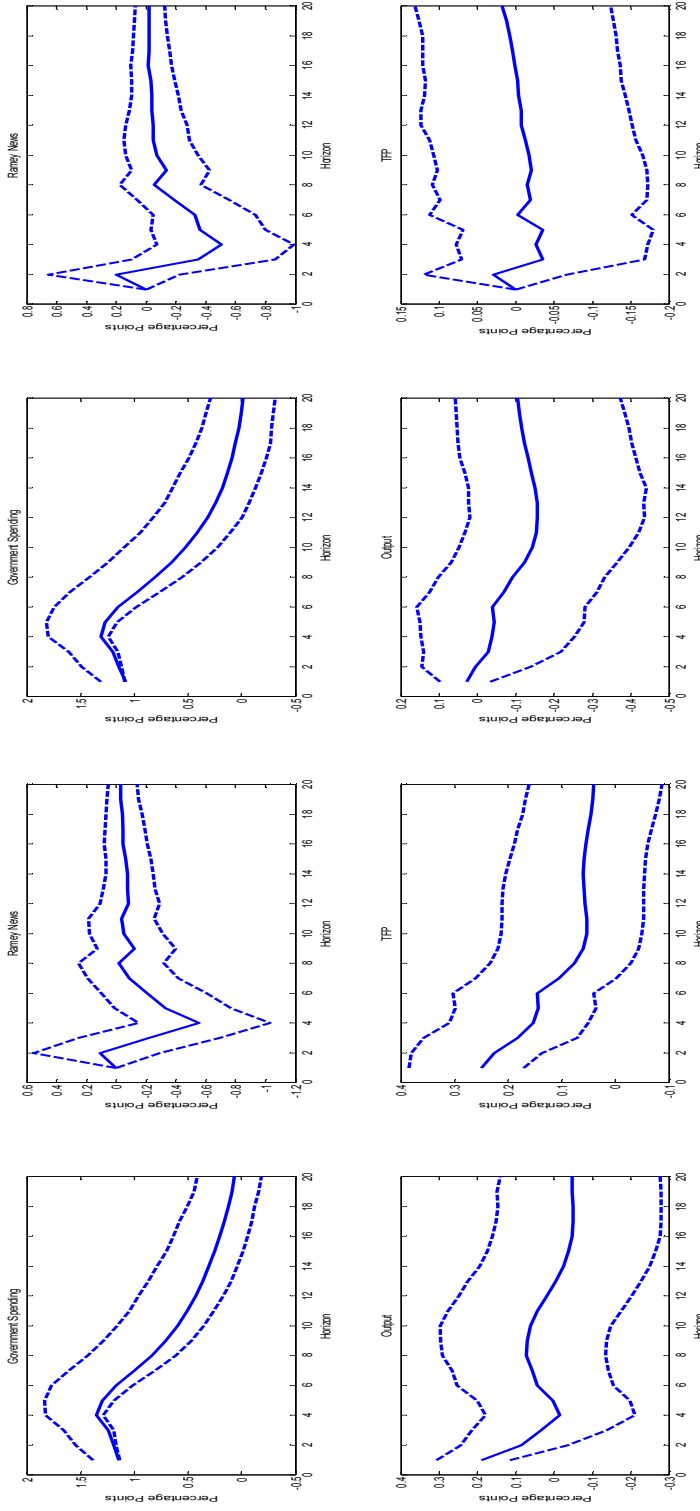


(a) Impulse Responses to a One Standard Deviation Unanticipated Defense Shock (Unrestricted TFP).  
(b) Impulse Responses to a One Standard Deviation Unanticipated Defense Shock (TFP Response Shut Down).

*Notes:* Panel (a): The solid, dashed, dotted and dash-dotted lines are the estimated impulse responses to the unanticipated defense shock from a VAR with 4, 5, and 6 lags, respectively. 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 3, 4, 5, and 6 lags, respectively. The shock is orthogonalized with respect to TFP in addition to the [Ramey \(2011\)](#) news series. Horizon is in quarters.



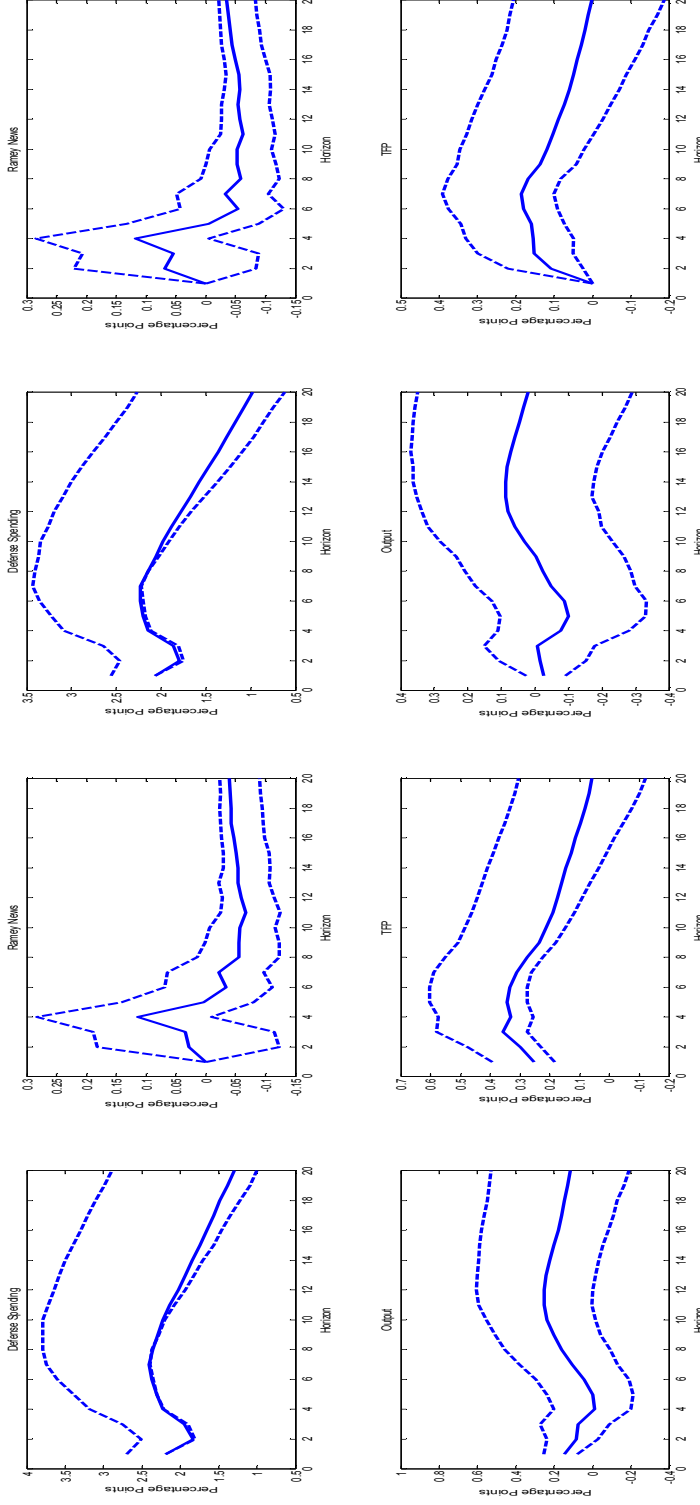
Figure 6: Total Government Spending Shock: (a) Unrestricted TFP; (b) TFP Response Shut Down



