Understanding the Effects of Government Spending on Consumption

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Abstract

Recent evidence on the effects of an exogenous increase in government spending on consumption cannot be easily reconciled with existing optimizing business cycle models. We develop a simple dynamic model where the interaction of rule-of-thumb consumers and staggered price setting in goods markets can potentially account for that evidence.

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1 Introduction

What are the effects of changes in government spending on aggregate economic activity ? How are those effects transmitted? Even though such questions are central to macroeconomics and its ability to inform economic policy, there is no widespread agreement on their answer, either at the empirical or at the theoretical levels.

The debate on the effectiveness of fiscal policy is often expressed in terms of the size of the "fiscal multiplier," i.e. the quantitative effect on aggregate output of a unit increase in government purchases or, more formally, the value of the derivative $\frac{dY_t}{dG_t}$. As a matter of accounting, the size of the multiplier will depend on the response of consumption, investment and other components of aggregate demand to the increase in government spending. That response, and its pattern over time, will generally depend on several features of the economy, as well on the details of the fiscal intervention analyzed. In particular, it is likely to depend on the kind of frictions present in the economy, the persistence of the shock, its impact on taxes or debt, and any possible direct effect on productivity or utility.

Though most macroeconomic models imply a positive fiscal multiplier, i.e. $\frac{dY_t}{dG_t} > 0$, they often differ regarding the effects of government spending on consumption, the largest component of aggregate demand and, hence, a key determinant of the eventual impact of the policy intervention. In that regard, the textbook IS-LM model and the standard RBC model provide a stark example of such differential qualitative predictions.

Thus, the standard RBC model generally predicts a decline in consumption in response to a rise in government spending.[1] In a nutshell, an increase in (non-productive) government purchases (financed by current or future lump-sum taxes) has a negative wealth effect which induces a rise in the quantity of labor supplied at any given wage. That effect leads, in equilibrium, to a lower real wage, higher employ-

[1] The mechanisms underlying those effects are described in detail in Aiyagari et al. (1990), Baxter and King (1993), and Christiano and Eichenbaum (1992), among others.

ment and higher output. The increase in employment leads, if sufficiently persistent, to a rise in the expected return to capital, and may trigger a rise in investment. In the latter case the size of the multiplier is greater or less than one depending on parameter values.[2]

On the other hand, the basic textbook IS-LM model predicts the opposite effect, namely, an increase in consumption (and a decline in investment) as a result of an increase in government spending.[3] The rise in consumption is caused by the higher disposable income generated from the direct effect of government spending on the level of economic activity, combined with the assumed dependence of consumption on current disposable income.[4] That response has the opposite sign to the one implied by the neoclassical model, and will tend to amplify the effects of the expansion in government spending on output, thereby increasing the effectiveness of fiscal policy as a policy tool.[5]

What does the existing empirical evidence say regarding the consumption effects of changes in government purchases? Can it help discriminate between the two paradigms mentioned above, on the grounds of the observed response of consumption? A number of recent empirical papers aim at shedding some light on those questions. They all apply multivariate time series methods in order to estimate the responses of consumption and a number of other variables to an exogenous increase in government spending. They differ, however, on the assumptions made in order to identify

[2] The expansionary effect of increases in government spending will crucially depend on the responses labor, and so on labor supply elasticity (see, for instance, Fatás and Mihov (2001)). In general, the higher the labor supply elasticity the higher the responses of hours which in turn favours investment increases.

[3] See, e.g., Blanchard (2001).

[4] In the textbook model, in order for the change in consumption to be strictly positive, part of the increase in spending should be be financed with a current deficit.

[5] The effect on output will also depend on the investment response. Under the assumption of a constant money supply, generally maintained in textbook versions of that model, that rise in consumption is accompanied by an investment decline (resulting from a higher interest rate). If one assumes instead that the central bank holds the interest rate steady in the face of the increase in government spending, the implied effect on investment is nil. However, any "intermediate" response of the central bank (i.e., one that does not imply full accommodation of the higher money demand induced by the rise in output) will also induce a fall in investment.

the exogenous component of that variable. In Section 2 we describe in some detail the findings from that literature that are most relevant to our purposes, and provide some new empirical results of our own. In particular, and like several other authors that preceded us, we find that fiscal expansions lead to a significant increase in consumption, while investment either falls or does not respond significantly to an increase in government spending. Thus, our evidence seems to be more consistent with the predictions of IS-LM type models than with those of the neoclassical paradigm.

After reviewing and supplementing the existing evidence, we turn to our paper's main contribution: the development of a simple dynamic general equilibrium model that can potentially account for that evidence. Our framework shares many ingredients with recent dynamic optimizing sticky price models,[6] though we modify the latter by assuming the presence of rule-of-thumb consumers (who do not borrow or save, consuming their wage instead), in coexistence with conventional infinite-horizon optimizing consumers. The model setup and the derivation of its equilibrium dynamics is presented in Section 3. In section 4. we analyze the implications of the interaction between rule-of-thumb consumers and staggered price setting in goods markets for the response of consumption and investment to a government spending shock. In particular, we show how under certain assumptions, our calibrated model can potentially account for the positive response of consumption to an increase in government spending .

Section 6 summarizes the main findings of the paper and points to potential extensions and directions for further research.

2 The Evidence

In the present section we summarize the existing evidence on the responses of consumption, investment and other variables to an exogenous increase in government spending, and provide some new evidence of our own. Most of the existence evi-

[6] Rotemberg and Woodford (1999), Clarida, Gali and Gertler (1999), or Woodford (2001).

dence relies on structural vector autoregressive models, with different papers using alternative identification schemes.

Blanchard and Perotti (2002) and Fatás and Mihov (2001) identify exogenous shocks to government spending by assuming that the latter variable is predetermined relative to the other variables included in their VAR. Their most relevant findings for our purposes can be summarized as follows. First, a positive shock to government spending leads to a persistent rise in that variable. Second, the implied fiscal expansion generates a positive response in output, with the implied multiplier being greater than one in Fatás and Mihov (2001), but close to one in Blanchard and Perotti (2002). Third, in both papers the fiscal expansion leads to large (and significant) increases in consumption. Fourth, the response of investment to the spending shock is found to be insignificant in Fatás and Mihov (2001), but negative (and significant) in Blanchard and Perotti (2002). Perotti (2002) extends the methodology of Blanchard and Perotti (2002) to data for the U.K., Germany, Canada and Australia, with findings qualitatively similar to the ones obtained for the U.S. regarding the response of consumption (positive) and investment (negative) to an exogenous increase in government spending.

In related work, Mountford and Uhlig (2002) apply the agnostic identification procedure originally proposed in Uhlig (1997) (based on sign and near-zero restrictions on impulse responses) to identify and estimate the effects of a "balanced budget" and a "deficit spending shock." As in Blanchard and Perotti (2002) and Fatás and Mihov (2001), Mountford and Uhlig (2000) find that government spending shocks crowd out both residential and non-residential investment, but do not reduce consumption.

Overall, we view the evidence discussed as to tend to favor the predictions of the Keynesian model, over those of the Neoclassical model (though see below for discrepant results based on alternative identification schemes). In order to assess the robustness of the above findings, here we provide some new evidence using an identification scheme originally proposed by Rotemberg and Woodford (1992). In particular we estimate the response of different macro variables to an innovation in the military component of government spending, arguably the one for which the assumption of predeterminedness may be less stringent. We use quarterly U.S. data for 1954:I-1999:IV, drawn from the DRI database. Our baseline VAR includes military spending (GGFENQ), government spending (federal, state and local, GGFEQ+GGSEQ), output (GDPQ), hours (LPMHU), real interest rates -computed as the nominal rate (FYGM) minus current inflation based on the GDP deflator (GDPD)- and a fifth changing variable. For the latter we consider, in turn, GDP deflator inflation (GDPD), the real wage (LBCPU/GDPD), consumption of nondurable and services (GCNQ+GCSQ), and non-residential investment (NRIPDC1). The military spending variable is the real consumption expenditures and gross investment in national defense. All quantity variables are in log levels, and normalized by the size of the population of working age (P16). We included four lags of each variable in the VAR.

Figure 1(a) displays our main findings. Total government spending rises significantly and persistently, with a half-life of about 3 years. Consumption rises on impact and remains significantly above zero for more than two years. By contrast investment falls slightly with a delayed effect. Notice that under this identification the maximum effects of output and its demand components are not on impact and appear lagged by two to five quarters.

