The Effects of a Government Expenditures Shock*

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This Version: October 2006

Abstract

We study how the main variables in the economy react to a government expenditure shock. The fact that consumption rises and prices drop in response to an increase in government spending as been seen in the literature as a mystery, since it has been difficult to reconcile with the basic general equilibrium model. We study whether the behavior of the Federal Reserve might provide an explanation for this puzzle. We include monetary variables in the usual vector autoregression. The empirical results from an identified vector autoregression reveal that positive innovations in government consumption are followed by strong increases in consumption, employment, and money and decreases in interest rate and prices. We argue that the behavior of the central bank is important to understand the puzzle. A simple model is able to deliver the results referred, as long as the central bank follows a standard Taylor rule.

*The views expressed in this paper are of the authors and do not necessarily those of Banco de Portugal. We would like to thank Isabel Correia, José Ferreira Machado, Marco Del Negro and João Sousa for their comments to the paper. Corresponding author’s email: badao@bportugal.pt
1 Introduction

Over the years macroeconomic theories have been divided on whether the shocks that cause economic fluctuations should be viewed as demand shocks or supply shocks. One part of the literature, for instance Cooley and Prescott (1995) and King and Rebelo (1999), claim a central role for exogenous variations in technology as a source of economic fluctuations in industrialized economies. The other side of the literature, for instance Galí and Rabanal (2004), points to demand factors as the dominant force behind business cycles. A potential important demand shock to explain economic fluctuations, and over which relatively little is known, is the government expenditure shock. This paper is another small step in the direction of better understanding that relation. In it we describe a model that is able to capture many of the relationships between an impulse in the government expenditures and the main variables in the economy.

In a simple general equilibrium model, for instance Baxter and King (1988), the central mechanism by which government spending affects the remaining macro variables in the economy is the negative wealth effect, implied by the increased taxes necessary to finance the rising government expenditure, which with standard preferences, leads to a decrease in private consumption, investment (which represents future consumption) and an increase in labor supply. The fall in investment and the increase in employment leads to lower real wages.

In view of this, the results in the empirical literature are puzzling. Some of the variables, like investment and labor supply, behave as predicted by the simple model, but others do not. There is evidence, from Edelberg et al. (1999), Fatás and Mihov (2001) and Mountford and Uhlig (2004), about a
counter-intuitive negative relationship between prices and government spending. The evidence for the real wages is, for instance in Pappa (2005), Fatás and Mihov (2001) and Gali et al. (2006), that either real wages increase somewhat or that the effect is not significantly different from zero.

The evidence for the private consumption is at odds with the standard model too, as most of the empirical literature points towards a non decrease in private consumption in response to a government expenditure shock. The evidence on private consumption obtained from structural vector autoregressive (VAR) models depends on the identification scheme used. While Blanchard and Perotti (2002), Fatás and Mihov (2001) and Gali et al (2004), using the same identification scheme, get that private consumption rises significantly and persistently after an unanticipated increase in government purchases,\(^1\) Mountford and Uhlig (2004), using a different identification method find negligible effects on consumption. There is also other type of evidence, besides that obtained from VARs, that consumption might not drop after an impulse in government expenditures. Perotti (1999) studies the comovement of private consumption and government consumption and finds out that only during fiscal consolidation episodes, characterized by large spending cuts, private consumption and output rise, but in all other experiences the opposite happens, private consumption moves together with government consumption.\(^2\) Others, like Edelberg et al. (1999), and Burnside et al. (2003) use additional information such as timing of wars to identify the fiscal policy shock. They reach the conclusion that the fiscal policy has no noticeable impact on private consumption.

Most of the recent theoretical literature has been concentrated in explaining why consumption increases in reaction to a positive government shock.\(^3\)

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\(^1\)In the same methodological vein, Perotti (2004) finds that this result is pretty robust to a sample of five OECD countries.

\(^2\)Also, Correia et al. (1992) document that for the period 1914-50 in England, which is a period in which shocks to government expenditures are extremely prominent, there is a negative comovement between consumption and government expenditure.
There are explanations based on alternative utility functions. Linnemann and Schabert (2004) consider a model where government consumption provides utility to households. Private consumption is crowded in by a positive government consumption shock as long as the elasticity of substitution between the private and the public good is sufficiently small. Linnemann (2006) considers a utility function that does not depend on government consumption, but with a sufficiently large complementarity between consumption and labor. The negative wealth effect of the government expenditure shock pushes agents to increase labor supply but, if the complementarity between consumption and labor is strong enough, this raises the marginal utility of consumption, increases consumption and decreases savings.

