Private and public consumption and counter-cyclical fiscal policy

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This paper builds a closed-economy NK-DSGE model with no capital, in which consumers value both private and public consumption and fiscal policy is determined by a feedback rule responding to output gap. We analyse how different degrees of substitutatibility/complementarity between private and public consumption and a pro/counter-cyclical stance of fiscal policy affect equilibrium determinacy and the response of the model economy to a wide range of shocks. Results show that determinacy is ensured by counter-cyclical fiscal policy under complementarity; increasing substitutability also pro-cyclical stance becomes stable. Differences can be observed also in response to shocks.

JEL classification:E62, E63, H40

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1. Introduction

This paper belongs to the literature on equilibrium determinacy and response to shocks in New Keynesian Dynamic Stochastic General Equilibrium models. The two features we inserted in order to enrich the standard framework have to do with the nature of the relationship between government expenditure and private consumption, and with the pro/counter cyclical attitude of the former.

Regarding the first issue, the question of whether private and public consumption are complements or substitutes has been studied by a large literature (Aschauer 1985, Campbell and Mankiw 1990, Graham and Himarios 1991, Graham 1993, Karras 1994, Ni 1995, Amano and Wirjanto 1998, Okubo 2003), with mixed evidence, slightly in favour of complementarity. Fiorito and Kollintzas (2004) operate a distinction among different categories of public expenditure, concluding that while public goods seems to substitute private consumption, merit goods tend to be featured by complementarity. In time, the issue has come to play a relevant role for the functioning of theoretical and empirical DSGE models who became the main tool for policy analysis in macroeconomics (Christiano and Eichenbaum 1992, Baxter and King 1993, Deveraux et al. 1996). In this paper, we construct a Constant-Elasticity of Substitution (CES) basket between private and public consumption, inside a Constant-Relative-Risk-Advesion (CRRA) functional form; complementarity or substitutability arise according to a given relationship between the corresponding structural parameters, namely the elasticity of substitution and the risk adversion coefficient. In doing so, we choose the useful government expenditure approach (in line with contributions such as Garelli 2001, Bouakez, Rebei 2003, Gali, Monacelli 2005), which is one the three main approaches that are being used in order to break the Ricardian and so attempt to replicate with general equilibrium models the main empirical regularities concerning government variables.[3] The other issue at the heart of this paper's analysis is the relative desiderability of pro/counter cyclical fiscal policy. We do not perform any welfare analysis, but we only examine the different responses of the model economy (in terms of determinacy and response to shocks) to the sign of the feedback rule linking government expenditure to output gap. A widespread consensus has been achieved on the beneficial effects of counter-cyclical fiscal policy, as it provides stabilization over the business cycle, enables the economy to effectively fight recessions without damaging public finance equilibrium, and it is consistent with optimal tax-smoothing (Barro1979). However the policy debate is still struggling to fully internalize this prescription and to conceive effective institutional arrangements to successfully implement it; one of the main criticisms made to the Stability and Growth Pact concerns the insufficient effort it produces in order to avoid asymmetry and procyclical bias in the conduct of national fiscal policies. Many observers pointed out that the Pact does not entirely ensure fiscal consolidation during good times and induces pro-cyclical adjustments during an economic downturn or, at least, it does not seem to do the job in a symmetric way. Accusation of tendency to procylicality is made by Coricelli and Ercolani (2002) and confirmed by Orbàn and Szapàrt (2004), and also by Balassone, Monacelli (2000) and Buti, Eijffinger,Franco (2003). Although the above example would better be addressed by an optimal taxation analysis in open economy, here we rather focus on showing the effects of pro/counter cyclical fiscal rules in a closed economy framework, in which the way public expenditure interacts with private consumption is more adequately taken into account.

[3]The other two approaches are finite-horizon (or overlapping generations) models and the rule of thumb (or credit constrained) agents models.

