The Effects of Fiscal Shocks on Measured TFP *

Nadav Ben Zeev† Evi Pappa‡

April 14, 2014

Abstract

Many empirical studies find a positive unconditional relation between TFP and defense spending. We examine the response of TFP to an unexpected defense spending shock. The positive relation continues to hold: unexpected shocks to defense spending tend to increase TFP and output and decrease private investment. Yet, the output multiplier is zero when the TFP channel is shut down. We examine various explanations for this phenomenon. We find that changes in defense spending induce a sectoral reallocation, suggesting that the effects of unanticipated government spending shocks on output are induced mostly by supply factors.

JEL classification: E32, E62

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

---

*We would like to thank Markus Bruckner, Fabio Canova, Tomasso Oliviero, Valerie Ramey, Nora Traum, and participants at the VIII REDg Workshop and CSEF seminar for helpful comments and suggestions, Akos Valentinyi for providing us with data on hours in different industries, and Zelda Brutti and Andresa Lagerborg for their assistance. Evi Pappa acknowledges the financial support from the Spanish Ministry of Science and Innovation through grant ECO2012-32392, the Generalitat of Catalonia through grant SGR2009-00350., and the Barcelona Graduate School Research Network.

†Ben Gurion University of the Negev, Israel. E-mail: nadavbz@bgu.ac.il.
‡European University Institute, UAB, BGSE, and CEPR. E-mail: evi.pappa@eui.eu.
1 Introduction

Real business cycle models attribute a central role to technology shocks as drivers of business cycles. However, measured total factor productivity, henceforth TFP, is far from exogenous. In early studies, Hall (1988), Mankiw (1989), and Evans (1992) show that TFP can be forecast using defense spending, or monetary policy indicators. Furthermore, Evans (1992) finds that the influence of money, interest rates, and government spending is economically significant: their innovations account for between one-quarter and one-half of TFP forecast error variance.

Although several follow up studies have identified factors that may drive an important wedge between TFP and true technology shocks, like variable utilization and labor effort or changes in markup rates, and these wedges have been partially incorporated in the TFP measurement provided by Fernald (2012), still the relationship between defense spending and TFP identified in Evans (1992) seems to persist. Regressing the measure of TFP of Fernald (2012) that accounts for variable factor utilization on current and lagged defense spending, the results of which are presented in Table 1, demonstrates that we can still confirm the results of Evans (1992): TFP can still be forecasted by defense spending.

The fact that TFP can be forecasted by defense spending together with the fact that some researchers have used military build ups as a source of exogenous variations in government spending (see, e.g., Ramey and Shapiro (1998)) lead naturally to the following question: How does TFP react after a military build up? Obviously, the answer to this question is crucial for understanding the effects of government spending shocks (especially, those identified using the dummy variable approach). If TFP reacts positively to a shock in defense spending then the effects of the fiscal shock might have little to do with demand stimulus and more with supply factors. According to the common wisdom, and many textbook analysis, 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.

1 See, e.g., Burnside and Eichenbaum (1996) and Jaimovich and Floetotto (2008).
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 of fiscal expansions is crucial from both academic and policy analysis.

In this paper we investigate how TFP reacts to 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 at times shocks occur and, most importantly, most 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 news series about fiscal shocks.\footnote{Ben Zeev and Pappa (2013) identify news shocks about fiscal policy using a different strategy and model anticipated changes in government spending in a DSGE model.}

We show that unexpected increases in defense spending increase 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 generate any significant demand effects and the positive responses of output to such shocks are induced mostly by supply factors.

The results we obtain on the positive relation between TFP and defense spending are by no means unique to the U.S. economy: Similar results obtain from estimating corresponding VARs for Australia, Canada, Japan, and the U.K.. Hence, there seems to be a robust mechanism that is responsible for a generic contemporaneous relation between TFP and defense spending.
What, then, is the mechanism that makes unexpected increases in defense spending to increase TFP? Earlier work by Phelan and Trejos (2000) show in a theoretical model that sectoral reallocations due to military buildups can generate responses that are qualitatively similar to productivity shocks. In a similar spirit, Ramey and Shapiro (1998) argue that many of the significant changes in overall government spending are directed to a few subcategories of spending and, as a result, variations in spending on those programs can represent important shifts in demand for the output of key industries. We investigate whether the observed response of TFP can be explained by changes in sectoral reallocation by exploiting the relation derived in Basu and Fernald (1997) between the aggregate TFP growth rate, technological growth, and reallocation to obtain a proxy for reallocation. We show that our identified defense shock significantly raises this reallocation proxy and has a 30% correlation with it, while our shock which is orthogonalized with respect to TFP does not and only has an 0.08 correlation with it, implying that reallocation is a significant factor explaining the observed movements in TFP after the fiscal shock.