Another approach is to add limited rationality or credit constrained agents to the standard model. For instance, Gali et al. (2006) modify substantially the standard model by including non-Ricardian rule-of-thumb consumers, which are consumers that consume all their available disposable income in each period. After the shock the wage income goes up, and the presence of the rule-of-thumb consumers ensures that private consumption does not drop after a government consumption shock, because of the wealth effect.

The explanation in this paper does not rely on limited rationality of the agents nor on a particular utility function. In order to calibrate the model and to simplify the explanation of the results, we assumed that consumers have a GHH instantaneously utility function, as in Greenwood et al. (1988), which has the property that there are wealth effects only on consumption, i.e. there are no wealth effects over the labor supply. Thus, it can be argued that our explanation does not rely on a particular utility function, as we take the case most difficult to explain, the case where the negative effect of the positive government expenditure shock over consumption is maximized.

The model is a monetary one, where the nominal interest rate represents simultaneously a distortion between the marginal rate of substitution among leisure and consumption and the real wage and a distortion between the
marginal productivity of labor and the real wage. There is a central bank that follows a rule, such that the current nominal interest rate responds positively to the expected inflation. In this context, a positive government expenditure shock leads to a decrease in the nominal interest rate, which makes consumption less expensive relatively to leisure and leads to higher consumption and higher labor hours. It also reduces firms’ costs, which leads to an increase in production. Thus, the effect over private consumption of the reduction in the interest rate is positive, and it might compensate the negative wealth effect of the government expenditure shock. In fact, we present a reasonable calibration in which that happens.

The intuition, for the decrease in the interest rate, is better understood in a simplified version of the model without capital. Assume the interest rate remained unchanged, after the government shock, to get a contradiction. Since the shock has no wealth effects over the labor supply, then the feasibility constraint implies that consumption in this period goes down and consumption in the next period will return to its original level. The marginal utility of this period’s consumption will go up, but the marginal utility of next period’s consumption will remain unchanged. The intertemporal Euler equation, that connects two consecutive marginal utilities of consumption, determines that next period’s inflation will be lower. Thus, we have reached a contradiction, because the central bank, by following its feedback rule, will respond to the expected deflation by decreasing the nominal interest rate.

Previous researchers gave little consideration to the way monetary policy is conducted, as a possible explanation for the puzzling results referred above. To our knowledge, among the empirical papers Mountford and Uhlig (2004) is the only one that includes the nominal interest rate in the structural VAR. There are at least two reasons behind it. The conventional wisdom has been that the reasonable monetary policy will amplify the private consumption direct response to the government expenditure shock. The government shock will create inflationary pressures and the anti-inflationary central bank will
increase the interest rate in order to control inflation expectations. Thus, in that way it will decrease further the private consumption. Moreover, even among authors with opposing views in many other subjects, the monetary policy has always been thought has having small effects on the economy. For instance Cooley and Hansen (1995) and Galí and Rabanal (2004) agree that money shocks cannot be key impulses driving aggregate fluctuations.

We estimate a structural VAR, which includes among other variables, the instruments at the disposal of the central bank, money supply and nominal interest rate. As it turns out, we estimate that a positive government consumption shock triggers a reaction on the part of the monetary authorities, the real money supply rises and the nominal interest rate decreases. Mountford and Uhlig (2004) obtained that the nominal interest rate decreases, but only in a few of the cases is it significantly different from zero. That may be due to a variety of reasons: a different identification procedure, a different definition of interest rate, or the analysis of a different period. The impulse responses, obtained by us, for the other variables are similar to the ones that were obtained by the empirical literature that used the VAR methodology together with the more traditional identification scheme.

The rest of the paper is organized as follows. Section 2 describes the empirical evidence obtained by us and compares it with the one obtained in the literature. Section 3 explains the effects of the government shock in the context of the model we propose. In this section we calibrate the model, compute the impulse response functions to a government expenditure shock and compare them with the ones obtained in the VAR. Section 4 concludes.

2 Empirical Evidence

In this section we describe the empirical analysis. Additional details are supplied in appendix 1. We do a VAR and use the traditional identification procedure. The one that takes government consumption as predetermined
relative to the other variables in the VAR. In doing so, we use a longer sample, which imparts added robustness to the results. We include all the standard variables as well as others less used, like money and nominal interest rate, in order to test empirically the predictions of our model.

2.1 Identification of the Government Expenditure Shock

In the context of structural VARs, Blanchard and Perotti (2002) developed a methodology to identify fundamental government consumption shocks as well as their dynamic effects on a set of macroeconomic variables. Their identification strategy bears on the insight that the institutional framework that lies behind fiscal policy decisions is such that public consumption is essentially exogenous. In practice, this means assuming that government consumption is predetermined with respect to the other variables in the VAR.\(^3\) For our purposes, we follow the strategy of Blanchard and Perotti (2002) with an added twist, needed to make our identification strategy consistent with the possibility that the central bank may react to innovations in government consumption. So, apart from assuming that the government consumption is predetermined relative to all the other variables in our VAR,\(^4\) we also impose the supplementary identifying restriction that monetary policy reacts contemporaneously only to shocks to itself and to government consumption. The results hardly change if instead of considering both the nominal interest rate and the money supply, we consider only one of them in the VAR.