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

*Notes:* Panel (a): The unanticipated government spending shock is identified as the VAR innovation in total government spending orthogonalized with respect to the [Ramey \(2011\)](#) news series. Dashed lines represent 2.5th and 97.5th percentile [Hall \(1992\)](#) confidence bands generated from a residual based bootstrap procedure repeated 2000 times. Horizon is in quarters. Panel (b): The unanticipated defense spending shock is identified as the VAR innovation in total government spending orthogonalized with respect to the [Ramey \(2011\)](#) news series and TFP. Dashed lines represent 2.5th and 97.5th percentile [Hall \(1992\)](#) confidence bands generated from a residual based bootstrap procedure repeated 2000 times. Horizon is in quarters.

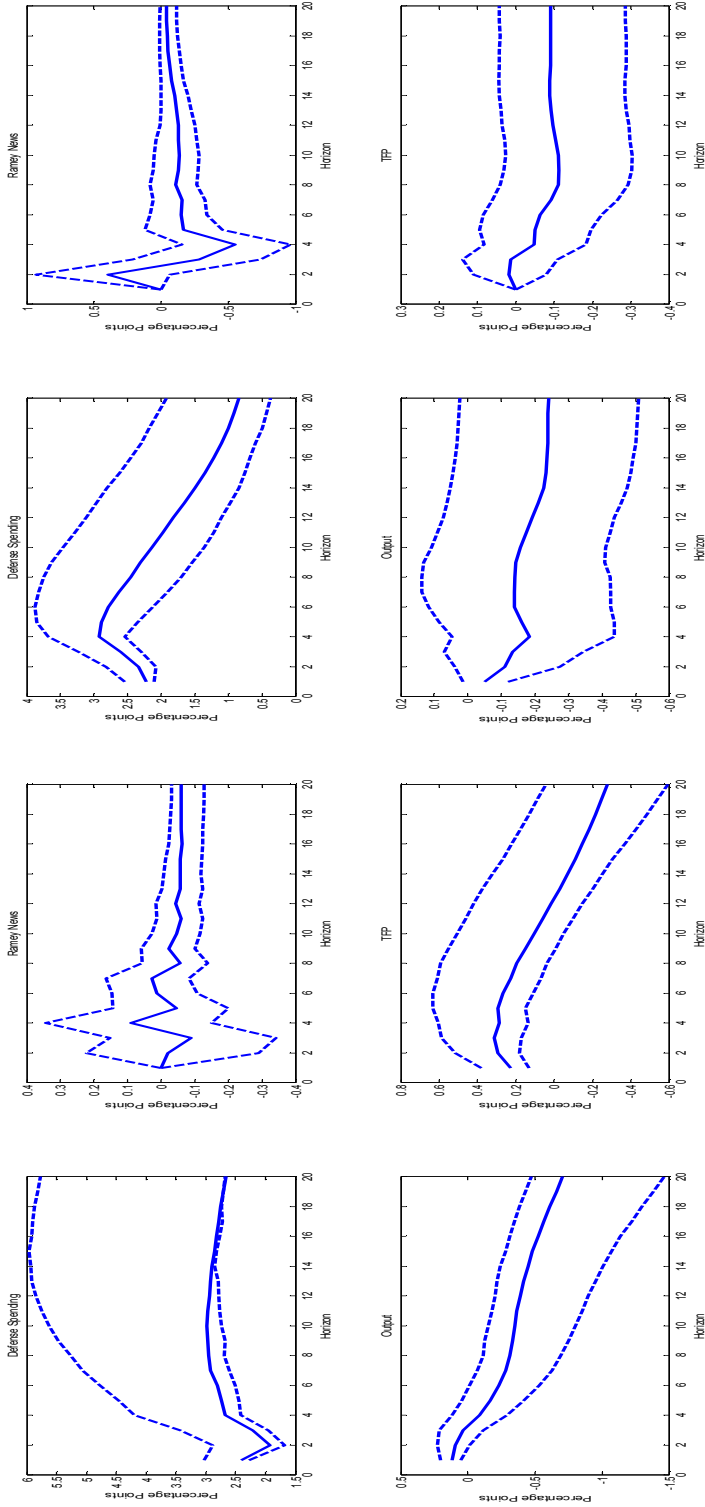
Figure 7: Post-Korea Sample (1955-2008): (a) Unrestricted TFP; (b) TFP Response Shut Down



(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 in defense spending orthogonalized with respect to the [Ramey \(2011\)](#) news series using the sample period 1955-2008. Dashed lines represent 2.5th and 97.5th percentile [Hall \(1992\)](#) confidence bands generated from a residual based bootstrap procedure repeated 2000 times. Horizon is in quarters. Panel (b): The unanticipated defense spending shock is identified as the VAR innovation in defense spending orthogonalized with respect to the [Ramey \(2011\)](#) news series and TFP using the sample period 1955-2008. Dashed lines represent 2.5th and 97.5th percentile [Hall \(1992\)](#) confidence bands generated from a residual based bootstrap procedure repeated 2000 times. Horizon is in quarters.

