Measuring the Impact of Fiscal Policy in the Face of Anticipation: a Structural VAR Approach*

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Abstract

This paper examines the problem of estimating the impact of government spending shocks if some of the innovations to fiscal policy are anticipated. Anticipation effects can give rise to nonfundamental moving average representations of structural VAR estimates of the dynamic impact of fiscal shocks. However, theory is very precise about the source of nonfundamentalness and this leads us to propose an augmented fiscal SVAR estimator that is robust to the presence of anticipation effects. We derive the estimator, examine its properties in simulations, and apply it to U.S. data. We do not find evidence to support the view that the positive response of consumption to government spending shocks in the SVAR literature is due to misguided timing assumptions. Nevertheless, we also point out that the augmented SVAR estimator, while correcting for the possible presence of anticipation effects, comes at the cost of forcing one to introduce additional identifying assumptions.

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1 Introduction

Despite years of intensive research, the empirical literature on fiscal policy has yet to reach consensus on the macroeconomic impact of fiscal policy shocks. Disagreements concern central issues such as the size of output multipliers and the impact of government spending shocks on consumption and the real wage. Clearly, such level of disagreement constrains our ability to give simple guidelines for the operation of one of the most important stabilization policies.

A key empirical obstacle is the measurement of innovations to fiscal policy. One strand of the literature employs structural vector autoregressive (SVAR) methods and achieves identification based on the presence of decision lags or sign restrictions (see e.g. Blanchard and Perotti, 2002, Mountford and Uhlig, 2005, Galí, Lopez-Salido and Valles, 2007, or Perotti, 2007). This literature has derived moderate estimates of government spending output multipliers but, controversially, also finds that private consumption and real wages increase following an expansion of government purchases of goods and services. Another line of research identifies fiscal shocks using the narrative approach. This literature finds larger output multipliers but declines in private consumption and real wages following an expansionary government spending shock (see e.g. Ramey and Shapiro, 1998, Edelberg, Eichenbaum and Fisher, 1999, or Burnside, Eichenbaum and Fisher, 2004).

Recently, Ramey (2008) has highlighted that the timing assumptions implicit in the measurements of fiscal shocks may be responsible for the conflicting results in the literature. She shows that narrative account based datings of fiscal shocks have predictive power for SVAR estimates of fiscal shocks. One explanation for this finding is that fiscal innovations may often be anticipated in advance of their actual implementation. Such anticipation effects can arise due to the use of phased-in changes in fiscal instruments, the use of sunsets, pre-announcement of fiscal interventions during presidential speeches, and sustained changes in fiscal policy in response to events such as military conflicts. Ramey (2008) provides Monte Carlo evidence to support the view that timing matters. She estimates fiscal VARs on artificial data from a DSGE model in which government spending increases give rise to lower real wages and lower private consumption and finds that SVAR estimates produce upward biased responses of consumption and the real wage in the presence of government spending shocks that are anticipated.

Anticipation effects present serious challenges to empirical research. SVAR based methods may not only mismeasure the timing of shocks, but their moving average (MA) representation may have nonfundamental roots (roots inside the unit circle), see Leeper, Walker and Yang (2008). In this case, measured fiscal spending shocks are a mix of past and future innovations to spending, giving rise to potentially highly misleading estimates of impulse response functions, see also Hansen and Sargent (1991) and Lippi and Reichlin (1993, 1994). On the other hand, if a good narrative account of shocks is available, econometricians may control directly for the announcement of future fiscal innovations. Indeed, such an approach has been used in a number of microeconometric studies of the consumption response to pre-announced tax changes, see e.g. Heim (2007), Parker (1999), and Souleles (1999, 2002), as well as in macroeconomic studies of tax changes, see e.g. Poterba (1988) and Mertens and Ravn (2009). However, good narrative account datasets are hard to come by and may not be sufficiently rich to accurately estimate the effects of both anticipated and unanticipated changes in fiscal policy. Alternatively, maximum likelihood estimators of DSGE models can be applied, see e.g. Kriwoluzky (2009), for an application to government spending, but such estimators may be very sensitive to specific modeling assumptions. Moreover, some structural estimation techniques suffer from the same nonfundamentalness problems as SVAR estimators.

We investigate whether SVAR estimators can be adapted to environments where anticipation effects are relevant and show that under certain assumptions this is indeed the case. This derives from the exact manner in which anticipation effects show up in the MA representation of time series generated by many DSGE models. The augmented SVAR estimator combines insights from economic theory with econometric results in Lippi and Reichlin (1993, 1994). These authors analyze how nonfundamental impulse responses can be computed by using Blaschke matrices, which essentially "flip" the nonfundamental roots. Linear rational expectations models have strong predictions for how news shocks map into MA representations that are not invertible in the past. The structure induced by news shocks involves a key parameter that we, following Ljungqvist and Sargent (2004), refer to as the anticipation rate. The anticipation rate measures the rate at which rational forward looking agents discount future innovations, and it is the key input into the Blaschke matrix that allows the econometrician to trace out correct impulse responses to shocks. Our methodology to derive estimates for unanticipated and anticipated fiscal spending shocks, however, comes at the cost of additional identification restrictions which are needed to disentangle anticipated fiscal shocks from other structural shocks. These are required even if the unanticipated fiscal shock is the only shock of interest. We achieve this by assuming that the long run impact of fiscal innovations does not depend on whether they were anticipated or not. For that reason we focus on permanent spending shocks and adopt a VECM framework. In short, our estimation strategy combines standard short run identifying assumptions with a long run identifying assumption and with structural assumptions regarding the Blaschke matrix.

We study the performance of our estimation technique, referred to as VECM-BM, and the standard fiscal VECM in Monte Carlo experiments using data generated by a DSGE model with both anticipated and unanticipated government spending shocks. Our analysis suggest that ignoring anticipated spending shocks becomes problematic for the standard VECM when anticipation rates are low and when anticipated shocks explain a relatively large share of the exogenous shocks to government spending. If one is interested in estimating the response to anticipated changes or low anticipation rates and significant anticipated shocks are a concern, the VECM-BM estimator provides a better approach. We argue it is difficult to construct realistic business cycle models with low anticipation rates. The reliability of existing fiscal VAR or VECM results, which aims at estimating the response of unanticipated fiscal shocks, in practice might therefore depend primarily on whether anticipated shocks explain most of the exogenous movements in government spending or not.

Lastly, we apply our analysis to U.S. quarterly data on government spending, output, and consumption. The main result that we uncover in the data is that, regardless of the anticipation rate and the implementation lag, output and consumption rise in response to an unanticipated permanent increase in government spending. Moreover, we also find an increase in private consumption after the announcement and implementation of an anticipated increase in government spending, a result that appears very challenging for economic theory.

2 Theory

This section studies the impact of anticipation effects in a dynamic stochastic general equilibrium framework. We show that the impact of anticipated government spending shocks follows very special dynamics that introduce certain restrictions on the dynamics of a VAR representation of observable variables. We derive these results in a very specific setting of a neoclassical real business cycle model, but key insights carry over to more general settings. In particular, while we study a neoclassical model in which increases in government spending crowds out private consumption, introducing features that overturn this result does not affect the key insights that we are interested in.[1]

[1] There are alternative mechanisms that can bring about a rise in private sector consumption following an increase in government spending. Galì, López-Salido and Vallés (2006) study a model with rule-of-thumb consumers, sticky prices, and debt financing that is consitent with an increase in private consumption after a temporary rise in government spending. Ravn, Schmitt-Grohe and Uribe (2006) instead propose a model with countercyclical markups due to deep habits. In this model, persistent increases in government spending leads to lower markups and therefore higher real wages and potentially higher private sector consumption. Corsetti, Meier and Mueller (2009) derive a positive consumption response in a new-keynesian setting when

2 .1 Anticipation in a Neoclassical Model

Consider an economy that is inhabited by a representative infinitely-lived household with rational expectations that supplies labor and capital services to firms. The household spends its after tax income on purchasing a final good, which it either consumes or invests. A representative competitive firm produces the final good by combining capital and labor services. There is a government in the economy that purchases goods and taxes the household sector. Government spending is modeled as an exogenous stochastic process and we assume that government spending is financed exclusively by lump-sum taxes. There are two types of exogenous innovations to government spending: Surprise innovations and anticipated innovations. Anticipated changes in government spending enter the information sets of the agents in the economy ahead of any impact on government spending. Since agents are forward looking, they will adjust their plans once new information arrives, and news about future changes in government spending therefore gives rise to anticipation effects.

We assume that preferences are given by:

$$V_0 = E_0 \sum_{t=0}^{\infty} \beta^t U(C_t, N_t) \tag{1}$$

$$U(C_t, N_t) = \ln C_t + \ln(1 - \psi N_t^{\theta}) \tag{2}$$

where E_0 denotes the mathematical expectations operator conditional on all information available at date 0, $0 < \beta < 1$ is the subjective discount factor, $\psi > 0$ is a preference weight, N_t denotes labor supply and $\theta > 0$ is a parameter that determines the labor supply elasticity. The household maximizes utility subject to a sequence of budget constraints:

$$C_t + I_t = r_t K_t + w_t N_t - TR_t \tag{3}$$

government spending shocks are associated with strong future spending reversals.

where I_t denotes expenditure on investment goods, r_t is the capital rental rate, K_t is the household's stock of capital, w_t is the real wage, and TR_t denotes lump-sun taxes. The capital accumulation equation is given by:

$$K_{t+1} = (1 - \delta) K_t + I_t \tag{4}$$

where $0 \leq \delta \leq 1$ is the depreciation rate. The firm's production function is given as:

$$Y_t = K_t^{\alpha} (X_t N_t)^{1-\alpha} \tag{5}$$

where Y_t denotes output of the final good, and $0 \leq \alpha < 1$ is the capital share in income and X_t denotes labor augmenting technology which evolves according to

$$\begin{aligned} \ln(X_t/X_{t-1}) &= x_t \\ \mu_x(L)x_t &= \mu_x(1)\gamma + \sigma_x e_t^x \end{aligned} \tag{6}$$

where where $\mu_x(L)$ is a stable polynomial in the lag operator L defined by $L^s x_t = x_{t-s}$, $\gamma \geq 0$ is the economy's average growth rate and e_t^x is a unit variance white noise random process and $\sigma_x \geq 0$.