The analysis is based on the following reduced-form VAR,

\[
Z_t = \eta + B(L) Z_{t-1} + u_t, \quad Eu_t u_t' = V
\]

where \(Z_t \equiv [G_t, M_t, Y_t, C_t, T_t, P_t, R_t, W_t]\) is the vector of the endogenous vari-

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\(^3\)Other VAR studies, like Mountford and Uhlig (2004), employ a different identification method. They use what is known as the sign restriction method.

\(^4\)In other words, government spending is done for reasons other than immediate reaction to macroeconomic conditions. This is a plausible but untestable hypothesis.
ables comprising the following variables: real government consumption, real money supply, real GDP, real private consumption, real net taxes, GDP deflator, nominal interest rate and real wage. $B(L)$ is a polynomial of order $q$ in the lag operator, $L$, and $u_t$ is the vector of the one-step-ahead forecast errors to $Z_t$ with invariant variance matrix $V$. One important variable that we did not include in the VAR is investment. We proceed this way for two reasons, because we already had many variables in our VAR and because there is unanimity in the literature that a public spending shock crowds-out investment.

### 2.2 Data Description

The statistical series used to measure the variables in our VAR come in quarterly frequency, and cover the period 1948:I-2004:III, which is the longest available sample for the United States. We took, for comparability reasons, the same data definitions of government consumption and revenue as Blanchard and Perotti (2002). For government consumption ($G$) we took the item real government consumption and gross investment from the National Income and Product Accounts (NIPA) tables of the Bureau of Economic Analysis (BEA). The measure for nominal net taxes is defined as current government receipts less current transfer payments and interest payments. The real net taxes ($T$) were obtained by dividing the nominal net taxes by the GDP deflator. The real GDP ($Y$) and GDP deflator ($P$) series were extracted from the NIPA tables, BEA. The consumption variable ($C$), was taken from the item real personal consumption expenditures of the NIPA tables, BEA. The real money supply ($M$) is the ratio between the nominal money aggregate M1 and the GDP deflator. The M1 series was taken from the FRED database of the Federal Reserve Bank of St. Louis in monthly frequency and transformed into quarterly series by simple averaging. The

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5 Most papers like Mountford and Uhlig (2004), Fatas and Mihov (2001) and Blanchard and Perotti (2002) also consider public investment as part of government expenditures.
variable $R$ was proxied by the secondary market yield of the three-month Treasury Bill as published by the Board of Governors of the Federal Reserve System. This series was transformed from monthly frequency into quarterly frequency through simple averaging. The real wage variable ($W$) was computed by dividing the nominal hourly compensation of the non-farm business sector published by the Bureau of Labor Statistics (BLS), by the GDP deflator. Except for $R$, which is expressed in levels, all variables are expressed in log levels and are seasonally adjusted. All quantity variables were normalized by the size of the working age population as measured by the series $P16$ published by the BLS.

### 2.3 Impulse Responses

Our VAR analysis is conducted for the period 1949:I-2004:III, since we have to drop the first four observations to account for the fact that we set the VAR lag-length to four ($q = 4$). The plots of the impulse response to a government consumption shock are displayed in figure 1. These plots are similar to the ones obtained by the empirical VAR literature, overviewed in the introduction.

All variables are measured in percentage deviations from the baseline, except for $R$, which is measured in basis point deviations. The dashed lines correspond to 95% confidence bands constructed using standard error estimates of impulse responses obtained from 2,000 bootstrap simulations.

Many of the results are similar to the ones obtained in the literature. The shock induces a significant and protracted rise in both government consumption and real GDP. In much of the literature, the impact on consumption is significantly different from zero since the moment of the shock, while here it is only after the first year. The government consumption multiplier on real GDP was estimated to be of 0.7 and 1.5 after one and two years, respectively\(^6\), values that are in line with Blanchard and Perotti (2002) and Gali

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\(^6\)In these calculations we used the sample mean of the share of $G$ in $Y$, which is around
Prices decrease after the shock, like in Fatas and Mihov (2001) and Mountford and Uhlig (2004). Like in other VARs, for instance Gali et al (2004) real net taxes increase after the shock, but are significantly different from zero only a year and half later. Overall, real wages increase but are not significantly different from zero. With respect to this variable the results in the literature depend on the definition used for wages. For instance in Gali et al (2004) and Fatas and Mihov (2001) hourly manufacturing wages are considered, and only on impact is the response significantly different from zero, being the magnitude extremely tiny.