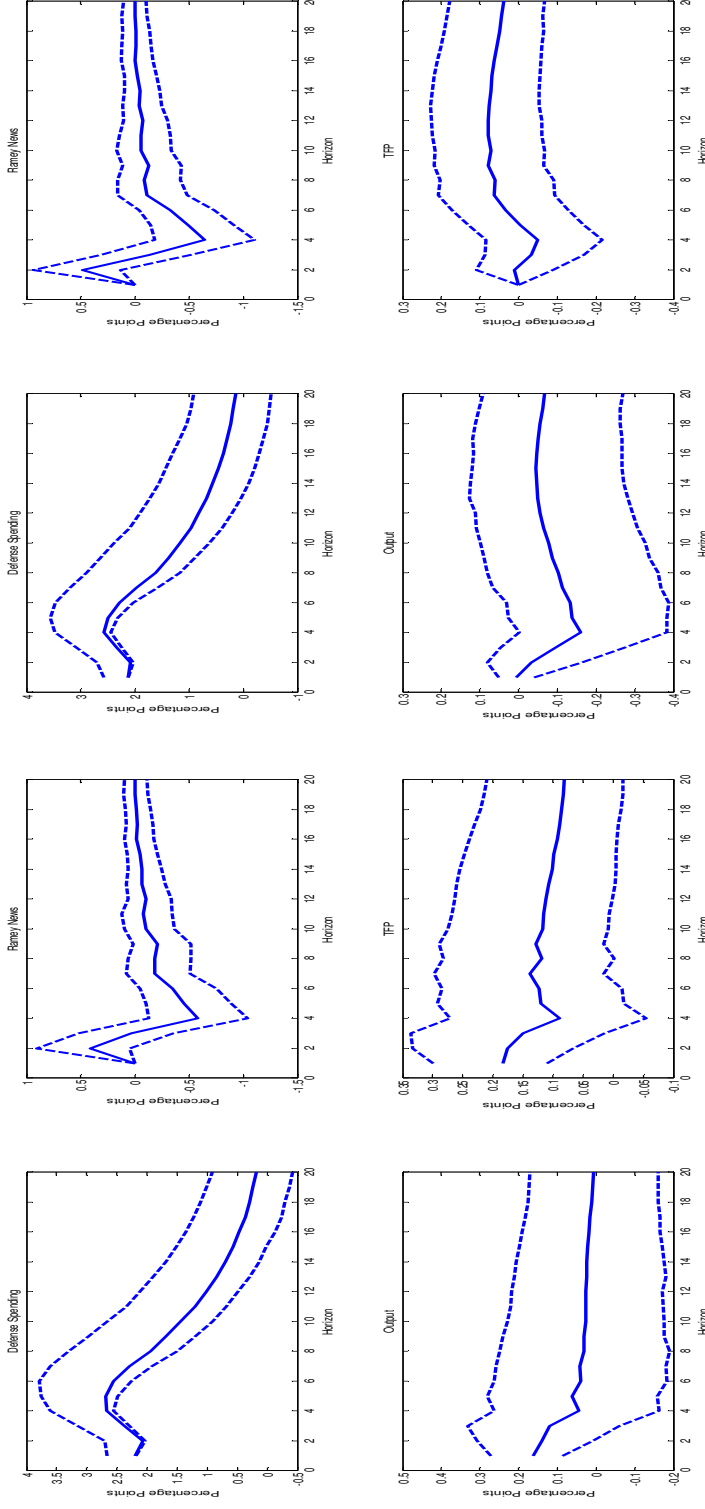
Figure 8: Post-1983 Sample (1983-2008): (a) Unrestricted TFP; (b) TFP Response Shut Down



(a) Impulse Responses to a One Standard Deviation Unrestricted 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 orthogonalized with respect to the [Ramey \(2011\)](#) news series using the sample period 1983-2008. Dashed lines represent 2.5th and 97.5th percentile [Hall \(1992\)](#) confidence bands generated from a residual based bootstrap procedure repeated 2000 times. Horizon is in quarters. Panel (b): The unanticipated defense spending shock is identified as the VAR innovation in defense spending orthogonalized with respect to the [Ramey \(2011\)](#) news series and TFP using the sample period 1983-2008. Dashed lines represent 2.5th and 97.5th percentile [Hall \(1992\)](#) confidence bands generated from a residual based bootstrap procedure repeated 2000 times. Horizon is in quarters.

