THE EFFECTS OF A GOVERNMENT CONSUMPTION SHOCK*

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1. INTRODUCTION

There are two puzzling results in the empirical literature. The first is that either private consumption is unchanged or rises in response to an unanticipated increase in government consumption. The second is that prices decline in response to the same shock. The behavior of consumption has deserved more attention than the behavior of prices. The behavior of consumption, although, consistent with the Keynesian multiplier theory, stands in stark contrast with the prediction of the standard real business cycle (RBC) model. That is because in the standard RBC model an increase in government consumption raises the present value of the stream of taxes over time which generates a negative wealth effect that brings down private consumption. This prediction of the RBC model is described in Christiano and Eichenbaum (1992) and Baxter and King (1993), among others. The behavior of prices is even more difficult to explain since with the shock, aggregate demand increases more than aggregate supply. This pushes up prices.

A few explanations have been proposed for the behavior of private consumption but none for the behavior of the prices. To explain the behavior of consumption researchers were led to search for features that could be introduced in the standard RBC model in order to account for the empirical finding that private consumption responds positively to fiscal spending shocks. The few existing explanations are very intricate. Rather than using a complex model, full of frictions, to explain the apparent puzzles what we propose in this paper is a simple RBC model without capital but with three added features. All these features are empirically relevant. First, we give money a role in transactions by introducing cash-in-advance constraints for the agents, as in Lucas and Stockey (1987). Second, we assume that monetary policy has a liquidity effect like in Fuerst (1992) and Lucas (1990). Third, we suppose that the monetary authority reacts to government consumption innovations.

The first modification places the interest rate in the consumption-leisure margin. This gives the monetary policy additional power to influence the economy. The second assumption makes the monetary policy non-neutral. As agents choose their portfolio of assets in advance, unexpected changes in the money supply change the interest rate. The third assumption allows the monetary policy to react to shocks in the economy, in particular to government consumption shocks. Theory shows that monetary policy improves economic performance if it is used to respond to shocks.

It has been thought that there cannot be a positive response in private consumption to government consumption shocks as long as monetary policy is conducted in a reasonable manner. The common wisdom has been that the reasonable monetary policy will amplify the private consumption response. 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. To obtain the reverse result it would be necessary that the monetary

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policy be specified so that the central bank would react by increasing the money supply in response to a government consumption shock. In doing that the central bank would be, due to the rigidity in the adjustment of portfolios, varying the interest rate, decreasing it.

In the context of a simple RBC model with a cash in advance constraint for private consumption, a positive government consumption shock has a negative income effect that decreases both consumption and leisure. If money supply is unchanged, from the cash in advance constraint we obtain that the price level must increase. An active central bank that has as one of its main objectives to maintain price stability will react to this shock by using the instruments at its disposal to counteract the effects of this shock over the prices. In the context of our model in order for the prices to decrease the central bank must decrease the interest rate.

Since we do not have any a priori or any hard evidence on how the central bank reacts to a government consumption shock, we take this matter to the data by conducting our own empirical analysis in a structural VAR framework. We allow the monetary policy to react contemporaneously to the government consumption shock and to all past variables. It is important to allow the monetary policy to react contemporaneously to the shock because, otherwise the central bank will not be able to counteract the effect of the shock over the current prices. As it turns out, we estimate that a positive government consumption shock triggers an accommodating reaction by the monetary authorities, the real money supply rises and the nominal interest rate decreases. In the context of our model, that affects the consumption-leisure margin in such a way that an increase in private consumption and a decrease in leisure of private individuals is possible. As a consequence output goes up. Moreover, the interest rate reaction to the shock has an effect over the price level that is of the opposite sign to the one generated by the government shock, prices drop. This explains why a central bank that has the incumbency of maintaining price stability might want to have an expansionary policy in response to a positive government shock.

The rest of the paper is organized as follows. Section 2 presents the results in the literature, section 3 describes the empirical evidence obtained by us, section 4 explains the effects of the government shock in the context of the model and section 5 concludes. In the end there are two appendices that give additional details of the empirical results and of the model.