The main scope of this paper is to assess if and how the determinacy of the rational expectations equilibrium and the response to technological, fiscal and cost-push shocks are affected by the different degrees of complementarity/substitutability between private and public consumption and of pro/counter cyclicality of fiscal policy. We do so by building a closed economy NK-DSGE with no capital which incorporates the two above novelties. The main conclusion is that the two above aspects cannot really be separated, as one can relevantly affect the other. In fact, effects on the economy of a pro/counter cyclical fiscal stance can be depending on the way public consumption interacts with government expenditure. Indeed, the latter creates a good-market effect (a movement in private expenditure) and a labour-market effect (a movement in the wedge between marginal utility of consumption and marginal disutility of working), and both depend on the nature of the relationship between private and public consumption.

The paper is organized as follows. Section 2 outlines the theoretical set up, section 3 deals with the resulting system of equations in which the economy collapses and the calibration; section 4 is concerned with stability analysis, section 5 with impulse responses. Section 6 concludes and discusses possible extensions.

2. The model

2.1 Households and aggregate demand

The economy is composed of a continuum of infinitely-lived individuals, whose measure is normalized to unity. Each of them consumes a consumption basket $\tilde{C}_t$ and supplies labour N_t to a continuum of monopolistically-competitive intermediate firms. Wealth is allocated into one-period bonds (B_t) .

The instantaneous utility function amounts to be:

$$U_t = \frac{\tilde{C}_t^{1-\gamma}}{1-\gamma} - \frac{a_n}{1+\gamma_n} N_t^{1+\gamma_n} \tag{1}$$

where the consumption basket is a mix of public and private consumption:

$$\tilde{C}_t = \left[\theta C_t^{\frac{\nu-1}{\nu}} + (1-\theta) G_t^{\frac{\nu-1}{\nu}} \right]^{\frac{\nu}{\nu-1}} \tag{2}$$

The representative household choose a pattern for $\left[C_{t+i}, N_{t+i}, \frac{B_{t+i}}{P_{t+i}} \right]_{i=0}^{\infty}$ to solve:

$$\max E_t \sum_{i=0}^{\infty} \beta^i U_{t+i} \tag{3}$$

It is important to note that the representative household does not choose G_t , but just use the quantity that the government provides in accordance to the fiscal policy rule (which governs public expenditure and not taxation).

Households' budget constraint is:

$$C_t = \frac{W_t}{P_t} N_t + \Pi_t - T_t - \frac{M_t - M_{t-1}}{P_t} - \frac{\left(\frac{1}{i_t}\right) B_t - B_{t-1}}{P_t} \tag{4}$$

with:

Π_t = real-profits from the firms

T_t = lump-sum taxes

i_t = nominal interest rate

$\gamma, \gamma_m, \gamma_n \quad > 0$

Fisher-parity holds:

$$R_{t+1} = i_t E_t \left(\frac{P_t}{P_{t+1}} \right) \tag{5}$$

with R_{t+1} being the ex-post real interest rate.

First order condition for consumption is:

$$\frac{C_{t+1}}{C_t} = (\beta E_t R_{t+1})^{\nu} \left(\frac{\tilde{C}_{t+1}}{\tilde{C}_t} \right)^{1-\gamma\nu}$$

In the special case $\gamma\nu = 1$ (which, as it will become clear further below, corresponds to the case where public consumption has no effects on private consumption) we have the standard Euler equation.

First order condition with respect to labour supply:

$$\theta C_t^{-\frac{1}{\nu}} \left[\theta C_t^{\frac{\nu-1}{\nu}} + (1-\theta) G_t^{\frac{\nu-1}{\nu}} \right]^{\frac{-\gamma\nu+1}{\nu-1}} \frac{W_t}{P_t} = a_n N_t^{\gamma_n} \tag{6}$$

Equation (6) makes clear the supply-side effects of fiscal policy: by entering the consumption basket, it creates a wedge between marginal disutility of labour supply and marginal utility of private consumption. The sign of the wedge is given by the structural parameters γ and ν, as it is clear from several points of views. Also here we can see that in the special case $\gamma\nu = 1$ we are back to the standard condition for optimality in the labour market.