The government spending multiplier on output resulting from an exogenous shock to military spending is 1.33 in the first period, with a maximum of 2.16 reached on the second quarter. If the multiplier is calculated from the response to an exogenous shock in total government spending that magnitude is 1 in the first quarter and 1.4 in the second one. Thus, our estimated multiplier effects are of a magnitude similar to the ones reported by Blanchard and Perotti (2002).[7]

With respect to the labor variables, both hours worked and real wages rise sig-

[7] To calculate the multiplier effect we use the fact that the ratio of military spending to output is 6 percent and that the ratio of government spending to output is 20 percent, according to data for the nineties.

nificantly during the first four quarters, following a hump-shaped pattern Moreover, given the response of labor productivity, the rise in real wages is not enough to generate a delayed fall in the price markup, followed by a subsequent recovery into positive territory. A significant rise on real wages in response to a spending shock was also found in Fatas and Mihov (2001) when measured as compensation per hour in the non-farm business sector.

Most of the previous qualitative results are robust to the use of total government purchases (instead of military spending only) as a predetermined variable in the VAR, as shown in Figure 1(b). Other robustness exercises included the inclusion of net taxes. We also experimented with VARs in which variables that are possibly non-stationary are entered in first-differences. The results in terms of the short-run effects and the multipliers were not affected (though the government spending response was much more persistent.)

As noted above, we also find it necessary to mention here the existence of a branch of the literature on the effects of fiscal policy shocks which has produced some evidence which is, in several important dimensions, at odds with the previous findings and the literature referred to above. The key defining feature of the discrepant papers is the use of a dummy variable to indicate the beginning of military build-up episodes, as defined by Ramey and Shapiro (1998). For example, Edelberg, Eichenbaum and Fisher (1999) have shown that after a rise in government purchases, as defined by these dummies, there is fall in real wages independently of the measure used for labor compensation. Furthermore, consumption of nondurables and services falls after a delay (though durables consumption increases on impact), while nonresidential investment increases. An analysis of the reasons for those differences lies beyond the scope of this paper.

3 A New Keynesian Model with Rule-of-Thumb Consumers

The economy consists of two types of households, a continuum of firms producing differentiated intermediate goods, a perfectly competitive final goods firm, and a monetary and a fiscal authority. Next we describe their objectives and constraints.

3.1 Households

We assume a continuum of infinitely-lived households, indexed by $i \in [0,1]$. A fraction $1-\lambda$ of households have access to capital markets where they can trade a full set of contingent securities, and buy and sell physical capital (which they accumulate and rent out to firms). We use the term *optimizing* as a qualifier to refer to that subset of households. The remaining fraction λ of households do not own any assets, and just consume their labor income flow. We refer to them as "*rule of thumb*" (ROT) consumers. Different interpretations of the latter include: myopia, lack of access to capital markets, fear of saving, ignorance of intertemporal trading opportunities, etc. Campbell and Mankiw (1989) provide some evidence, based on estimates of a modified Euler equation, of the quantitative importance of ROT consumers in the U.S. and other industrialized economies.

3.1.1 Optimizing Households

Let C_t^o, and N_t^o represent consumption and hours of work for optimizing households. Preferences are defined by the discount factor $\beta \in (0,1)$ and the period utility $U(C_t^o, N_t^o)$. Optimizing households seek to maximize

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

subject to the sequence of budget constraints

$$P_t \, (C_t^o + I_t^o) + E_t\{\Lambda_{t,t+1} D_{t+1}\} = W_t \, N_t^o + R_t^k \, K_t^o + D_t - T_t \tag{2}$$

and the capital accumulation equation

$$K_{t+1}^o = (1-\delta)\ K_t^o + \phi\left(\frac{I_t^o}{K_t^o}\right)\ K_t^o \tag{3}$$

Hence, at the beginning of the period the consumer receives labor income $W_t N_t^o$ (where W_t denotes the nominal wage), and income from renting his capital holdings K_t^o to firms at the (nominal) rental cost R_t^k. D_t denotes the (gross) payoff from the portfolio carried over from period $t-1$ (including shares in firms) and T_t.lump-sum taxes (or transfers, if negative). $P_t I_t^o$ denotes expenditures on capital goods. Capital adjustment costs are introduced through a the term $\phi\left(\frac{I_t^o}{K_t^o}\right)\ K_t^o$, which determines the change in the capital stock induced by investment spending I_t^o. We assume $\phi' > 0$, and $\phi'' < 0$, with $\phi'(\delta) = 1$, and $\phi(\delta) = \delta$.

In what follows we specialize the period utility to take the form:

$$U(C_t^o, N_t^o) = \log C_t^o - \frac{(N_t^o)^{1+\varphi}}{1+\varphi}$$

where $\varphi \geq 0$ represents the elasticity of the marginal disutility of labor.

The first order conditions for the optimizing consumer's problem are:

$$C_t^o\ (N_t^o)^{\varphi} = \frac{W_t}{P_t} \tag{4}$$

$$1 = \beta R_t\ E_t\left\{\frac{C_t^o}{C_{t+1}^o}\frac{P_t}{P_{t+1}}\right\} \tag{5}$$

$$Q_t = \beta\ E_t\left\{\left(\frac{C_t^o}{C_{t+1}^o}\right)\left[\frac{R_{t+1}^k}{P_{t+1}} + Q_{t+1}\left((1-\delta) + \phi_{t+1} - \left(\frac{I_{t+1}^o}{K_{t+1}^o}\right)\ \phi_{t+1}'\right)\right]\right\} \tag{6}$$

where $Q_t \equiv \left[\phi'(\frac{I_t^o}{K_t^o})\right]^{-1}$ is the shadow value of capital in place (Tobin's Q). Notice that, under our assumption on ϕ, the elasticity of the investment-capital ratio with respect to Q is given by $-\frac{1}{\phi''(\delta)\delta} \equiv \eta$.

3.1.2 Rule of Thumb Households

ROT households do not attempt (or are just unable) to smooth their consumption path in the face of fluctuations in labor income. Each period they solve the following static problem:

$$\max \ \log C_t^r - \frac{(N_t^r)^{1+\varphi}}{1+\varphi} \tag{7}$$

subject to the zero-savings constraint:[8]

$$P_t C_t^r = W_t N_t^r \tag{8}$$

The associated first order condition is given by:

$$C_t^r \ (N_t^r)^{\varphi} = \frac{W_t}{P_t}$$

which combined with (8) yields

$$N_t^r = 1 \tag{9}$$

hence implying a constant employment for ROT households, and a consumption level equal to the real wage:[9]

$$C_t^r = \frac{W_t}{P_t}$$

3.1.3 Aggregation

Aggregate consumption and hours are a weighted average of the corresponding variables for each consumer type. Formally:

$$C_t \equiv \lambda \ C_t^r + (1-\lambda) \ C_t^o \tag{10}$$

and

[8] Notice that rule of thumb households are assumed not to be subject to taxes. We find that assumption not unrealistic.

[9] Alternatively we could have directly assumed a constant labor supply rule $N_t^r = 1$, interpreted as a "simple rule".

$$N_t \equiv \lambda\ N_t^r + (1-\lambda)\ N_t^o \tag{11}$$

Similarly,

$$I_t \equiv (1-\lambda)\ I_t^o$$

and

$$K_t \equiv (1-\lambda)\ K_t^o$$

We can combine (10) and (11) with the optimality conditions (4) and (9) to obtain,

$$N_t \equiv \lambda + (1-\lambda)\ N_t^o$$

and

$$C_t = \frac{W_t}{P_t}\ \left[\lambda + (1-\lambda)^{1+\varphi}(N_t-\lambda)^{-\varphi}\right]$$

Using the fact that $C_t^o = \frac{W_t}{P_t}\ (N_t^o)^{-\varphi} = \frac{(1-\lambda)^{\varphi}\ C_t}{\lambda(N_t-\lambda)^{\varphi}+(1-\lambda)^{1+\varphi}} \equiv C_t\ f(N_t)$, the Euler equation and the equation describing investment dynamics can be written in terms of aggregate variables as follows:

$$1 = \beta R_t\ E_t\left\{\frac{C_t\ f(N_t)}{C_{t+1}\ f(N_{t+1})}\frac{P_t}{P_{t+1}}\right\}$$

$$Q_t = \beta\ E_t\left\{\frac{C_t\ f(N_t)}{C_{t+1}\ f(N_{t+1})}\ \left[\frac{R_{t+1}^k}{P_{t+1}} + Q_{t+1}\left((1-\delta)+\phi_{t+1}-\left(\frac{I_{t+1}}{K_{t+1}}\right)\ \phi'_{t+1}\right)\right]\right\}$$

Notice that, to a first order approximation,

$$\log f(N_t) \simeq \log f(N) - \frac{\omega_\lambda}{\vartheta_u}\ \varphi\ n_t$$

where $\vartheta_u \equiv \frac{N-\lambda}{N} \in [0,1]$ is the share of optimizing households' hours in total hours in the steady state, and $\omega_\lambda \equiv \frac{\lambda(N-\lambda)^{\varphi}}{\lambda(N-\lambda)^{\varphi}+(1-\lambda)^{1+\varphi}}\ \in [0,1]$. As $\lambda \to 0$, we have $\omega_\lambda \to 0$ and $\vartheta_u \to 1$, in which case the previous intertemporal conditions collapse to the standard ones.