2. LITERATURE

As already referred much of the evidence in the literature concerns the behavior of consumption. Evidence about prices can be obtained from Edelberg, Eichenbaum and Fisher (1999), Fatás and Mihov (2001) and Mountford and Uhlig (2002). They find a negative response of prices to the government shock. The evidence on private consumption suggests that either private consumption is unchanged or rises in response to an unanticipated increase in government consumption. Some of the evidence is obtained from structural vector autoregressive (VAR) models. Blanchard and Perotti (2002), Fatás and Mihov (2001) and Gali et al (2004) identify exogenous shocks to government consumption by assuming that this variable is predetermined with respect to the other variables. They find that private consumption rises significantly and persistently after an unanticipated increase in government purchases. In the same methodological vein, Perotti (2004) finds that this result is pretty robust to a sample of five OECD countries. Mountford and Uhlig (2002) employing a different identification method obtain similar results.

There is also other type of evidence, besides that obtained from VARs. 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. Others, like Edelberg, Eichenbaum and Fisher (1999), and Burnside, Eichenbaum and Fisher (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.[1] Edelberg, Eichenbaum and Fisher (1999) find a small and delayed fall in the consumption of nondurables and services, though durables consumption increases on impact. Burnside, Eichenbaum and Fisher (2003) find a flat response of aggregate consumption in the short run, followed by a small (and insignificant) rise in that variable several quarters after the shock.

Researchers either have not been able or have not been willing to explain the behavior of prices, but there have been attempts to understand the behavior of consumption. As the standard RBC model is not able to explain the behavior consumption, researchers were led to search for features that could be introduced in the standard RBC model in order to account for the empirical finding that private consumption responds positively to fiscal spending shocks. Linnemann and Schabert (2003) consider a sticky price 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. Devereux, Head and Lapham (1996) have a production function of the final good with constant returns on the quantity employed of intermediate goods but increasing returns to an expansion of variety, holding constant the quantity employed of each intermediate good. An increase in government consumption will create an opportunity for profits, inducing more firms to enter which will increase the variety of intermediate goods produced. If the degree of increasing returns is sufficiently high the real wage will increase as well as private consumption. The negative wealth effect of increased taxation on households is more than offset by the increase in factor productivity due to the entry of new firms. Gali, Lopez-Salido and Valles (2004) offers an explanation for the effects over private consumption of a government spending shock financed by a deficit rather than current taxes. They modify substantially the RBC model by including non-Ricardian rule-of-thumb consumers, which are consumers that consume all their available disposable income in each period, and by assuming that employment is determined by firms alone. The labor market assumption is there to make real wages increase significantly so that the wage income of the rule-of-thumb consumers goes up after the shock. The rule-of-thumb consumers are necessary to ensure that private consumption does not drop after a government consumption shock because of the wealth effect.

3. EMPIRICAL EVIDENCE

In this section we describe our 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. Moreover, we include the variables money and interest rate in order to test empirically the predictions of our model.

3.1. 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 macroeco-

(1) Rotemberg and Woodford (1992) consider an autoregressive model where innovations in military spending are treated as an exogenous shock that is uncorrelated with any other shocks. They obtain that the responses of output, hours and real wage to a military spending shock are positive.

nomic 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. 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, we also impose the supplementary identifying restriction that money supply reacts contemporaneously only to shocks to itself and to government consumption. The reason for imposing that the money supply reacts contemporaneously only to government consumption is to ensure that the response, on impact, of money to a government consumption shock is being driven by that shock directly and not indirectly through the dynamic response of the remaining variables in the VAR.

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

$$Z_t = \eta + B(L)Z_{t-1} + u_t, Eu_t u_t^{'} = V \qquad (1)$$

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 variables 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. η is a vector of constants, $B(L)$ 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.

3.2. 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 the same definitions of government consumption and revenue as Blanchard and Perotti (2002). For government consumption (G) we took the item real government consumption 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 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 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.

3.3. 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.

All variables are measured in percentage deviations from the base line, 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.