The government spends G_t on purchases of goods, and finances its expenditure by lump-sum taxes. The government budget constraint is given as:

$$G_t = TR_t \tag{7}$$

The process for government spending is given as:

$$\mu_g(L) \ln (G_t/X_{t-1}) = \mu_g(1) \ln(\bar{g}) + \sigma_g e_{0,t}^g + \sigma_g \lambda e_{q,t-q}^g \tag{8}$$

where $\mu_g(L)$ is a polynomial in L and $\bar{g} > 0$. We allow for the possibility that $\mu_g(L)$ contains a unit root. At date t two shocks enter agents' information sets, $e_{0,t}$ and $e_{q,t}$. The former of these shocks denotes surprise government spending shocks that affect the level of government spending immediately. $e_{q,t}^g$ instead denotes anticipated government spending shocks that do not impact government spending until period $t+q$. This implies that the agents' information sets includes the vector $e_t^g = \left[e_{0,t}^g, e_{q,t-q}^g, e_{q,t-q+1}^g, \ldots, e_{q,t}^g\right]$ which contains announced but not yet implemented changes in government spending. We assume that $e_{0,t}^g$ and $e_{q,t}^g$ are unit variance white noise processes and $\sigma_g \geq 0$. The parameter $\lambda \geq 0$ parametrizes the relative standard deviation of the anticipated and surprise innovations to the government spending process. The information structure assumed in (8) can easily be extended to the case where a vector of news shocks of anticipation horizons from 1 to q periods are realized every period. This is the formulation of e.g. Christiano, Ilut, Motto and Rostagno (2008) and Schmitt-Grohe and Uribe (2009) in their estimation of the impact of technology news shocks. Here we focus on the simpler information structure with a single news shock.

The equilibrium conditions are described by the following system of equations

$$-U_{N,t} = U_{C,t}\left(1-\alpha\right)Y_t/N_t \tag{9a}$$

$$U_{C,t} = \beta E_t\left[U_{C,t+1}\left(1-\delta+\alpha Y_{t+1}/K_{t+1}\right)\right] \tag{9b}$$

$$Y_t = K_{t+1} - (1-\delta)K_t + C_t + G_t \tag{9c}$$

where $U_{C,t} = C_t^{-1}$ and $U_{N,t} = \left(1-\psi N_t^{\theta}\right)^{-1}\theta\psi N_t^{\theta-1}$, together with the production function in (5) and the government spending process in (8). The first condition requires the intratemporal marginal rate of substitution between consumption and labor to equal the marginal product of labor. The second condition sets the intertemporal marginal rate of substitution between current and future consumption equal to the gross real return on capital. The final condition is the economy's resource constraint.

The solution to a log-linearized approximation of the model in terms of detrended variables can be formulated as:

$$k_{t+1} = \phi_{kk}k_t + \phi_{kx}x_t + \phi_{kg}g_t + \sum_{i=0}^{q-1}\phi_{k,q-i}e_{q,t-i} \tag{10a}$$

$$z_t = \phi_{zk}k_t + \phi_{zx}x_t + \phi_{zg}g_t + \sum_{i=0}^{q-1}\phi_{z,q-i}e_{q,t-i}, \tag{10b}$$

where we use the notation that $k_{t+1} = \ln\left(K_{t+1}/X_t/\bar{k}\right)$, $z_t = \ln\left(Z_t/X_t/\bar{z}\right)$ ($\bar{k}$ and $\bar{z}$ denote the values of K_{t+1}/X_t and Z_t/X_t respectively at the point of approximation) and $z_t = c_t, y_t, i_t, n_t$ or any linear combination of these variables. Our point of approximation is the deterministic steady state at a given value of $\bar{g}$. The coefficient ϕ_{kk} is the stable root of the characteristic polynomial:

$$\rho^2 - (\eta_1 + \eta_4)\rho + (\eta_1\eta_4 - \eta_2\eta_3) = 0 \tag{11}$$

where the parameters η_1 to η_4 are complicated functions of the structural parameters, see Appendix 1. In a saddle path solution, this quadratic equation has two real roots, $\mid \rho_1 \mid < 1$ and $\mid \rho_2 \mid > 1$. The parameter ϕ_{kk} is the first of these roots. The coefficients relating to the impact of anticipated government spending shocks can be expressed as:

$$\phi_{z,q-i} = \omega^{q-1-i}\phi_{z,1} \quad \text{for } i = 0, \ldots, q-1$$

$$\phi_{k,q-i} = \omega^{q-1-i}\phi_{k,1} \quad \text{for } i = 0, \ldots, q-1$$

It is straightforward to show that the discounting factor ω is given as:

$$\omega = \frac{1}{\eta_4 + \eta_1 - \rho_1}$$

By inserting this in (11), it is easy to verify that this parameter is precisely the inverse of the unstable root of the polynomial in z, see also Ljungqvist and Sargent (2004, chapter 11). Thus:

$$\omega = \rho_2^{-1}$$

In a saddle path solution, the unstable root necessarily exceeds unity in absolute value. Therefore it follows that $| \omega |< 1$ such that news about government spending is discounted at a constant rate determined by the inverse of the unstable root of the characteristic polynomial of the rational expectations system. ω can therefore be viewed as the "anticipation rate" that measures the extent to which news about future changes in government spending affects the economy prior to implementation.

The result of constant discounting by the inverse unstable root generalizes to much more complicated settings. As long as there is a single unstable root in the saddle-path stable dynamic system, the result holds. Thus, introducing more control variables, alternative production or utility functions, more exogenous state variables, etc. will have no consequences for the direct relationship between ρ_1, ρ_2 and the anticipation rate ω. When there is more than one distinct unstable root in the dynamic system, the result generalizes, but the mapping between the anticipation rate and the roots of the system is more complicated. However, even in these cases, one can show that news about future government spending innovations is discounted at a constant rate.[2]

2 .2 Quantifying the Anticipation Rate

Obtaining a plausible value of the anticipation rate will be key to our empirical methodology. Before proceeding, we therefore examine how government spending shocks impact on the economy in the neoclassical model and assess the likely size of the anticipation rate. For this purpose we calibrate the model above assuming that one period corresponds to a quar-

[2] A formal proof is available from the authors.

ter. We set the quarterly real interest rate equal to one percent and the average quarterly growth rate of the economy to 0.4%. β is determined as the inverse of the (gross) quarterly interest rate. We assume that agents work 30 percent of the time endowment, an estimate that is close to the average amount of time devoted to labor market activities in the U.S. according to time-use surveys. We set the curvature parameter θ equal to one. These values imply a Frisch labor supply elasticity of 1.18. The depreciation rate is assumed to equal 2.5 percent per quarter and the labor share of income equal to 2/3. We assume that the steady state government spending share is equal to 20 percent. Finally, we assume an AR(1) process for government spending with persistence of either 0.95, or 1, such that in the latter case government spending shocks are permanent as in Baxter and King (1993).

Figure 1 illustrates the impact of a surprise government spending shock for the transitory government spending shock together with the impact of an anticipated government spending shock when the anticipation horizon is equal to 8 quarters. Figure 2 reports the corresponding results for a permanent government spending shock. In both cases we show the impact of a one percent increase in government spending. A surprise temporary increase in government spending brings about a persistent increase in hours worked and in output, while consumption and investment fall persistently. The drop in consumption and the increase in hours worked are due to the decline in private sector wealth and an increase in the real interest rate. When the change in government spending is anticipated, output and hours worked increase when the news about future spending is received, while consumption drops immediately (see also Ramey, 2008).

The impact of a permanent increase in government spending is very similar to the impact from a temporary increase in government spending with the exception of investment. Investment increases in response to an implemented permanent increase in government spending, while it falls in response to an implemented temporary increase in government spending. This difference is due to a larger wealth effect on hours worked following a permanent change in government spending, which gives rise to an increase in the demand for capital. However, regardless of the persistence of the change in government spending, private sector investment increases during the pre-implementation period in response to an anticipated increase in government spending.

In the benchmark calibration the anticipation rate is $\omega = 0.95$, which is independent of the properties of the stochastic processes for government spending or technology. The value of this parameter is very robust to realistic changes in the calibration. Consider the more general momentary utility function:

$$U(C_t, N_t) = \frac{C_t^{1-\sigma}\left(1 - \psi N_t^{\theta}\right)^{1-\sigma} - 1}{1-\sigma}$$

Figure 3 shows the anticipation rate when we vary α, β , θ and σ. These parameters determine the capital income share, the steady state real interest rate, the Frisch labor supply elasticity and the intertemporal elasticity of substitution. The anticipation rate is hardly affected by changes in α, σ and the Frisch elasticity, taking on values above 90 percent regardless of the exact calibration of any of these parameters. Variations in the discount factor have more dramatic effects, and when agents are very impatient the anticipation rate basically goes to 0. However, for realistic values of the steady state real interest rate, the anticipation rate remains well above 90 percent. We experimented with different utility functions and other model features, such as additively separable preferences, habit persistence, capital adjustment costs and variable capacity utilization, and found a value of the anticipation rate between 0.90 and 1 to be robust across models for realistic parameter values.

2 .3 Time Series Implications of Anticipation

We now consider the consequences of anticipation effects for VAR based estimates of the impact of government spending shocks. The analysis is analogous to Leeper, Walker and Yang (2008) who study the effects of foresight about anticipated tax changes. For simplicity, we assume that there are no technology shocks ($\sigma_x = 0$) and focus attention on a bivariate time series representation of a vector consisting of a control variable z_t, and government spending g_t. We also assume transitory government spending shocks, such that $\mu_g(L)$ is a stable polynomial. The insights that we bring out, however, extend to larger dimensional VARs (as long as more structural shocks are included in the model), to assuming that information can arrive with any anticipation horizon between 1 and q periods, and to permanent shocks in the context of a VECM framework.[3]

From equations (8) and (10b), the process for the vector of observables can be formulated as:

$$\begin{bmatrix} g_t \\ z_t \end{bmatrix} = \begin{bmatrix} 0 & 1-\mu_g(L) \\ \phi_{zk} & \phi_{zg} \end{bmatrix} \begin{bmatrix} k_t \\ g_t \end{bmatrix} + \begin{bmatrix} 1 & L^q \\ 0 & \phi_{z,1}\Theta(L) \end{bmatrix} \Sigma_e e_t \tag{12}$$

where

$$\begin{aligned} \Theta(L) &= \omega^{q-1} + \omega^{q-2}L + \cdots + \omega L^{q-2} + L^{q-1} \\ \Sigma_e &= \sigma_g \begin{bmatrix} 1 & 0 \\ 0 & \lambda \end{bmatrix} \quad , \quad e_t = \begin{bmatrix} e^g_{0,t} \\ e^g_{q,t} \end{bmatrix} \end{aligned}$$

[3]Stochastic singularity of the VAR, however, cannot generally be addressed by including more news shocks in the model.