The corresponding log-linearized versions of the above equilibrium conditions are (ignoring constants):

$$c_t + \frac{(1-\omega_\lambda)}{\vartheta_u} \varphi \; n_t = w_t - p_t$$

$$c_t = E_t\{c_{t+1}\} - (r_t - E_t\{\pi_{t+1}\}) - \frac{\omega_\lambda}{\vartheta_u} \varphi \; E_t\{\Delta n_{t+1}\}$$

$$q_t = \beta \; E_t\{q_{t+1}\} + [1-\beta(1-\delta)] \; E_t\{(r^k_{t+1} - p_{t+1})\} - (r_t - E_t\{\pi_{t+1}\})$$

and

$$i_t - k_t = \eta \; q_t$$

where $\varphi_\lambda = \frac{(1-\omega_\lambda)}{\vartheta_u} \varphi \leq \varphi$, $rr^k_t \equiv r^k_t - p_t$, and where lower case letters denote the logarithms of the original variables.

The capital accumulation equation can also be linearized to yield:

$$k_{t+1} = \delta \; i_t + (1-\delta) \; k_t$$

Remark: notice that we can solve the consumption Euler equation forward and write:

$$\begin{aligned} c_t &= \frac{\omega_\lambda}{\vartheta_u} \varphi \; n_t - \sum_{j=0}^{\infty} E_t\{(r_{t+j} - \pi_{t+1+j})\} \\ &= \frac{\omega_\lambda \; \varphi}{\vartheta_u(1-\alpha)} \; (y_t - \alpha k_t) - rr^l_t \end{aligned}$$

3.2 Firms

We assume the existence of a continuum of monopolistically competitive firms producing differentiated intermediate goods. The latter are used as inputs by a (perfectly competitive) firm producing a single final good.

3.2.1 Final Goods Firm

The final good is produced by a representative , perfectly competitive firm with a constant returns technology:

$$Y_t = \left(\int_0^1 Y_t(j)^{\frac{\varepsilon-1}{\varepsilon}} \, dj \right)^{\frac{\varepsilon}{\varepsilon-1}}$$

where $Y_t(j)$ is the quantity of intermediate good j used, for all $j \in [0,1]$. Profit maximization, taking as given the final goods price P_t and the prices for the intermediate goods $P_t(j)$, all $j \in [0,1]$, yields the set of demand schedules

$$Y_t(j) = \left(\frac{P_t(j)}{P_t} \right)^{-\varepsilon} Y_t$$

as well as the zero profit condition $P_t = \left(\int_0^1 P_t(j)^{1-\varepsilon} \, dj \right)^{\frac{1}{1-\varepsilon}}$.

3.2.2 Intermediate Goods Firm

The production function for a typical intermediate goods firm (say, the one producing good j) is given by:

$$Y_t(j) = A \; K_t(j)^{\alpha} \; N_t(j)^{1-\alpha} \tag{12}$$

where $K_t(j)$ and $N_t(j)$ represents the capital and labor services hired by firm j, and A is a technology parameter common to all firms. Cost minimization, taking the wage and the rental cost of capital as given, implies the optimality condition:

$$\frac{K_t}{N_t} = \left(\frac{\alpha}{1-\alpha} \right) \left(\frac{W_t}{R_t^k} \right)$$

Marginal cost is common to all firms and given by (in nominal terms):

$$MC_t^n = \Theta \; (R_t^k)^{\alpha} \; W_t^{1-\alpha}$$

where $\Theta \equiv \frac{\alpha^{\alpha}(1-\alpha)^{1-\alpha}}{A}$.

Price Setting Intermediate firms are assumed to set nominal prices on a staggered basis, as in Calvo (1983). Each firm resets its price with probability $1-\theta$ each period, independently of the time elapsed since the last adjustment. Thus, each period a measure $1-\theta$ of producers reset their prices, while a fraction θ keep their prices unchanged

Let $\Lambda_{t,t+k} \equiv \beta \, \frac{C_t^o}{C_{t+1}^o} \frac{P_t}{P_{t+1}}$ be the stochastic discount factor used to value as of t a nominal payoff at $t+k$. A firm resetting its price in period t will seek to maximize

$$\max_{P_t^*} \; E_t \sum_{k=0}^{\infty} \theta^k \; E_t \left\{ \Lambda_{t,t+k} \; Y_{t+k}(j) \; \left(P_t^* - MC_{t+k}^n \right) \right\}$$

subject to the sequence of demand constraints $Y_{t+k}(j) = \left(\frac{P_t^*}{P_{t+k}} \right)^{-\varepsilon} \; Y_{t+k}$ and where P_t^* represents the price chosen by firms resetting prices at time t.

The first order conditions for the above problem is:

$$\sum_{k=0}^{\infty} \theta^k \; E_t \left\{ \Lambda_{t,t+k} \; Y_{t+k}(j) \; \left(P_t^* - \frac{\varepsilon}{\varepsilon - 1} \; MC_{t+k}^n \right) \right\} = 0 \qquad (13)$$

The equation describing the dynamics for the aggregate price level is given by

$$P_t = \left[\theta \; P_{t-1}^{1-\varepsilon} + (1-\theta) \; \left(P_t^* \right)^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}} \qquad (14)$$

Log-linearization of (13) and (14) around the zero inflation steady state yields the familiar equation describing the dynamics of inflation as a function of the deviations of the average (log) markup from its steady state level

$$\pi_t = \beta \; E_t\{\pi_{t+1}\} - \lambda_p \; \mu_t$$

where $\lambda_p = \frac{(1-\beta\theta)(1-\theta)}{\theta}$ and, ignoring constant terms, the markup can be written as

$$\begin{aligned} \mu_t &= p_t - mc_t^n \\ &= - \; [\alpha \; (r_t^k - p_t) + (1-\alpha) \; (w_t - p_t)] \end{aligned}$$

Notice also that to a first order approximation, aggregate output can be written as

$$y_t = (1 - \alpha)\ n_t + \alpha\ k_t$$

3.3 Fiscal and Monetary Policy

The government absorbs a quantity G_t of the final good, financing those purchases by means of lump sum taxes. Government purchases evolve exogenously according to a stochastic process:

$$g_t = (1 - \rho_g)\ g + \rho_g\ g_{t-1} + u_t$$

The nominal interest rate is set according to a simple Taylor rule:

$$r_t = \rho + \phi_\pi\ \pi_t$$

3.4 Market Clearing

Market clearing requires

$$Y_t = C_t + I_t + G_t$$

for all t. Log linearization around the steady state yields (ignoring constants):

$$y_t = (1 - s_g - s_i)\ c_t + s_g\ g_t + s_i\ i_t$$

where $s_g \equiv \frac{G}{Y}$ is determined exogenously, and $s_i \equiv \frac{I}{Y} = \frac{\delta K}{Y} = \frac{\alpha\delta}{(\rho+\delta)(1+\mu)}$.

4 Analysis of Equilibrium Dynamics

The present section is devoted to the analysis of the properties of the model's equilibrium dynamics. We start by describing the calibration that we use as a benchmark.

Each period is assumed to correspond to a quarter. With regard to preference parameters, we set the discount factor β equal to 0.99 and the elasticity of the marginal disutility of hours, φ , equal to 1. The elasticity of substitution across intermediate goods, ε, is set to 6, a value consistent with a steady state markup μ of 20 percent. The rate of depreciation δ is set to 0.025. Following King and Watson (1996), we set η (the elasticity of investment with respect to q) equal to 1.0. The elasticity of output with respect to capital, α, is assumed to be $\frac{1}{3}$, a value roughly consistent with income share given the assumed low steady state markup. All the previous parameters are kept at their baseline values throughout the present section. Next we turn to the parameters for which we conduct some sensitivity analysis.