As already referred the results reported in figure 1 are comparable to the ones in the VAR literature. The novelty concerns the responses of the monetary variables. These are compatible with the monetary authority accommodating the government consumption shock, by raising the money supply and decreasing the nominal interest rate, which suggests the presence of a liquidity effect.

3 Model

Here we present in detail the simple model economy that we use, which is able to replicate the main features of the data. The economy consists of a representative household, a representative firm, a representative financial intermediary and a government. The economy is a monetary one, with two cash-in-advance constraints, one for the households and another for the firms. There are shocks in the economy. The history of these shocks up to 23%.

Some definitions are of average wages others are of hourly wages. Some definitions include just a few sectors of production while others are more inclusive.

It is important to note that the presence of financial intermediaries as well as the presence of a cash-in-advance for the firms are unnecessary ingredients for the results. However, since we think they are realistic and we also want to calibrate the model we decided to have them.
period \( t \), is the state of the economy in period \( t \). All variables are indexed to the state of the economy, but to simplify notation we do not do it explicitly. An equilibrium in this economy is a sequence of policy variables, quantities and prices such that firms, financial intermediaries and households solve their problems given the sequence of policy variables and prices, the budget constraints of the government and of the central bank are satisfied and markets clear.

**Government and Central Bank:**

The government gets revenues from lump-sum taxes \( T_t \), makes government consumption \( G_t \), and supplies money \( M_t^s \). Government consumption is a random variable. Since there are lump-sum taxes, government debt plays no role. Taxes are an endogenous variable.

The central bank makes a lump-sum monetary transfer \( X_t \) to the representative financial intermediary at each date \( t = 0, 1, 2, \ldots \). The money supply evolves according to \( M_t^s = M_{t-1}^s + X_t \). The gross nominal interest rate, \( R_t \), set by the central bank depends on the expected gross inflation rate \( \pi_{t+1} \), according to a simple feedback rule

\[
\frac{R_t}{R} = \left( \frac{E_t \pi_{t+1}}{\pi} \right)^\tau, \quad \text{where } \tau > 0, \tag{2}
\]

where \( R \) is the steady state interest rate and \( \pi \) the steady state inflation rate.

**Financial Intermediaries:**

The representative financial intermediary receives deposits \( L_t \) from the households and make loans \( M_t^f \) to the firms. The gross nominal interest rate on the deposits and on the loans to the firm is \( R_t \). The financial intermediary receives from the monetary authority the transfer of money \( X_t \). In order to maximize profits the financial intermediary chooses \( M_t^f = L_t + X_t \).

**Households:**

The preferences of the representative household are described by the ex-
pected utility function:

\[ U = E_0 \left\{ \sum_{t=0}^{\infty} \beta^t u(\tilde{C}_t, N_t) \right\} \quad (3) \]

where \( \beta \) is a discount factor, \( \tilde{C}_t \) is composite consumption and \( N_t \) is hours of work. The variable \( \tilde{C}_t \) is defined as

\[ \tilde{C}_t = (1 - \eta) C_t + \eta (C_t - C_{t-1}), \quad \eta \in (0, 1), \quad (4) \]

where \( C_t \) is consumption of period \( t \). Consumption is not separable over time. Past consumption affects the present utility of current consumption. The intuition behind this functional form for the utility function is that consumers may want to smooth not only consumption, but also its rate of change. The instantaneous utility is a GHH function\(^9\)

\[ u(\tilde{C}_t, N_t) = \frac{1}{1 - \sigma} \left( \tilde{C}_t - \frac{(N_t)^{1+\chi}}{1 + \chi} \right)^{1-\sigma}, \quad \sigma > 0, \chi > 0. \quad (5) \]

In this section, to ease up the exposition we take \( \eta = 0 \), so that instantaneous utility only depends on the instantaneous consumption.

We follow the Lucas timing. The asset market is open at the beginning of each period and the good market at the end of each period. At the beginning of period \( t \) the household is in the asset market with wealth \( W_{t-1} \), part of it he decides to maintain as cash to carry out transactions in period \( t \), \( M_t^h \), and the remaining, \( L_t \), he decides to deposit at the intermediary. Thus,

\[ L_t + M_t^h \leq W_{t-1} \quad (6) \]

