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Government Purchases Reloaded : Informational Insufficiency and Heterogeneity in Fiscal VARs

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Government Purchases Reloaded:
Informational Insufficiency and Heterogeneity in Fiscal VARs

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Abstract

Using a large Bayesian VAR, we approximate the flow of information received by economic agents to investigate the effects of changes to government purchases. We document robust evidence that informational insufficiency in conventional models explains inconsistent results across samples and commonly employed identifications in recursive Structural VARs and Expectational VARs. Furthermore, we report heterogeneous effects of components of government purchases. While aggregate government purchases do not appear to produce strong stimulative effects with output multiplier around 0.7, government investment components have multipliers well above unity. State and local consumption, which captures investment in education and health, elicits a strong response.

JEL classification: C32, E32, E62.

Keywords: fiscal shocks, government purchases, fiscal foresight, Large Bayesian VARs.

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1 Introduction

The deep economic recession triggered by the 2008 global financial crisis has brought government purchases of good and services back to the centre of policy debate as a tool for economic stabilisation. Unfortunately, academic research has provided no clear guidance on the macroeconomic impact of fiscal shocks. Estimated output multipliers for government purchases are vastly different and depend on the details of the identification, the sample period, and the information set adopted. Crucially, different studies disagree not just on the magnitude but even on the sign of the responses of output components such as consumption and investment.¹

The standard econometric model adopted in hundreds of studies, covering several countries and time periods, is a Structural Vector Autoregression (SVAR) with a core set of 3 to 5 variables including government purchases, taxes and output. Shocks to government purchases are identified using statistical identifications, and their propagation is studied on a larger set of variables by adding them to the model one at a time, using a ‘marginal approach’ (see, for example, Blanchard and Perotti 2002). Amongst other criticisms of these small VAR models, three issues have been intensely debated. First, the identification of shocks to government purchases is clouded by potential anticipation effects of fiscal policy changes due to their lagged implementation – a phenomenon known as ‘fiscal foresight’ – as highlighted by Ramey (2011b) and Leeper et al. (2013).²

¹Recent surveys on the effects of government purchases can be found in Hall (2009), Parker (2011) and Ramey (2011a, 2016).

²A commonly proposed solution to this problem is to use Expectational VARs (EVARs) that enlarge the information set of the VAR model by including a variable proxying for agents’ expectations about

Second, small VARs potentially suffer from the omission of several variables that can be important for the transmission of fiscal shocks – e.g. the monetary policy stance, the credit and financial market conditions, the way in which spending is financed, the level of debt, the degree of openness of the markets, etc. Finally, small VARs that examine total government purchases do not account for the potential heterogeneity of the underlying components of government purchases.

These three seemingly unrelated issues are best thought of as different aspects of a more fundamental problem of ‘informational insufficiency’ of the employed econometric models, due to a misalignment between the information sets of the agents and of the econometrician. Indeed, these issues are related to the misspecification of the econometric information set of the VAR that does not incorporate relevant information to control for (i) anticipation effects, (ii) variables that are important for the transmission of the shocks, and (iii) the heterogeneous components of government purchases. Hence, adding the missing information to the model is a natural response to this problem of model misspecification (see also Lütkepohl, 2014). This paper builds on this observation and analyses the effects of shocks to government purchases in the US using (i) a large information model to approximate the flow of information received by economic agents, and (ii) the two most commonly employed identifications – the recursive identification à la Blanchard and Perotti (2002), and the Survey of Professional Forecasters (SPF) expectational identification of Ramey (2011b).³ Large Bayesian VARs (BVARs) with

future fiscal changes, e.g. Ramey (2011b), and Fisher and Peters (2010).

³A key intuition is that forward looking variables – e.g. commodity prices, financial markets, invent-

informative priors offer a robust solution to the ‘curse of dimensionality’ problem related to the large number of parameters to be estimated, while allowing the VAR framework and identification methods to be employed with a large econometric information set (see Banbura et al., 2010). Importantly, a Large BVAR also enables us to investigate the heterogeneous effects of different, but potentially correlated, components of government purchases.⁴

Using quarterly data from 1959Q1-2015Q4, we document that much of the previously reported disagreement is explained by missing information in the information sets employed in small VARs. In fact, (1) Large SVARs with recursive identification and Large EVARs with Ramey’s SPF forecast errors identification deliver virtually identical estimates of dynamic responses to shocks to government purchases; (2) multipliers for government purchases are stable across samples; and (3) fiscal shocks identified using small models are forecastable using factors extracted from a dataset containing 136 macroeconomic variables.

We find that in the aggregate, government purchases do not appear to produce strong stimulative effects with multipliers well below unity. Consumption, private investment and real wages are mostly unresponsive to slightly negative. The positive responses previously found in small VARs are likely to be due to informational insufficiency. However,

ories, consumer and business confidence, among others – help to control for anticipation, disentangling anticipated from unanticipated fiscal shocks. In doing this we develop the intuition originally proposed by Sims (1988) to supplement small VARs with financial variables. Also, it is worth observing that in SVARs the correct identification crucially depends on both the correct specification of the econometric set and the selection of an appropriate identification to disentangle different contemporaneous shocks.

⁴We disaggregate total US government purchases into consumption and investment components at federal defense, federal non-defense, and state and local levels.

we report remarkably heterogeneous dynamic responses for disaggregated components of government purchases. Non-defense and state and local components generally produce larger responses than the defense components. Significantly, investment components have large multipliers, hinting at a positive effect of public capital on economic activity.

Our paper is closely related, in spirit, to Forni and Gambetti (2010), in which shocks to government purchases are studied using a large factor model and sign restrictions. The common underlying intuition is that large dimension datasets incorporating forward looking variables are necessary to close the gap between the information sets of economic agents and the econometrician. We offer an alternative approach by incorporating large information in BVARs, which has the following advantages: (1) BVARs allow us to treat variables in a transparent manner that retains their economic interpretation, while factor models are less general and summarise the information in a purely statistical manner. (2) Factor models impose a stringent structure on the moving average functional form of the data generating process and this may affect impulse response functions. (3) BVARs can conveniently accommodate commonly used identification strategies, enabling an examination of the source of disagreement. We also add robust evidence to the recent literature studying heterogeneous effects of fiscal instruments, that has relied on small VARs and a marginal approach (e.g. Perotti, 2011, Pappa, 2009, and Bénétrix, 2012).

2 Troubles with Small Fiscal VARs

The extant literature on shocks to government purchases has mostly used small SVARs with a core set of 3-5 variables – usually aggregate measures of government purchases, taxes, output and rates – by employing a marginal approach. The identification of shocks to government purchases is obtained from the forecast errors of the model (the residuals of a linear projection onto past values), using restrictions motivated by economic theory such as, for example, on the timing of the responses of macroeconomic variables (i.e. ‘recursive identification’ as in Blanchard and Perotti 2002, Galí et al. 2007, and Perotti 2008), or on their sign (see Mountford and Uhlig, 2009). The dynamic effects of identified shocks are then examined for a larger set of variables that are added one at a time to the small VAR model.

Amongst other criticisms, the debate on small fiscal SVARs has pointed to three seemingly unrelated potential issues with these standard models: (i) the presence of fiscal foresight and hence the non-fundamentalness of VAR representations; (ii) the potential omission of variables that are relevant to the transmission of government shocks, (iii) the unmodelled underlying heterogeneity in government purchases.

Fiscal foresight. An intrinsic feature of fiscal policy actions is that economic agents constantly receive and react to advance information about future changes to fiscal policy, informed by the institutional process through which they are implemented (see Ramey, 2011b; Mertens and Ravn, 2010, 2012; Leeper et al., 2013). This fiscal foresight is known to pose a challenge to econometric analyses of fiscal policy because it can generate equi-

libria with a non-fundamental moving average representation.⁵ The issue arises due to a misalignment between the information sets of the agents and of the econometrician, with agents basing their decisions on more information than the econometrician possesses. A commonly proposed solution to fiscal foresight is to enlarge the information set of the VAR model to include a variable proxying for agents' expectations about future fiscal policy changes using Expectational VARs (EVARs).⁶

Omitted variables. Small fiscal SVARs are also likely to omit variables that are important for the transmission of fiscal policy shocks such as the debt level (e.g. Favero and Giavazzi, 2007), the exchange rate regime (e.g. Corsetti et al., 2012), the monetary policy stance (e.g. Woodford, 2011), and financial and credit conditions, among potentially many others. If the information set of the VAR is misspecified, estimates of the parameters – transmission coefficients and covariance matrix alike – are inconsistent (see Braun and Mittnik, 1993). This affects the identification of the disturbances, the variance covariance decomposition, and the derived impulse response functions (IRFs).