To examine if other 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 supply factors. Our analysis revives the relevance of RBC models for explaining the transmission of unexpected shocks in government spending and calls for future research in developing models in which the propagation of fiscal shocks arises through the supply side of the economy.

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 explanations for the responses of TFP to unexpected defense shocks and Section 6 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:

\[ \epsilon_t = \kappa \epsilon_{t-1} + \epsilon_{t-1} + \eta_t \]  

(1)

where parameter \( 0 \leq \kappa < 1 \) describes the persistence of the process. \( \eta_t \) is an \( iid \) unanticipated defense shock, while \( \epsilon_t \) 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 future 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 \( \epsilon_{t-1} \)), 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. 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

\[ y_t = B_1 y_{t-1} + B_2 y_{t-2} + \ldots + B_p y_{t-p} + B_c + u_t \]  

(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 \((kp + 1) \times k\) matrix \( B = [B_1, ..., B_p, B_c]'\) 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

\[
u_t = Av_t
\]  \hspace{1cm} (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 \( (D' = D^{-1}, \text{which entails } D'D = DD' = I) \). 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 \( \Sigma \).\(^3\)

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. Recent work by Leeper et al. (2013) and Ramey (2011) has discussed how the lack of information with respect to fiscal news events can undermine identification in SVAR’s. One efficient way to address this problem is to add more information to the VAR, as shown by Sims (2012). To comply with this, we also include the Ramey (2011) news series. we also include in the VAR 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

\(^3\)The recursive identification strategy effectively imposes on the first two columns of the orthonormal matrix \( D \) to have one element equal to one in the first and second rows, respectively, and zeros in all other elements.
workweek), constructed by Fernald (2012) and available on his website. Apart from the TFP series, we downloaded all of the data from Ramey’s website.

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 show 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 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.

4http://www.frbsf.org/economics/economists/staff.php?fernald
5http://weber.ucsd.edu/ vramey/
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. 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 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, 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 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

---

6We use the Hall confidence intervals (see Hall (1992)) which attain the nominal confidence content, at least asymptotically, under general conditions and has relatively good small sample properties, as shown by Kilian (1999).
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 doesn’t 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 crowd out moderately private consumption. Furthermore, investment declines more compared to the benchmark case with a peak response of 0.92% compared to the benchmark 0.84% peak. Hence, in accordance with the standard RBC model the unanticipated government expansion generates a complete crowding out of the private sector.

3.5 International Evidence

To examine whether the positive contemporaneous relation between TFP and defense spending we found for the U.S. economy extends to other developed economies, we estimated similar VARs for Australia, Canada, Japan, and the U.K.. Apart from The VARs contain the same variables as our benchmark U.S. VAR except that due to data limitations we omit a narrative-based defense news measure. To obtain a measure of TFP, we compute capital utilization-adjusted TFP measures for the four economies, i.e., Solow residuals that account for changes in capital utilization. Details on the latter TFP computation procedure as well as the sources and sample size of the international data series are given in Appendix A.

Figures 4a-5b shows the response of the variables to a one standard deviation unanticipated fiscal shock for the four economies. It is apparent that the significant contemporaneous response of TFP to the fiscal shock is also present in these four economies. We can thus infer that the TFP-fiscal spending relation is robust and generic and is prevalent not only in the U.S. but also in other developed economies.

Footnotes:

7To the best of our knowledge, there are currently no available narrative-based defense news series for countries other than the U.S. Notwithstanding this limitation, we still view the resulting identification procedure as informative given that we were able to obtain similar results for the U.S. also when the Ramey (2011) news series was omitted from the benchmark VAR.

8We were also constrained to use government spending for Canada rather than defense spending as data on it was only available from 1997 and instead of the marginal tax rate we used tax revenues as percentage of GDP for all countries.
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 run to establish the robustness of our findings in section 3.

4.1 VAR lags

Figures 6a and 6b 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.\(^9\) 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. Figure 7a presents the responses of the variables to the unanticipated government spending shocks while Figure 7b 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 defense shock is orthogonalized with respect to TFP, the multiplier falls to zero just like in the benchmark case.