Our baseline setting for the weight of ROT households λ is 0.5, a value consistent with the estimates in Campbell and Mankiw (1989). The fraction of firms that keep their prices unchanged, θ, is given a baseline value of 0.75, which corresponds to an average price duration of one year. We set the size of the response of the monetary authority to inflation, ϕ_π, to 1.5, a value commonly used in empirical Taylor rules (and one that satisfies the so-called Taylor principle). For the two parameters describing fiscal policy, we assume baselines values of 0.2 for the average government spending share (s_g), and 0.9 for ρ_g, the autoregressive coefficient in the government spending process. The previous values are roughly consistent with the U.S. evidence, including the impulse response of government spending to its own shock shown in Figure 1. Nevertheless, below we also consider two alternative calibrations for the same parameters: $\rho_g = 0.3$ (*low persistence* calibration) and $s_g = 0.5$ (which we refer to, for convenience, as *large government*).

Much of the sensitivity analysis below focuses on the weight of ROT households (λ) and its interaction with θ, ϕ_π, ρ_g, and s_g. Next we provide an analysis of the conditions that guarantee the uniqueness of equilibrium. That analysis is followed by a study of the model's implications for the response of different macro variables to an exogenous shock to government spending.

4.1 Determinacy Analysis

In this section we briefly discuss some of the implications for the model's equilibrium properties of the coexistence of the ROT consumers and nominal rigidities. A more detailed analysis of the conditions for determinacy in an economy similar to the one considered here can be found in Galí, López-Salido and Vallés (2002). The latter paper shows that the presence of ROT consumers can alter dramatically the equilibrium properties of an otherwise standard dynamic sticky price economy. In particular, it is shown that under certain parameter configurations the economy's equilibrium may be indeterminate (and thus may display stationary *sunspot* fluctuations) even when the interest rate rule is one that satisfies the Taylor principle (which corresponds to $\phi_\pi > 1$ in our model).[10]

Figure 2 illustrates that phenomenon for the model developed in the previous section. In particular the blank region in the figure displays configurations of (λ, θ) values for which the equilibrium is unique, while the grey region shows the set of admissible parameters associated with an indeterminate equilibrium. The remaining parameters, including the inflation coefficient in the interest rate rule, are left at their baseline values. We see that indeterminacy arises whenever a high degree of price stickiness coexists with a sufficiently large weight of ROT households. Both frictions are thus seen to be necessary in order for indeterminacy to emerge as a property of the equilibrium dynamics. The figure also makes clear that the equilibrium is unique under our baseline calibration ($\lambda = 0.5$, $\theta = 0.75$). The analysis in the remainder of the paper is restricted to calibrated version of the model for which the equilibrium is determined.

[10] The "Taylor principle" refers to a property of interest rate rules for which a permanent increase in inflation eventually leads to a more than one-for-one rise in the nominal interest rate. See Woodford (2001)

5 The Effects of Government Spending Shocks

In the present section we analyze the effects of shocks to government spending in the dynamic sticky price model with ROT consumers. In particular, we focus on the conditions under which an exogenous increase in government spending has a positive effect on consumption, as found in much of the evidence discussed above. Throughout we restrict ourselves to calibrations for which the equilibrium is indeterminate.

Figure 3(a) shows the contemporaneous response of output, consumption and investment to a positive government spending shock, as a function of the autoregressive coefficient in the government spending process, ρ_g, and with the remaining parameters at their baseline values. The figure shows clearly the possibility of crowding-in of consumption, i.e., an increase in consumption in response to a rise in government spending. That crowding-in effect obtains for values of ρ_g below 0.7. Notice also that the response of investment to the same shock is negative over most of the admissible range of ρ_g, with the exception of values very close to unity (i.e., near-random walk processes for government spending).

Figure 3(b) displays similar graphs for some alternative calibrations. Each calibration assumes a limiting value for one (or two) parameters, while keeping the rest at their baseline values. Thus, the *flexible price* scenario assumes $\theta = 0$, the *optimizing consumers* economy assumes $\lambda = 0$, the neoclassical calibration combines both flexible prices and lack of ROT consumers ($\theta = \lambda = 0$) and, finally, the *large government* calibration assumes a higher steady state government spending share ($s_g = 0.5$). Notice that when prices are fully flexible, or when all consumers are optimizing (or when both features coexist, as under the neoclassical calibration) consumption is always crowded-out in response to a rise in government spending, independently of the degree of persistence of the latter. On the other hand, when we look at our large government economy we find it easier to generate a procyclical response of consumption in response to a rise in government spending; in that case, values for ρ_g below 0.8 are sufficient to generate the desired effect.

To complete the picture, Figure 4 displays the dynamic responses of output and its three components after a positive government spending shock under the four scenarios considered above and, for each of them, under two alternative assumptions on the shock persistence ($\rho_g = 0.3$ and $\rho_g = 0.9$). Not surprisingly, the persistence in the response of all variables is positively related to the persistence of the shock. Furthermore, in all cases the adjustment of the different variables is monotonic, implying that the sign of the conditional correlations can already be inferred from the impact responses shown above. Notice also that the responses under the flexible price and the neoclassical scenarios are almost identical, thus suggesting that the presence of ROT consumers does not have in itself (i.e., in the absence of sticky prices) a significant impact on the equilibrium responses to a government spending shock. On the other hand, the introduction of sticky prices (while assuming that all households are optimizing) is sufficient to have significant quantitative implication for the same responses (though it does not change the sign of the comovements). In particular, the crowding-out effect on consumption and investment are much more muted when the shock is little persistent.

Figure 5 allows us to illustrate the influence of the weight of ROT consumers (as measured by λ).on the impact responses of output and its components to a one percent government spending shock. The graph on the upper panel correspond to a low persistence scenario ($\rho_g = 0.3$), those on the lower panel assume highly persistent shocks ($\rho_g = 0.9$). As usual, the remaining parameters are kept at their baseline values. The analysis is restricted to the range of λs for which the equilibrium is determinate. We observe that the impact response of consumption and output are increasing in λ, whereas the response of investment is decreasing in the same parameter. Furthermore, in the low persistence scenario, the response is positive for values of λ as low as 0.2; in the high persistence scenario, by contrast, the impact response of consumption remains negative for all values of λ.[11]

[11] If we allow for a high spending share (as under our *Large Government* calibration), the response of consumption becomes very sensitive to the weight of ROT consumers: with a low λ the response

The graphs in Figure 6 represent the sensitivity of the impact responses to variations in the degree of price stickiness, where the latter is indexed by parameter θ. A key result seems to emerge: independently of the degree of persistence of the government spending shock, the size of the response of output and its two components (consumption and investment), is increasing in the degree of price rigidities. That dependence on θ appears to be much stronger, however, in the low persistence scenario. Hence, and with the exception of the scenario without ROT consumers, a positive response of consumption to a rise in government spending is possible for sufficiently high values of θ.

Figure 7 displays a similar set of graphs showing the response of output, consumption and investment as a function of ϕ_π, the coefficient of inflation in the interest rate rule. Qualitatively, the picture appears as the mirror image to the one shown in Figure 6: the stronger the central bank's response to inflation, the weaker is the impact of a government spending shock on output and its components. That finding may not be surprising since in staggered price setting models of the sort analyzed here, the central bank can approximate arbitrarily well the flexible price equilibrium allocation by following an interest rate rule that responds with sufficient strength to inflation.

6 Summary and Tentative Assessment of the Model

In the previous analysis we have shown how the interaction between ROT households (whose consumption equals their labor income) and sticky prices (modeled as in the recent New Keynesian literature) makes it possible to generate an increase in consumption in response to an expansion in government spending, in a way consistent with much of the recent evidence. The mechanism through which that effect is brought about can be summarized as follows. The expansion in government spending shifts the demand schedule facing each firm, and thus the possibility of selling more output at an unchanged price. In the short run, the only way to increase output

is negative, but it turns positive for a sufficiently high λ even in the high persistence scenario.

is by hiring more labor (from optimizing consumers, since ROT consumers have an inelastic labor supply). Simultaneously, optimizing consumers increase their labor supply (at any given wage), as a result of the negative wealth effect generated by the higher levels of taxes needed to finance the fiscal expansion. Whether that hiring leads to an increase or a decrease in the real wage depends on the strength of the wealth effect (the size of the shift in labor supply) relative to the elasticity of the marginal disutility of labor (the slope of the labor supply schedule). If the latter effect is dominant (e.g., when the increase in G is not too persistent), the real wage will increase and, with it, the consumption of ROT households. If the weight of the latter is large enough, aggregate consumption will increase. Clearly, for the previous mechanism to be operative in equilibrium it must be the case that prices are sufficiently rigid. Otherwise, average markups (or, equivalently, real marginal costs) would remain largely unchanged in the face of the rise in government spending, which in turn would require a downward adjustment of real wages in parallel with the decline in the marginal product of labor. That explains why we need *both* strong nominal rigidities and large weight of ROT consumers in order to obtain the desired procyclical response of consumption.