Heterogeneity. Finally, differences in estimates across studies may be due to the different components of government purchases being studied (see for example the discussion in Perotti, 2011 and results in Pappa, 2009, Bénétrix, 2012). In fact, contrary to what is generally assumed in theoretical models, government consumption and invest-

⁵The issue of non-fundamentalness in VARs was originally studied by Hansen and Sargent (1980), and Lippi and Reichlin (1993, 1994). A comprehensive review is in Alessi et al. (2011).

⁶Among the expectational proxies proposed, commonly used ones are SPF forecast errors for government consumption and investment Ramey (2011b), SPF forecast revisions at different horizons (see Forni and Gambetti, 2016 and Ricco, 2015), the military news variable based on an ex-post collection of real time news about defense purchases proposed by Ramey (2011b), and movements in stock returns of large US defense contractors (see Fisher and Peters, 2010).

ment is a complex bundle of goods and services with heterogeneous components that may activate demand and supply channels differently. In small fiscal VARs, where aggregate government purchases are employed, a shock to government purchases can only be thought of as some kind of average shock and the IRFs are the responses to such an average shock. Also, the composition of US government purchases has undergone a remarkable shift through time, raising doubts about the stability of the macroeconomic properties of the aggregate variable used in much of previous research.⁷ Time variation in the composition of government purchases and the potentially heterogeneous effects of purchase components can lead to unstable estimated effects across samples.

We think of these three potentially distinct issues – fiscal foresight, omitted variables, and heterogeneity – as related facets of the general problem of informational insufficiency of small fiscal SVARs (see Forni and Gambetti, 2014).⁸ Hence, adding the missing information to the model is a natural response to the problem.

2.1 A Simple Model of Fiscal Foresight

Using a simple model we illustrate how the issue of non-fundamentality can arise in VAR models and how a large information approach can address the issue (similar models are in Perotti, 2011; Leeper et al., 2013). Let us consider an economy with forward looking agents maximising their intertemporal utility $U = \mathbb{E}_t \sum_{i=0}^{\infty} \beta^i \log C_{t+i}$

⁷Over the last 50 years government purchases have shifted away from federal investment and defense components towards federal non-defense and state and local purchases (see Online Appendix).

⁸When the model is informationally insufficient, structural shocks cannot be recovered from current and past fiscal data – a central assumption of conventional econometric methods – and are non-fundamental for the variables included in the model.

subject to the constraint $C_t + K_t + G_t = Z_t K_{t-1}^\alpha$, where C_t , K_t and G_t are consumption, capital and government expenditure, respectively. The productivity factor Z_t follows a lognormal process with mean zero and variance σ_z^2 .

Let us start from the simple case where log deviations for government expenditure follow an exogenous process specified by $g_t = \gamma_{t|t-1}$, where $\gamma_{t|t-1}$ is a white noise shock that is known at time $t-1$. This implies that due to an implementation lag the innovation is known to the agent one lag before being realised, and no other shocks to g_t are realised at the time of implementation. The MA representation of the log-linearised system can be written as

$$\begin{pmatrix} g_t \\ z_t \\ k_t \end{pmatrix} = \begin{pmatrix} L & 0 \\ 0 & 1 \\ \frac{\pi_1 + \pi_0 L}{1 - \lambda_1 L} & \frac{\delta}{1 - \lambda_1 L} \end{pmatrix} \begin{pmatrix} \gamma_{t+1|t} \\ z_t \end{pmatrix}, \quad (1)$$

where the lower case letters denote log deviations from the steady state (details of the derivations are provided in the Online Appendix).

In such a setting, structural shocks are non-fundamental for all ‘small’ two-variable VARs. Let us consider the square subsystem given by capital and government expenditure. The determinant of the relative squared MA subcomponent vanishes at zero, inside the unit circle.⁹ This is also true for the other two-by-two subsystems in (g_t, z_t) and (z_t, k_t) whose determinants have roots 0 and $-\pi_1/\pi_0$, respectively, both less than one in modulus. This implies that standard VAR techniques are unable to correctly estimate

⁹With no anticipation, this MA subcomponent would be a two-by-two identity matrix, and hence the structural shocks would be fundamental in a VAR with capital and government expenditure.

fiscal shocks for any ‘small’ VAR with only two variables.

However, large information sets can solve the non-fundamentality issue. Indeed, in the ‘tall’ (3 rows and 2 columns) representation in Eq. (1) structural shocks are y_t -fundamental for the vector $y_t = (g_t \ z_t \ k_t)'$ since the MA representation has full rank (rank = 2) inside the unit circle, i.e. since the determinants of the three (2×2) submatrices of the MA representation have no common roots inside the unit circle (see Rozanov, 1967). The invertibility of the MA representation implies the existence of a finite order VAR(2) (reduced rank) representation in which the structural shocks are y_t -fundamental. A similar full-rank VAR(2) can be obtained in the more general case in which both anticipated and unanticipated shocks to g_t are present, $g_t = \gamma_{t|t-1} + \varepsilon_t$:

$$\begin{pmatrix} 1 + \frac{\pi_0}{\pi_1}L & \frac{\delta}{\pi_1}L & -\frac{1}{\pi_1}L + \frac{\lambda_1}{\pi_1}L^2 \\ 0 & 1 & 0 \\ -\frac{\pi_0}{\pi_1} & -\frac{\delta}{\pi_1} & \frac{1}{\pi_1} - \frac{\lambda_1}{\pi_1}L \end{pmatrix} \begin{pmatrix} g_t \\ z_t \\ k_t \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} \varepsilon_t \\ z_t \\ \gamma_{t+1|t} \end{pmatrix}. \quad (2)$$

3 An Empirical Assessment of Small VARs

Our benchmark Small VAR is a 5 variable SVAR with four lags of a fixed set of variables including total government purchases, marginal tax rate, gross domestic product, and real rates, as well as a rotating fifth variable of interest including real wages, total worked hours, output per hour, personal consumption of durables, nondurables, and services,

real private investment, and the real exchange rate.¹⁰ Following Blanchard and Perotti (2002), shocks to government purchases are identified under the assumption that government purchases do not react to other contemporaneous macroeconomic disturbances due to decision lags. This can be implemented using a recursive identification (Cholesky decomposition) with government purchases ordered first.

Figure 1 plots the IRFs obtained for a shock to aggregate government purchases for the sample period 1959Q1-2015Q4 (solid line) with shaded posterior coverage intervals at the 0.68 and 0.90 levels. The dynamic responses of macroeconomic variables of interest are plotted for a one percent shock in aggregate government purchases. The IRFs can be interpreted as elasticities since the variables are in log-levels. Overall, the shapes of the IRFs from the Small VAR are similar to those generally reported in prior SVAR literature – a shock to government purchases leads to positive and persistent responses of GDP, private consumption, and real wages, while real private investment is rather unresponsive and the real exchange rate depreciates in the medium run (see, for example, Blanchard and Perotti 2002, Galí et al. 2007, and Perotti 2011).

3.1 Instability of estimates

We first assess whether the Small VAR delivers stable estimates across subsamples by splitting our 1959Q1-2015Q4 sample into two subsample periods (1959Q1-1981Q4 and

¹⁰We use quarterly data from 1959Q1 to 2015Q4 in real log per capita levels for all variables except those expressed in rates. A complete description of the variables used in our study is presented in the Online Appendix. The Small VARs are estimated with non informative priors and therefore can be thought of as standard frequentist VARs.

1982Q1-2015Q4) and estimating IRFs for both periods separately.¹¹ The responses for the subsample periods are plotted as dashed (1959Q1-1981Q4) and dotted (1982Q1-2015Q4) lines in Figure 1. The results from the Small VAR appear to be highly unstable across samples. While shocks to government purchases seem to produce persistent expansionary effects for the entire sample and for its first half (1959Q1-1981Q4), they seem to have contractionary effects for the 1982Q1-2015Q4 sample. In particular, consumption and real private investment expand following an increase in purchases in 1959Q1-2015Q4 and 1959Q1-1981Q4, but they contract in 1982Q1-2015Q4. Instabilities across subsamples and differences across identifications have been observed in previous works (e.g. Perotti, 2008), and have been related either to the presence of structural breaks (e.g. credit market developments or changes in the fiscal-monetary policy regime), or to variations in the composition of government purchases over time, or to issues of fiscal foresight in the proposed identifications.