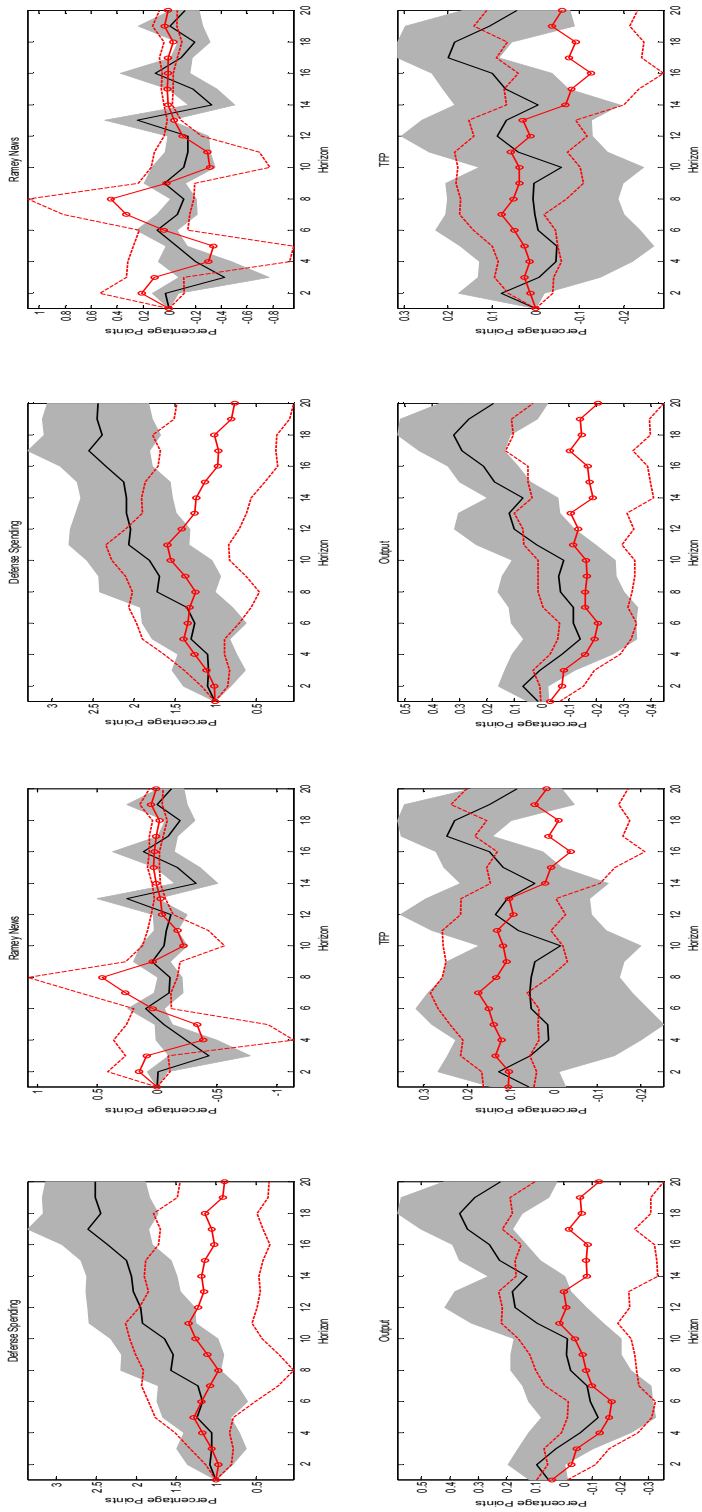
Figure 9: Alternative TFP measure: (a) Unrestricted TFP; (b) TFP Response Shut Down



(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 orthogonalized with respect to the [Ramey \(2011\)](#) news series using a standard Solow residual as the TFP measure. Dashed lines represent 2.5th and 97.5th percentile [Hall \(1992\)](#) confidence bands generated from a residual based bootstrap procedure repeated 2000 times. Horizon is in quarters. Panel (b): The unanticipated defense spending shock is identified as the VAR innovation in defense spending orthogonalized with respect to the [Ramey \(2011\)](#) news series and TFP using a standard Solow residual as the TFP measure. Dashed lines represent 2.5th and 97.5th percentile [Hall \(1992\)](#) confidence bands generated from a residual based bootstrap procedure repeated 2000 times. Horizon is in quarters.

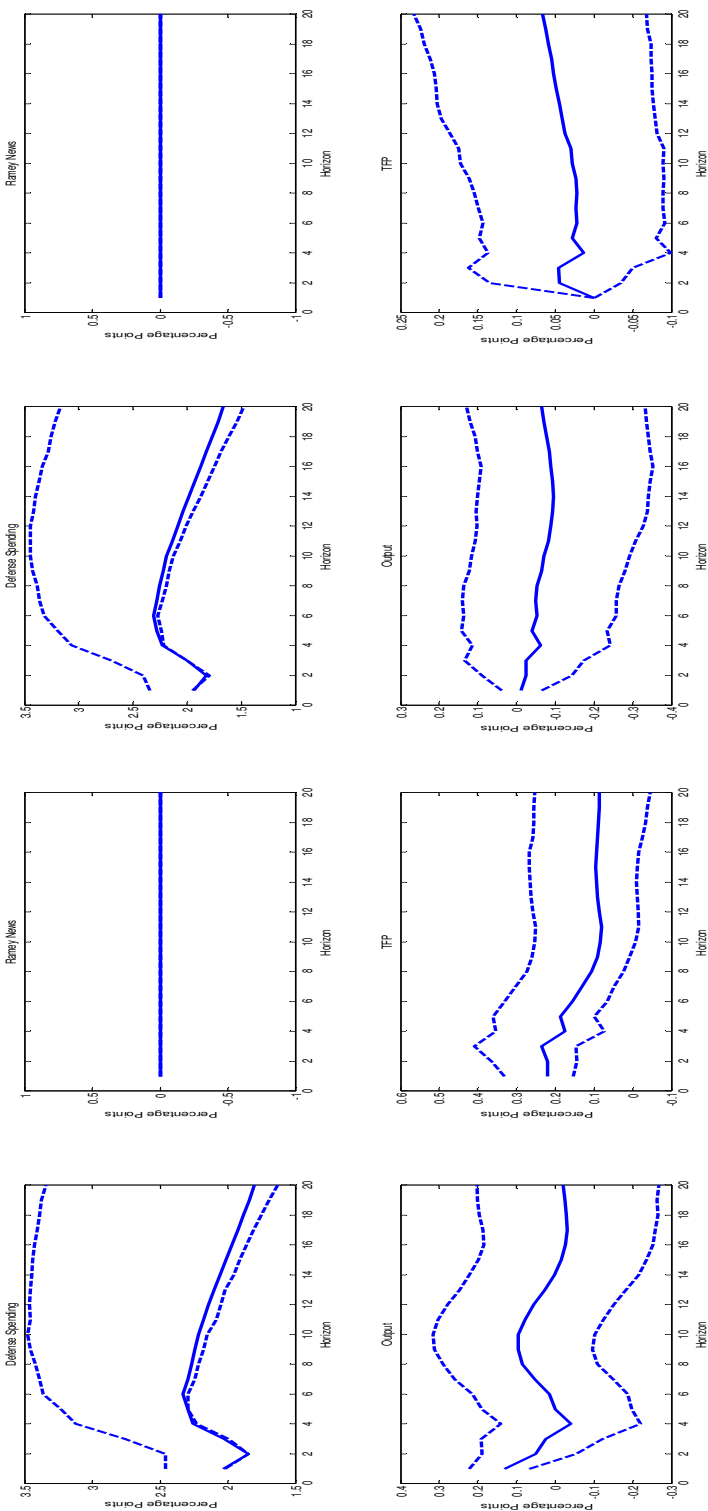
Figure 10: State-Dependent Impulse Responses: (a) Unrestricted TFP; (b) TFP Response Shut Down