\(^9\)We need to specify the functional form of the utility function as we will perform a numerical analysis later on. As we will see, the functional form chosen for the utility function is not determinant for the argument as if it was not for the monetary policy, a positive government consumption shock would crowd-out private consumption.
The household goes to period $t$’s good market with outstanding money balances, $M^h_t$, and outstanding deposits at the financial intermediary, $L_t$. The purchases of consumption goods have to be made with cash so that,

$$P_tC_t \leq M^h_t. \quad (7)$$

The household also invests $I_t$, receives the gross returns on the loans $R_tL_t$, receives the labor income, $W_tN_t$, where $W_t$ is the wage rate, receives the payment on the capital rented to firms, $r_tK_{t-1}$, where $K_{t-1}$ is the stock of capital, and pays taxes $T_t$. Thus, the cash holdings for the household at period $t$ are

$$W_t = M^h_t + W_tN_t + P_tr_tK_{t-1} - P_t(C_t + I_t) - T_t + R_tL_t. \quad (8)$$

The representative household maximizes (3) subject to (6), (7), and (8). Investment induces a law of motion for capital

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

Among the first order conditions we have,

$$-u_N(t) \quad u_C(t) = \frac{W_t}{R_tP_t},$$

$$u_C(t) \quad P_t = \beta R_t E_t \frac{u_C(t + 1)}{P_{t+1}},$$

$$E_t \frac{P_{t+1}}{R_{t+1}} (r_{t+1} + (1 - \delta)) = P_t,$$

The first condition is the standard intratemporal condition and the second condition is the standard intertemporal condition between two consecutive consumption levels. The last condition says that in expected value the return from investing must be equal to the return from depositing at the financial intermediary.
Firms:

The problem of the representative firm is to choose production in order to maximize profits. Since we assume that wages must be paid in advance, the profits are,

$$\Pi_t = P_t Y_t - W_t n_t - P_t r_t K_{t-1} - (R_t - 1) M^I_t,$$

where $Y_t$ is production, $M^I_t$ is the cash used to pay wages, and $n_t$ is hours of labor employed. The firm solves the problem

$$\max \Pi_t$$

subject to a Cobb-Douglas technology

$$Y_t \leq A_t n_t^{\alpha} K_{t-1}^{1-\alpha},$$

where $A_t$ is the level of technology, and subject to the cash-in-advance restriction

$$W_t n_t \leq M^I_t.$$

Among the first order conditions we have: an expression for the real wage

$$\frac{W_t}{P_t} = \frac{\alpha A_t n_t^{\alpha-1} K_{t-1}^{1-\alpha}}{R_t},$$

and an expression for the rental rate of capital

$$r_t = (1 - \alpha) A_t n_t^{\alpha} K_{t-1}^{-\alpha}.$$

Market clearing:

The clearing conditions for the deposits, good, labor and money markets are:

$$L_t + X_t = M^I_t = W_t n_t$$
\[ C_t + G_t + I_t = Y_t \]
\[ N_t = n_t \]
and
\[ M^S_t = M^f_t + M^h_t. \]

The clearing condition on the capital market does not need to be imposed as it was imposed already.

4 Fiscal shock transmission

In this section we analyze the mechanism by which changes in government spending affect the macroeconomic variables we are interested in. Towards this, the next subsection discusses a simpler model without investment where only the impact effect is considered. We show that if the interest rate is unchanged, then consumption is crowded out by the government spending shock. However, if the central bank follows a rule that responds to expected inflation then there will be deflation and consumption can be crowded in.

The remaining subsection considers the full model. The results are obtained through simulations of calibrated versions of model. We consider two calibrations one without habits and one with habits. We obtain the impulse responses of the calibrated versions of the model and compare them with the ones found in the "data". We conclude that there is a rough match of the two types of impulse responses. The two calibrated versions give similar results, except that the one with habits can produce a positive hump-shaped response of private consumption to the government consumption shock, like it is found in the "data", while the other version cannot.
4.1 The impact effect in a simpler model

In this subsection we study if the model has the potential to deliver on impact increases in private consumption, output and money, and decreases in interest rate and prices after a positive government consumption shock. In order to get more intuition we simplify the model in this subsection. We assume that production requires only labor, i.e. the production function is $A_t n_t^\alpha$, and that there is no investment. There are no shocks in the economy except for a temporary positive government spending shock that will occur just once at some unknown date. The shock occurs in period $T$, i.e. $G_T > G = G_t$, where $G$ is the government consumption steady state level, for $t < T$ and $t \geq T + 1$. The economy before the shock in period $T$ is in its deterministic steady state and as the shock is temporary it takes only one period to adjust. In period $T + 1$ the economy is back to the steady state.