3.2 EVARs and fiscal foresight

We contrast results from the recursive SVARs with the ones from a similarly specified EVAR with the SPF expectational identification for federal purchases shocks proposed by Ramey (2011b). As a measure of agents' forecast errors, the median one quarter ahead SPF federal purchases forecast errors (in growth rates) $-\Delta g_t^{f.err.} =$

¹¹The 1982Q1 split point is consistent with a large stream of literature that finds a structural break in the US economy in the early 1980s. This split point also enables comparability of the SVAR and EVAR specifications since the SPF data is available only after 1981.

$\Delta g_t - \text{Median}_i(E_{t-1}^i \Delta g_t) -$ are added to the VAR and ordered first, where $E_{t-1}^i \Delta g_t$ is the forecasted growth rate one quarter ahead of panelist i .¹² Figure 2 reports results from the Small EVAR on the sample 1982Q1:2015Q4, and shaded posterior coverage intervals at the 0.68 and 0.90 levels. For sake of comparability, the IRFs show the dynamic response of macroeconomic variables to an innovation in SPF forecasts errors normalised such that federal government purchases peaks at one. The pattern of responses of the SPF EVAR shows contractionary effects with output and private consumption and investment falling, while real wages increase in the short run but decline after a few quarters. Figure 2 also contrasts the EVAR IRFs with the IRFs from the benchmark Small SVAR with recursive identification (1959Q1:2015Q4), which indicate expansionary effects of the shock.

3.3 Granger causality tests

Finally, we examine whether commonly used Small VARs may suffer from informational insufficiency using the test proposed by Forni and Gambetti (2014). This involves (1) testing informational sufficiency of the identified shocks from the Small SVARs shown in Figure 1 and from similarly specified small SVARs for components of government purchases, (2) verifying the forecastability of SPF forecast errors and expectation revisions for federal and state and local series, and (3) testing informational sufficiency of

¹²Differently, from Ramey (2011b) we do not merge a discontinued SPF time series for defense spending 1969-1981 with the SPF time series for federal government purchases. We do this in order to avoid issues of heterogeneity and limited comparability between the methodologies of the two series. This explains differences in the shapes of the IRFs from those reported in Ramey (2011b).

the identified shocks to purchases from a small EVAR. We also test for the alternative expectational military spending news variable proposed by Ramey (2011b).¹³

Four factors that explain over 99 percent of the variance in the data are extracted from a large dataset of 136 macroeconomic variables.¹⁴ These four factors are used to conduct Granger causality tests on identified shocks (and expectational proxies) by regressing them on four lags of the shock itself and four lags of the factor. Each of the factors is separately tested using the null hypothesis that the coefficients on the four lags of each factor are not jointly significantly different from zero at conventional levels. The intuition supporting this test is that if the factors contain relevant information useful for forecasting fiscal shocks, then economic agents could have used this information to shape their decision prior to the realisation of the forecasted shock to purchases.

Table 1 reports the results for the Granger causality tests. Factors Granger cause identified shocks in several of the SVARs – e.g. Factor 1 Granger causes the shocks for the 1982Q1 to 2015Q4 subsample, while Factor 2 and Factor 3 Granger cause the shocks from defense investment, state and local consumption or state and local investment. The factors also seem to predict forecast errors in SPF federal and state and local purchases. Furthermore, the Small EVAR identified shocks associated with government purchases forecast errors appear to be Granger caused, albeit significance is weak. These findings may be due to deviation from perfect information or from perfect rationality as is being

¹³This variable is not employed in our study, since as observed in Ramey (2011b): ‘all indications are that this variable is not informative for the period after the Korean War’.

¹⁴To extract factors, first differences in the real log per capita levels for all variables are used, except those expressed in rates, to stationarise the dataset.

explored in recent works (see Coibion and Gorodnichenko, 2012, Andrade and Le Bihan, 2013 and Ricco, 2015).¹⁵ Overall, our three related tests indicate that small SVARs and EVARs suffer from informational insufficiency and that retrieved fiscal shocks are likely to be combinations of anticipated and unanticipated fiscal changes.

4 A Large Fiscal VAR

We have argued that models that are able to incorporate large information sets offer a general solution to the problem of informational insufficiency. In particular, Bayesian VARs with informative priors can overcome the ‘curse of dimensionality’ of large models while allowing for the use of common identification strategies (see Banbura et al., 2010).

We employ a Large Bayesian VARs with standard macroeconomic priors (‘Minnesota’ and ‘sum-of-coefficients’ priors) incorporating a rich information set to study the macroeconomic effects of shocks to government purchases.¹⁶ The baseline Large VAR specification with aggregate government purchases has 43 variables and four lags. These include many forward-looking variables in order to approximate the flow of information received by economic agents – e.g. consumer sentiment, asset prices, inventories, etc. –, as well as potentially omitted variables relevant to the transmission of fiscal shocks

¹⁵We also conduct a Granger causality test using the Ramey’s military spending news variable and find that it is significantly explained by Factor 3 at the 10 percent significance level.

¹⁶Details on these priors can be found in the Online Appendix. The use of our Bayesian priors introduces a bias toward zero in the estimates of the VAR coefficients and the IRFs. For this reason, our estimated multipliers can be better framed as lower bounds for values of the multipliers. However, in selecting the informativeness of the priors we adopt the method of Giannone et al. (2015) that allows for an optimal bias-variance tradeoff in the parameter estimation.

– e.g. taxes, public deficit, exchange rates, monetary aggregates, interest rates, public debt, savings, and housing, among others.¹⁷

Figure 3b reports the dynamic responses of macroeconomic variables to shocks to total government purchases for a Large VAR using the full sample and a recursive identification. Overall, a shock to government purchases produces a short lived expansion in output, with negative, albeit insignificant effects on consumption components and private investment. The GDP multiplier is 0.77 upon impact and then declines (see Table 2 and Figure 7).¹⁸ Output per hour increases significantly on impact, while real wages and worked hours are largely unresponsive. The average marginal tax rate peaks on impact and then declines. These patterns are reminiscent of the effects of government purchases predicted by a neoclassical baseline model, with the crowding out of private consumption and investment due to the implied negative wealth effect (see, for example, Baxter and King, 1993). It is worth noticing that the IRFs from the Small VAR are quite often outside the posterior coverage intervals, and deliver biased estimates. Thus, the positive and persistent response of consumption in Small VARs appears to be due to the misspecified information set of the econometric model.

First, we evaluate whether the instability exhibited by Small VARs is indeed resolved in the Large VAR. Figure 3a presents the impulse responses to a shock in total govern-

¹⁷See the Online Appendix for a complete list of variables.

¹⁸Multipliers are defined as is standard in the related literature (e.g. Ilzetzki et al., 2013). Multipliers at horizon h are computed as the response of the variable of interest at horizon h divided by the impact impulse. For $h = 0$ they are called impact multipliers. Cumulative multipliers are computed as the net present value of the cumulative response function of output divided by the cumulative government purchases impulse function, also in net present value. Further details are in the Online Appendix.

ment purchases over 24 quarters for the full sample 1959Q1-2015Q4 as well as for the two subsamples, 1959Q1-1981Q4 and 1982Q1-2015Q4. The plots also show the posterior coverage intervals at the 0.68 and 0.9 levels for the full sample. Shocks to government purchases are identified using a recursive identification with purchases ordered first. While the IRFs for the Small VAR exhibit subsample instability, the Large VAR IRFs do not. In fact, in line with our prediction, the Large VAR IRFs for both subsamples are within the posterior coverage interval at the 0.68 level for virtually all horizons. Overall, these results suggest that the previously reported subsample instability is not mainly due to structural changes but instead points to a misspecification of the information set of the models employed. However, the residual variation across subsamples may be accounted for by the changing composition of government purchases over time and perhaps by structural changes.¹⁹

Second, we assess whether Large SVARs and Large EVARs deliver similar results. Informational sufficiency of the Large VAR would imply that the proxy variables for expectations should not provide additional information over and above what is provided by the forward looking variables used in the SVARs to control for anticipated fiscal changes. Provided that fiscal shocks are correctly identified under both specifications, a Large SVAR and a Large EVAR should yield the same results and IRFs in statistical terms. Figure 4 reports results for Large and Small SVARs with recursive identification,

¹⁹Given the consistency of results, the Large VAR can be used for different subsamples without loss of validity (e.g. our analysis of government expectations over 1982Q1-2015Q4). Our results are also robust to the exclusion of the recent financial crisis.

and for EVARs with SPF forecast errors identification, in the first and second columns. Differently from the Small SVAR and EVAR, the Large SVAR and EVAR deliver virtually identical results. This indicates a role for ‘fiscal foresight’ and suggests that missing information may explain the inconsistent results.²⁰

For sake of completeness, we explore a different specification of the EVARs that includes the agents’ expectation revisions at time t for the growth of government purchases at time t , defined as $\Delta g_t^{exp.rev.} = \text{Median}_i(E_t^i \Delta g_t) - \text{Median}_i(E_{t-1}^i \Delta g_t)$ (see Perotti, 2011). IRFs for aggregate federal government purchases are reported in the last columns of Figure 4. The shapes of the IRFs are intriguingly different from the Ramey EVAR specification and may point to the stimulative effect of fiscal news. However, the low statistical significance of the IRFs also points to the high level of noise contained in this alternative measure for expectations. A detailed discussion of the properties of expectation revisions exceeds the scope of this paper (see Ricco, 2015, Caggiano et al., 2015, and Forni and Gambetti, 2016).