Having discussed the mechanism behind our main results, we turn to some important caveats of the analysis and puzzles that remain unsolved.

First, our theoretical analysis assumes that the increase in government spending is financed by means of lump-sum taxes (current or future). If only distortionary labor and/or capital income taxes are available to the government, the response of the different macroeconomic variables to a government spending shock will generally differ from the one that obtains in the economy with lump sum taxes analyzed above, and will depend on the composition and timing of the taxation. We are currently extending our framework to analyze that case.

Second, there is a sense in which our model cannot, strictly speaking, account for the evidence, at least under our baseline calibration: a rise in government spending generates an increase in aggregate consumption only if it is not too persistent (otherwise the dominating wealth effect will push the real wage downward, thus aborting the key channel through which consumption eventually raises.) Yet, when we look at the empirical dynamic response of government spending to its own shock we observe a very persistent pattern. Since the latter is possibly better approximated by the $\rho_g = 0.9$ calibration, the finding that consumption generally falls under that calibration (unless some extreme values for θ and λ are chosen). Of course that puzzle may be related to our choice of a baseline calibration. We plan to explore alternative plausible calibrations which may overturn that result by dampening the *relative importance* the negative wealth effect (relative to the slope effect). The most natural avenue would involve raising φ to values possibly more realistic. Unfortunately, there is very little room left to go: values of φ above some threshold close to 2 render the equilibrium indeterminate under our baseline calibration.

Appendix: Steady State

In a zero inflation steady state we have:

$$Q = 1$$

$$R = (1-\delta) + \frac{R^k}{P} = \beta^{-1}$$

In the zero inflation steady state the real marginal cost is constant and given by

$$MC = 1 - \frac{1}{\varepsilon}$$

Hence, using $MC = \frac{(R^k/P)}{\alpha(Y/K)}$, we obtain

$$\frac{K}{N} = \left[\frac{(1-\frac{1}{\varepsilon})\ \alpha A}{\rho+\delta}\right]^{\frac{1}{1-\alpha}}$$

$$\begin{aligned} C &= \frac{W}{P}\ \left[\lambda + (1-\lambda)^{1+\varphi}(N-\lambda)^{-\varphi}\right] \\ &= (1-\frac{1}{\varepsilon})\ (1-\alpha)A\left(\frac{K}{N}\right)^{\alpha}\ \left[\lambda + (1-\lambda)^{1+\varphi}(N-\lambda)^{-\varphi}\right] \end{aligned}$$

In addition,

$$\begin{aligned} C &= Y - G - I \\ &= N\ \left[(1-s_g)\ A\left(\frac{K}{N}\right)^{\alpha} - \delta\ \left(\frac{K}{N}\right)\right] \end{aligned}$$

Thus, combining the above expressions, we obtain an equation which determines (implicitly) steady state hours:

$$\frac{(1-\alpha)(\rho+\delta)}{(1-s_g)(\rho+\delta)(1+\mu)-\delta\ \alpha} = \frac{N\ (N-\lambda)^{\varphi}}{\lambda(N-\lambda)^{\varphi}+(1-\lambda)^{1+\varphi}} \equiv h(N)$$

Notice that $h(\lambda) = 0$, $h' > 0$, and $\lim_{N\to+\infty} h(N) = +\infty$, which has a unique solution satisfying $N > \lambda$.

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Figure 1(a). Responses to a Military Spending Shock
Sample Period: 1954:1-1999:4

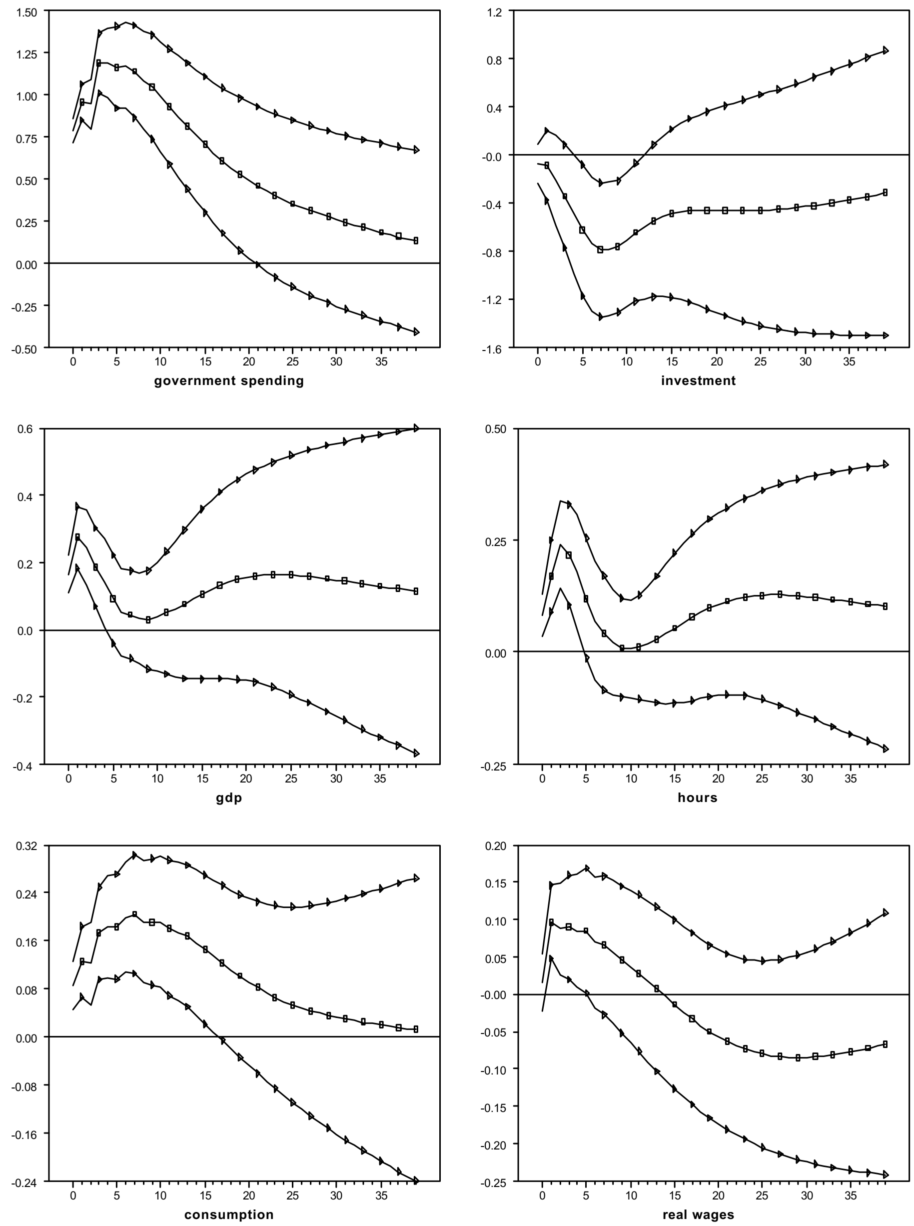


Figure 1(b). Responses to a Government Spending Shock
Sample Period: 1954:1-1999:4