Loglinearizing the equation of optimal consumption:

$$\tilde{C}_t^{\frac{1-\gamma\nu}{\nu}} C_t^{-\frac{1}{\nu}} = \beta E_t R_{t+1} \; \tilde{C}_{t+1}^{\frac{1-\gamma\nu}{\nu}} C_{t+1}^{-\frac{1}{\nu}} \tag{7}$$

Brings to:

$$c_t = -\nu r_{t+1} + (1-\gamma\nu)\tilde{c}_t - (1-\gamma\nu) E_t \tilde{c}_{t+1} + E_t c_{t+1} \tag{8}$$

Loglinearizing (2) leads to:

$$\tilde{c}_t = \theta\left(\frac{C}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}} c_t + (1-\theta)\left(\frac{G}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}} g_t \tag{9}$$

Plugging (9) and the same expression shifted one period forward into (8) I get:

$$c_t = \frac{\nu}{\left[1-(1-\gamma\nu)\theta\left(\frac{C}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}}\right]} r_{t+1} - \frac{\left[(1-\gamma\nu)(1-\theta)\left(\frac{G}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}}\right]}{\left[1-(1-\gamma\nu)\theta\left(\frac{C}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}}\right]}(E_t g_{t+1} - g_t) + E_t c_{t+1} \tag{10}$$

(10) is the Euler equation for this case.

Defining:

$$\frac{\nu}{\left[1-(1-\gamma\nu)\theta\left(\frac{C}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}}\right]} = \Phi$$

$$\frac{\left[(1-\gamma\nu)(1-\theta)\left(\frac{G}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}}\right]}{\left[1-(1-\gamma\nu)\theta\left(\frac{C}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}}\right]} = \Omega$$

$$c_t = -\Phi r_{t+1} - \Omega(E_t g_{t+1} - g_t) + E_t c_{t+1} \tag{11}$$

Log-linearized aggregate resource constraint leads to:

$$y_t = \frac{\bar{C}}{\bar{Y}} c_t + \frac{\bar{G}}{\bar{Y}} g_t \tag{12}$$

and:

$$E_t c_{t+1} = \frac{Y}{C} E_t y_{t+1} - \frac{G}{C} E_t g_{t+1} \tag{13}$$

Rearranging:

$$y_t = -\frac{\bar{C}}{\bar{Y}} \Phi r_{t+1} + E_t y_{t+1} + \left[\frac{\bar{G} + \bar{C}\Omega}{\bar{Y}} \right] [g_t - E_t g_{t+1}] \tag{14}$$

(14) is the IS curve of this economy.

2.1.1. Relationship between private and public consumption

The scope of this paper is to investigate how the standard framework changes when we take into account the different way public expenditure interacts with private consumption; we have already seen from first order conditions on labour supply and consumption the importance of the structural parameters γ (risk adversion) and ν (elasticity between G and C in the consumption basket). Let us now derive the formal conditions.

Marginal utility of private consumption amounts to:

$$\frac{\partial U}{\partial C_t} = \theta C_t^{-\frac{1}{\nu}} \tilde{C}_t^{-\gamma+\frac{1}{\nu}} \tag{15}$$

Loglinearizing and using the loglinearized basket (9):

$$\theta\left(\frac{C}{\tilde{C}}\right)^{-\frac{1}{\nu}} \tilde{C}^{-\gamma} - \theta\left(\frac{C}{\tilde{C}}\right)^{-\frac{1}{\nu}} \tilde{C}^{-\gamma}\left[\frac{1}{\upsilon} - \theta\left(\frac{C}{\tilde{C}}\right)^{-\frac{1}{\nu}+1}\left(\frac{1}{\nu}-\gamma\right)\right]c_t + \theta\left(\frac{C}{\tilde{C}}\right)^{-\frac{1}{\nu}} \tilde{C}^{-\gamma}\left(\frac{1}{\nu}-\gamma\right)(1-\theta)\left(\frac{G}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}} g_t$$