Finally, we conduct Granger causality tests on the identified shocks from our Large VARs. None of the factors appear to Granger cause the identified shocks in any specification (see Online Appendix). Overall, our examination of the Large VAR model using the three criteria above suggests that the informational insufficiency issues of Small VARs are resolved by the large information approach.

²⁰Large SVARs and EVARs for state and local purchases also deliver almost identical results. The results are reported in the Online Appendix.

5 The Heterogenous Effects of Government Purchases

Shocks to total government purchases may mask the underlying heterogeneity by averaging the dynamic responses of macroeconomic variables to different components of government purchases. Thus, following what was done for aggregated government purchases, we use similarly specified Large Bayesian VARs incorporating various components of government purchases. We disaggregate total government purchases along three dimensions (i) public consumption vs. investment in public capital, (ii) civilian vs. defense, and (iii) national level vs. state and local level. Such a decomposition is consistent with many of the arguments in the debate and helps to shed light on the differences in some of the estimates in the literature. For example, much of the debate between proponents of SVARs and EVARs has been related to the use of total government purchases vs. military purchases. Also, public investment can have externalities and hence may confound results in studies that do not distinguish between productive and unproductive components of government purchases. Furthermore, this is the finest level of disaggregation for which data are available at quarterly frequency. In fact, a functional decomposition of the different components is only available at yearly frequency, making the identification of fiscal shocks more questionable.

The IRFs for shocks to consumption expenditure components of government purchases are reported in Figure 5. Shocks are identified using a recursive identification where federal components are always ordered above state and local ones, and the shock variable is ordered last after the other related components of government purchases.

This identification generalises the recursive identification for total government purchases, while controlling for correlations between components of government purchases. In fact, component-specific shocks are identified by assuming zero contemporaneous effects of the shock variable onto the other related components.^{21,22} Federal defense consumption elicits a positive, significant but short lived response from GDP, with an impact multiplier of 0.91, while private consumption is unresponsive and investment is negative. Following a shock to federal non-defense consumption, GDP drops, albeit not significantly, while durables consumption and investment are crowded out. Interestingly, state and local consumption shocks produce a slowly increasing response from GDP, from the components of consumption, as well as from investment that peaks after 2 (see also Figure 7). The cumulative multiplier for GDP increases in the long run towards 2.²³

A federal non-defense investment shock produces a slowly rising hump-shaped response that peaks after 2 years, while the largest effect of state and local investment is upon impact (see Figure 6). Non-military investment components result in large and statistically significant impact multipliers of 2.31 and 4.97 for state and local investment and federal non-defense investment, respectively. In addition, private investment responds strongly to federal non-defense investment with multipliers well over 1. This may suggest the activation of a supply channel possibly providing feedback and rein-

²¹Results are robust to different ordering among components of government purchases, pointing to limited contemporaneous correlation. The Online Appendix reports these additional results.

²²Clemens and Miran (2012) observed that the balanced budget requirement can induce procyclicality for state and local components, which may affect our identification. However, we note that our results are robust to excluding the last recession for which the issue should be more pronounced.

²³A large portion of state and local consumption is due to education and health services. Positive effects on human capital may explain the pass-through effects on aggregate output.

forcing the effects of the increased public capital.²⁴ Similar results, hinting at stronger stimulative effects of government investment have also been reported in Aschauer (1989), Auerbach and Gorodnichenko (2012) and Leduc and Wilson (2012).

In stark contrast with the other investment components, federal defense investment yields large negative cumulative multipliers. This result can be explained by recalling that purchases of military hardware are accounted for as investment in national accounts. While other forms of federal investment can have a positive effect on aggregate output by increasing the stock of productive public capital, military hardware and installations do not directly enter the production function and provide security services over time (a public good). Hence, federal defense investment can be viewed as the ‘thrown-into-the-ocean’ government spending of the neoclassical model.

We complete the empirical analysis of the effects of identified shocks to government purchases by reporting the forecast error variance decomposition (FEVD) for output and its components in Table 3. Shocks to total government purchases contribute about 7 percent to GDP variance in the first four quarters, and the contribution declines to 2.8 percent by 12 quarters. In line with previous literature, fiscal shocks seem to explain a relatively small part of GDP fluctuations (see, for example, Ramey, 2016). Consistent with the intuition that shocks to total government purchases are an average of heterogeneous underlying shocks, some of its disaggregated components explain a higher portion of GDP variance (and some a lower portion). All together the identified

²⁴Baxter and King (1993) find output multipliers between 4 and 13 in the long run for public investment in a neoclassical model.

shocks for the components of government purchases seem to explain around a fifth of GDP variance.

Overall, our Large VAR uncovers multipliers that crucially depend on the component of government purchases. This helps in reconciling diverging results reported in the literature, using different components of government purchases. In particular, two stylised facts emerge: (1) consumption components appear to have short lived and relatively weak effects. State and local consumption stands out as providing a slow growing but sustained stimulus to output, personal consumption components and private investment; (2) investment components – with the exception of defense – have larger multipliers than consumption components hinting at a direct productive effect on economic activity.

6 Conclusions

The main contributions of this paper can be summarized as follows. First, we show that previously reported unstable results across samples and popular identifications are due to informational insufficiency of small VARs. In contrast, large information Bayesian VAR techniques yield multipliers and IRFs that are stable across samples and identifications, overcoming issues of fiscal foresight and non-fundamentality. This is a theoretically well grounded approach that is operationally feasible in many countries where reliable expectational series are not available. Second, we estimate fiscal multipliers for different components of government purchases at federal and state and local level, and

uncover significant heterogeneity in the responses of macroeconomic variables. While consumption components do not appear to stimulate the economy, investment components generally have output multipliers well above unity. These findings are of interest to the current policy debate. Our results also offer general empirical insights on how to employ large information techniques to capture the information flow received by economic agents, and to control for anticipation effects. These techniques can potentially be applied to the identification of other structural shocks, such as, for example, monetary policy, oil and technology shocks.

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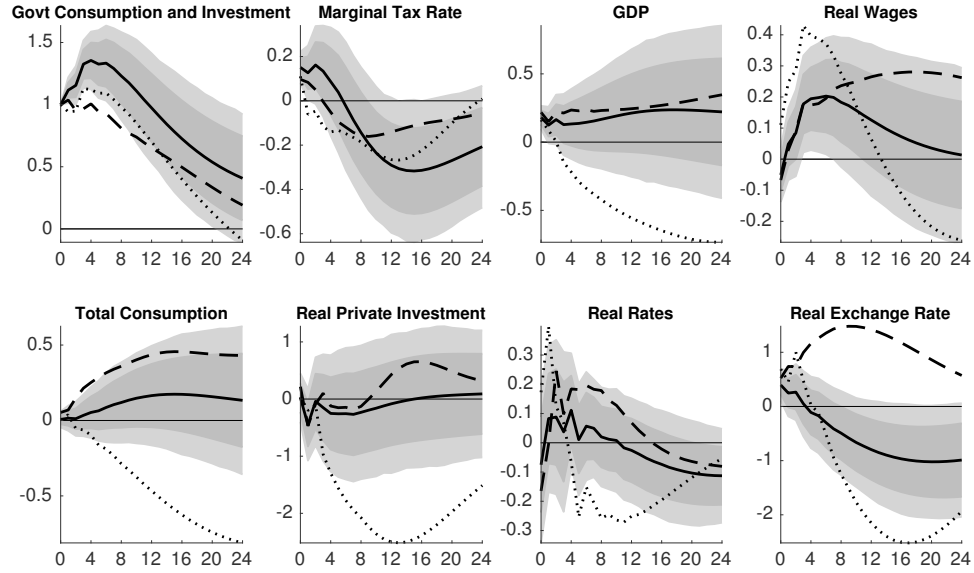


Figure 1: Fiscal Responses in Small SVAR. This figure plots the impulse response functions to a shock in aggregate government purchases (Govt Consumption and Investment) for the 1959Q1 to 2015Q4 period as solid lines with shaded posterior coverage intervals at the 0.68 and 0.9 level. Responses for subsample periods are plotted as dashed (1959Q1:1981Q4) and dotted lines (1982Q1:2015Q4) in each chart.