\(^9\)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.
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 8a and 8b correspond to Figures 2 and 3, 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. 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 9a and 9b 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 10a and 10b 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.\footnote{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.}

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 5.2, 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.\footnote{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.}
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 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:

\[
y_t = I_{t-1}[\Phi_{A,h}(L)\text{def}_t + \Xi_{A,h}(L)\text{news}_t + \Gamma_{A,h}(L)y_{t-1} + \Upsilon_{A,h}(L)tfp_{t-1} + \alpha_{A,h}] + \\
(1 - I_{t-1})[\Phi_{B,h}(L)\text{def}_t + \Xi_{B,h}(L)\text{news}_t + \Gamma_{B,h}(L)y_{t-1} + \Upsilon_{B,h}(L)tfp_{t-1} + \alpha_{B,h}] + u_{t+h}
\]

where \(\text{def}_t\) is defense spending, \(\text{news}_t\) 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 confidence bands and are based on Newey-West standard errors that account for the serial correlation induced in the regressions when \(h > 0\).

Figure 11a shows the state-dependent responses of defense spending, the Ramey (2011) news variable, output, and TFP to the unanticipated defense shock whereas Figure 11b presents the state-dependent responses to the defense shock that is orthogonalized with respect to current TFP.\(^{12}\) 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

\(^{12}\)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.
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 also when we consider a state-dependent model which allows for different effects in recessions and expansions.

4.7 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.\[13\]

\[13\text{We have also tried another battery of sensitivity tests regarding the number of variables in the VAR and found that our results are insensitive to such changes that we do not present here for economy of space.}\]
5 Why Does TFP Rise Following Unanticipated Defense Shocks?

In this section we examine various explanations for our finding on the relation between unanticipated defense shocks and TFP. We first start by presenting the evidence in favor of a sectoral reallocation based explanation and then turn to discussing other alternative explanations we have investigated.

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

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

(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.

To shed light on the importance of the reallocation mechanism that takes place following an unanticipated defense shock, one needs to have a measure of the reallocation term in Equation (5). We measure the reallocation term as the difference between the annual aggregate TFP growth measure of Fernald (2012) and the purified annual technological growth measure of Basu et al. (2006). The former does not account for reallocation of factor inputs and simply calculates a utilization-adjusted aggregate Solow residual whereas the latter accounts for reallocation by constructing aggregate technological growth from industry-specific utilization-adjusted Solow residuals. Note that both measures use essentially the same utilization adjustment. Our proxy for reallocation runs annually from 1948 to 1996.
Figures 13 and 14 present the results from a VAR that includes the reallocation term and our annualized benchmark unanticipated defense shocks as well as a VAR that contains the reallocation terms and the annualized unanticipated defense shocks orthogonalized with respect to current TFP, respectively. Both figures show the response of the reallocation term to the respective defense shock. We can see clearly that reallocation jumps significantly following the unanticipated shock. This is consistent with the significant correlation of 30% that these two variables have. In contrast, the unanticipated shock that is orthogonal to TFP has an insignificant effect on reallocation. This too is consistent with the observed low correlation of 8% between the two series. Overall, the results from this exercise indicate that a reallocation mechanism appears to be the driving force behind the relation between unanticipated defense shocks and TFP.

Why, then, does the defense shock induce a positive reallocation effect? According to Nekarda and Ramey (2011), a government spending shock can induce an increase in productivity by raising inputs in durable goods producing sectors more than in non-durable ones, where the former having larger returns to scale than the latter, as found by both Nekarda and Ramey (2011) and Basu and Fernald (1997), is what makes the increase in aggregate productivity possible. To examine the durable-nondurable sectoral reallocation argument, we have tried to investigate whether reallocations of hours between durable and nondurable goods can account for the TFP responses to defense spending shock. However, the responses of durables and nondurables hours to the unanticipated defense spending shock were not significant.\(^{14}\)

We believe that further disaggregation is needed to recover significant effects, but due to unavailability of data we have decided to concentrate on the effects of the defense shock on capacity utilization in aerospace and related industries instead. It is generally known that government spending is mainly concentrated in these industries: as Table 1 in Nekarda and Ramey (2011) demonstrates,\(^{15}\) over 60% of shipments in aerospace and related industries go to the federal government. Hence, a potentially important aspect of the reallocation mechanism could be that factor inputs in these industries are used more intensely relative to other sectors.

To confirm this conjecture, we added the log of the ratio of the capacity utilization rate in

---

\(^{14}\)These results are available upon request from the authors.