Let us study the sign of the coefficient on g_t :

$$\text{sign}\,\theta\left(\frac{C}{\tilde{C}}\right)^{-\frac{1}{\nu}} \tilde{C}^{-\gamma}\left(\frac{1}{\nu}-\gamma\right)(1-\theta)\left(\frac{G}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}} = \text{sign}\left(\frac{1}{\nu}-\gamma\right)$$

We see that if $\frac{1}{\nu}-\gamma>0$ then public consumption raises the marginal utility of private consumption, whereas the opposite occurs if $\frac{1}{\nu}-\gamma<0$. So if $\nu<\frac{1}{\gamma}$ then G and C are complements, and if $\nu>\frac{1}{\gamma}$ they are substitutes. So in the former case after an increase in public expenditure, two things occur: in the goods market, private consumption increases, because of complementarity; in the labour market, marginal utility of working one hour more (the LHS of (labour supply)) increases, and so labour supply increases. In the latter case, private consumption decreases, because of substitutability, and labour supply increases by a less extent.

2.2 Firms

There are two kind of firms: final goods producers and intermediate goods producers.

2.2.1. Final goods producers

Final goods producers are perfectly competitive firms producing an homogeneous good Y_t using intermediate goods, since there are a continuum of intermediate goods producers of measure unity, each producing a differentiated input for final goods production. Let $Y_t(f)$ being the input produced by intermediate goods firm f and z the types available; the production function that transforms intermediate goods into final output is:

$$Y_t = \left[\int_0^1 Y_t^f(z)^{\frac{\varepsilon-1}{\varepsilon}} dz \right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{16}$$

with $\varepsilon > 1$ being the elasticity of substitution between intermediate goods. We can see that this CES production function exhibits diminishing marginal product, a property that will drive the firms to diversify and produce all the intermediate goods available.

The final good producer will minimize its cost; therefore it will choose $Y_t^f(z)$ to:

$$\min \int_0^1 P_t(z) Y_t^f(z) dz \tag{17}$$

subject to the production function (production function).

Total demand curve for intermediate good z is:

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

and aggregate price index:

$$P_t = \left[\int_0^1 P_t(z)^{\frac{1}{1-\varepsilon}} dz\right]^{\frac{1}{1-\varepsilon}}$$

2.2.2. Intermediate goods producers

Intermediate goods firms are monopolistically competitive and have the following standard constant-return-to-scale production function:

$$Y_t(f) = A_t N_t \tag{18}$$

with A_t being the technological parameter following a stationary AR(1) process of the form:

$$a_t = \rho a_{t-1} + \varepsilon_t$$

where $\varepsilon_t \sim (0, \sigma^2)$.

They set prices on a Calvo-Yun based staggered framework, with $(1-\zeta)$ being the probability that each period the firm adjusts its price, and ζ being obviously the probability that it keeps prices constant.

Intermediate firms maximize expected discounted profits subject to the production function (18) and the demand curve they face; in the flexible-prices equilibrium the maximization problem leads to the usual condition:

$$MC_t = \frac{1}{1+\mu} \tag{19}$$

with $1+\mu = \frac{\varepsilon}{1-\varepsilon}$ being the steady-state mark-up.

With sticky prices, the relevant maximization problem for the firm becomes:

$$\max \sum_{i=0}^{i=\infty} (\zeta\beta)^i E_t \Lambda_{t,i} \left[\frac{P_t(f) - MC^n_{t+i}(f)}{P_{t+i}} Y_{t,t+i}(f) \right]$$

with:

$MC^n_t(f) = P_t MC_t(f) =$ nominal marginal cost

$\Lambda_{t,i} = \left(\frac{C_{t+i}}{C_t}\right)^{-\gamma} =$ stochastic discount factor

subject to (18).