Substituting in the solution for capital in (10a), the MA representation of the variables is

$$
\begin{aligned}
\begin{bmatrix} g_t \\ z_t \end{bmatrix} &= \Upsilon(L)\,\Sigma_e e_t \qquad (13)\\
&= \mu_g(L)^{-1} \begin{bmatrix} 1 & L^q \\ \frac{\phi_{zk}\phi_{kg}L}{(1-\rho_1 L)} + \phi_{zg} & \left(\frac{\phi_{zk}\phi_{k,1}}{1-\rho_1 L}L + \phi_{z,1}\right)\mu_g(L)\Theta(L) + \left(\frac{\phi_{zk}\phi_{kg}}{1-\rho_1 L}L + \phi_{zg}\right)L^q \end{bmatrix} \Sigma_e e_t
\end{aligned}
$$

A necessary condition for the MA representation to be invertible in the past is that the roots of the determinant of $\Upsilon(L)$ has roots that are all outside the unit circle. The determinant of this matrix is given as:

$$
|\Upsilon(L)| = \left(\frac{\phi_{zk}\phi_{k,1}}{1-\rho_1 L}L + \phi_{z,1}\right)\mu_g(L)\Theta(L) \qquad (14)
$$

The polynomial $\Theta(L)$ is a cyclotomic polynomial and its roots will be roots of $|\Upsilon(L)|$. When q is even, it follows directly that one of its roots is equal to $-\omega$ which is inside the unit circle since $\omega \in (0,1)$. In the general case, the roots are given as ω times the $q-1$ roots of unity, representing a circle with radius $\mid \omega \mid$ in the complex plane. Given that $\mid \omega \mid < 1$, it follows that when $q > 1$, the MA representation is nonfundamental such that there exists no VAR representation in which the residuals are linear combinations of contemporaneous structural innovations (see also Hansen and Sargent, 1991, and Leeper, Walker and Yang, 2008).[4] As a result of anticipation of future government spending changes, inference about the effect of any type of government spending innovations is problematic in the standard VAR framework.

[4]Notice that, in contrast to Lippi and Reichlin (1993), the nonfundamentalness arises endogenously from the agents' choices made in response to anticipated government spending changes rather than from an exogenous stochastic process that is noninvertible in the past.

3 An Augmented Fiscal SVAR estimator

The problem of nonfundamentalness implies that applying conventional identification restrictions in VARs results in impulse responses to innovations that are linear combinations of the entire history of anticipated and unanticipated government spending shocks. These responses obviously no longer have any useful structural interpretation. As pointed out by Lippi and Reichlin (1993, 1994), one can, however, still derive estimates of the nonfundamental impulse responses. These impulse responses exploit that fact that the roots of the MA representation can be flipped using a Blaschke matrix, see Lippi and Reichlin (1993, 1994). In general, there are a very large number of possible nonfundamental responses that can be derived. However, given the theoretical result of constant discounting of news, we can be very explicit about the appropriate Blaschke matrix in the presence of anticipated fiscal spending shocks. Consider

$$\begin{bmatrix} g_t \\ z_t \end{bmatrix} = \Upsilon(L)\,\Sigma_e B(L) B(L)^{-1} e_t \tag{15}$$

where $B(L)$ is a Blaschke matrix such that $\mid \Upsilon(L)\, B(L) \mid = 0$ has all roots outside the unit circle, and

$$u_t = B(L)^{-1} e_t \tag{16}$$

is orthonormal vector white noise. In our setup, this is achieved by

$$
\begin{aligned}
B(L) &= KM_1(L)M_2(L)\dots M_{q-1}(L) \\
M_i(L) &= \begin{bmatrix} 1 & 0 \\ 0 & \frac{1-\omega_i L}{L-\bar{\omega}_i} \end{bmatrix} \\
K &= \frac{1}{\sqrt{1+(\lambda\omega^q)^2}} \begin{bmatrix} 1 & -\lambda\omega^q \\ \lambda\omega^q & 1 \end{bmatrix}
\end{aligned}
\tag{17}
$$

where ω_i, $i = 1, ..., q-1$ are the roots of the polynomial $\Theta(L)$ and $\bar{\omega}_i$ denotes the complex conjugate.

Now suppose that the econometrician assumes the following two-dimensional VAR for the time series $v_t = [g_t, z_t]'$:

$$A(L)v_t = D\varepsilon_t \tag{18}$$

where $A(L) = I - A_1L - A_2L^2 + \dots$ and D is the contemporaneous impact matrix associated with the orthonormal white noise innovations ε_t. Comparing to the MA representation in (13), it will be the case that

$$A(L) = \Upsilon(0)\Sigma_e B(0)(\Upsilon(L)B(L))^{-1} \tag{19a}$$

$$D = \Upsilon(0)\Sigma_e B(0) \tag{19b}$$

$$\varepsilon_t = u_t = B(L)^{-1}e_t \tag{19c}$$

The matrix $\Upsilon(0)\Sigma_e$ is the contemporaneous impact matrix associated with the structural shocks. In the fiscal SVAR, with government spending ordered first in the VAR, the typical restriction on $\Upsilon(0)$ is

$$\Upsilon(0) = \begin{bmatrix} 1 & 0 \\ \upsilon_{21} & \upsilon_{22} \end{bmatrix}$$

This specification of $\Upsilon(0)$ implies that government spending is predetermined relative to the other variables in the VAR. It can be verified from (13) that this restriction holds in our theoretical example. However, this identification restriction alone is not sufficient to identify the response to an unanticipated shock to government spending. Doing so also requires knowledge of the Blaschke matrix $B(L)$, which depends only on three model parameters: the anticipation horizon q, the relative standard deviation of surprise and anticipated shocks λ and the anticipation rate ω.

Our empirical methodology is based on obtaining values for these parameters, constructing the Blaschke matrix and tracing out the impulse responses according to (19a)-(19c).[5] Implementing this strategy requires additional assumptions: first, one needs to make assumptions regarding the anticipation horizon, q, and the anticipation rate, ω. Second, in VARs of dimensions larger than two, one needs to introduce an additional identifying assumption in order to discriminate between anticipated government spending shocks and other structural shocks. This additional assumption is necessary even if one is only interested in estimating the impact of the unanticipated shock. This is because the appropriate column of Υ_0 and an estimate of the relative standard deviation λ are required in the computation of the response to the unanticipated shock.

A natural way of introducing the assumptions to discriminate between anticipated government spending shocks and other structural shocks is to focus on permanent changes in government spending. The impact of changes in government spending at the infinite forecast horizon can reasonably be assumed to be independent of whether they were anticipated or

[5] Although impulse responses can uncovered, it is not possible to obtain the realizations of the shocks from (19c).

not. As is evident from (14), if $\mu_g(L)$ contains a unit root, so will the determinant of the MA polynomial. Therefore, invoking the long run identifying assumption requires that we reparametrize the VAR as a vector error correction model (VECM). The fact that anticipation effects force us to look at permanent government spending shocks implies a significant cost in terms of generality. Unfortunately, it is not clear that there are any readily available short run restrictions that achieve the same objective.

There are two fundamentally different ways of dealing with the anticipation rate. One approach is to calibrate this parameter on the basis of economic theory. Above we argued that theory leads one to select relatively high values of this parameter. Alternatively, one can estimate the anticipation rate by exploiting the fact that the nonfundamental roots should correspond to the radius of a circle in the complex plane of the roots of the determinant of $A(L)$. Practical problems in taking that route are that there might be more than one empirical circle of roots or that the radius is poorly estimated. However, in principle, it is feasible to derive an estimate of the anticipation rate from the empirical VAR. The assumptions regarding q, the implementation lag, are easier to deal with. Essentially, one can experiment with alternative values of this parameter, examining the impact of anticipation effects for alternative implementation lags.

4 The Properties of the Estimator

In this section, we discuss in detail how we operationalize our estimator of fiscal shocks and examine its properties in small samples on the basis of Monte Carlo simulations of the model described above. The point of departure is the following VECM model

$$\Delta v_t = \Pi v_{t-1} + C(L)\Delta v_{t-1} + D\epsilon_t \tag{20}$$

where $v_t = [GOV_t, GDP_t, CON_t]$ where GOV_t denotes government spending, GDP_t is gross domestic product and CON_t is consumption, all real and in logarithms. rank$(\Pi) = r$ is the cointegration rank and (20) omits a constant for brevity. As in the VAR case of the previous section, $D = \Upsilon(0)\,\Sigma_e B(0)$ and $\varepsilon_t = B(L)^{-1}e_t$ where e_t contains the structural shocks of interest. The Blaschke matrix is now a three dimensional identity matrix except for the upper left 2×2 block which is identical to the expression in (17). Nine unknown coefficients in $\Upsilon(0)\Sigma_e$, three unknown parameters in $B(L)$ and the cointegration rank r are to be determined. In the simulations, the anticipation rate ω, the anticipation horizon q and the cointegration rank r are treated as known by the econometrician. Note that the correct cointegration rank in the model is $r = 1$. Despite the presence of permanent fiscal shocks, the variables in v_t cointegrate since the investment-output ratio is unaffected by the level of government spending in the long run. This leaves 10 parameters to be determined. Six restrictions follow from the fact that DD' equals the variance-covariance matrix of the VAR residuals. Two additional restrictions obtain from the standard assumption in fiscal VARs that GOV_t is not affected contemporaneously by any shock other then the unanticipated fiscal shock (see Blanchard and Perotti, 2002). The remaining two identification assumptions are that the long run effects on v_t of anticipated and unanticipated spending shocks are proportional and that the constant of proportionality is given by λ. Note that this amounts to only two parameter restrictions since by construction the long run impact matrix will be of rank 2. These additional restrictions are akin to those in Beaudry and Portier (2006): The unanticipated government spending shock is allowed to affect the level of government spending immediately, while the anticipated government spending shock is assumed not to affect government spending within one quarter. However, the two shocks are restricted to have the same long run impact on the level of government spending.

We apply these identification restrictions either directly on the VECM (the standard VECM) or after the application of the Blaschke matrix (VECM-BM). Note that for the standard

VECM, we only need the two short run restrictions and the long run restriction of proportionality. The standard VECM will never uncover the true impulse responses, even in infinite samples, as long as anticipated shocks with $q > 1$ are present, whereas the VECM-BM will asymptotically produce the correct theoretical responses. In order to assess how useful the VECM-BM procedure is relative to the standard analysis in small samples, we compare their performance by simulating 1000 samples of 200 quarters that are generated from the model described above. We adopt the following specifications for the stochastic processes:

$$\begin{aligned} x_t &= 0.01 e_t^x \\ (1-L)\ln\left(G_t/X_{t-1}\right) &= \mu_g(1)\ln(0.20\bar{y}) + \begin{cases} 0.003 e_{0,t}^g + 0.009 e_{8,t-8}^g & \text{or,} \\ 0.009 e_{0,t}^g + 0.003 e_{8,t-8}^g \end{cases} \end{aligned}$$

These parametrizations roughly match the unconditional standard deviations of the growth rates of GDP_t and GOV_t in US data. We consider two alternative specifications for the government spending process: in the first, $\lambda = 3$ such that anticipated fiscal shocks are three times as volatile as unanticipated fiscal shocks; in the second case, $\lambda = 1/3$ such that unanticipated shocks are three times as volatile as anticipated shocks. Both parametrizations imply that government spending shocks account only for a relatively small part of the fluctuations in output and consumption. In the simulations, we always include 8 autoregressive lags in the specification of the VECM.