The shock induces a significant and protracted rise in both government consumption and real GDP. The government consumption multiplier on real GDP was estimated to be of 0.7 and 1.5 after one and two years, respectively[2], values that are in line with Blanchard and Perotti (2002) and Gali et al (2004). The results of figure 1 are compatible with the monetary authority accommodating the government consumption shock by raising the money supply and decreasing the nominal interest rate. We do observe the puzzle reported in the literature, private consumption going up with the government consumption shock. Finally, the response of prices to a government consumption shock is negative. The deflation rate is bigger after the shock and converges to zero.[3]

4. THE GOVERNMENT SHOCK

In this section we propose a dynamic general equilibrium model which is described in more detail in appendix 2. We study whether the model can replicate the impulse responses obtained in the VAR and shown in Figure 1. We are interested in knowing if the model can deliver increases in private consumption, output and money and decreases in interest rate and prices after a positive government consumption shock. We assume that the economy is in its deterministic steady state when it receives a positive temporary government shock and the central bank responds by increasing the money supply.

The model is a dynamic general equilibrium model with two cash in advance restrictions, one for the households and one for the firms, with a friction to deliver money non-neutrality and without capital. The friction considered is sticky portfolios. Government levies lump-sum taxes, injects money and makes consumption expenditures. Households maximize expected utility $U = E_0\left\{\sum_{t=0}^{\infty} \beta^t u(C_t, 1-N_t)\right\}$ where β is a discount factor, C_t is consumption, $1-N_t$ is leisure and N_t is hours of work. We simplify the exposition by taking a particular utility function, $u(C_t, N_t) = \frac{1}{1-\sigma}\left(C_t - \frac{(N_t)^{1+\chi}}{1+\chi}\right)^{1-\sigma}$, $\sigma > 0, \chi > 0$. Firms maximize profits. The production function is $Y_t = AN_t, A > 0$. All markets clear.

As the only friction present in the model economy is that the portfolios must be chosen one period in advance, the economy is only one period outside the steady state. In order to get the persistence that the responses show in the VAR and graphically represented in Figure 1 it would be necessary to include additional frictions.[4] Instead of following that route we opted for the less realistic, but perhaps