Optimal price results to be:

$$P_t^* = (1+\mu)\sum_{i=0}^{i=\infty} \vartheta_{t,i} MC_{t+1}^n \tag{20}$$

with:

$\vartheta_{t,i} = f(\Lambda_{t,i}, Y_{t+i})$

that is, the optimal price equals the steady-state mark-up times a weighted average of expected future nominal marginal costs; the weights depend on how much the firm discounts future cash flows in each period $t+i$ (taking into account that prices remain fixed along the way) and on the revenue expected in each period.

Considering also that the aggregate price index is a combination of price charged by those firms who get to change their prices and those who do not:

$$P_t = [\zeta P_t^{1-\varepsilon} + (1-\zeta) P_t^{*1-\varepsilon}]^{\frac{1}{1-\varepsilon}} \tag{21}$$

2.3. Potential output

Let us start by looking for an equilibrium on the labour market. This has to imply that firms' wage decisions based on cost minimization problem must be equal to the wage decision by households based on their optimizing behaviour. From the firms' point of view we have the usual condition coming from cost minimization:

$$\frac{\frac{W_t}{P_t}}{A_t} = MC_t \tag{22}$$

which, combined with the steady-state expression for marginal cost (19) becomes:

$$\frac{W_t}{P_t} = \frac{A_t}{1+\mu} \tag{23}$$

Combining with households'optimal labour supply (6):

$$\frac{A_t}{1+\mu} = \frac{a_n N_t^{\gamma_n}}{\theta C_t^{-\frac{1}{\nu}} \tilde{C}_t^{-\gamma+\frac{1}{\nu}}} \tag{24}$$

using the production function (18), after few simple algebrical manipulations:

$$Y_t = A_t^{\frac{1+\gamma n}{\gamma n}} a_n^{-\frac{1}{\gamma n}} (1+\mu)^{-\frac{1}{\gamma n}} \tilde{C}^{\frac{(-\gamma+\frac{1}{\nu})}{\gamma n}} \theta^{\frac{1}{\gamma n}} C^{\frac{-1}{\nu\gamma n}} \tag{25}$$

which is, in level, the supply function of our economy under flexible prices.

Solving for the steady-state mark-up:

$$(1+\mu) = Y_t^{-\gamma_n} A_t^{\gamma_n+1} \tilde{C}_t^{-\gamma+\frac{1}{\nu}} a_n^{-1} \theta C^{-\frac{1}{\nu}} \tag{26}$$

Loglinearizing, and using expressions (9) and (12):

$$\mu_t = (\gamma_n + 1)a_t + (-\gamma + \frac{1}{v})\left[\theta\left(\frac{\bar{C}}{\tilde{C}}\right)^{\frac{v-1}{v}} \left[\frac{\bar{Y}}{\bar{C}} y_t - \frac{\bar{G}}{\bar{C}} g_t \right] + (1-\theta)\left(\frac{\bar{G}}{\tilde{C}}\right)^{\frac{v-1}{v}} g_t \right] - \gamma_n y_t - \frac{1}{v}\left[\frac{\bar{Y}}{\bar{C}} y_t - \frac{\bar{G}}{\bar{C}} g_t \right]$$

(27)

To find an expression for potential output let us set $\mu = 0$ (since at Y^* log-deviations from steady state mark up are equal to zero) and solve for y_t^* :

$$y_t^* = \frac{\gamma_n + 1}{\left((\gamma - \frac{1}{v})\theta\left(\frac{\bar{C}}{\tilde{C}}\right)^{\frac{v-1}{v}} \frac{\bar{Y}}{\bar{C}} + \frac{1}{v}\frac{\bar{Y}}{\bar{C}} + \gamma_n \right)} a_t + \frac{\left[(\gamma - \frac{1}{v})\theta\left(\frac{\bar{C}}{\tilde{C}}\right)^{\frac{v-1}{v}} \frac{\bar{G}}{\bar{C}} + (-\gamma + \frac{1}{v})(1-\theta)\left(\frac{\bar{G}}{\tilde{C}}\right)^{\frac{v-1}{v}} + \frac{1}{v}\frac{\bar{G}}{\bar{C}} \right]}{\left((\gamma - \frac{1}{v})\theta\left(\frac{\bar{C}}{\tilde{C}}\right)^{\frac{v-1}{v}} \frac{\bar{Y}}{\bar{C}} + \frac{1}{v}\frac{\bar{Y}}{\bar{C}} + \gamma_n \right)} g_t$$