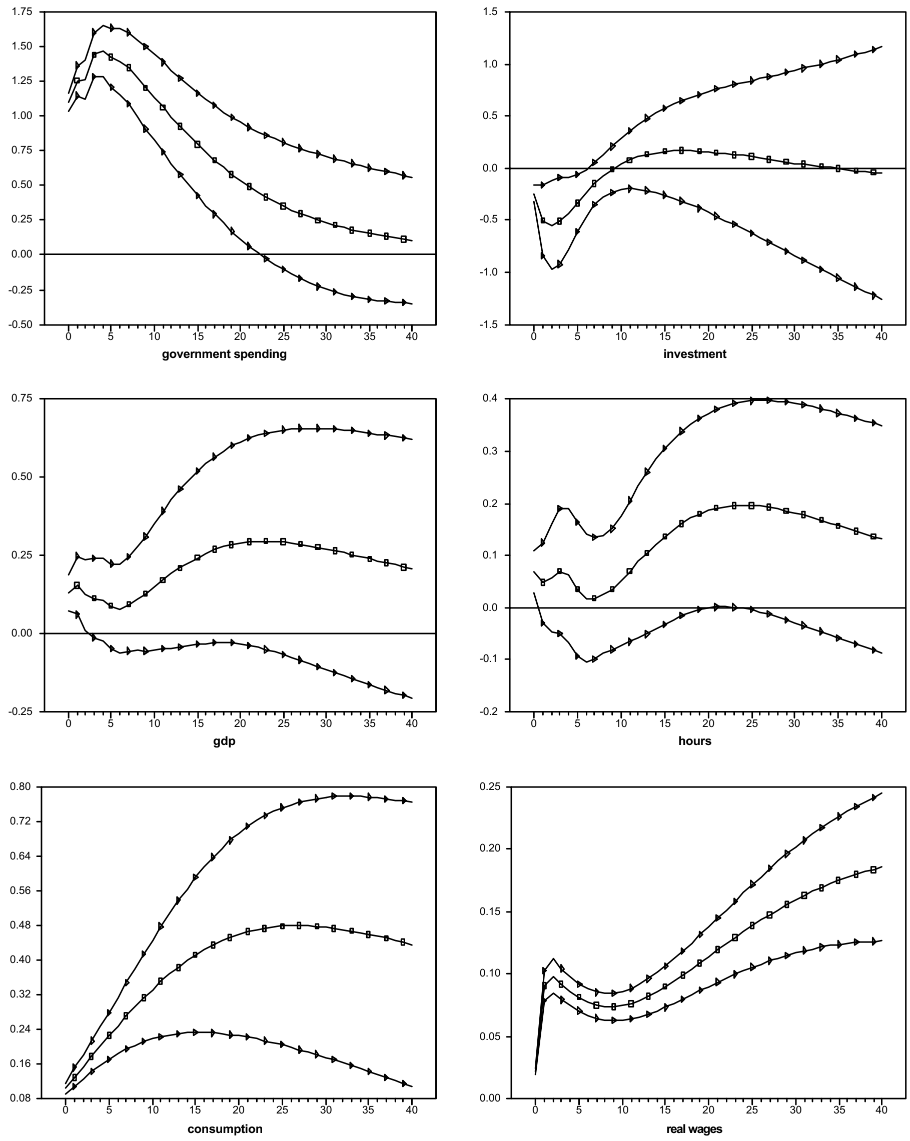


Figure 2. Determinacy Analysis

Baseline Calibration

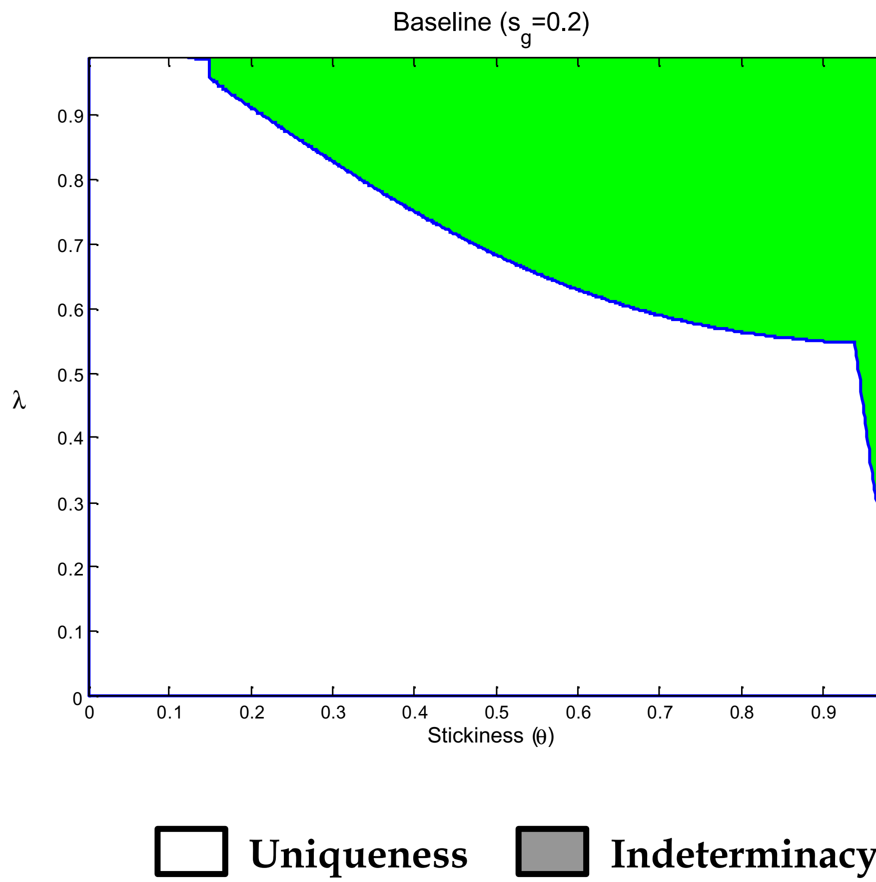


Figure 3(a). Impact Multipliers: Sensitivity to ρ_g

Baseline Calibration