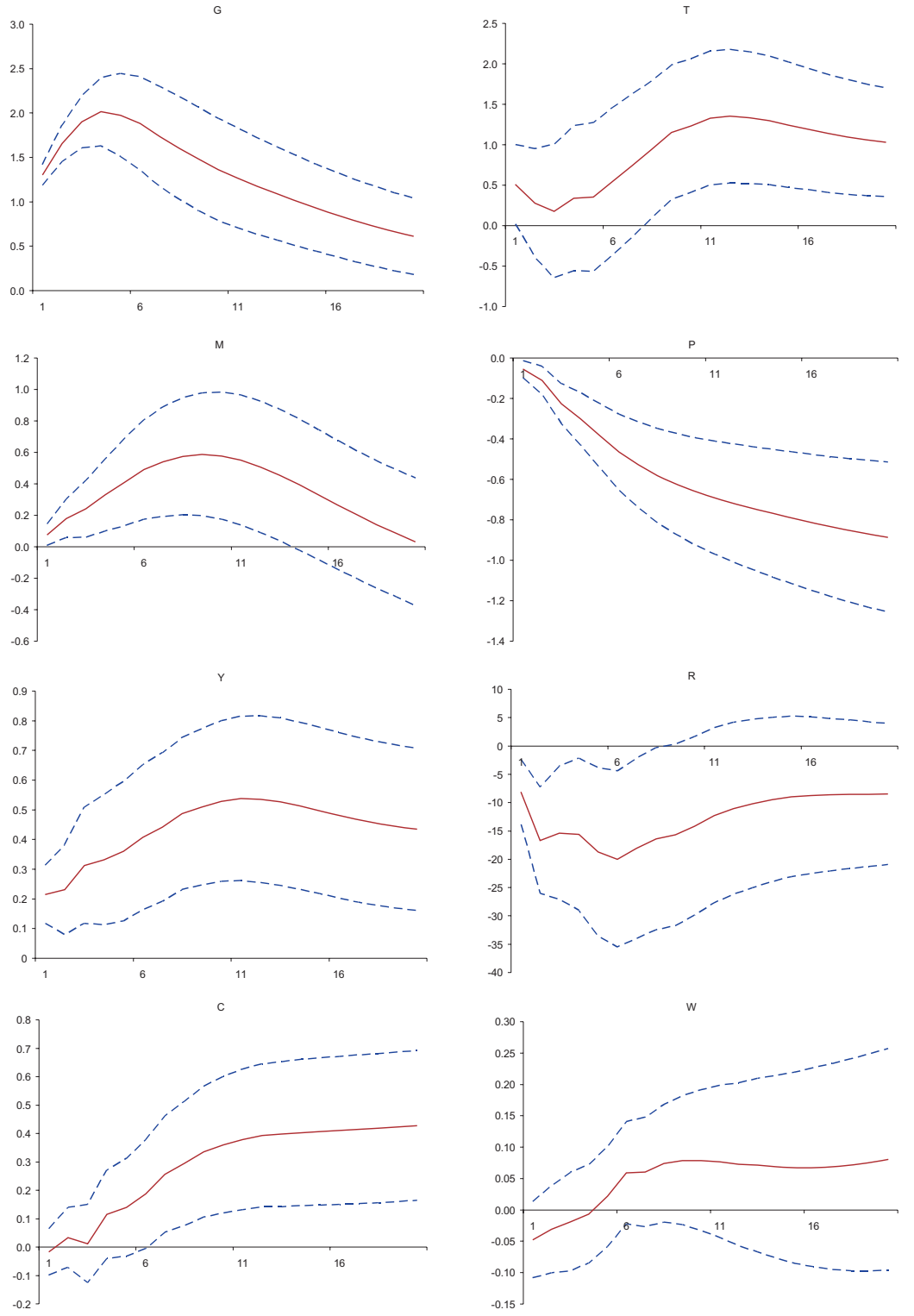
(2) In these calculations we used the sample mean of the share of *G* in *Y*, which is around 23%.

(3) The estimated effect over consumption is larger than the one obtained by Christiano *et.al.*(2005)for a monetary policy shock.The real wage increases after a few periods but it is not statistically significant. According to the model presented in section 4 the real wage should increase after the shock.

(4) For instance Gali *et al* (2004) are able to obtain persistence but need various frictions: monopolistic competition in the production of intermediate goods, Calvo price setting, a monetary policy rule, a special rule for tax-setting, a special labor market assumption consistent with countercyclical mark-ups and investment adjustment costs.

Figure 1

IMPULSE RESPONSES TO A GOVERNMENT CONSUMPTION SHOCK



more instructive one, of considering a simple economy that is able to deliver the impact responses of private consumption and prices observed in the data after a government consumption shock.

The shock occurs in period T. The economy before the shock in period T is in its deterministic steady state and as 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 money is zero, i.e. $\frac{M_t^S}{M_{t-1}^S} = 1$ for $t < T$ and $t \geq T+1$. The deterministic steady state for $t < T$ and for $t \geq T$ is characterized by the following equations,

$$R_t = \beta^{-1} \tag{2}$$

$$\frac{W_t}{P_t} = \frac{A}{R_t} \tag{3}$$

$$N_t^{\chi} = \frac{A}{R_t^2} \tag{4}$$

$$C_t = AN_t - G_t \tag{5}$$

and

$$\frac{P_t}{P_{t-1}} = \frac{W_t}{W_{t-1}} = 1 \tag{6}$$

Equation (2) says that in the steady state the nominal interest rate, R_t is equal to the inverse of the discount factor. Equation (3) is the condition that the real wage must equal the marginal productivity of labor. Equation (4) is derived from the condition that equates the intratemporal marginal rate of substitution between leisure and consumption to the marginal rate of transformation. Equation (5) is a feasibility condition. It says that private consumption is equal total production minus government consumption. Finally, equation (6) reflects the fact that in the steady state there is neither inflation nor wage increases.