We report results for four different simulation experiments. In the first two, the anticipated shock is relatively important ($\lambda = 3$) and we consider a model with either a realistic discount factor $\beta = 0.99$, yielding a high anticipation rate ($\omega = 0.95$), or a low discount factor $\beta = 0.80$, yielding a low value of the anticipation rate ($\omega = 0.62$). In the remaining two experiments we repeat the simulations for the case where the unanticipated shock is relatively important ($\lambda = 1/3$). Comparing results across experiments allows us to assess how both estimators perform when altering the role that anticipation effects play in the data generating process, while keeping the degree of sampling uncertainty constant. The simulation results are depicted in Figures 4 through 11, which present impulse response point estimates for both the VECM and VEMC-BM procedures, averaged across the samples. The grey areas cover the 16% and 84% quantiles of the simulated point estimates.

The simulation results yield the following conclusions:

1. When the anticipated shocks are relatively unimportant, regardless of the anticipation rate, both estimation procedures are on average relatively successful in uncovering the response to an unanticipated fiscal shock.

2. When the anticipation rate is low and the anticipated shocks relatively important, the estimates of both fiscal shocks in the standard VECM procedure are severely biased. The VECM-BM procedure in contrast, produces on average very accurate point estimates for both shocks.

3. When the anticipation rate is high and the anticipated shocks are relatively important, both procedures yield substantially biased estimates for the unanticipated shock.

4. Overall, the VECM-BM procedure is more successful in uncovering the shape of the response to anticipated spending shocks.

5. Estimates are always subject to a large amount of sampling uncertainty.

One should take care in generalizing these conclusions, as they are derived from a specific model setting. However, we believe they convey several useful insights for the fiscal VAR literature. Our analysis suggests that ignoring anticipated spending shocks becomes more problematic when anticipation rates are lower and when anticipated shocks explain a relatively larger share of exogenous changes in government spending. Ramey (2008) provides an extreme example of the latter case in which there are no unanticipated changes in government spending. If one is interested in estimating the response to anticipated changes, or when low anticipation rates and significant anticipated shocks are a concern, the VECM-BM estimator constitutes one possible empirical approach to deal with fiscal foresight in a structural VAR or VECM framework. Finally, with high anticipation rates and important anticipated shocks, both methods have some problems. The standard VECM with short run restrictions suffers from small sample uncertainty and misspecification due to nonfundamentalness. Note, however, that the bias is not nearly as severe as in the case with a low anticipation rate. Our intuition is that with a high anticipation rate, the linear space of past observations of the vector of observables is much more informative about future fiscal innovations as agents respond more strongly to fiscal news. At the same time, the VECM-BM is more sensitive to sampling uncertainty when ω is high. High anticipation rates imply that the backward looking component of the data generating process (the capital stock) is very persistent. In small samples, the long run impact matrix, which must be used to uncover the response to anticipated shocks in the VECM-BM, is poorly estimated. Above we argued that on theoretical grounds it is difficult to construct realistic models with capital accumulation in which the anticipation rate is below 0.90. This suggests that the reliability of existing fiscal VAR or VECM results, obtained using the short run restrictions only, in practice might depend mostly on whether anticipated shocks are relatively important or not in reality.

5 Empirical Results

In this section, we apply both the VECM and VECM-BM estimation procedure to US data. The empirical specification is identical to the last section. Our sample consists of quarterly data from the Bureau of Economic Analysis for 1954Q1-2006Q4 on GDP, government consumption expenditures and private consumption of nondurable goods and services, all measured in constant prices and per capita. Figure 12 reports the response to the government spending shocks obtained in the standard VECM model, i.e. without the application of the Blaschke matrix. The grey areas indicate the centered 68% confidence regions obtained from 1000 Monte Carlo draws. The size of the shocks is normalized such that government spending increases by 1% in the long run. The impact of an unanticipated shock (left panel), which can be identified by using only the two short restrictions, corresponds closely to standard results in the literature: both output and consumption increase. In response to the anticipated shock (right panel), for which we need the additional long run restriction, both output and consumption rise on impact and well before government spending expands significantly.

As we argued above, to the extent that anticipation effects are empirically relevant, these responses are not truly structural. Therefore, we next apply the VECM-BM procedure, which conditional on our identification assumptions, will reveal the correct structural responses, at least asymptotically. Doing so requires values for both the anticipation rate ω and the anticipation horizon q. In the benchmark, we set q equal to 8 quarters, but we will verify results for a range of plausible values for the anticipation horizon. Regarding the anticipation rate, we discuss results for two different approaches: in the first, ω is selected as the radius of an empirical circle of roots present in the VAR representation of the time series. Figure 13 plots the reciprocals of the VAR roots in the complex plane. Note that by construction the VECM specification implies that the VAR polynomial contains a unit root. We detect a clear circle of roots with radius of approximately 0.77, which is quite low compared to the general theoretical predictions described earlier. In the second approach, we calibrate ω to a value that we argued before is robust across a wide array of dynamic general equilibrium models. This leads us to a relatively high value $\omega = 0.95$.

Figure 14 and 15 display the estimation results for the low and high ω case, respectively. In the case where ω is low, the point estimate for the relative volatility of the anticipated shock is $\lambda = 0.81$. When ω is high, we obtain $\lambda = 1.44$. Both cases therefore indicate a substantial role for anticipated spending innovations. Regarding the unanticipated shock (left panel), the response of the variables is qualitatively similar to the standard VECM. Quantitatively, there are some differences between the estimation procedures. For the case of low ω, the reaction of government spending is almost the same in the short and the long run, whereas in the standard VECM, the short run increase in spending is substantially larger than the eventual impact of the shock. For high ω, the short run increase in spending is also more muted. Both for low and high ω, the response of output is substantially larger in the short run than in the standard VECM. The long run effects on output are quite similar in size. The response of consumption is quantitatively very similar for all specifications. This is an important finding, given the arguments of Ramey (2008) that fiscal foresight may yield upward biased consumption responses because of model misspecification. Our application of the Blaschke matrix to correct for this misspecification does not overturn the robust finding on consumption in SVARs with short run restrictions. Finally and interestingly, the confidence regions are narrower in comparison with the standard VECM for both the low and high ω case.

In response to the anticipated shock, results depend more importantly on the value of the anticipation rate. For the low value of ω, government spending first gradually decreases before rising in the longer run. As in the standard VECM, output and consumption rise gradually after the shock and well before the increase in government spending. For the high value of ω, government spending basically does not change until the date of implementation. After the implementation date, government spending spikes up and gradually rises towards its long run value of 1%. Again, both output and consumption rise immediately after the shock and well before the actual increase in government spending. The response of consumption is relatively similar across all specifications, but the size and shape of the output response differs more substantially.

Figure 16 displays the point estimates from the VECM-BM procedure for anticipation horizons of 2, 4, 6, 8, 10 and 12 quarters while keeping $\omega = 0.95$. Figure 17 shows the results for values of the anticipation rate ranging from $\omega = 0.5$ to $\omega = 0.95$ while keeping $q = 8$. Both robustness exercises reveal that qualitatively, the impulse responses are not very sensitive to variations in the anticipation horizon and anticipation rate. Most importantly, we find no parameter combinations of q and ω for which the VECM-BM estimator overturns the positive consumption response to increases in government spending.

6 Conclusions and Future Research

The objective of this paper was to explore the extent to which SVAR based estimators can be adapted to environments in which agents have information about future fiscal innovations. The main attraction of SVAR estimators is that they are easily applicable. Moreover, SVAR estimators can be directly related to economic theory, see Fernandez-Villaverde, Rubio-Ramirez, Sargent and Watson (2007). We proposed one approach to extend the SVAR methodology that can be applied to circumstances where there are anticipation effects. We described the estimation approach in the context of government spending shocks, but it is generally applicable to any kind of structural shock with a news component, such as technology shocks, monetary policy shocks or tax shocks. The new estimator relies upon assumptions regarding the anticipation horizon and the anticipation rate, and requires the introduction of an additional identifying assumption that allows one to discriminate between anticipated government spending shocks and any other structural shock.

We argued that anticipation effects are more likely to be problematic for inference about unanticipated shocks in the standard SVAR analysis if the anticipation rate is low and anticipated shocks are relatively important. Economic theory seems to robustly predict high values of the anticipation rate. This implies a smaller impact of anticipation effects on the estimated impulse response functions. Effectively, when the anticipation rate is high, the linear space of past observations of the vector of observables is more informative about agents' information on future fiscal innovations. The main problem in practice might therefore be that anticipated shocks are relatively important. Interestingly, however, we found indications in empirical fiscal VARs that the anticipation rate may indeed be quite low. This suggests that theoretical research perhaps needs to consider models in which agents discount future news at high rates.

We showed in an application of our estimation strategy to U.S. time series data that, independently of the anticipation rate, permanent increases in government spending appear to increase private consumption regardless of whether the spending shock is anticipated or not. Explaining a rise in consumption following the announcement of a future permanent spending increase could be even more challenging than accounting for consumption increases following surprise increases in government spending.

Finally, we would like to stress that the application of our methodology does not come for free. It forced us to concentrate on permanent changes in government spending and to import considerable structure from economic theory. Therefore, we keep an open mind towards alternative routes of tackling this important issue in empirical research. This said, the empirical results of our exercise are relevant since they do not appear to support the idea that timing is responsible for explaining why SVAR estimators imply positive consumption responses to increases in government spending.

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Appendix 1

The parameters of equation (11) are given by

$$
\begin{aligned}
\eta_1 &= 1-\delta' + \frac{\eta}{\beta}\frac{1+\xi}{1-\alpha} \\
\eta_2 &= -\left(\frac{s_c}{s_k} + \frac{\eta}{\alpha\beta}\right) \\
\eta_3 &= -\frac{\eta\xi}{1+\eta}\left(1-\delta' + \frac{\eta}{\beta}\frac{1+\xi}{1-\alpha}\right) \\
\eta_4 &= \frac{1}{1+\eta}\left(1+\eta\xi\left(\frac{s_c}{s_k} + \frac{\eta}{\alpha\beta}\right)\right)
\end{aligned}
$$

where $\delta' = \frac{\gamma+\delta-1}{\gamma}$, $\xi = \theta - 1 + \theta\frac{\psi\bar{N}^\theta}{1-\psi\bar{N}^\theta}$, $\eta = \frac{\alpha\beta}{s_k}\frac{(1-\alpha)}{\xi+\alpha}$, $s_k = \frac{\alpha\beta}{1-\beta(1-\delta')}$ and $s_c = 1-\delta' s_k - s_g$ and s_g is the share of government spending in GDP at the point of approximation.