\(^{15}\)See also Table 4 of Perotti (2007).
the aerospace and miscellaneous transportation equipment sector to the aggregate manufacturing capacity utilization rate to our benchmark VAR and ran the same identification exercise as in the benchmark case. These series were taken from the Board of Governors database and are available from 1948 in quarterly frequency. Figure 15 presents the results from this augmented VAR. As shown in the figure, the unanticipated defense shock significantly raises the relative capacity utilization rate on impact after which it continues to rise peaking at 0.4% after 11 quarters. The responses of the other variables are unchanged with respect to the benchmark VAR. Given the findings of Basu and Fernald (1997) and Nekarda and Ramey (2011) that returns to scale are generally higher in durable manufacturing than non-durable manufacturing, we can deduce that the reallocation of production towards the aerospace related industries is likely to generate higher aggregate TFP growth.

In sum, notwithstanding the limitation facing us of not being fully able to characterize what exactly is taking place in all of the sectors following the defense shock, we find it encouraging that we can at least say that i) a suitable measure of reallocation that summarizes all of the sectoral movements is responding in a way that is consistent with the reasonable view of there being a significant reallocation effect in response to government spending shocks and ii) the behavior of the ratio of capacity utilization in the most defense-dependant industries to the aggregate manufacturing capacity utilization rate is in line with the view that defense spending generates a reallocation of production towards industries that have larger returns to scale. Our conclusions are consistent with the results of Phelan and Trejos (2000) and Ramey and Shapiro (1998). However, alternative explanations for the observed responses of TFP to unanticipated defense spending shocks exist, since TFP measures unobservables that can affect production. We next examine some of these possibilities.  

\[ Y_t = F(A_t, K_t, N_t, K_g^p) \]  

where \( A_t \) is TFP, \( K_t \) and \( N_t \) are private capital and labor, respectively, and \( K_g^p \) is public capital and the accumulation of public capital is determined by:  

\[ K_{t+1}^g = I_t^p + (1 - \delta)K_g^p. \]  

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. Second, we also examined the possibility of reverse causality, that is, that technology is actually driving defense spending, by estimating the relation between the Basu et al. (2006) purified annual aggregate technology measure and our annualized

---

\[16\] We ruled out various other explanations for why defense spending increases TFP on the basis of being inconsistent with the data. While we do not present all of them so as to save on space, there two important such potential explanations that we would like to highlight here. First, defense spending could be viewed as public investment, \( I_t^p \). If the production function is given by:  

\[ Y_t = F(A_t, K_t, N_t, K_g^p) \]  

where \( A_t \) is TFP, \( K_t \) and \( N_t \) are private capital and labor, respectively, and \( K_g^p \) is public capital and the accumulation of public capital is determined by:  

\[ K_{t+1}^g = I_t^p + (1 - \delta)K_g^p. \]  

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. Second, we also examined the possibility of reverse causality, that is, that technology is actually driving defense spending, by estimating the relation between the Basu et al. (2006) purified annual aggregate technology measure and our annualized

---

16
5.2 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.\textsuperscript{17} Hence, increases in patriotism following unexpected increases in defense spending could increase unobservable labor effort and hence TFP.

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 VAR is positive but insignificant,\textsuperscript{18} 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.

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

We investigate this hypothesis by including consumer confidence data from the Michigan Survey defense shock. We obtained evidence that is inconsistent with the reverse causality conjecture, finding that the Basu et al. (2006) technology measure does not have a positive effect on our defense shock, but rather a slightly negative and insignificant effect. If the reverse causality conjecture were true, we would expect to see that the unanticipated component of defense spending is negatively correlated with technological innovations, which is not the case.

\textsuperscript{17}See Wikipedia, American propaganda during World War II.
\textsuperscript{18}These results are available upon request from the authors.
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 16. 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.\footnote{While \textit{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.}

### 5.4 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\footnote{A Shrinking Defense Budget May Take Neighbors With It, January 6, 2012, by Binyamin Appelbaum. \textit{New York Times}} 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 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 17 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.\footnote{We also found no significant positive effects of the defense shock on neither total R&D nor federal
6 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 all of the increase in output is stemming from sectoral reallocation effects that induce a significant impact increase in TFP after an unexpected increase in spending. Our results suggest that the Keynesian multiplier associated with unexpected increases in government spending is dead. Government spending per se cannot stimulate additional private spending and unless it affects sectoral reallocation its effect on aggregate demand is nil.