We now concentrate on the effect of the shock on the variables of period T. The relevant equations in period T to determine the evolution of prices, output and consumption are the cash in advance constraint for the households

$$P_T C_T = M_T^S \tag{7}$$

and equations (4) and (5) for period T. First, we consider the case in which the central bank does not react to the government shock. The N_T would remain constant according to (4), C_T would decrease from (5) and P_T would increase by (7). Thus, if the central bank would not react to the government shock prices would increase and consumption would decrease.[5]

Now we assume that the central bank to maintain price stability is going to react to the shock. It can be seen from (4) that if the value for χ is sufficiently small then when R_T decreases, N_T will increase substantially and more than G_T. From (5) when N_T increases more than G_T then C_T goes up.

It is trivial to show that the price level may go down in period T. The price level is given by (7).The P_T will fall if C_T increases by more than M_T^S. It is clear from (5) that in order for that to happen the output, AN_T, must respond strongly to the shock in G_T.

(5) 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.

Finally, the intuition for the negative relationship between interest rate and money supply is simple. Agents are willing to accept more money only if its opportunity cost, which is the nominal interest rate, goes down. A formal proof of this is given in appendix 2.

5. FINAL REMARKS

Past researchers have obtained evidence that indicates that a government consumption shock raises output, does not decrease consumption and decreases prices. This evidence is difficult to reconcile with the standard RBC model. In the standard RBC model a positive government consumption, no matter how it is financed, leads to smaller consumption and higher prices. The literature has a few explanations for that, we offer a different one. Our explanation was 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 an RBC model with a cash in advance and sticky portfolios the monetary authority can counteract the effects of a positive government shock by increasing money supply.

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 output and private consumption, but also that the central bank reacts to the government consumption shock by increasing money supply and decreasing the interest rate. The effect of the monetary policy over consumption is of the opposite sign and dominates the initial effect of the government consumption shock. A RBC model with portfolios chosen in advance is used to argue that this type of reaction by the central bank can explain the behavior of consumption after a 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 the price level up and to offset that effect the central practices an expansionary policy. 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.

The impulse responses of the various variables to the government consumption shock show a high degree of persistence that our simple model does not capture. To capture that persistence of the variables it would be necessary to include various type of frictions. That is the way it is done in the literature. We decided that, at this time, it was not worthwhile to complicate the model so that it could satisfy this feature of the evidence.

APPENDIX 1

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

$$A_0 Z_t = A(L) Z_{T-1} + e_t. \tag{8}$$

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:

$$u_t = De_t \quad Ee_t e_t^{'} = I$$

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

$$D = A_0^{-1}, \quad B(L) = A_0^{-1} A(L) \tag{9}$$

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 (9),

$$A_0^{-1}\left(A_0^{-1}\right)' = V \tag{10}$$

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

$$Z_t \equiv \left[G_t, M_t, X_t\right] \tag{11}$$

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 (10) be satisfied but also the following block-recursive structure to the matrix A_0:

$$A_0 = \begin{bmatrix} \underbrace{A_0^{1,1}}_{(1\times 1)} & \underbrace{0}_{(1\times 1)} & \underbrace{0}_{(1\times 6)} \\ \underbrace{A_0^{2,1}}_{(1\times 1)} & \underbrace{A_0^{2,2}}_{(1\times 1)} & \underbrace{0}_{(1\times 6)} \\ \underbrace{A_0^{3,1}}_{(6\times 1)} & \underbrace{A_0^{3,2}}_{(6\times 1)} & \underbrace{A_0^{3,3}}_{(6\times 6)} \end{bmatrix} \tag{12}$$

where A_0 is partitioned conformably with Z_t in (11). 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 (12) 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.

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 invariant to an arbitrary change in the ordering of the variables in X_t.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, without worrying about the order in which the variables in X_t appear in the reduced-form VAR.

APPENDIX 2

Here we present in detail the simple model economy that we use, similar in structure to Christiano, Eichenbaum and Evans (1995), 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. There are shocks in the economy. The history of these shocks up to 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 K_t to the representative financial intermediary at each date $t = 0, 1, 2, ...$ The money supply evolves according to $M_t^s = M_{t-1}^s + K_t$. The central bank reacts to the government consumption shock. Positive innovations in public consumption are met with contemporaneous increases in money supply.