Figure 1: The impact of a transitory government spending shock

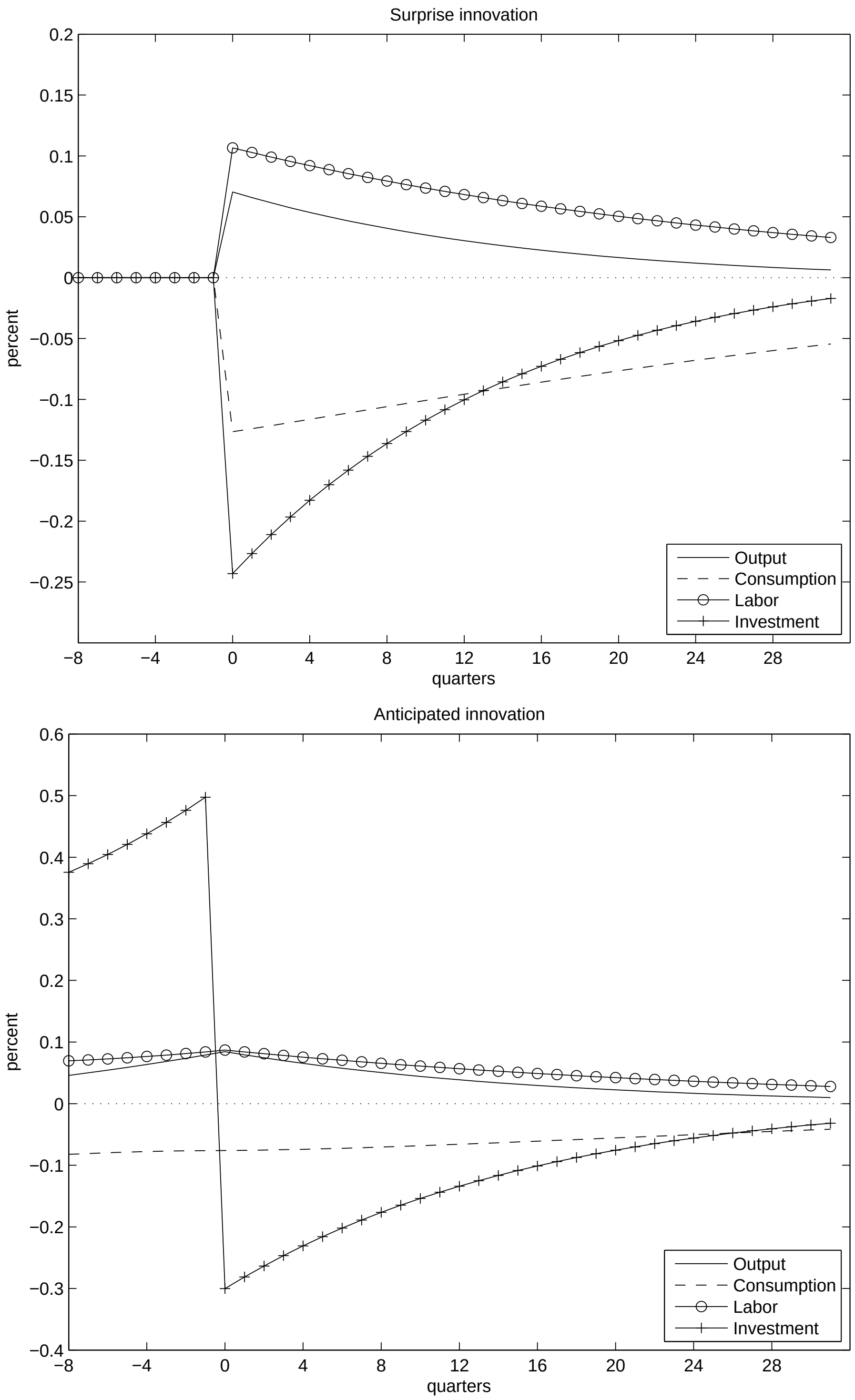

Figure 2: The impact of a permanent government spending shock

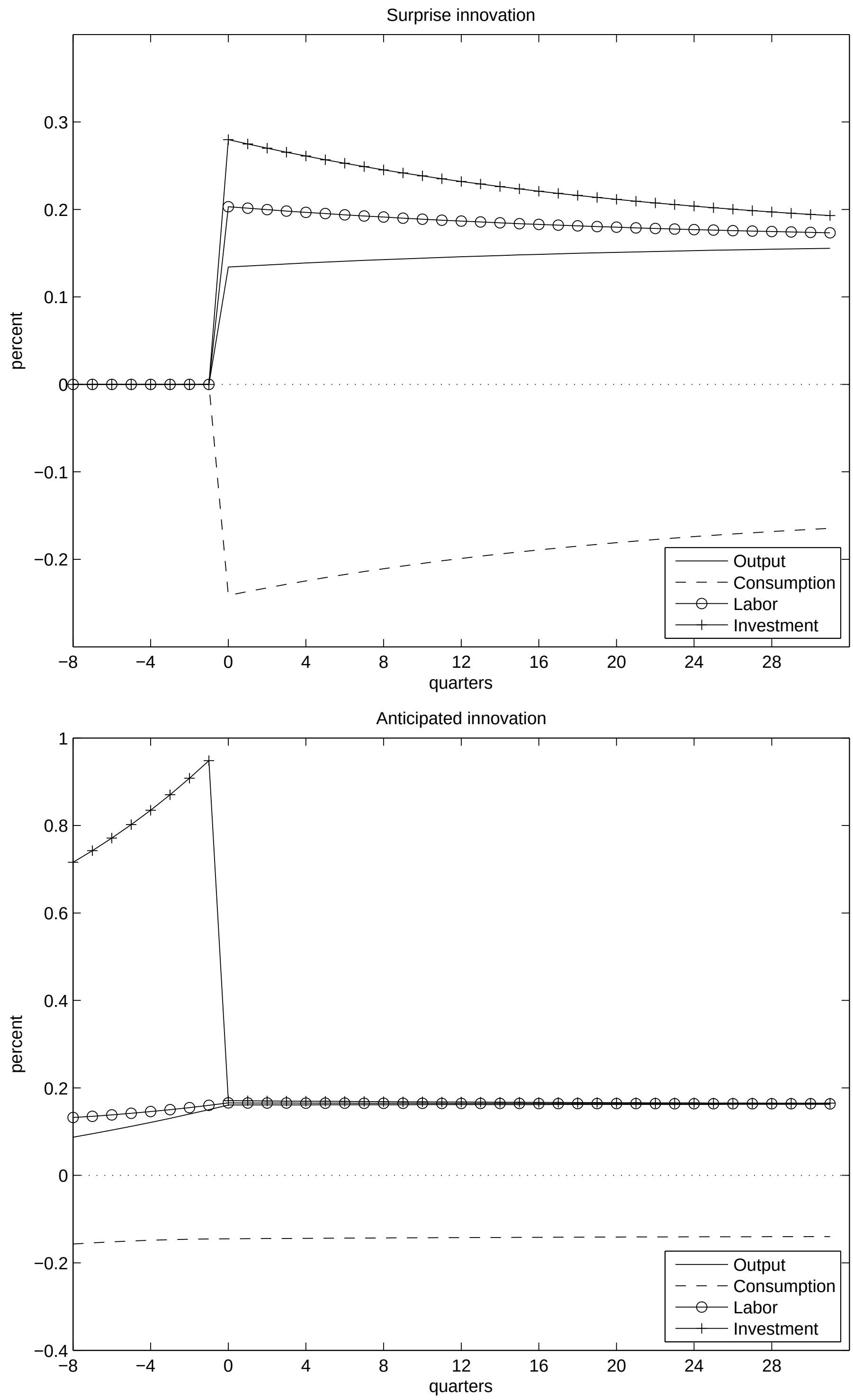

Figure 3: The Anticipation Rate in the Benchmark Model

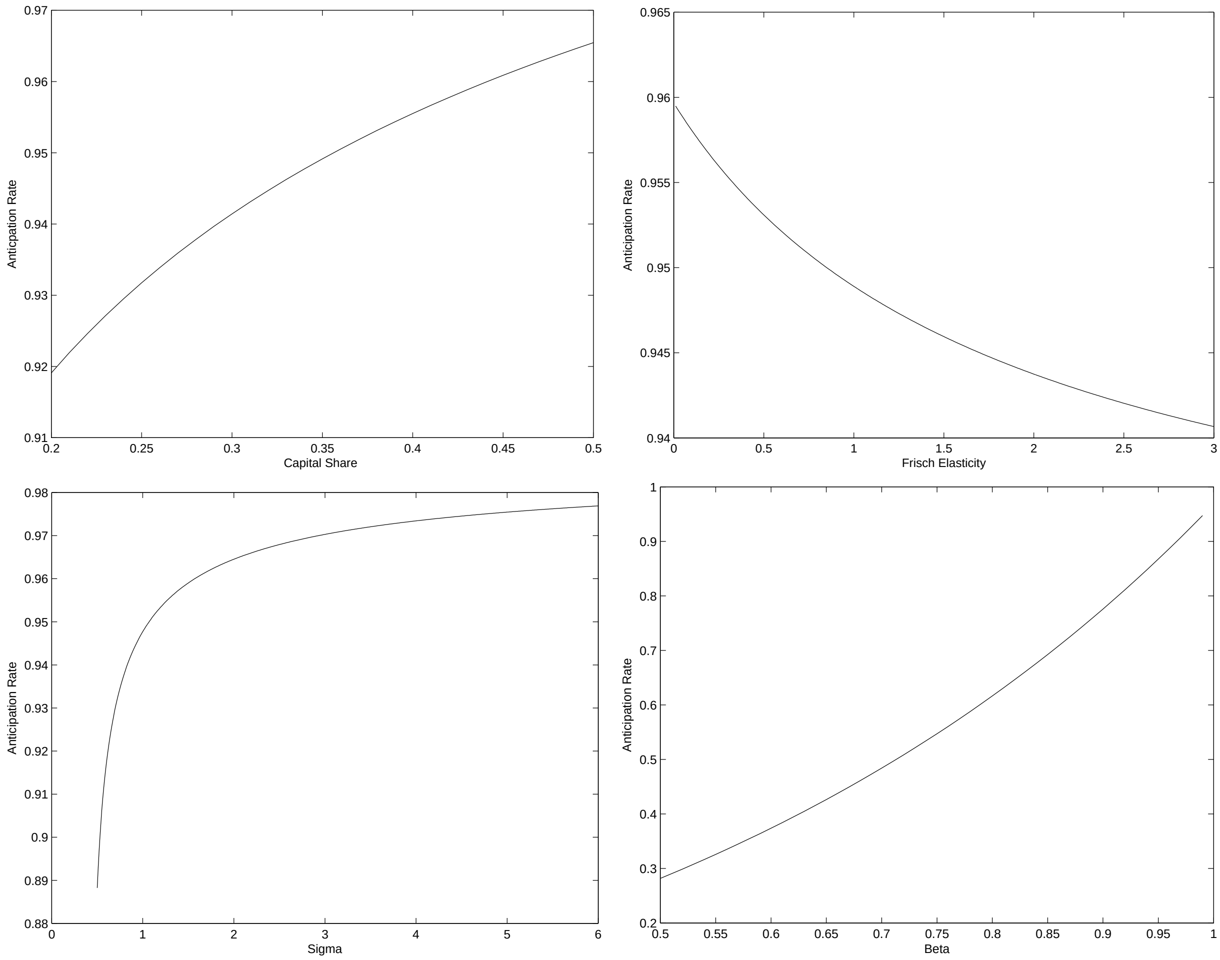

Figure 4: VECM: High Anticipation Rate-High Volatility of Anticipated Shock

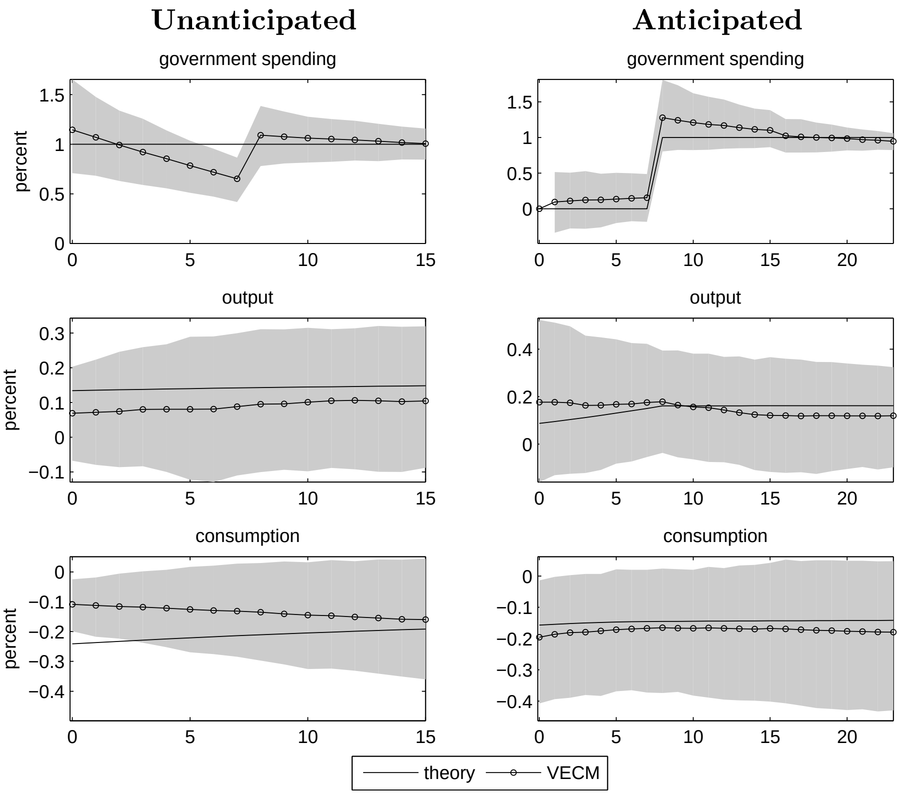