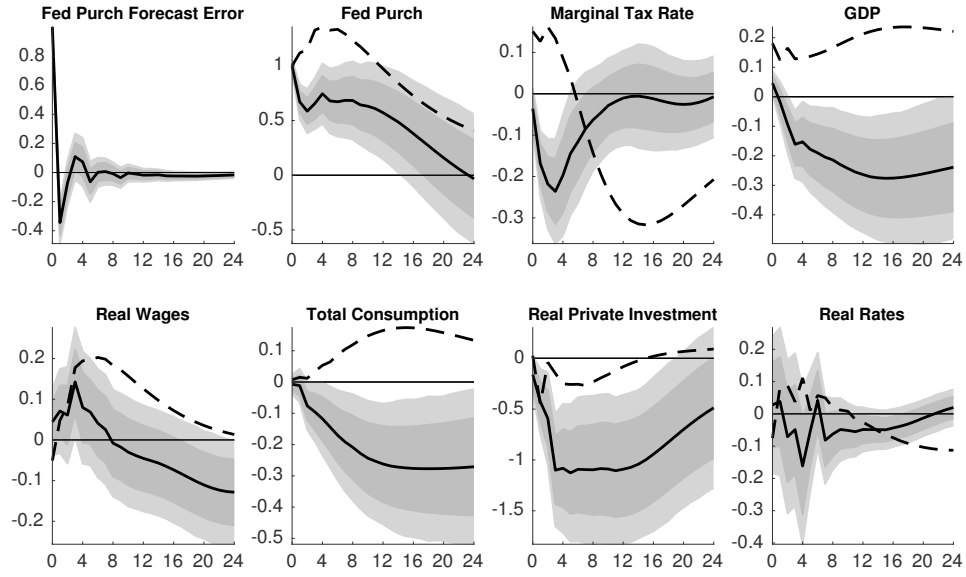
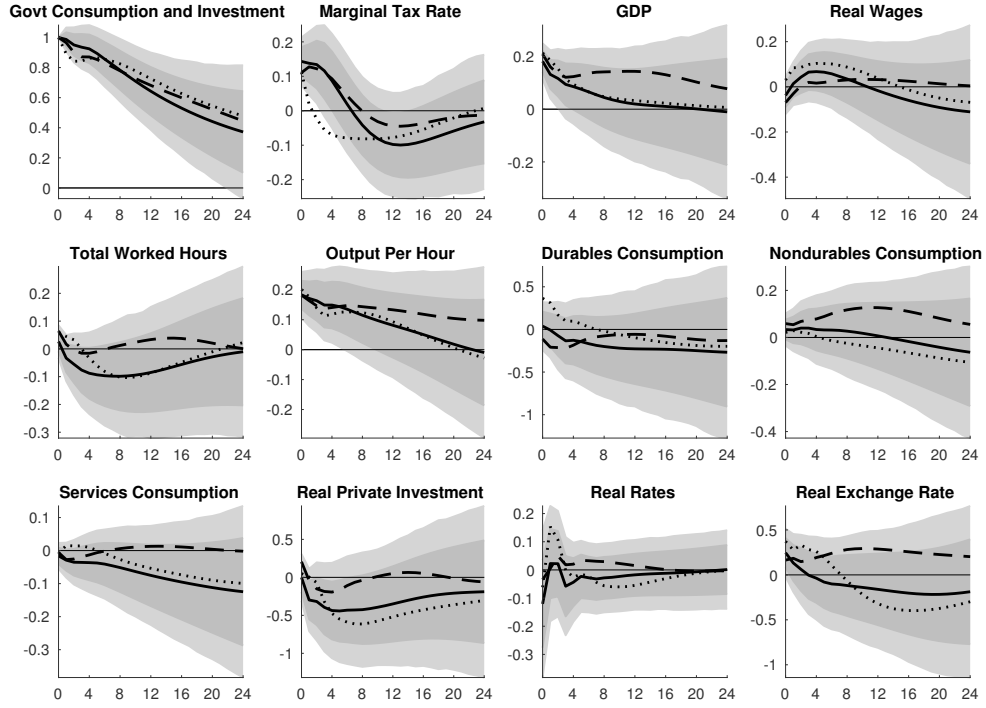
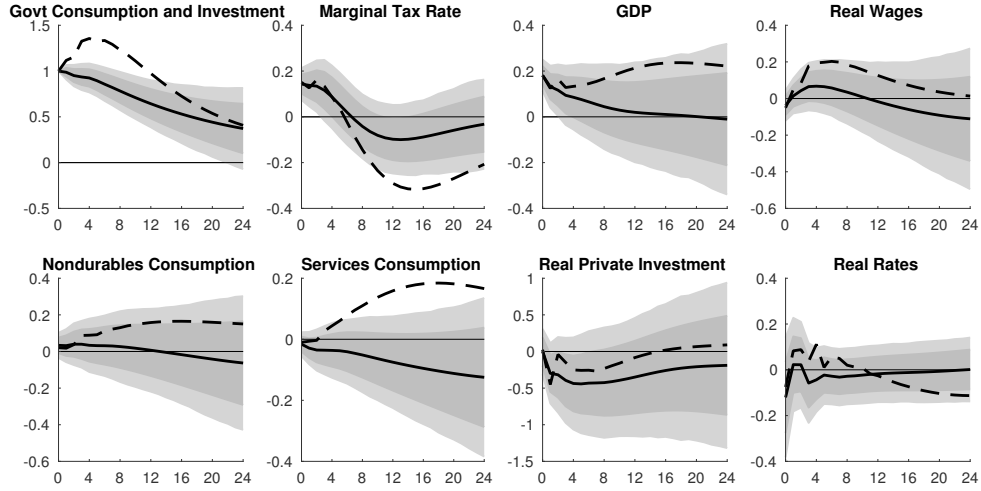


Figure 2: Fiscal Responses in Small EVAR. This figure plots the impulse response functions to a shock in SPF forecast errors of federal government purchases estimated for the 1982Q1 to 2015Q4 period as solid lines with shaded posterior coverage intervals at the 0.68 and 0.9 level. The impulse response functions to a shock in total government purchases using the Small SVAR for the period 1959Q1 to 2015Q4 are also plotted as dashed lines.



(a) Fiscal Responses in Large VAR for Subsamples.



(b) Fiscal Responses in Large VAR vs. Small VAR.

Figure 3: Fiscal Responses in Large VAR. Figure (a) plots the impulse response functions to a shock in aggregate government purchases for the 1959Q1 to 2015Q4 period as solid lines with shaded posterior coverage intervals at the 0.68 and 0.9 level. Responses for subsample periods are plotted as dashed (1959Q1:1981Q4) and dotted lines (1982Q1:2015Q4) in each chart. Figure (b) plots the Large VAR responses for the period 1959Q1 to 2015Q4 as a solid line with shaded posterior coverage intervals at the 0.68 and 0.9 level. The dashed line in each chart plots the response in the Small VAR for the same period.