- 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 K_t. In order to maximize profits the financial intermediary chooses $M_t^f = L_t + K_t$.

- Households:

The preferences of the representative household are described by the expected utility function:

$$U = E_0\left\{\sum_{t=0}^{\infty}\beta^t u\left(C_t, 1-N_t\right)\right\} \tag{13}$$

where β is a discount factor, C_t is consumption, $1-N_t$ is leisure and N_t is hours of work.

The good market is open at the beginning of each period and the asset market at the end of each period. At the end of period $t-1$ the household is in the asset market with wealth $\mathcal{W}_{t-1}$, 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,

$$L_t + M_t^h \leq \mathcal{W}_{t-1} \tag{14}$$

The household starts period t with outstanding money balances, M_t^h, and outstanding deposits at the financial intermediary, L_t. The household receives the labor income, W_tN_t, where W_t is the wage rate. The labor income is paid in advance and can be used to purchase consumption in the same period. The purchases of consumption goods are such that,

$$P_tC_T \leq M_t^h + W_tN_t. \tag{15}$$

At the end of the period, the household receives the gross returns on the loans R_tL_t and pays taxes T_t. Thus the cash holdings for the household at period t are

$$\mathcal{W}_t = M_t^h + W_tN_t - P_tC_t - T_t + R_tL_t \tag{16}$$

The representative household maximizes (13) subject to (14), (15), (16) and the requirement that portfolios must be chosen one period in advance.

Among the first order conditions we have,

$$E_t\frac{R_{t+1}u_{1-N}(t+1)}{W_{t+1}} = E_t\frac{u_C(t+1)}{P_{t+1}}$$

and

$$\frac{u_{1-N}(t)}{W_t} = \beta E_t \frac{R_{t+1} u_{1-N}(t+1)}{W_{t+1}}$$

The first condition is the standard intratemporal condition in expected value, since the household must decide his portfolio in advance. The second condition is the standard intertemporal condition between two consecutive leisure levels.

- Firms:

The problem of the representative firm is to choose production in order to maximize profits. The profits are,

$$\Pi_t = P_t Y_t - W_t n_t - (R_t - 1) M_t^f,$$

where Y_t is production and n_t is hours of labor employed. The firm solves the problem

$$\max \Pi_t$$

subject to the linear technology

$$Y_t \leq A_t n_t,$$

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

$$W_t n_t \leq M_t^f$$

A first order condition of this problem is the standard expression for the real wage

$$\frac{W_t}{P_t} = \frac{A_t}{R_t}. \qquad (17)$$

- Market clearing:

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

$$L_t + K_t = M_t^f = W_t n_t$$

$$C_t + G_t = Y_t$$

$$N_t = n_t$$

and

$$M_t^S = M_t^f + M_t^h$$

- Interest rate and money relationship:

Finally, we verify that the decrease in the interest rate, R_T can only be attained through an injection of money, K_T. Using the various market clearing conditions and cash in advance constraints we can write

$$\frac{M_T^h + W_T N_T}{K_T + L_T} = \frac{M_T^h}{K_T + L_T} + 1 = \frac{P_T C_T}{W_T + N_T} = \frac{R_T}{A_T} \frac{A_T N_T - G_T}{N_T} = R_T \left(1 - \frac{G_T}{AN_T}\right).$$

$$= R_T \left(1 - \frac{G_T}{A\left(\frac{A}{R_T^2}\right)^{\frac{1}{\chi}}} \right) = R_T - \frac{G_T}{R_T^{\frac{2}{\chi}-1} A^{1+\frac{1}{\chi}}}.$$

Since R_T decreases and $\frac{G_T}{R_T^{\frac{2}{\chi}-1} A^{1+\frac{1}{\chi}}}$ increases then the ratio $\frac{M_T^h}{K_T + L_T}$ goes down. Thus, K_T must go up since M_T^h and L_T were chosen in advance.

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