This result is robust and survives a battery of sensitivity tests we have performed. We have tried alternative explanations for interpreting the observed change in TFP after an unexpected defense increase and found that the only hypothesis that survives in the data is the sectoral reallocation one, confirming the findings in Ramey and Shapiro (1998) and Phelan and Trejos (2000).

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 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.

Yet, Ramey (2011) and others find significant responses of the macroeconomy to fiscal news. In Ben Zeev and Pappa (2013), we show that news about defense spending do affect aggregate demand, but the mechanism at work with respect to those shocks is very different relative to the mechanism characterizing the unexpected shocks we identify in the current paper and what economists (ourselves included) have modeled so far as fiscal shocks in dynamic stochastic general equilibrium models.

government R&D. These results are available upon request from the authors.
References


Appendix A  Description of International Data Sources

In this appendix we describe the details and sources of the international data we used for Australia, Canada, Japan, and the U.K. We used ten variables for each country's VAR, as described below.

1. **Australia** (Full Sample Coverage: 1989:Q3-2012:Q2)

   - Defense Spending: defense services, national accounts constant prices, SA, 1959:Q3-2013:Q3; Source: Australian Bureau of Statistics.
   - Private Consumption: consumption by households and non-profit institutions serving households, constant prices, SA, 1959:Q3-2013:Q3; Source: Australian Bureau of Statistics.
   - Investment: gross fixed capital formation, constant prices, SA, 1959:Q3-2013:Q3; Source: Australian Bureau of Statistics.
   - Real Wage: average hourly wage, deflated by CPI, SA, 1978:Q2-2012:Q2; Source: Australian Bureau of Statistics.
   - Average Tax Rate: tax revenues and social security contributions - percent of GDP, SA, 1989:Q1-2014:Q1; Source: OECD.
   - Hours Worked: total quarterly hours worked in the economy, SA, 1978:Q3-2013:Q4; Source: Australian Bureau of Statistics.
   - Interest Rate: 3-month Treasury bill rate, end of period, percent, NSA, 1969:Q3-2013:Q4; Source: Reserve Bank of Australia and the Federal Reserve.
   - Inflation: period-average CPI inflation rate (4-quarter log difference), percent, SA, 1951:Q1-2013:Q4; Source: Australian Bureau of Statistics.
   - Utilization-adjusted TFP: this was computed as a Solow residual using a Cobb-Douglas production function of output, total hours worked, and real capital stock weighed by the industry capacity utilization rate (Source: National Australia Bank), where the
labor share is the average labor share over the sample period 1989:Q3-2013:Q3; Source: National Australia Bank, OECD, World Penn Tables.

2. Canada (Full Sample Coverage: 1990:Q4-2013:Q3)

- Government Spending: government, total disbursements, constant prices, SA, 1970:Q1-2013:Q4; Source: OECD.
- Output: gross domestic product, constant prices, SA, 1960:Q1-2014:Q1; Source: OECD.
- Private Consumption: consumption by households and non-profit institutions serving households, constant prices, SA, 1961:Q1-2014:Q1; Source: OECD.
- Investment: gross fixed capital formation, constant prices, SA, 1961:Q1-2014:Q1; Source: OECD.
- Real Wage: average hourly wage, deflated by CPI, SA, 1990:Q4-2013:Q4; Source: Oxford Economics.
- Average Tax Rate: tax revenues and social security contributions - percent of GDP, SA, 1970:Q1-2014:Q1; Source: OECD.
- Hours Worked: total quarterly hours worked in the economy, SA, 1976:Q1-2013:Q4; Source: OECD.
- Interest Rate: 3-month Treasury bill rate, end of period, percent, NSA, 1951:Q1-2013:Q4; Source: Statistics Canada.
- Inflation: period-average CPI inflation rate (4-quarter log difference), percent, SA, 1951:Q1-2013:Q4; Source: Statistics Canada.

- Utilization-adjusted TFP: this was computed as a Solow residual using a Cobb-Douglas production function of output, total hours worked, and real capital stock weighed by the industry capacity utilization rate (Source: National Australia Bank), where the labor share is the average labor share over the sample period 1980:Q1-2013:Q3; Source: OECD, Oxford Economics, World Penn Tables.
3. **Japan** (Full Sample Coverage: 1980:Q1-2012:Q3)

- Defense Spending: current government expenditure on defense deflated by CPI (linearly interpolated from annual data), SA, 1965:Q3-2012:Q3; Source: Ministry of Finance, Japan.

- Output: gross domestic product, constant prices, SA, 1960:Q1-2014:Q1; Source: OECD.