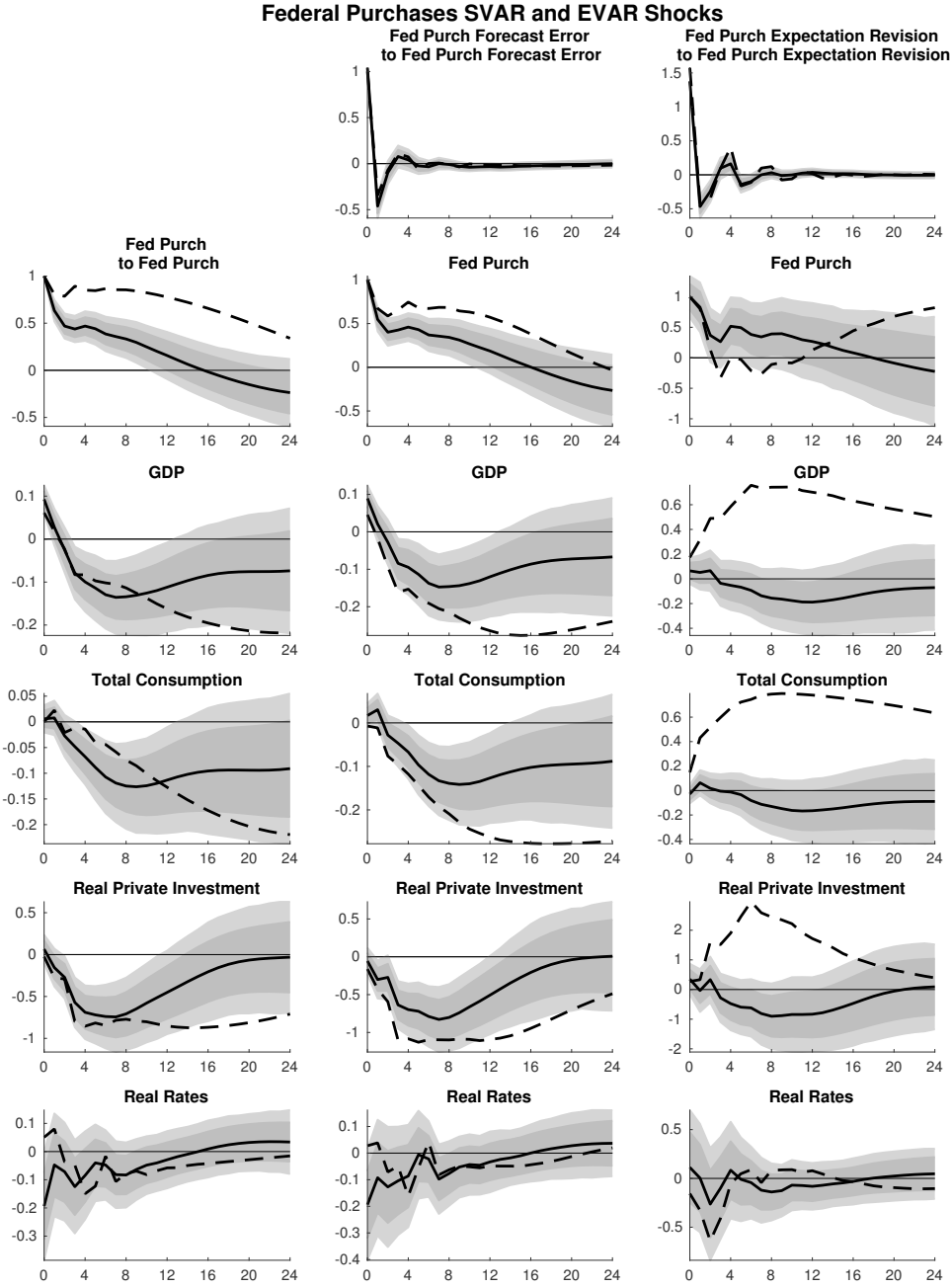


Figure 4: Fiscal Responses in Large EVAR (1982Q1:2015Q4). This figure presents the impulse response functions to a shock in federal government purchases and SPF forecasts of federal government purchases. The left, middle and right columns of plots depict the responses to a shock in federal purchases, federal purchases forecast error, and federal purchases expectation revision, respectively. Each chart shows the Large VAR response for the period 1982Q1 to 2015Q4 as a solid line with shaded posterior coverage intervals at the 0.68 and 0.9 level. The dashed line in each chart plots the response in the Small VAR for the same period.

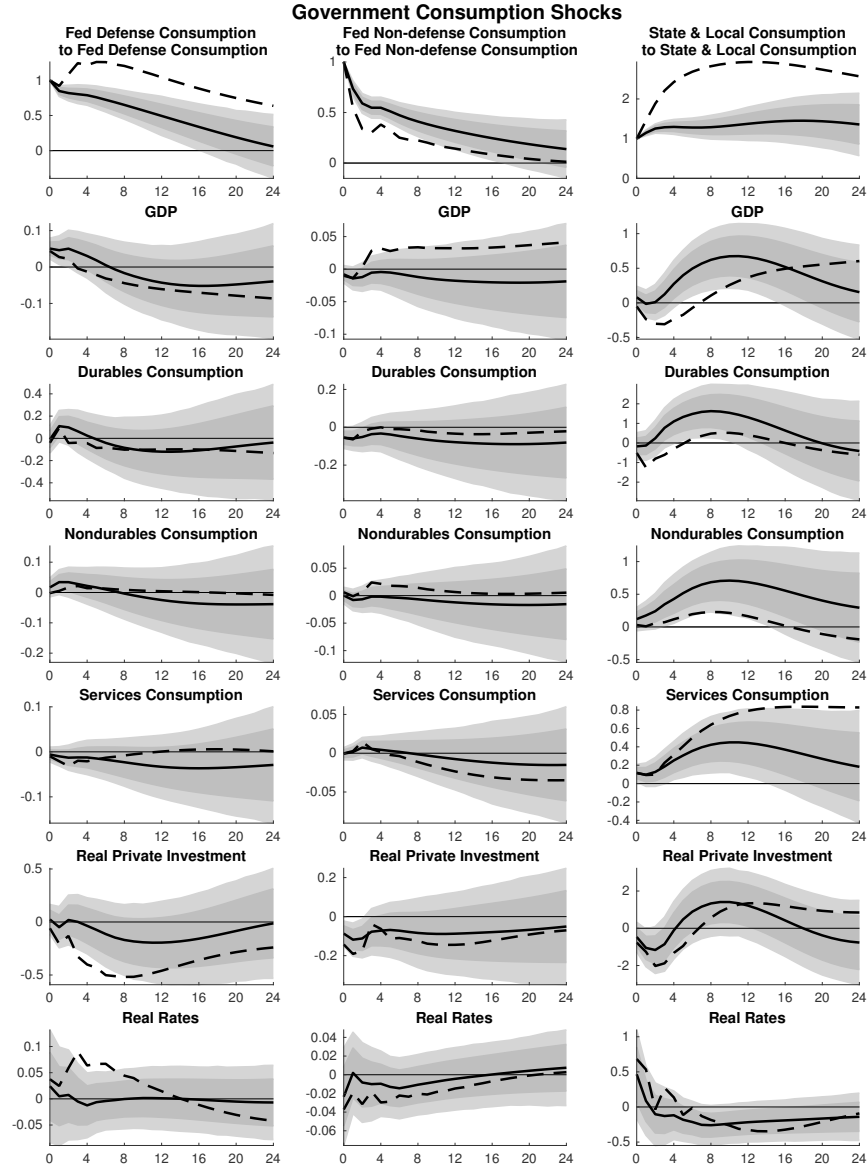


Figure 5: Fiscal Responses in Large VAR – Government Consumption Components (1959Q1:2015Q4). This figure presents the impulse response functions to a shock in a specified component of government consumption. The left, middle and right columns depict the responses to a shock in federal defense consumption, federal non-defense consumption, and state and local consumption, respectively. Each chart shows the Large VAR response for the period 1959Q1 to 2015Q4 as a solid line with shaded posterior coverage intervals at the 0.68 and 0.9 level. The dashed line in each chart plots the response in the Small VAR for the same period.