In the steady state the growth rate of all variables is zero. The nominal interest rate is equal to the inverse of the discount factor, i.e. $R_t = \beta^{-1}$, and in the steady state there are neither inflation nor wage increases, i.e. $\frac{P_t}{P_{t-1}} = \frac{W_t}{W_{t-1}} = 1$. At all dates, the following equations are verified,

\[ \frac{W_t}{P_t} = \frac{\alpha A}{R_t N_t^{1-\alpha}} \]  \hspace{1cm} (11)

\[ N_t^{\chi+1-\alpha} = \frac{\alpha A}{R_t^2} \]  \hspace{1cm} (12)

and

\[ C_t = A N_t^\alpha - G_t. \]  \hspace{1cm} (13)

Equation (11) is the condition that the real wage must equal the marginal productivity of labor. Equation (12) is derived from the condition that equates the intratemporal marginal rate of substitution between leisure and consumption to the marginal rate of transformation. Equation (13) is a feasibility condition. It says that private consumption is equal total production.
minus government consumption.

We now concentrate on the effect of the shock on the variables of period \( T \). The relevant equations in period \( T \) to determine labor and consumption are equation (12) and equation (13) for period \( T \). First, we consider the case in which the central bank does not change the interest rate in reaction to the government shock.\(^{10}\) Then, \( N_T \) and \( N_{T+1} \) will remain constant according to (12). From (13) we obtain that \( C_T \) will decrease and \( C_{T+1} \) will be the steady state value for consumption. The household’s intertemporal condition

\[
\frac{u_C(T)}{P_T} = \beta R_T \frac{u_C(T+1)}{P_{T+1}} \tag{14}
\]

implies a lower inflation in period \( T + 1 \), i.e. \( \frac{P_{T+1}}{P_T} < 1 \), since \( u_C(T) > u_C(T+1) \). Thus, if the central bank would not react to the government shock, inflation next period and current consumption would decrease\(^{11}\). The impact on the real wage will depend on the parameters of the economy; we assume it will be zero by setting \( \chi = 1 - \alpha \).

Now, we assume that the central bank to maintain inflation stability is going to react to the shock and that only the real variables at date \( T \) will change. We show that according to the interest rate feed-back rule, (2) with \( \tau < 1 \), the nominal interest rate \( R_T \) must decrease. Loglinearization around the deterministic steady state of (14) gives,

\[
C \hat{C}_T - N^{1+\chi} \hat{N}_T = \frac{u_C}{u_{CC}} \left( 1 - \frac{1}{\tau} \right) \hat{R}_T, \tag{15}
\]

\(^{10}\)The utility function we use in this paper is also non-additively separable, but unlike Linnermann’s, Linnermann (2006), utility function, it cannot explain the puzzles unless monetary policy is present also. In our utility function the negative wealth effect over private consumption dominates if the central bank keeps the interest rate unchanged.

\(^{11}\)In this case output remains constant in response to the shock. This is entirely due to the functional form chosen for the preferences. The preferences chosen belong to a particular class of preferences, in which there are no income effects over the labor supply. For general preferences, the income effect of a positive government shock is negative, so that labor supply increases.
where a hat over any variable represents its growth rate. By loglinearizing around the deterministic steady state (12) and (13) we obtain respectively

\[ C\hat{C}_T = \alpha AN^\alpha \hat{N}_T - G\hat{G}_T, \]  

(16)

and

\[(\chi + 1 - \alpha) \hat{N}_T = -2\hat{R}_T. \]  

(17)

By putting together (15) and (16) we obtain

\[ \alpha AN^\alpha \hat{N}_T - G\hat{G}_T - N^{1+\chi} \hat{N}_T = \frac{u_C}{u_{CC}} \left( 1 - \frac{1}{\tau} \right) \hat{R}_T, \]  

(18)

By replacing (17) in (18) we get,

\[ \left( -\frac{\alpha AN^{-\chi}}{\chi} + \frac{N^\chi}{\chi} \right) N\hat{R}_T - \frac{u_C}{u_{CC}} \left( 1 - \frac{1}{\tau} \right) \hat{R}_T = G\hat{G}_T, \]

or using (12),

\[ \left[ \left( -1 + \frac{1}{\hat{R}_T^2} \right) \frac{\alpha AN^{1-\chi}}{\chi} - \frac{u_C}{u_{CC}} \left( 1 - \frac{1}{\tau} \right) \right] \hat{R}_T = G\hat{G}_T, \]  

(19)

The coefficient of \( \hat{R}_T \) in (19) is negative if \( \tau < 1 \). Thus, when \( G\hat{G}_T > 0 \) then \( \hat{R}_T < 0 \) and \( N_T \) will increase. From (13) when \( N_T \) increases more than \( G_T \) then \( C_T \) goes up. The demand for money \( \frac{M^l + M^h}{P_T} \) goes up because households make more transactions, firms make more payments and the opportunity cost of money, the nominal interest rate, decreases.