(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 orthogonalized with respect to the [Ramey \(2011\)](#) news series and 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 the [Ramey \(2011\)](#) news series and TFP and is normalized such that defense spending rises by 1% on impact. Horizon is in quarters.

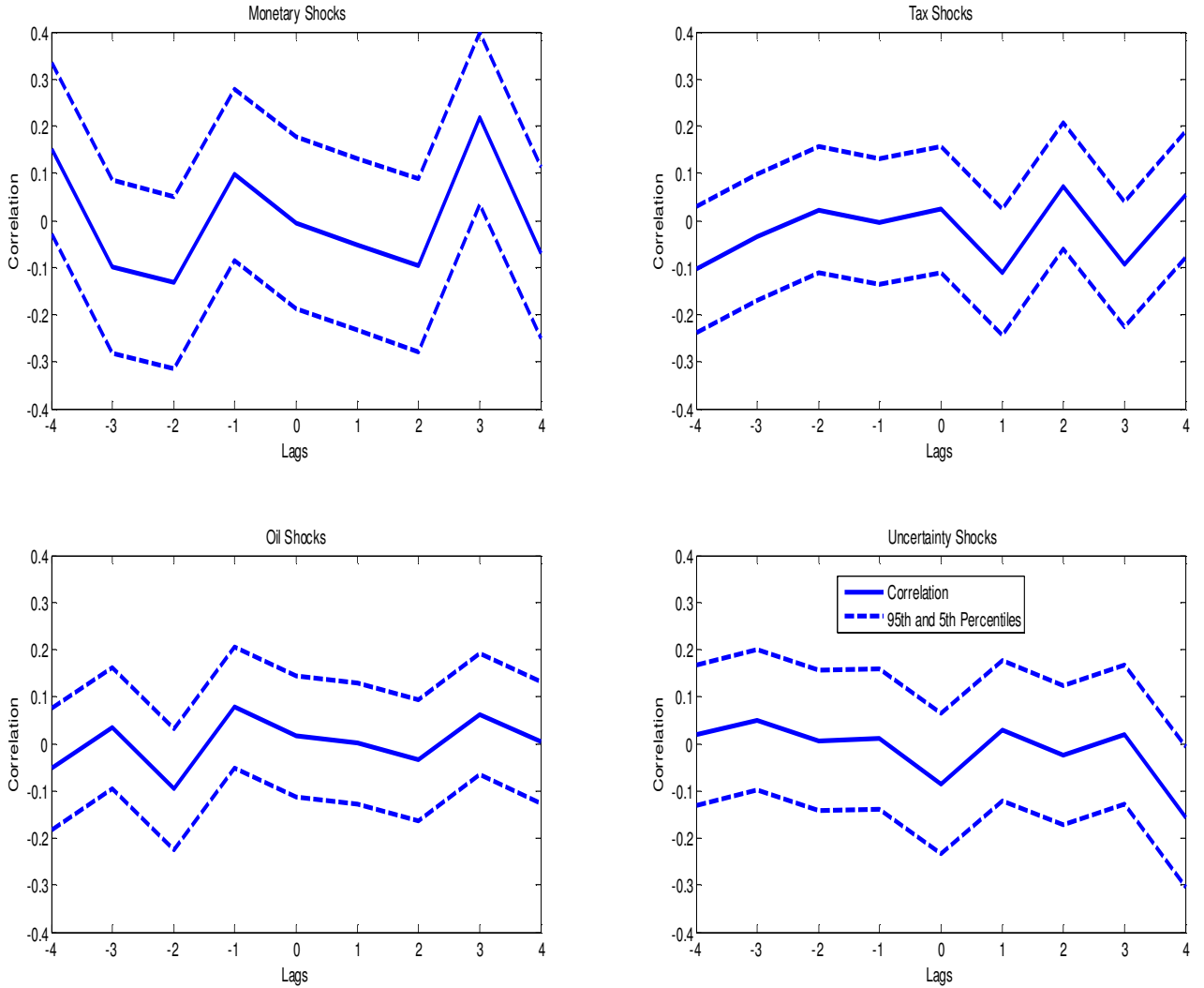
Figure 11: Exogenizing the Ramey (2011) News Series: (a) Unrestricted TFP; (b) TFP Response Shut Down



(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 orthogonalized with respect to the Ramey (2011) news series, which is now only allowed to depend upon its own lags. Dashed lines represent 2.5th and 97.5th percentile Hall (1992) confidence bands generated from a residual based bootstrap procedure repeated 2000 times. Horizon is in quarters. Panel (b): The unanticipated defense spending shocks is identified as the VAR innovation in defense spending orthogonalized with respect to the Ramey (2011) news series and TFP, where the Ramey (2011) news series is now only allowed to depend upon its own lags. Dashed lines represent 2.5th and 97.5th percentile Hall (1992) confidence bands generated from a residual based bootstrap procedure repeated 2000 times. Horizon is in quarters.