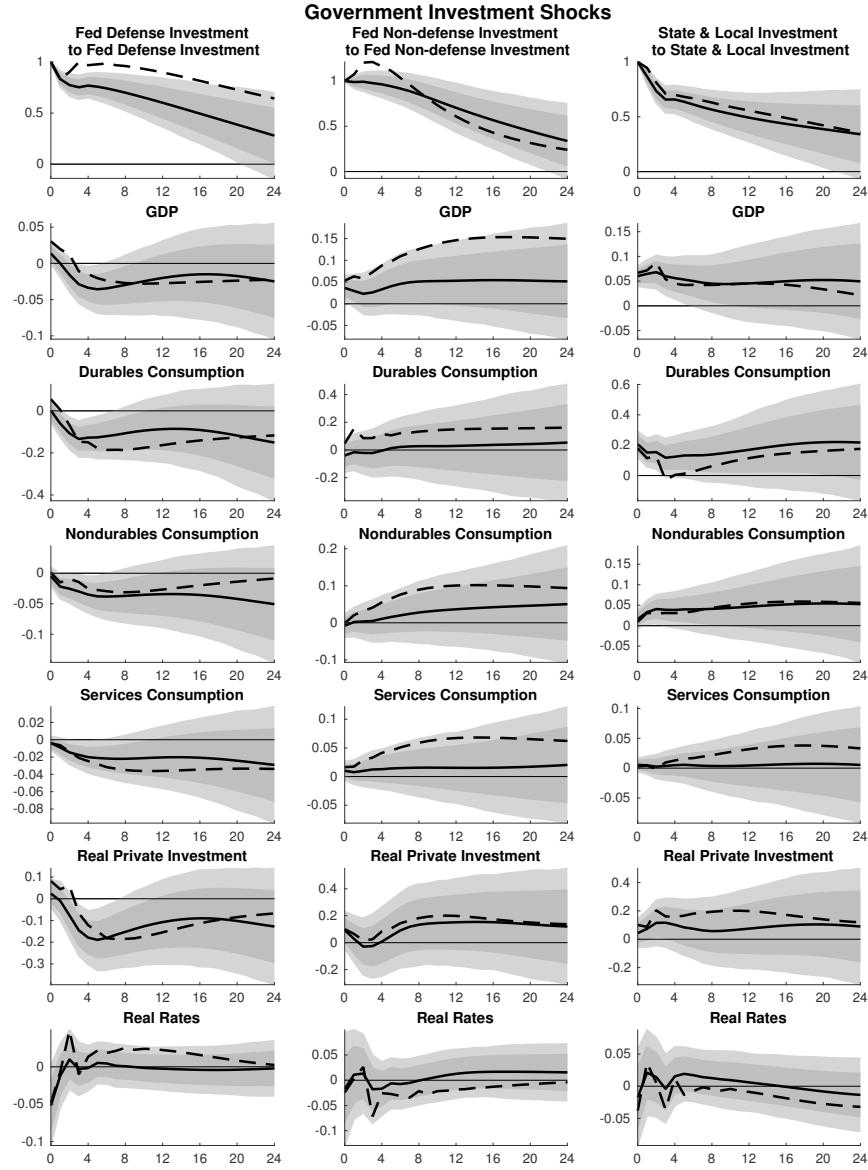


Figure 6: Fiscal Responses in Large VAR – Government Investment Components (1959Q1:2015Q4). This figure presents the impulse response functions to a shock in a specified component of government investment. The left, middle and right columns depict the responses to a shock in federal defense investment, federal non-defense investment, and state and local investment, respectively. Each chart shows the Large VAR response for the period 1959Q1 to 2015Q4 as a solid line with shaded posterior coverage intervals at the 0.68 and 0.9 level. The dashed line in each chart plots the response in the Small VAR for the same period.

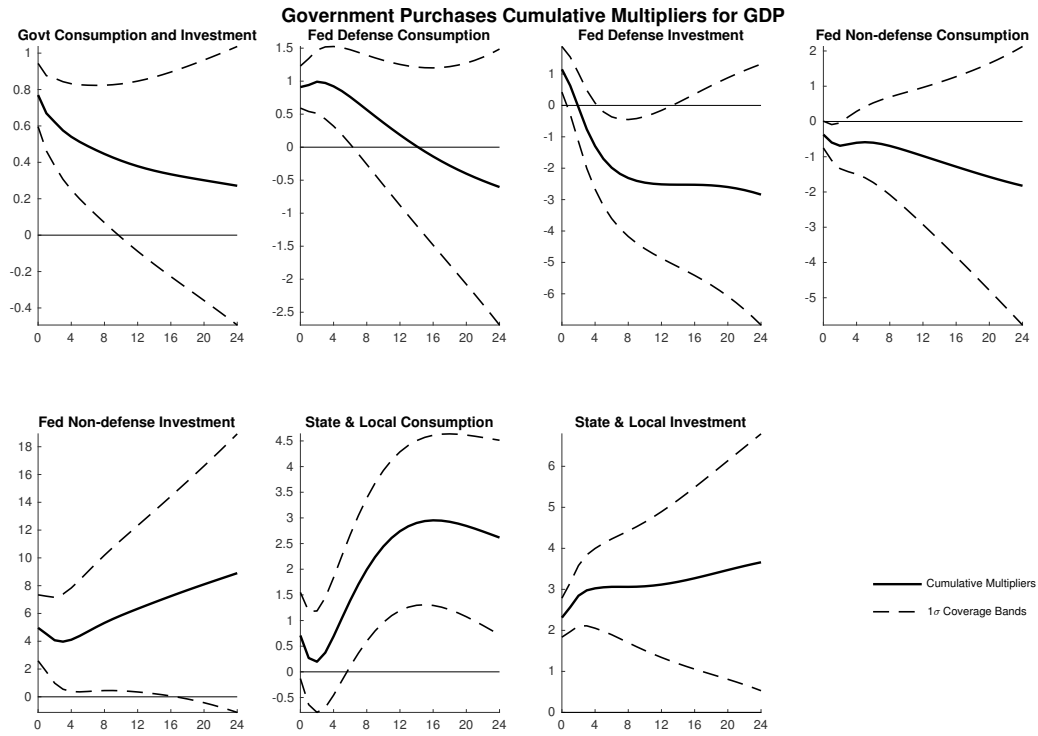


Figure 7: **Government Purchases Cumulative Multipliers for GDP.** This figure presents the ratio of the cumulative increase in the net present value of GDP and the cumulative increase in the net present value of the indicated component of government purchases.

Table 1: Granger Causality Tests. This table reports F-statistics and p-values for Granger causality tests. Four factors are extracted from a dataset with 136 macroeconomic variables and we test whether these factors Granger cause the identified shocks to government purchases and expectational proxies. Specifically, we regress each identified shock variable on four lags of the shock itself and four lags of the factor. We examine each of the factors separately, and test the null hypothesis that the coefficients on the four lags of each factor are not jointly significantly different from zero at conventional levels. The asterisks *, **, *** denote statistical significance at two-tailed 10 percent, 5 percent and 1 percent levels, respectively.

	Factor 1	<i>p-value</i>	Factor 2	<i>p-value</i>	Factor 3	<i>p-value</i>	Factor 4	<i>p-value</i>
Small SVAR (1959 – 2015)	1.48	(0.211)	1.37	(0.245)	0.28	(0.893)	1.86	(0.118)
<i>Defense Consumption</i>	0.61	(0.659)	0.53	(0.710)	0.19	(0.943)	0.69	(0.597)
<i>Defense Investment</i>	1.06	(0.376)	3.11**	(0.016)	0.40	(0.806)	1.14	(0.341)
<i>Non-defense Consumption</i>	0.31	(0.872)	1.05	(0.380)	0.88	(0.477)	1.01	(0.402)
<i>Non-defense Investment</i>	1.28	(0.279)	0.37	(0.833)	0.26	(0.902)	0.72	(0.577)
<i>State & Local Consumption</i>	0.63	(0.639)	2.27*	(0.063)	0.58	(0.677)	1.14	(0.338)
<i>State & Local Investment</i>	1.53	(0.193)	3.40**	(0.010)	2.31*	(0.059)	1.32	(0.265)
Small SVAR (1982 – 2015)	2.29*	(0.064)	0.04	(0.997)	1.03	(0.395)	0.93	(0.450)
Small SVAR (1959 – 1981)	0.18	(0.947)	0.92	(0.456)	0.86	(0.493)	0.85	(0.495)
Fed Purchases Forecast Error	4.73***	(0.001)	3.27**	(0.014)	1.52	(0.200)	0.92	(0.457)
<i>Small EVAR Shocks</i>	1.28	(0.281)	1.02	(0.400)	0.88	(0.475)	0.17	(0.953)
Fed Purchases Exp. Revision	1.44	(0.213)	2.37**	(0.044)	0.22	(0.953)	1.33	(0.257)
<i>Small EVAR Shocks</i>	0.03	(0.998)	1.13	(0.346)	1.12	(0.349)	0.59	(0.671)
S&L Purchases Forecast Error	3.96***	(0.005)	2.31*	(0.062)	0.67	(0.616)	3.77***	(0.006)
<i>Small EVAR Shocks</i>	0.62	(0.649)	0.45	(0.770)	1.41	(0.234)	0.62	(0.652)
S&L Purchases Exp. Revision	1.25	(0.294)	1.32	(0.265)	3.19**	(0.016)	0.51	(0.728)
<i>Small EVAR Shocks</i>	1.00	(0.413)	0.10	(0.983)	0.62	(0.652)	0.22	(0.925)
Ramey News Variable	0.57	(0.451)	0.17	(0.680)	2.94*	(0.088)	0.32	(0.570)

Table 2: **Multipliers for GDP, Consumption and Investment.** This table reports multipliers with standard errors in italics. Inv is Investment and Dur, ND, and Svs are durables, nondurables and services consumption, respectively. The asterisks *, **, *** denote statistical significance at 10 percent, 5 percent and 1 percent levels.