### 4.2 Numerical results

The question is whether there are empirically reasonable parameters that are able to deliver the impulse responses we "observe" in the data. Some of the parameters were calibrated using steady-state information, and other
parameters were set to values used or estimated in the literature. The values chosen for the parameters were the following: $\alpha = 2/3$, which is the steady state for the share of labor in the output, $\beta = 0.993$, which implies a quarterly steady state interest rate of 0.07% , $\chi = 0.5$, which is a relatively conservative value for the labor supply elasticity,$^{12}$ $\sigma = 1$, which is a value commonly taken for the intertemporal consumption elasticity of substitution, $\delta = 0.03$, which is an intermediate value for the depreciation rate as in the literature it can take values as low as 0.01 or as high as 0.05. The steady state values taken for the various expenditure shares were $C/Y = 0.6$, and $G/Y = I/Y = 0.2$. Instead of estimating the humped shaped response of the government expenditures to an unexpected shock, we followed Linnemann (2006) by considering a simple AR1 process for the government expenditures with a coefficient $\rho = .9$.

We decided to adopt a parsimonious approach concerning the interest rate rule. Our central bank decides according to equation (2), the nominal interest rate depends on the inflation expected in the next period. We decided for a coefficient close to one in equation (2), $\tau = .95$, that also guarantees determinacy of the equilibrium.

The conditions that describe the equilibrium were loglinearized and calibrated as explained above. The model was solved using Uhlig’s code contained in Uhlig (1995) and simulations were done in Matlab. We also used Dynare to check the results. Figure 2 contains the impulse responses of the main variables to a government spending shock in period 0. All variables are measured in percentage deviations from the steady state. We considered that the fiscal shock is a 2% change to the steady state government expenditure, which is similar to the one obtained in the VAR.

The graphs with a solid line contained in Figure 2 show that the model specifications without habits yield results that are not to far from the ones

$^{12}$The expression $1/\chi$ is the labor supply elasticity. Burstein et all (2006) chose $\chi = .25$, which implies a labor elasticity of 4. Normally, micro studies conclude for smaller labor supply elasticities.
obtained in the VAR. The area under them, i.e. the integral, as well as the extreme values of the responses, the maximum or the minimum, are comparable. For consumption the maximum response in the VAR is about 0.45% while in the model is 0.55%. The interest rate has a maximum response in the VAR of about 20 basis points while in the model the maximum response is of about 30 basis points. For the real wage, in the VAR we get a maximum response of about 0.06%, while in the model we get one of 0.05%, i.e. in both cases the real wage hardly moves. The maximum increase in output is of about 0.5% in the VAR, while in the model it is of about 0.45%. Prices decline in both cases. Moreover, in the model we also get that investment responds negatively as is reported in the literature.

The impulse responses of figure 1 and those with the solid line in figure 2 contrast in one aspect. In figure 2 all adjustments to the fiscal shock take place in a monotonic way over time.\textsuperscript{13} However, typically the impulse responses in the VARs are hump-shaped for most variables, like in figure 1. As others have done before, Christiano et al. (2005) and Linnermann (2006) we verified whether habit formation in consumption could improve the impulse response functions in that dimension. We use the formulation of Linnermann (2006) for the habit formation, which corresponds to (4) and is comparable to Christiano et al. (2005), with habit parameter $\eta = 0.5$. Since the rest of the model remains the same, all the equations that characterize the equilibrium are unchanged, except for the first order conditions of the household’s problem which change substantially. However, as the Blanchard-Khan (1980) were not satisfied we had to change one of the remaining parameters. We decided to change the one that would raise less objections, we decreased the labor supply elasticity, we set it to 1.5, $\chi = 1.5$. The impulse response functions of the various macroeconomic variables are shown by the broken lines in Figure 3. The results change very little. The only significant change hap-

\textsuperscript{13}In part this is due to the behavior assumed for the government expenditures. Had we assumed a more humped shaped behavior for the government expenditures, and we would probably get more variables behaving in that way too.
pens with consumption. Now, is more in line with the "empirical evidence", consumption responds in a hump-shaped way.

5 Final Remarks

Past researchers have obtained evidence that indicates that a government consumption shock does not decrease consumption and produces deflation. This evidence has been regarded as difficult to reconcile with the standard macroeconomic model. It has been thought that in the standard macroeconomic model a positive government consumption shock, no matter how it is financed, leads to smaller consumption and higher prices. The literature has a few explanations for that evidence, we offer a different one. Our explanation is motivated by economic theory. According to theory the central bank should use the instruments at its disposal to respond to shocks. In the context of a standard model with cash in advance restrictions, the monetary authority can counteract the effects of a positive government expenditure shock over prices by decreasing the interest rate.