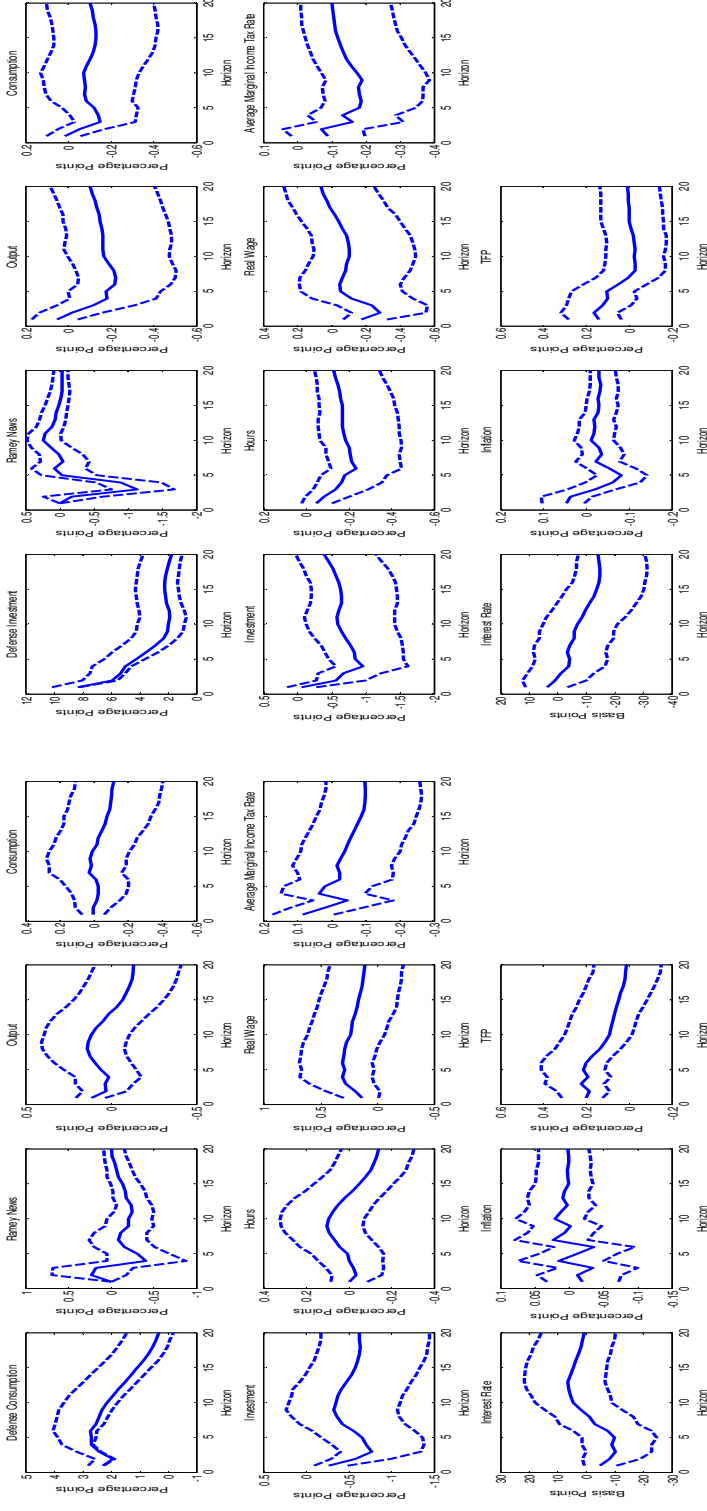
Figure 12: The Cross-Correlation between the unanticipated defense Shock and Lags/Leads of Other Structural Shocks.



*Notes:* The solid line is the cross-correlation and the dashed lines represent the 95% asymptotic confidence interval. The other shocks 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 13: Impulse Responses to Consumption and Investment Defense Shocks: (a) Defense Consumption; (b) Defense Investment