Figure 5: VECM-BM: High Anticipation Rate-High Volatility of Anticipated Shock

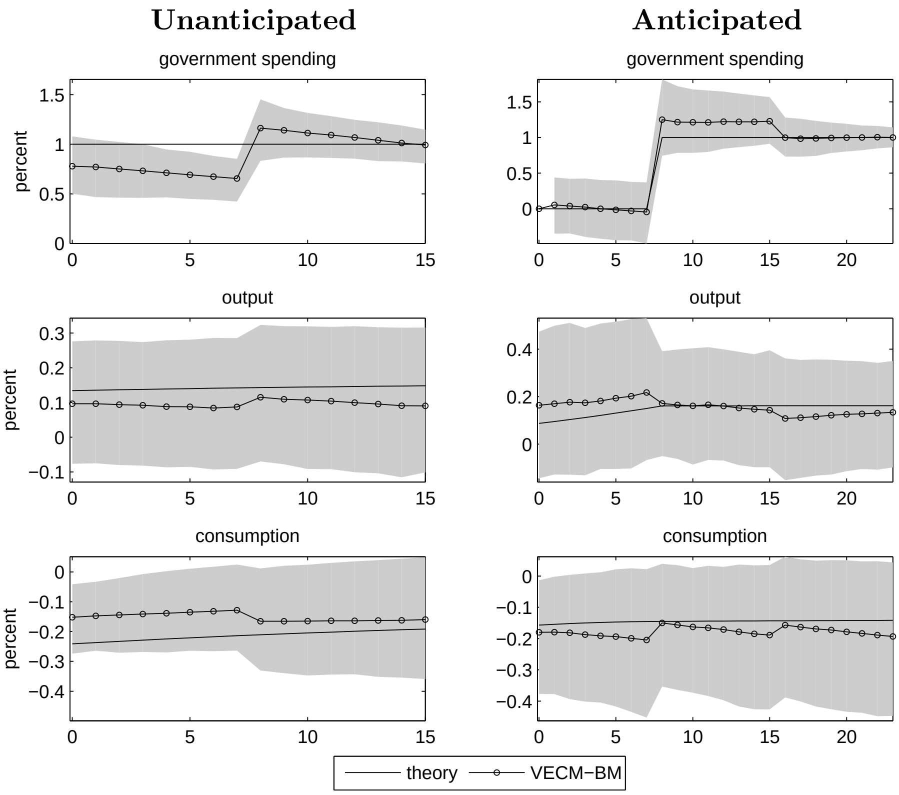

Figure 6: VECM: Low Anticipation Rate-High Volatility of Anticipated Shock

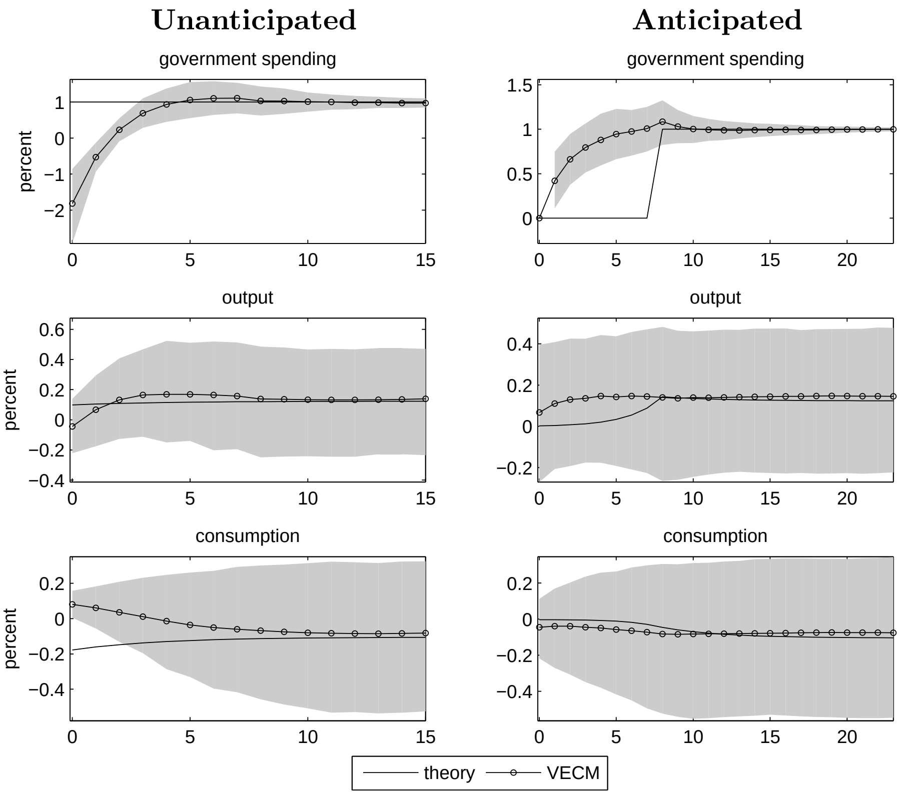

Figure 7: VECM-BM: Low Anticipation Rate-High Volatility of Anticipated Shock

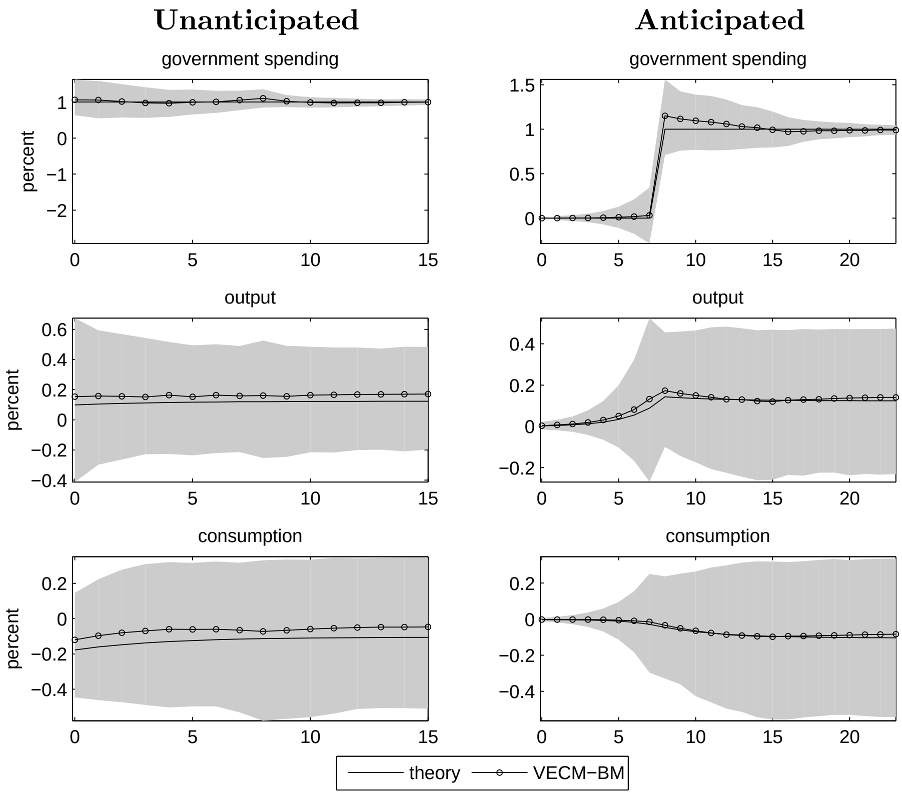

Figure 8: VECM: High Anticipation Rate-Low Volatility of Anticipated Shock

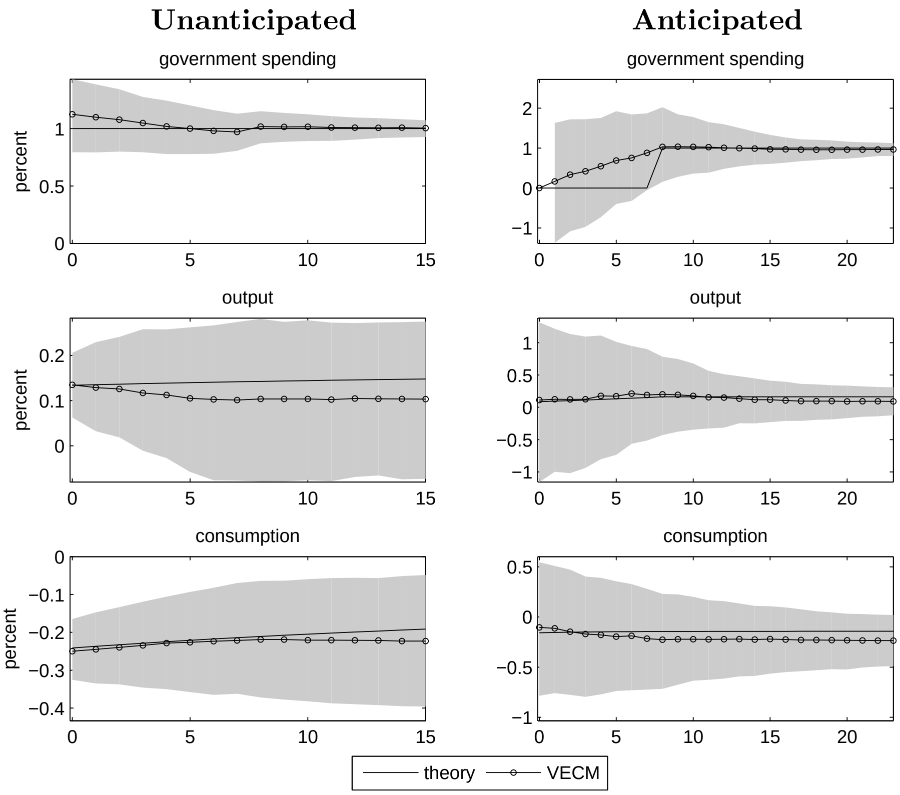