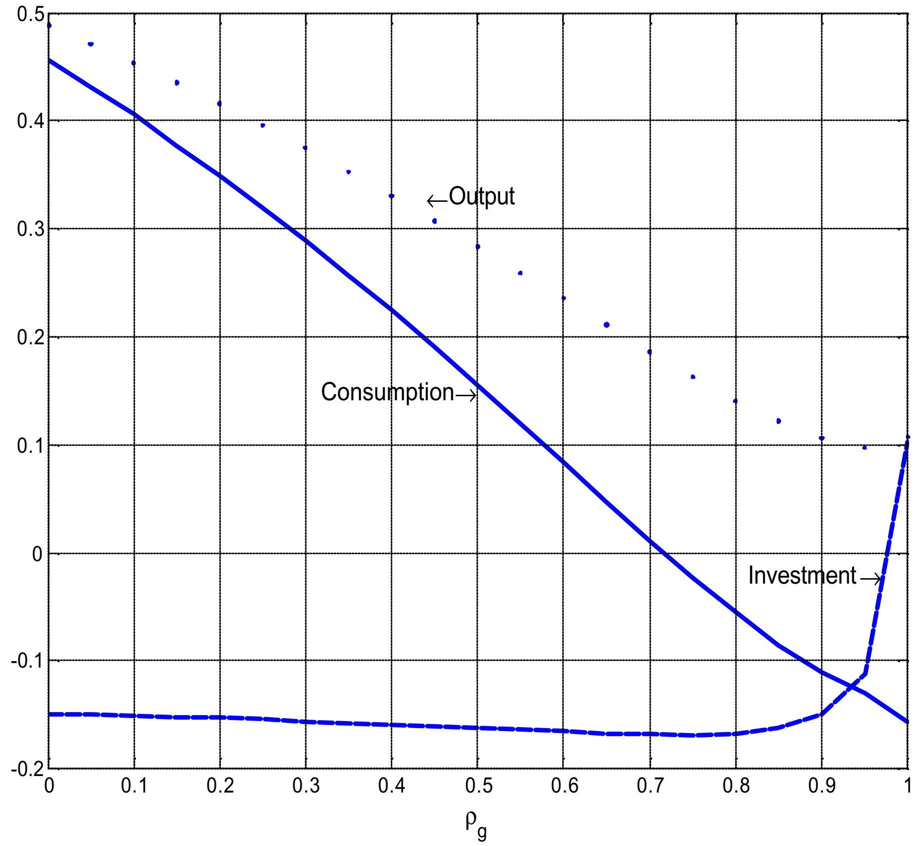


Figure 3(b). Impact Multipliers: Sensitivity to ρ_g

Alternative Calibrations

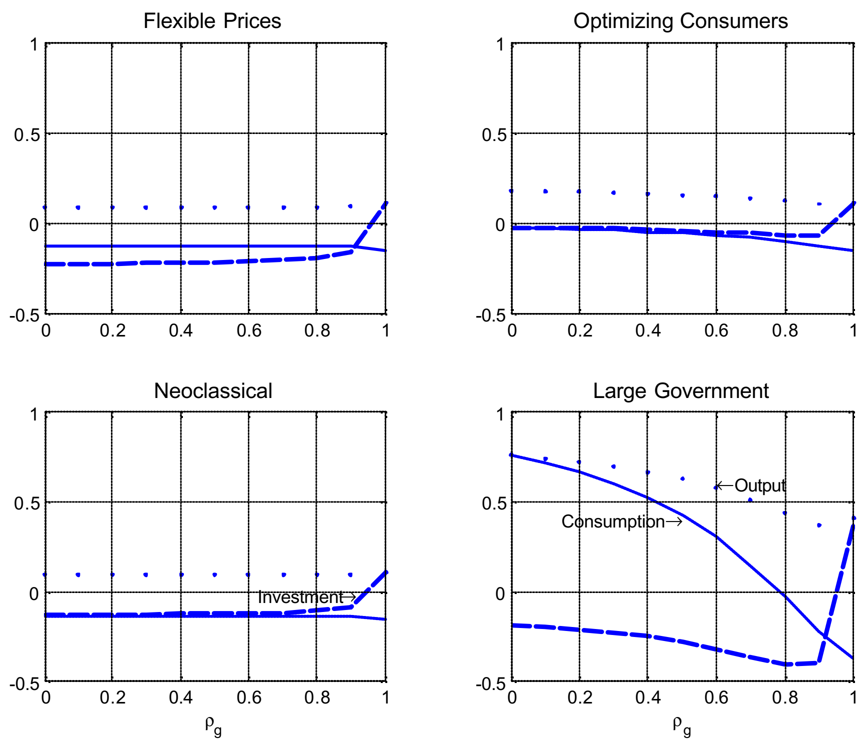
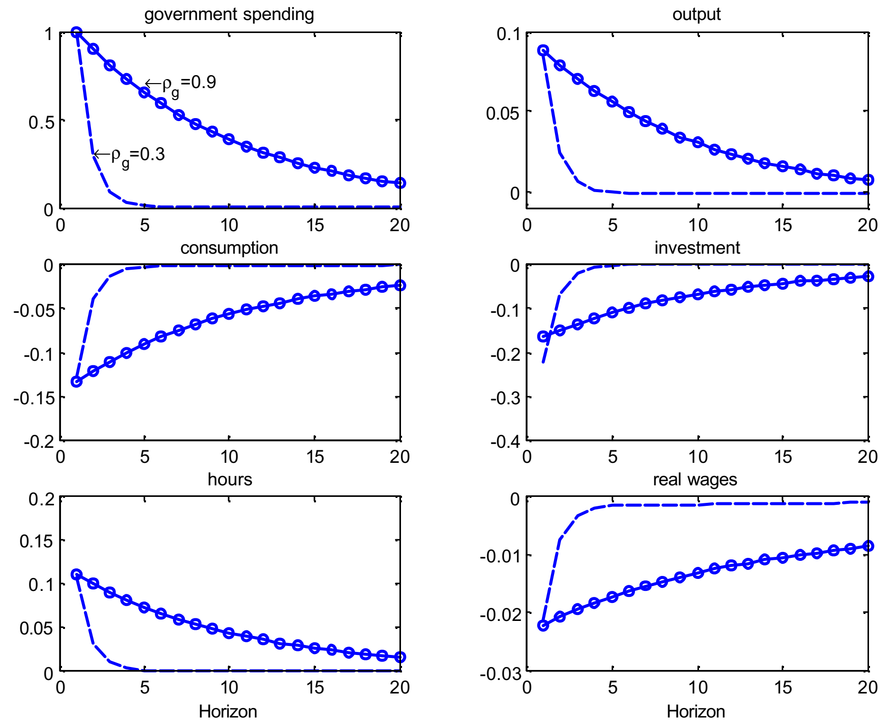
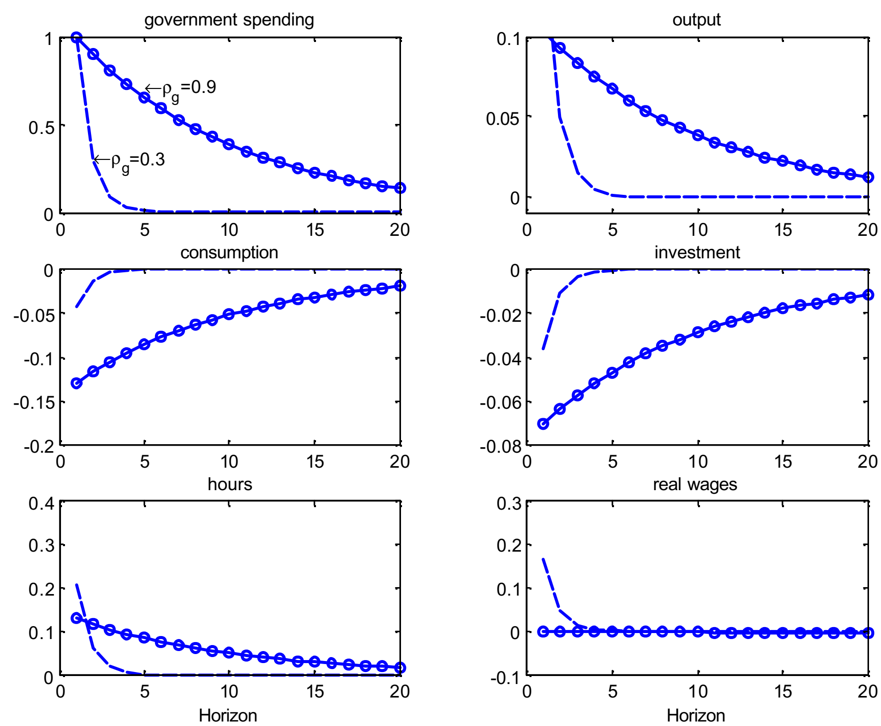