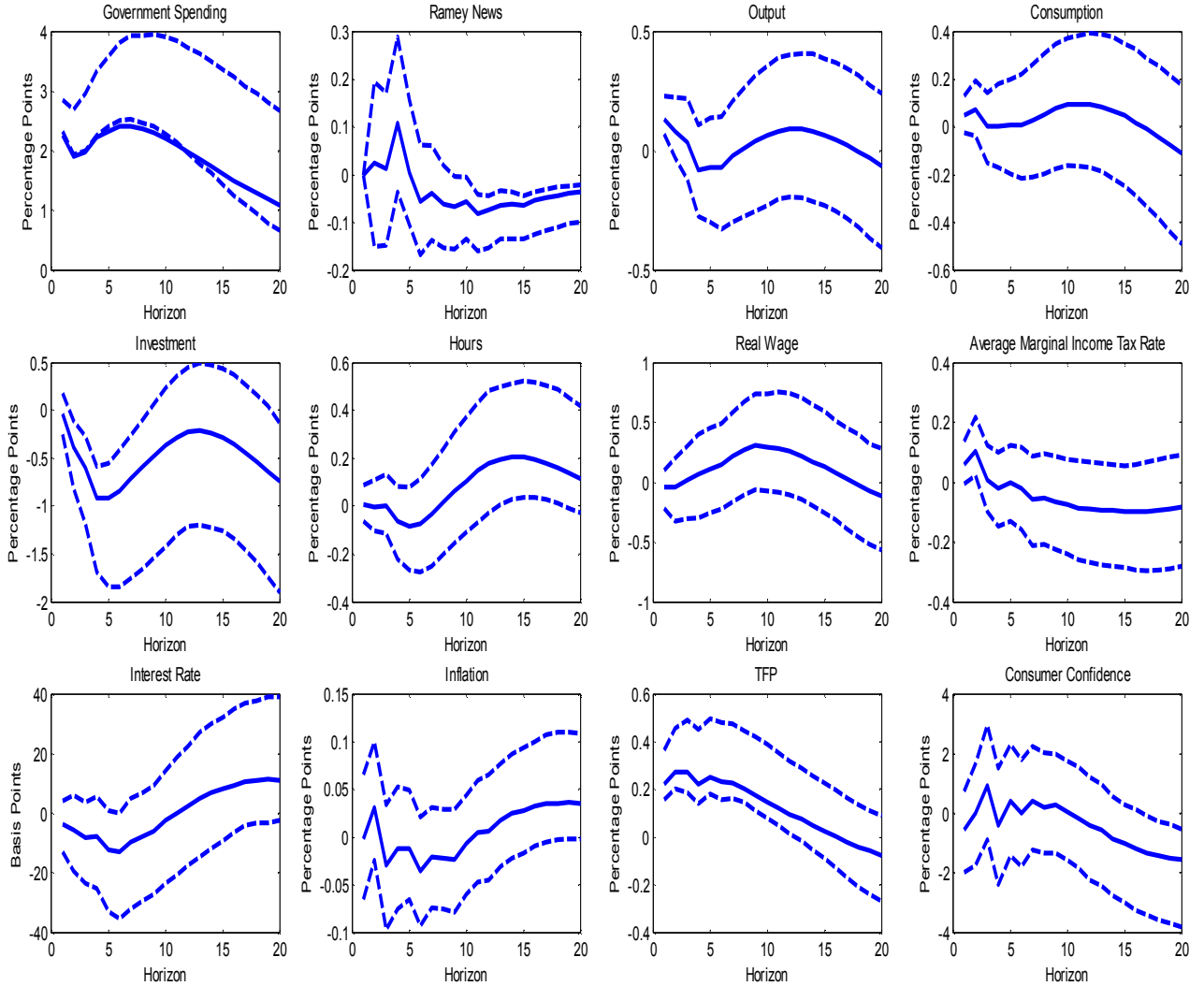


(a) Impulse responses to an Unanticipated Defense Consumption Shock. (b) Impulse responses to an Unanticipated Defense Investment Shock.

*Notes:* Panel (a): The unanticipated defense consumption shock is identified as the VAR innovation in defense consumption spending orthogonalized with respect to the Ramey (2011) news series. Dashed lines represent 2.5th and 97.5th percentile Hall (1992) confidence bands generated from a residual based bootstrap procedure repeated 2000 times. Horizon is in quarters. Panel (b): The unanticipated defense investment shock is identified as the VAR innovation in defense investment spending orthogonalized with respect to the Ramey (2011) news series. Dashed lines represent 2.5th and 97.5th percentile Hall (1992) confidence bands generated from a residual based bootstrap procedure repeated 2000 times. Horizon is in quarters.