Figure 9: VECM-BM: High Anticipation Rate-Low Volatility of Anticipated Shock

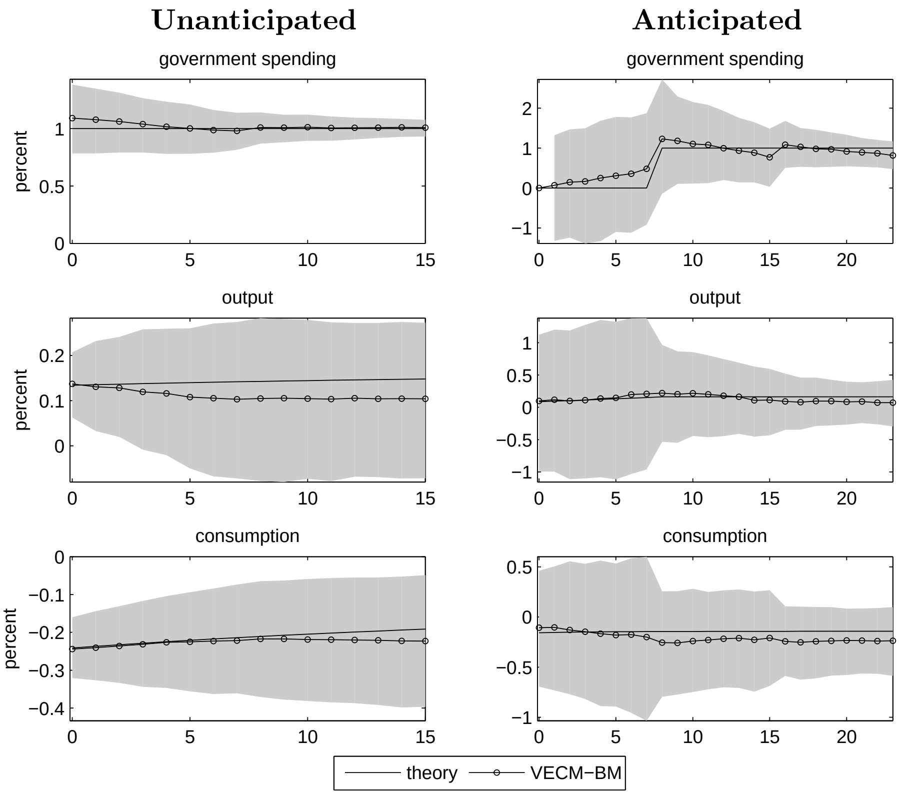

Figure 10: VECM: Low Anticipation Rate-Low Volatility of Anticipated Shock

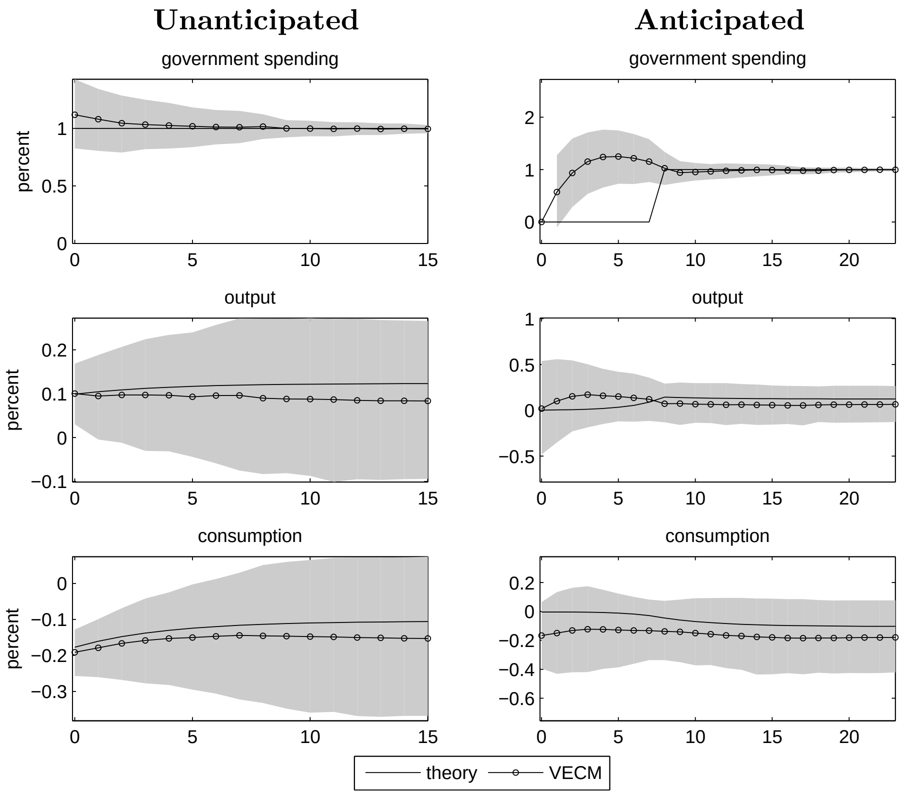

Figure 11: VECM-BM: Low Anticipation Rate-Low Volatility of Anticipated Shock

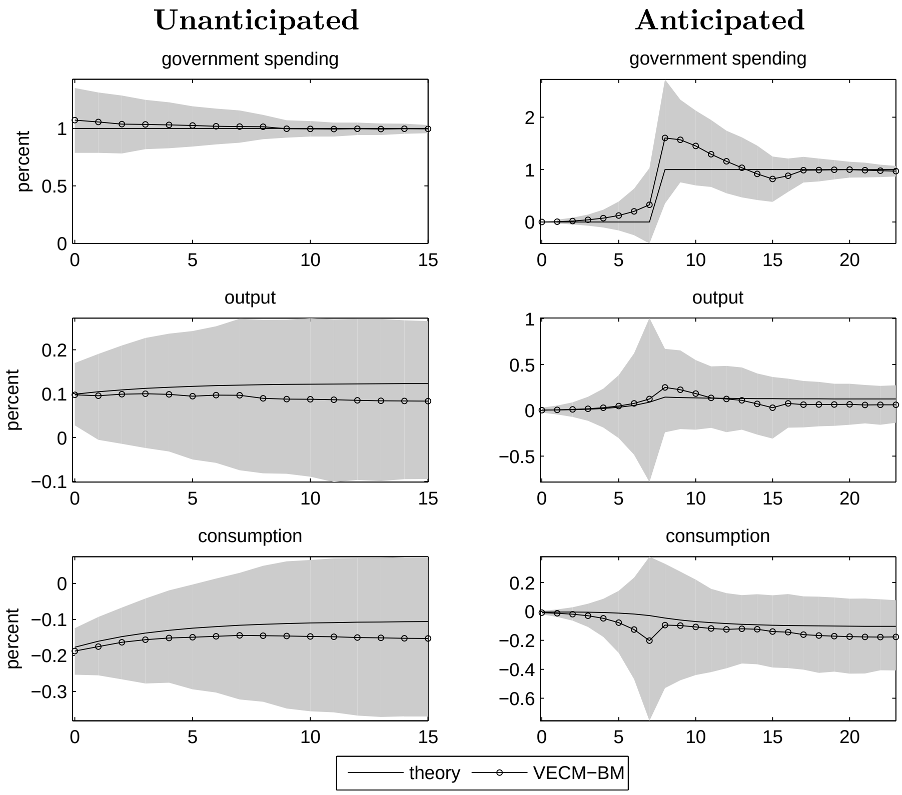

Figure 12: US Data: VECM Estimates of Fiscal Shocks

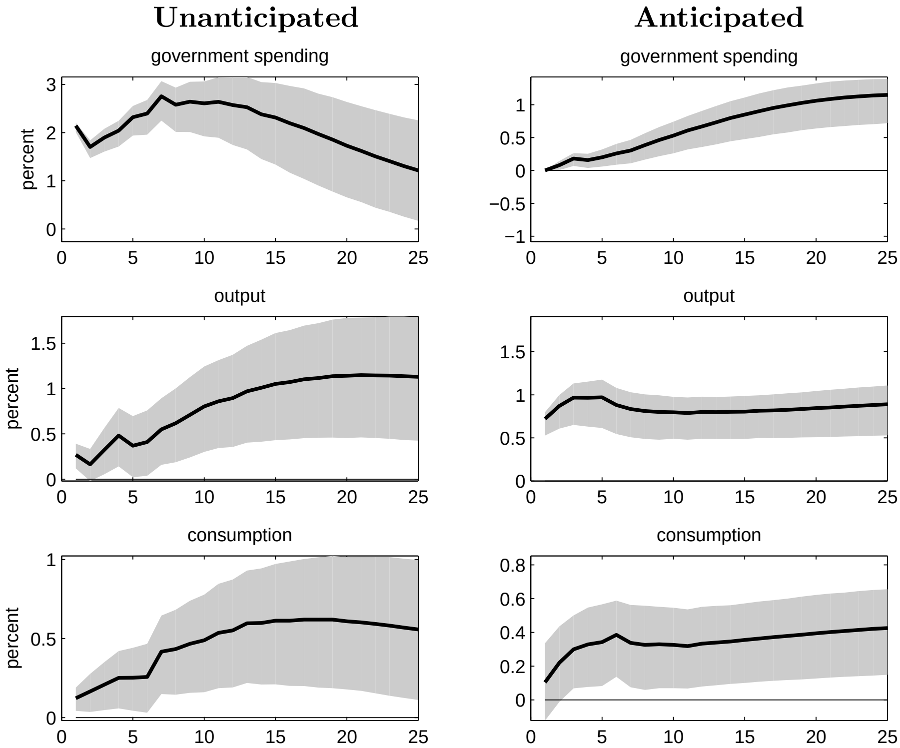

Figure 13:

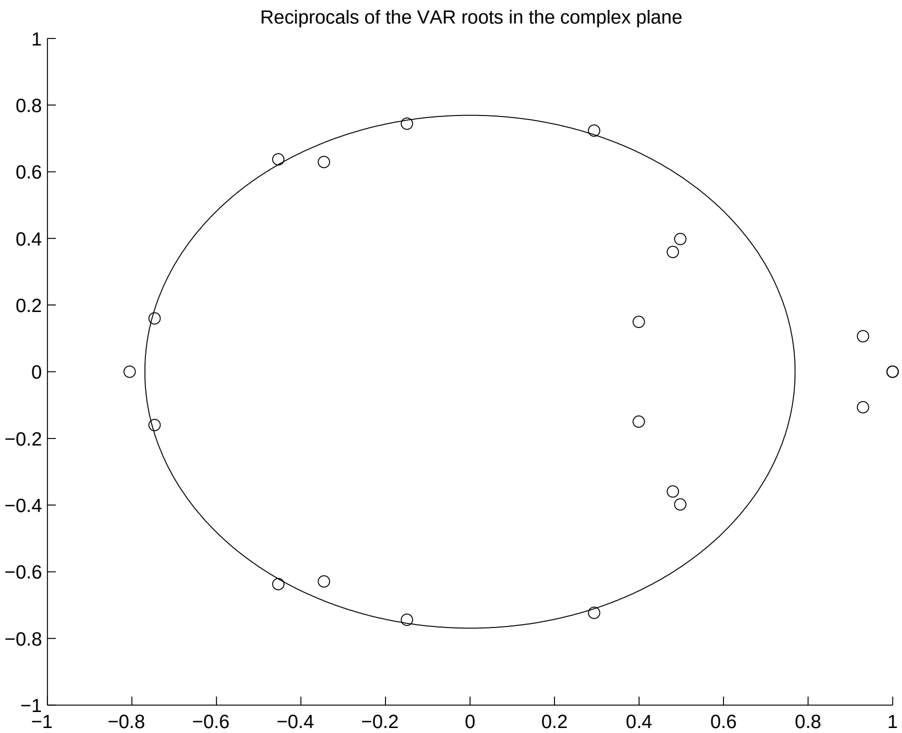

Figure 14: US Data VECM-BM Estimates of Fiscal Shocks: Low Anticipation Rate

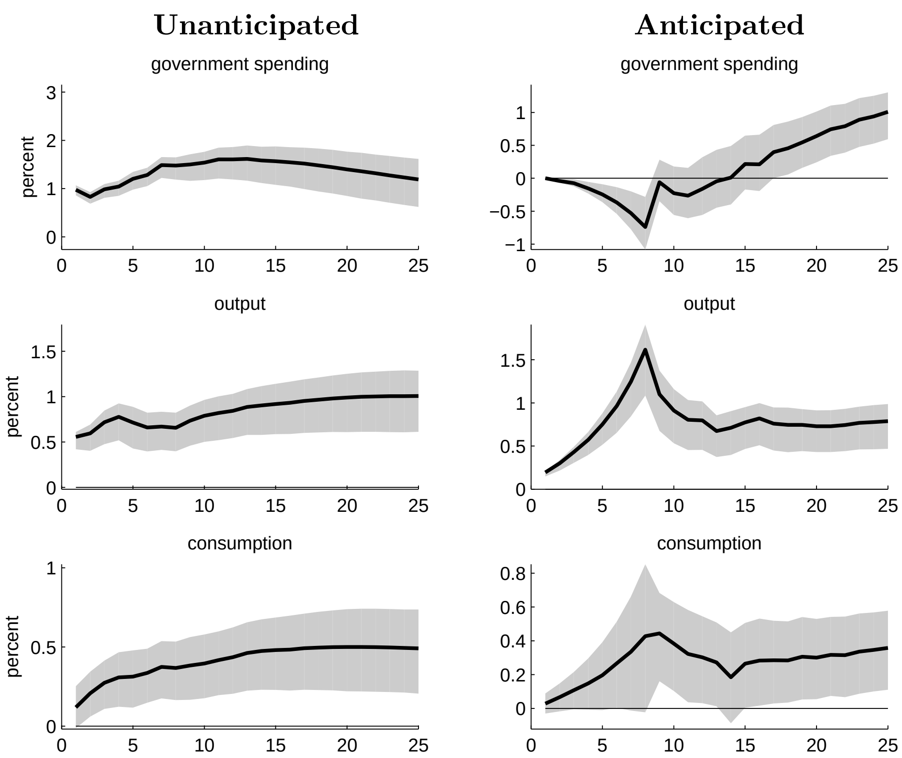

Figure 15: US Data VECM-BM Estimates of Fiscal Shocks: High Anticipation Rate

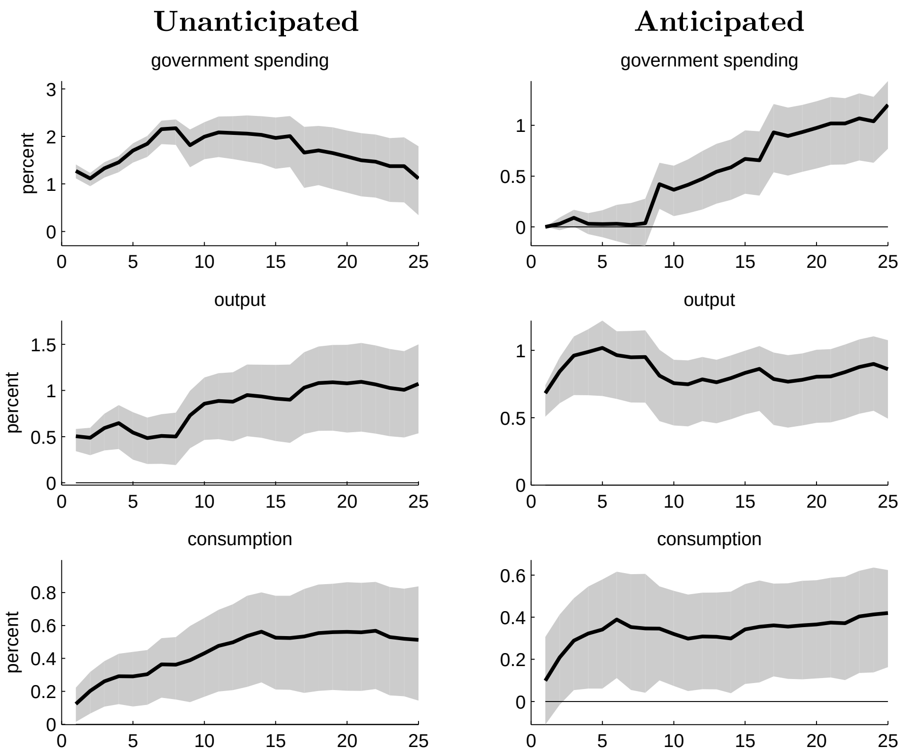

Figure 16: Robustness: Varying the Anticipation Horizon

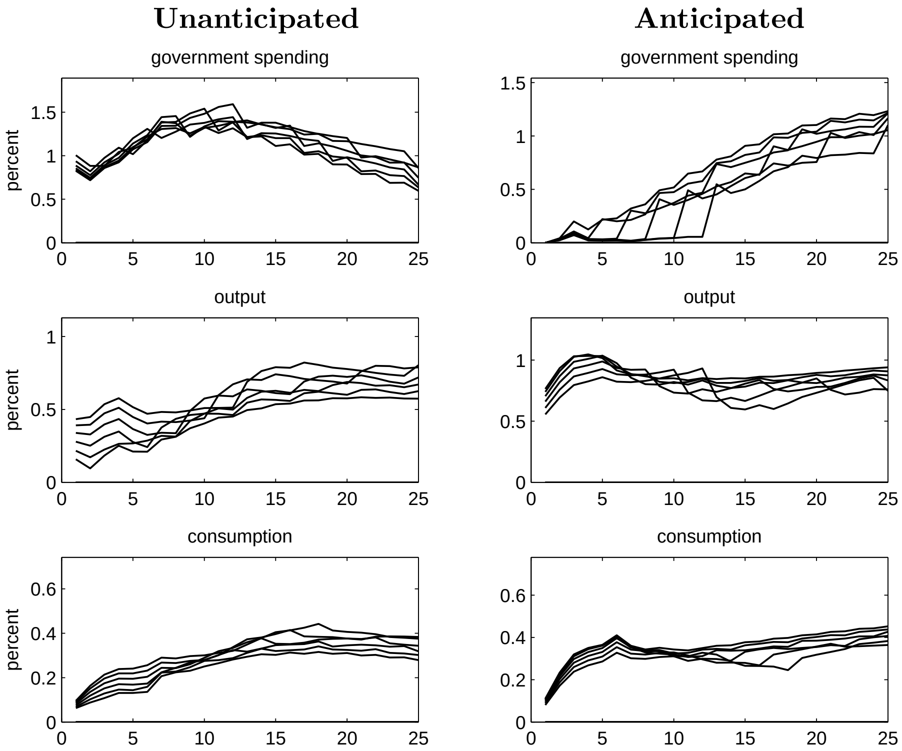

Figure 17: Robustness: Varying the Anticipation Rate