(28)

Equation (28) is the expression for potential output in log-deviations from the steady-state. We can justify the presence of g_t with the wedge that public expenditure creates in the optimality condition for labour supply, as discussed before.

2.4. New Keynesian Phillips Curve

In order to get the New Keynesian Phillips curve, let us solve (28) for a_t and plug it back into (27);considering the loglinearization of the mark-up (19) :

$$\mu = -mc \tag{29}$$

we easily get to:

$$mc = \left[(-\gamma + \frac{1}{v})\theta \left(\frac{\bar{C}}{\tilde{C}} \right)^{\frac{v-1}{v}} \frac{\bar{Y}}{\bar{C}} + \frac{1}{v} \frac{\bar{Y}}{\bar{C}} + \gamma_n \right] (y_t - y_t^*) \tag{30}$$

if we go back to the firm sector and plug the expression for optimal price P_t^* (20) into the aggregate price index (21), after some long but standard algebra and dropping all the terms involving a product of two or more variables in log-deviation from the steady-state[4], we get to the standard formulation of the New Keynesian Phillips Curve:

$$\pi_t = \left[\frac{(1-\zeta)(1-\beta\zeta)}{\theta} \right] mc_t + \beta E_t \pi_{t+1} \tag{31}$$

Plugging (30):

$$\pi_t = \left[\frac{(1-\zeta)(1-\beta\zeta)}{\theta} \right] \left[(-\gamma + \frac{1}{v})\theta \left(\frac{\bar{C}}{\tilde{C}} \right)^{\frac{v-1}{v}} \frac{\bar{Y}}{\bar{C}} + \frac{1}{v} \frac{\bar{Y}}{\bar{C}} + \gamma_n \right] (y_t - y_t^*) + \beta E_t \pi_{t+1} \tag{32}$$

[4]That is because we are not interested in second-order terms.

we see that also the derivation of the New Keynesian Phillips Curve is affected by the innovation introduced in the model; equation (32) in fact represents the more general case, which include the standard formulation as special case when there is no useful government expenditure.

2.5 Monetary policy rule

In line with most of the literature we assume a Taylor-like monetary policy rule for the evolution of the nominal interest rate with inertia:

$$i_t = \phi_i i_{t-1} + \phi_\pi \pi_t + \phi_x (y_t - y_t^*) \tag{33}$$

where obviously interest rate responds to movements in current inflation and current output gap.

2.6. Fiscal policy rule

We assume that government applies a counter-cyclical fiscal policy rule of the kind:

$$\frac{G_t}{\bar{G}} = \left(\frac{Y_t}{Y_t^*}\right)^{-\alpha} + \rho_g \left(\frac{G_{t-1}}{\bar{G}}\right) + \xi_t \tag{34}$$

where α is the parameter determining the intensity of the counter-cyclicality of the fiscal policy rule, ρ_g is the parameter measuring the inertia of government expenditure and ξ_t is a i.i.d. fiscal shock with zero mean and constant variance which captures all the deviations of government expenditure dynamics from the systematic part. Government operates under a balance-budget condition with no debt, collecting the amount of resources it needs every period by using lum-sum taxation.