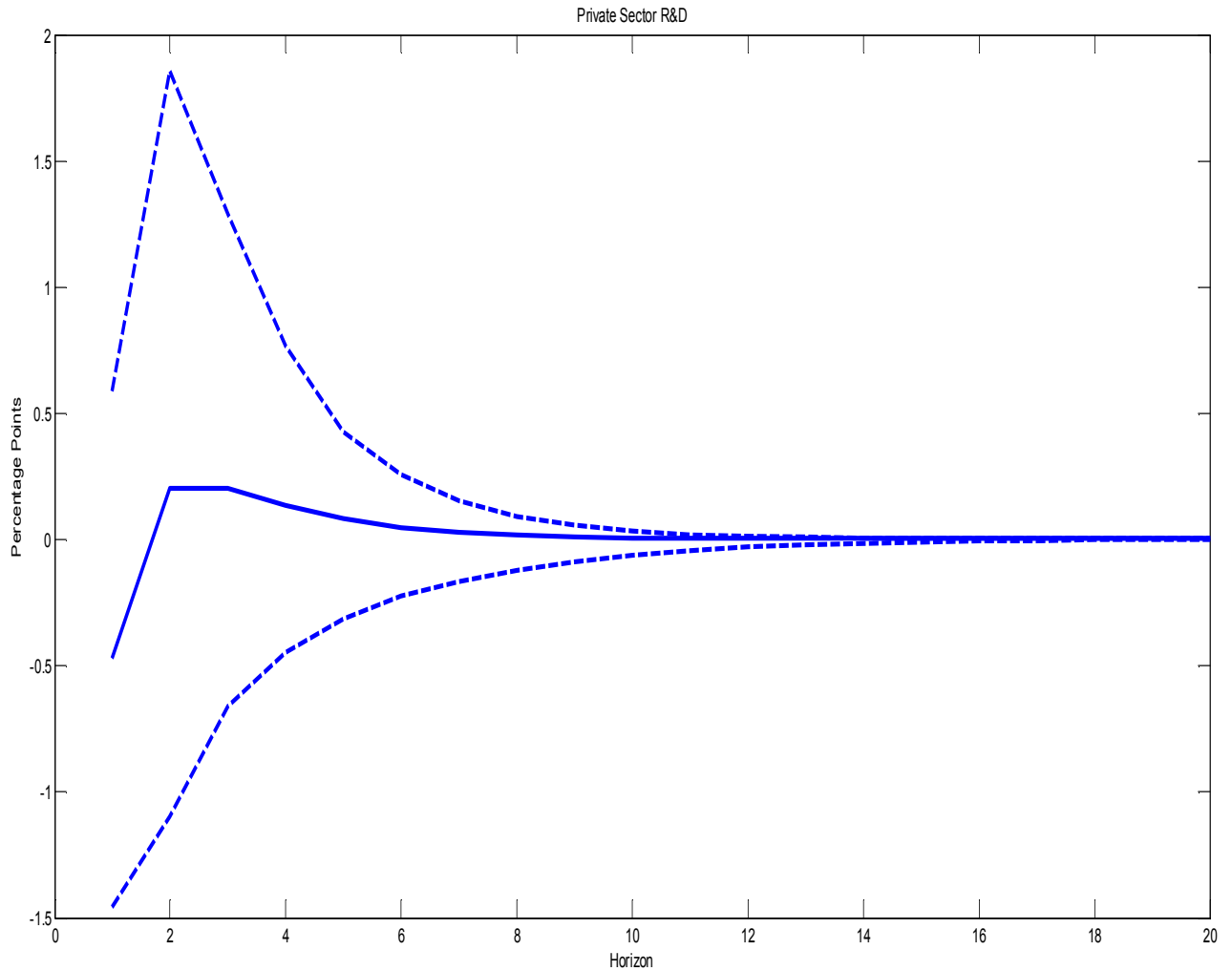


Figure 14: Impulse Responses to a One Standard Deviation Unanticipated Defense Shock (VAR with Consumer Confidence).



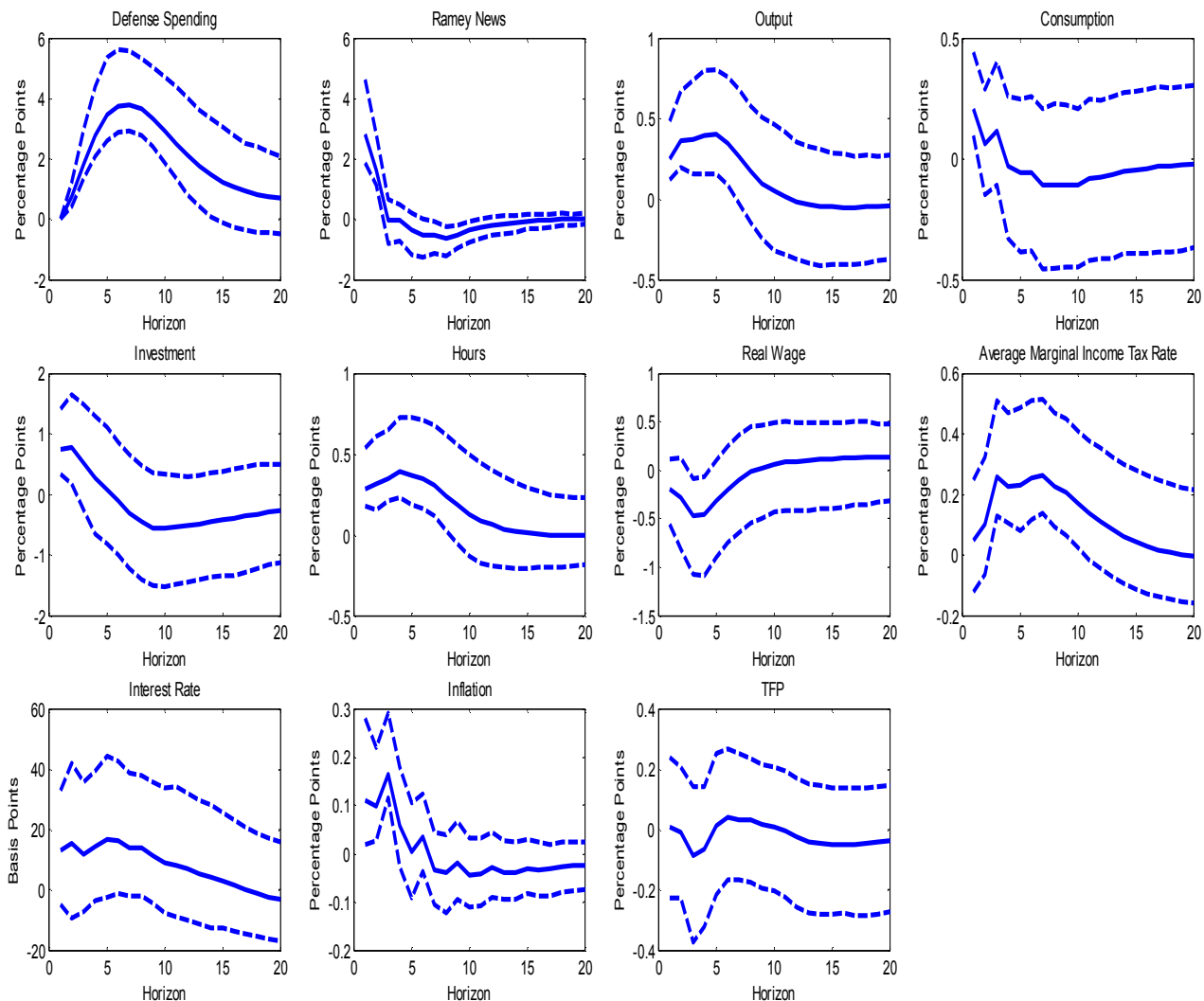
*Notes:* The unanticipated defense spending shocks is identified as the VAR innovation in defense spending orthogonalized with respect to the [Ramey \(2011\)](#) news series from a VAR that includes consumer confidence. Dashed lines represent 2.5th and 97.5th percentile [Hall \(1992\)](#) confidence bands generated from a residual based bootstrap procedure repeated 2000 times. Horizon is in quarters.

Figure 15: Impulse Responses of R&D Growth Rate to a One Standard Deviation Annualized Unanticipated Defense Shock.



*Notes:* The Response was obtained from a two variable annual VAR with private sector R&D Growth Rate and annualized unanticipated defense Shocks. Dashed lines represent 2.5th and 97.5th percentile [Hall \(1992\)](#) confidence bands generated from a residual based bootstrap procedure repeated 2000 times. Horizon is in years.

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. Dashed lines represent 2.5th and 97.5th percentile [Hall \(1992\)](#) confidence bands generated from a residual based bootstrap procedure repeated 2000 times. Horizon is in quarters.