- Private Consumption: consumption by households and non-profit institutions serving households, constant prices, SA, 1960:Q1-2014:Q1; Source: OECD.

- Investment: gross fixed capital formation, constant prices, SA, 1960:Q1-2014:Q1; Source: OECD.


- Average Tax Rate: tax revenues and social security contributions - percent of GDP, SA, 1960:Q1-2014:Q1; Source: OECD.


- Interest Rate: 3-month Treasury bill rate, end of period, percent, NSA, 1957:Q1-2013:Q4; Source: International Finance Statistics.

- Inflation: period-average CPI inflation rate (4-quarter log difference), percent, SA, 1957:Q1-2013:Q4; Source: Thomson Reuters.

- Utilization-adjusted TFP: this was computed as a Solow residual using a Cobb-Douglas production function of output, total hours worked, and real capital stock weighed by the industry capacity utilization rate (Source: National Australia Bank), where the labor share is the average labor share over the sample period 1980:Q1-2013:Q4; Source: OECD, Oxford Economics, World Penn Tables.


- Average Tax Rate: tax revenues and social security contributions - percent of GDP, SA, 1970:Q1-2014:Q1; Source: OECD.


- Interest Rate: 3-month Treasury bill rate, end of period, percent, NSA, 1968:Q1-2013:Q4; Source: Financial Times.


- Utilization-adjusted TFP: this was computed as a Solow residual using a Cobb-Douglas production function of output, total hours worked, and real capital stock weighed by the industry capacity utilization rate (Source: National Australia Bank), where the labor share is the average labor share over the sample period 1980:Q1-2011:Q3; Source: OECD, Oxford Economics, World Penn Tables.
Table 1: **Wald Test from Regressing TFP Growth Rate on Defense Spending Growth Rate**

<table>
<thead>
<tr>
<th>Test Statistic</th>
<th>Value</th>
<th>Degrees of Freedom</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-Statistic</td>
<td>2.51</td>
<td>(4,236)</td>
<td>4.28%</td>
</tr>
<tr>
<td>Chi-Square</td>
<td>10.03</td>
<td>4</td>
<td>3.99%</td>
</tr>
</tbody>
</table>

*Notes:* The Wald test is based on a regressing TFP growth on its own three lags and the current and three lags of the growth rate of defense spending. The null hypothesis is that the coefficients on current and lagged defense spending growth rates are all zero.
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: **International Evidence:** (a) Impulse Responses for Australia; (b) Impulse Responses for Canada

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

(b) Impulse Responses to a One Standard Deviation Unanticipated Government Spending Shock (Canada).

**Notes:** Panel (a): The unanticipated defense spending shock is identified as the VAR innovation in defense spending in Australia. 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 government spending shock is identified as the VAR innovation in government spending in Canada. 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 5: International Evidence: (a) Impulse Responses for Japan; (b) Impulse Responses for the U.K.

Notes: Panel (a): The unanticipated defense spending shock is identified as the VAR innovation in defense spending in Australia. 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 government spending shock is identified as the VAR innovation in government spending in Canada. 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 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 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 7: 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 8: 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 9: Post-1983 Sample (1983-2008): (a) Unrestricted TFP; (b) 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 10: 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 11: 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 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 the Ramey (2011) news series and TFP and is normalized such that defense spending rises by 1% on impact. 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 of Reallocation Measure to a One Standard Deviation Annualized Unanticipated Defense Shock.**

Notes: The Response was obtained from a two variable annual VAR with reallocation and annualized unanticipated defense Shocks. Reallocation is measured as the difference between the annual Fernald (2012) aggregate TFP measure and the purified technology measure of Basu et al. (2006). 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 14: Impulse Responses of Reallocation Measure to a One Standard Deviation Annualized TFP-Orthogonaiized Unanticipated Defense Shock.

Notes: The Response was obtained from a two variable annual VAR with reallocation and annualized unanticipated defense Shock series that is orthogonalized with respect to TFP (the shock series from Figure 3). Reallocation is measured as the difference between the annual Fernald (2012) aggregate TFP measure and the purified technology measure of Basu et al. (2006). 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 15: Impulse responses to a one standard deviation Unanticipated Defense Shock (VAR with Relative Aerospace Capacity Utilization).

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 the log of the ratio of capacity utilization in the Aerospace and Miscellaneous Transportation Equipment Sector to the aggregate manufacturing capacity rate. 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 16: 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 17: **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.