Loglinearization of (34) leads to:

$$g_t = -\alpha(y_t - y_t^*) + \rho_g g_{t-1} + \xi_t \tag{35}$$

3. The system of equations

The economy is described by the system of equations (14),(28),(32),(33),(35)

Defining the parameters:

$$\frac{\gamma_n+1}{\left((\gamma-\frac{1}{\nu})\theta\left(\frac{\bar{C}}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}}\frac{\bar{Y}}{\bar{C}}+\frac{1}{\nu}\frac{\bar{Y}}{\bar{C}}+\gamma_n\right)} = b_1$$

$$\frac{\left[(\gamma-\frac{1}{\nu})\theta\left(\frac{\bar{C}}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}}\frac{\bar{G}}{\bar{C}}+(-\gamma+\frac{1}{\nu})(1-\theta)\left(\frac{\bar{G}}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}}+\frac{1}{\nu}\frac{\bar{G}}{\bar{C}}\right]}{\left((\gamma-\frac{1}{\nu})\theta\left(\frac{\bar{C}}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}}\frac{\bar{Y}}{\bar{C}}+\frac{1}{\nu}\frac{\bar{Y}}{\bar{C}}+\gamma_n\right)} = b_2$$

$$\left[\frac{(1-\zeta)(1-\beta\zeta)}{\zeta}\right] = \lambda$$

$$\left[(-\gamma+\tfrac{1}{\nu})\theta\left(\frac{\bar{C}}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}}\frac{\bar{Y}}{\bar{C}}+\frac{1}{\nu}\frac{\bar{Y}}{\bar{C}}+\gamma_n\right] = \delta$$

$$\lambda\delta = k$$

$$\frac{\bar{C}}{\bar{Y}}\Phi = \frac{\bar{C}}{\bar{Y}}\frac{\nu}{\left[1-(1-\gamma\nu)\theta\left(\frac{\bar{C}}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}}\right]} = c_1$$

$$\left[\frac{\bar{G}+\bar{C}\Omega}{\bar{Y}}\right] = \frac{\bar{G}}{\bar{Y}}+\frac{\bar{C}}{\bar{Y}}\frac{\left[(1-\gamma\nu)(1-\theta)\left(\frac{\bar{G}}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}}\right]}{\left[1-(1-\gamma\nu)\theta\left(\frac{\bar{C}}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}}\right]} = c_2$$

Then the system is:

$$
\begin{aligned}
y_t^* &= b_1 a_t + b_2 g_t \\
\pi_t &= k(y_t - y_t^*) + \beta E_t \pi_{t+1} \\
i_t &= \phi_\pi \pi_t + \phi_x (y_t - y_t^*) \\
y_t &= -c_1 (i_t - E_t \pi_{t+1}) + E_t y_{t+1} + c_2 [g_t - E_t g_{t+1}] \\
g_t &= -\alpha (y_t - y_t^*) + \rho_g g_{t-1} + \xi_t \\
a_t &= \rho a_{t-1} + \varepsilon_t
\end{aligned}
$$

plus the equation defining the output gap as actual minus potential output. System in matrix form can be found in the Appendix.

Table 1 here shows the baseline calibration:

TABLE 1 HERE

As made clear in section 1, the degree of complementarity / substitutability between public and private consumption depends on the relationship between the elasticity of substitution between private and public consumption (ν), and the inverse of risk adversion coefficient ($\frac{1}{\gamma}$)[5] Whenever $\nu < \frac{1}{\gamma}$ we have complementarity, in the opposite case we have substitutability, whereas if they are equal we are in the benchmark case were there is no relationship between C and G. In the following two sections we will be varying the parameter ν above and below the threshold $\frac{1}{\gamma}$ so to check the model's

[5]Note that the ratio $\frac{1}{\nu}$ is, in standard frameworks, the intertemporal elasticity of consumption. In our more general framework, however, this measure is modified by the presence of government expenditure in the utility function and it is no longer the inverse of the risk adversion coefficient.

behaviour.[6] In particular, in section 4 we will see which range of fiscal policy parameter α is consistent with determinacy of the equilibrium, for different monetary policy stances (aggressive, standard, and passive). In section 5 we will see how the regime of complementarity or substitutability interacts with different degrees of pro/counter cyclicality of the fiscal rule (for given, standard, monetary policy stance) in responding to a wide set of shocks hitting the economy.