		GDP		Dur		ND		Svs		Inv	
On Impact	Total Govt. Purchases	0.77***	(0.17)	0.01	(0.04)	0.02	(0.03)	-0.03	(0.05)	0.00	(0.13)
	Defense Cons	0.91***	(0.32)	-0.01	(0.07)	0.05	(0.06)	-0.05	(0.08)	0.07	(0.24)
	Defense Inv	1.15	(0.74)	0.01	(0.16)	-0.06	(0.12)	-0.14	(0.17)	0.31	(0.52)
	Nondefense Cons	-0.37	(0.40)	-0.14	(0.09)	0.00	(0.07)	-0.01	(0.09)	-0.62**	(0.28)
	Nondefense Inv	4.97**	(2.31)	-0.29	(0.52)	-0.17	(0.41)	0.60	(0.57)	1.94	(1.66)
	State & Local Cons	0.71	(0.87)	-0.08	(0.19)	0.17	(0.15)	0.44*	(0.22)	-0.63	(0.67)
	State & Local Inv	2.31***	(0.47)	0.42***	(0.10)	0.10	(0.08)	0.09	(0.13)	0.25	(0.36)
After 4Q	Total Govt. Purchases	0.40	(0.34)	-0.03	(0.06)	0.03	(0.06)	-0.07	(0.09)	-0.26	(0.23)
	Defense Cons	0.73	(0.63)	0.06	(0.11)	0.08	(0.11)	-0.10	(0.17)	0.00	(0.43)
	Defense Inv	-2.43*	(1.36)	-0.60**	(0.24)	-0.41*	(0.22)	-0.65*	(0.36)	-1.88**	(0.93)
	Nondefense Cons	-0.25	(0.78)	-0.09	(0.13)	-0.01	(0.13)	0.11	(0.19)	-0.55	(0.53)
	Nondefense Inv	3.57	(4.35)	-0.16	(0.75)	0.11	(0.72)	0.74	(1.11)	-0.53	(2.98)
	State & Local Cons	1.09	(1.62)	0.36	(0.28)	0.50*	(0.27)	0.72*	(0.43)	-1.15	(1.13)
	State & Local Inv	2.30**	(0.90)	0.24	(0.15)	0.24	(0.16)	0.06	(0.24)	0.68	(0.63)
After 8Q	Total Govt. Purchases	0.23	(0.46)	-0.04	(0.08)	0.02	(0.08)	-0.09	(0.13)	-0.28	(0.28)
	Defense Cons	-0.12	(0.86)	-0.06	(0.15)	0.01	(0.15)	-0.16	(0.26)	-0.40	(0.52)
	Defense Inv	-2.72	(1.94)	-0.51	(0.33)	-0.52	(0.32)	-0.82	(0.57)	-2.14*	(1.21)
	Nondefense Cons	-0.45	(1.13)	-0.13	(0.19)	-0.04	(0.19)	0.00	(0.31)	-0.56	(0.71)
	Nondefense Inv	6.73	(5.92)	0.19	(1.01)	0.54	(1.01)	0.91	(1.73)	2.46	(3.52)
	State & Local Cons	5.02**	(2.18)	0.75**	(0.37)	0.93**	(0.37)	1.53**	(0.65)	1.57	(1.38)
	State & Local Inv	1.80	(1.27)	0.27	(0.21)	0.25	(0.22)	0.07	(0.38)	0.37	(0.79)
Cumulative 8Q Cumulative 4Q	Total Govt. Purchases	0.57**	(0.26)	-0.01	(0.05)	0.03	(0.04)	-0.06	(0.07)	-0.17	(0.19)
	Defense Cons	0.97*	(0.56)	0.07	(0.10)	0.10	(0.10)	-0.09	(0.14)	0.00	(0.39)
	Defense Inv	-0.78	(1.26)	-0.40*	(0.24)	-0.33	(0.21)	-0.50	(0.32)	-0.80	(0.88)
	Nondefense Cons	-0.65	(0.84)	-0.18	(0.15)	-0.04	(0.14)	0.10	(0.20)	-0.98*	(0.58)
	Nondefense Inv	3.96	(3.44)	-0.18	(0.63)	0.02	(0.57)	0.60	(0.84)	0.35	(2.41)
	State & Local Cons	0.38	(1.06)	0.07	(0.20)	0.27	(0.18)	0.43	(0.28)	-1.02	(0.76)
	State & Local Inv	2.98***	(0.85)	0.40**	(0.16)	0.25	(0.15)	0.09	(0.23)	0.63	(0.61)
	Total Govt. Purchases	0.46	(0.36)	-0.02	(0.06)	0.03	(0.06)	-0.07	(0.10)	-0.24	(0.24)
	Defense Cons	0.66	(0.79)	0.03	(0.14)	0.08	(0.13)	-0.13	(0.22)	-0.16	(0.51)
	Defense Inv	-2.22	(1.76)	-0.56*	(0.31)	-0.50*	(0.29)	-0.76	(0.48)	-1.87	(1.16)
	Nondefense Cons	-0.64	(1.32)	-0.19	(0.23)	-0.05	(0.22)	0.10	(0.33)	-1.01	(0.87)
	Nondefense Inv	5.05	(4.59)	-0.04	(0.80)	0.21	(0.77)	0.75	(1.22)	0.91	(3.00)
	State & Local Cons	1.74	(1.32)	0.30	(0.23)	0.45**	(0.22)	0.72**	(0.37)	-0.15	(0.90)
	State & Local Inv	3.07**	(1.27)	0.41*	(0.22)	0.31	(0.22)	0.10	(0.35)	0.68	(0.85)

Table 3: Variance Decomposition. This table reports the percentage variance in GDP, Durables Consumption, Nondurables Consumption, Services Consumption, and Real Private Fixed Investment that is explained by shocks to various variables for government purchases over horizons of 1, 4, 8 and 12 quarters. The different variables for government purchases are shown in the numbered columns and include (1) Total Government Purchases, and the following components of government purchases: (2) Defense Consumption, (3) Defense Investment, (4) Nondefense Consumption, (5) Nondefense Investment, (6) State & Local Consumption, and (7) State & Local Investment.

Horizon	(1)	(2)	(3)	(4)	(5)	(6)	(7)
GDP							
1	7.1	2.7	0.9	0.3	1.5	0.2	7.7
4	6.8	4.6	1.0	0.7	2.5	0.4	12.5
8	4.0	2.7	2.9	0.4	2.1	4.3	7.9
12	2.8	1.8	3.0	0.5	1.9	7.5	5.7
Durables Cons							
1	0.0	0.0	0.0	0.9	0.1	0.1	5.6
4	0.4	2.1	3.3	1.7	0.1	1.4	7.9
8	0.2	1.1	4.1	1.6	0.1	4.2	5.5
12	0.2	0.8	3.7	2.1	0.1	5.5	4.7
Nondurables Cons							
1	0.2	0.3	0.1	0.0	0.1	0.5	0.5
4	1.8	3.0	2.3	0.3	0.3	4.2	3.5
8	1.3	1.8	3.2	0.2	0.4	7.6	2.7
12	1.0	1.2	3.1	0.3	0.4	10.1	2.2
Services Cons							
1	0.2	0.1	0.2	0.0	0.4	1.4	0.2
4	0.1	0.0	3.6	0.0	0.8	2.9	0.7
8	0.2	0.0	4.4	0.1	0.8	5.9	0.6
12	0.4	0.2	4.4	0.3	0.7	7.9	0.4
Investment							
1	0.0	0.0	0.1	1.7	0.4	0.3	0.2
4	0.9	1.2	0.4	1.9	1.0	0.7	3.9
8	0.6	1.0	1.4	1.6	1.1	1.0	3.3
12	0.5	0.8	1.5	1.7	1.3	2.0	2.7