Figure 4. Responses to a Government Spending Shock

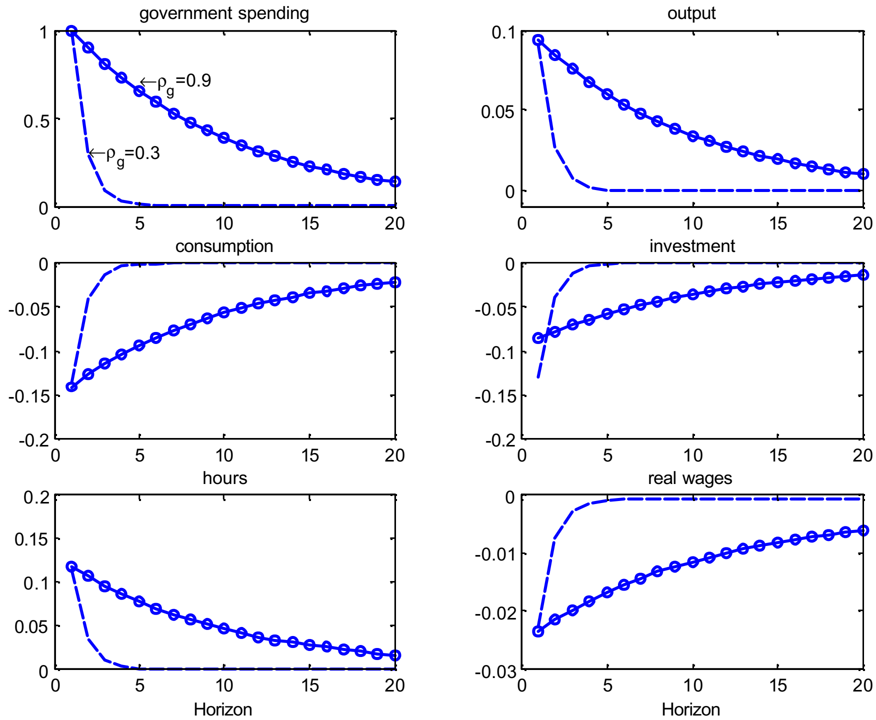
I. Flexible Prices



II. Optimizing Consumers



III. Neoclassical



IV. Baseline

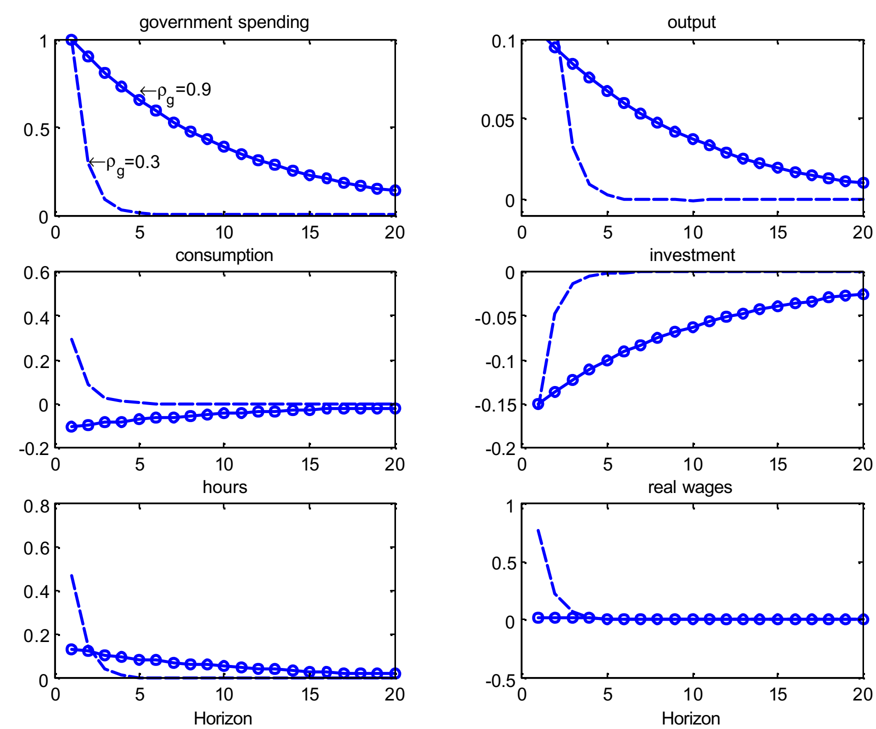
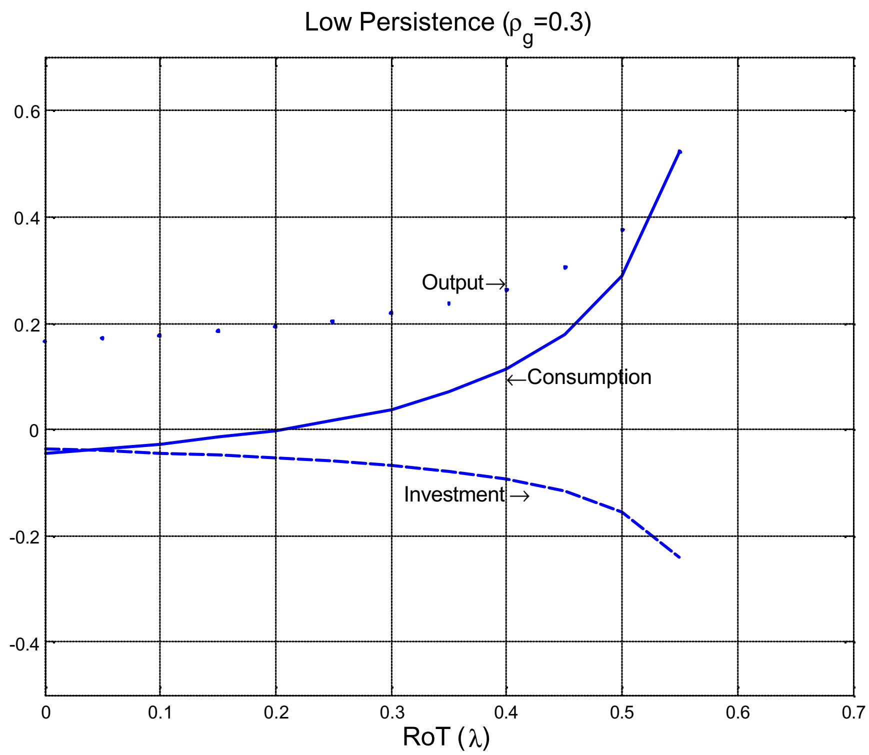


Figure 5. Impact Multipliers: Sensitivity to λ



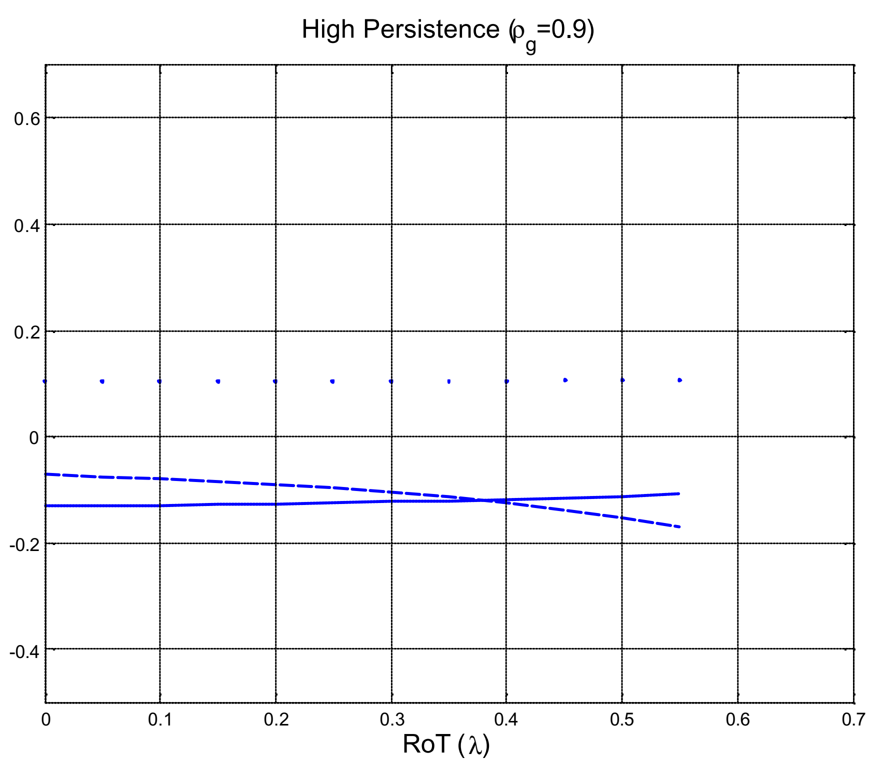


Figure 6. Impact Multipliers: Sensitivity to θ

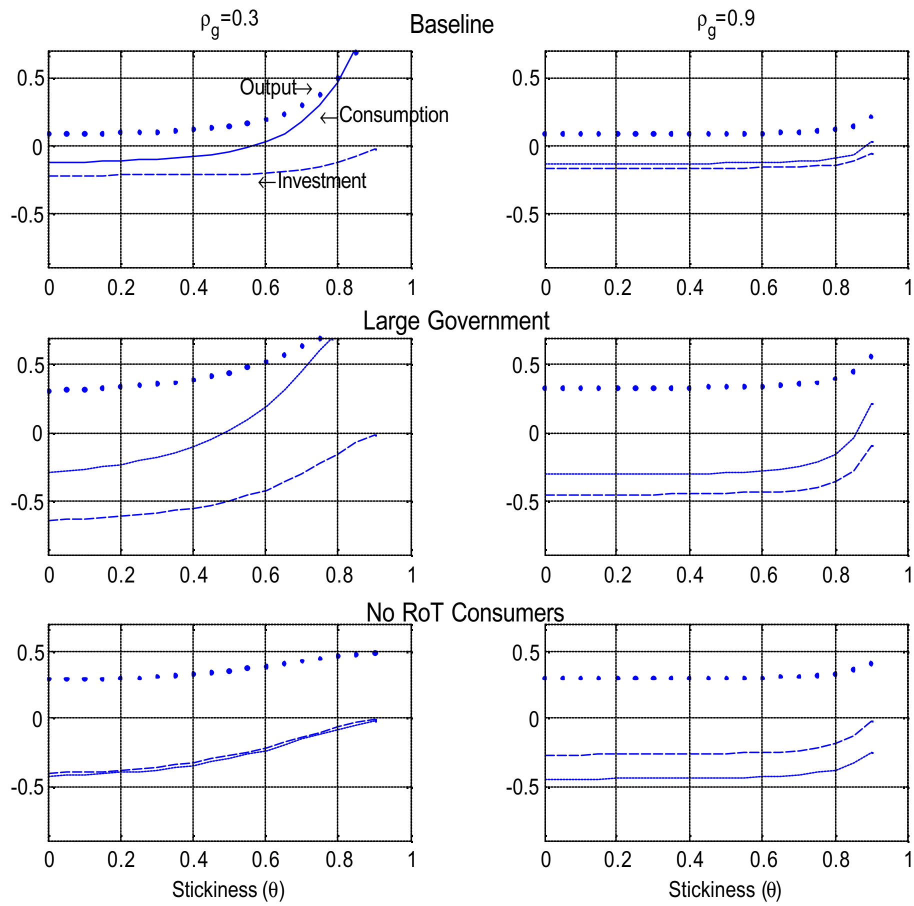


Figure 7. Impact Multipliers: Sensitivity to ϕ_π