We conduct a VAR analysis, as it is done in the literature, but with alternative variables and equations, for a longer time span that confirms that a government consumption shock raises private consumption and produces deflation, but also that the central bank reacts to the government consumption shock by increasing money supply and decreasing the interest rate. According to our model, the effect of the monetary policy over consumption is of the opposite sign and dominates the initial effect of the government consumption shock. The reaction of the central bank is taken as exogenous, but it is coherent with the objective alleged by many central banks of maintaining inflation stable. Ceteris paribus, the government shock brings deflation and to partially offset that effect, the central decreases the interest rate. The behavior of the central bank is in line with economic theory, which says that monetary policy must react to shocks in the economy. However, we do not
attempt to verify if the central bank’s reaction function is optimal.

In the "data" the impulse responses of the various variables to the government consumption shock show a high degree of persistence that would be nice to capture, but that our simple model does not get. We suspect that to capture that persistence of the variables it would be necessary to include additional frictions. That is the way it is done in the literature. We decided to leave that matter for a future research project.

Appendix

In this appendix we describe additional details of the VAR. The VAR can alternatively be represented by the structural form:

\[ A_0 Z_t = A(L) Z_{t-1} + e_t. \]  

(20)

where the structural shocks, \( e_t \), which are unobservable, are assumed to be mutually independent and related linearly to the one-step-ahead forecast errors, \( u_t \):

\[ u_t = D e_t, \quad E e_t e_t' = I. \]

The parameters of the structural form are therefore linked to those of the reduced form by:

\[ D = A_0^{-1}, \quad B(L) = A_0^{-1} A(L) \]  

(21)

where the first column of \( D \) is the object we need to identify uniquely in order to compute the impulse responses pertaining to a government consumption shock. Moreover, given (21),

\[ A_0^{-1} (A_0^{-1})' = V \]  

(22)

Let, for notational convenience, the vector of the VAR variables be re-written as:

\[ Z_t \equiv [G_t, M_t, X_t] \]  

(23)

where \( X_t \) includes all variables apart from government consumption and the
money supply. In this context, our identification strategy imposes not only that condition (22) be satisfied but also the following block-recursive structure to the matrix $A_0$:

$$A_0 = \begin{bmatrix}
  A_{0}^{1,1} & 0 & 0 \\
  (1 \times 1) & (1 \times 1) & (1 \times 6) \\
  A_{0}^{2,1} & A_{0}^{2,2} & 0 \\
  (1 \times 1) & (1 \times 1) & (1 \times 6) \\
  A_{0}^{3,1} & A_{0}^{3,2} & A_{0}^{3,3} \\
  (6 \times 1) & (6 \times 1) & (6 \times 6)
\end{bmatrix}$$

(24)

where $A_0$ is partitioned conformably with $Z_t$ in (23). The first row of $A_0$ reflects the assumption that government consumption is predetermined with respect to all other variables in the VAR. The second row reflects the assumption that the money supply is predetermined with respect to all other variables but government consumption. The absence of restrictions on the elements of the third row is just reflecting that we are not imposing any structure on the coefficients of the last six equations of our VAR. This means that the elements of the third row in (24) are not identified. That, however, does not constitute a problem for our purposes because the block-recursiveness implied by our identification strategy is enough to uniquely pin down the dynamic responses of all the variables to a government consumption shock.\(^{14}\)

It can be shown without any loss of generality that, first, the dynamic responses of the variables in $Z_t$ are uniquely identified if one adopts the normalization that $A_0$ is lower-triangular with positive diagonal elements and, second, that adopting that normalization, the dynamic responses are

\(^{14}\)The results do not change much if $M_t$ and $R_t$ interchange positions, i.e. if instead of having $M_t$ as the second element of $Z_t$ we have $R_t$ as the second element of $Z_t$ and $M_t$ as one more variable in $X_t$. Moreover, the results are robust to throwing out one of the two monetary variables from $Z_t$. That is, the main results still hold, if either we take out $R_t$ from the $X_t$ or if we do not consider $M_t$ in the regression and instead consider $R_t$ as the second element of $Z_t$.\)
invariant to an arbitrary change in the ordering of the variables in $X_t$.\textsuperscript{15} This implies that we can uniquely identify the impulse responses pertaining to a government consumption shock by setting $A_0$ equal to the inverse of the Choleski factor of the $V$ matrix,\textsuperscript{16} without worrying about the order in which the variables in $X_t$ appear in the reduced-form VAR.

References


\textsuperscript{15} Although the identification strategy pursued in this paper differs from the one discussed in Christiano, Eichenbaum and Evans (1999), the proof of the statements in this paragraph is analogous to the one presented in Christiano, Eichenbaum and Evans (1999) section 4.1. We, therefore, omit the proof to conserve on space.

\textsuperscript{16} Notice that, since the Choleski factor of $V$ is unique, this particular choice of $A_0$ corresponds to the unique lower-triangular matrix that satisfies our identification assumptions summarized in (22) and (24).
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