4. Stability analysis

In the following experiments, we vary ν above and below $\frac{1}{\gamma}$, varying also the monetary policy stance (modifying the coefficient on inflation ϕ_π). The first three case in both the following tables depicts the benchmark case (i.e. no relationship between private and public consumption), whereas the following two triples show us what happens increasing in two steps the degree of, respectively, complementarity and substitutability between private and public consumption. The last column indicates the range of the fiscal policy parameter α consistent with equilbrium determinacy; given the fiscal rule (35), $\alpha > 0$ corresponds to counter-cyclical fiscal policy, while $\alpha < 0$ to pro-cyclical.

TABLE 2 HERE

[6]As we vary ν, we will remember to vary accordingly also the ratios of private and public consumption over the basket, since they are function of structural parameters θ and ν.

Increasing complementarity does not seem to modify the Taylor principle: no matter the degree of complementarity, the coefficient on inflation still needs to be greater than one for the equilibrium to be determined. We also do not find any (significant) changes with respect to benchmark as we increase complementarity; in all cases determinacy of the equilibrium is given by all range of α leading to counter-cyclicality (and a small range of pro-cyclicality).

Table 3 show us the results as we induce and increase substitutability.

TABLE 3 HERE

Also in this case Taylor principle is confirmed, no matter how substitute C and G are. Furthermore, we note that increasing the degree of substitutability makes pro-cyclical fiscal policy also determinate, for an increasing range of pro-cyclical parameters of the fiscal policy rule; equivalently, increasing complementarity (=decreasing substitutability) makes only counter-cyclical regime consistent with determinacy.

The main conclusion we can draw is that increasing the substitutability between public and private consumption allows for stability of pro-cyclical fiscal policy, in addition to counter-cyclical, which is the only stability rule in case of complementarity. The intuition behind this result is that if government expenditure is pro-cyclical, namely it is directly proportional to the dynamics of actual output, the inflationary pressure is dumped by the optimizing behaviour of consumers, who endogenously decrease private consumption in response to an increase in public consumption, because of the presence of complementarity in the utility function.

5. Response to shocks

This section shows the response of output gap and public expenditure to three types of stochastic shocks: technological, fiscal and cost-push shock. Autoregressive parameters are calibrated as in Table 1 in section 3. All results are derived for a given monetary policy ($\phi_\pi = 1.5$). Since in most cases differences are hard to notice in a graph, quantitative simulations on variables'initial reactions can be found in Appendix A.

5.1 Technological shock

Let us start from showing the benchmark case, in which the risk adversion coefficient (γ)is set at 0.5 and the elasticity of substitution between private and public consumption (ν) is set at 2. So we are back to the standard case where public consumption does not affect the consumption basket in the utility function. Here are the results, for different values of the fiscal policy pararamer α :

FIGURE 1 HERE

The upper panel shows the counter-cyclical case, for different degrees of intensity $(\alpha = 0.5, 1, 1.5)$, whereas the lower panel shows the pro-cyclical case. More complete quantitative simulations can found in appendix.

In the counter-cyclical case, this is the mechanism at work. Technological shock has a positive effect on both actual and potential output, but the latter is stronger so the overall effect on output gap is negative. At this point, three effects start working: decrease in the interest rate (through Taylor rule) which pushes up actual output, decrease in inflation (through Phillips curve) which also puts downward pressure on interest rate, and increase in government expenditure due to the counter-cyclical stance of the fiscal policy rule;so the three effects push in the same upward direction of closing the output gap by raising actual output. The more counter-cyclical fiscal policy is, the stronger the third effect, and so the lower is the initial (negative) response of output gap, the higher the initial (positive) response of government expenditure, the quicker the re-absorption of output gap.

In the pro-ciclical case, the third effect works in the opposite direction, since now public expenditure follows the negative trend of the output gap induced by the technological shock. The negative effect on output gap is thus more and more severe as the degree of prociclicality increases; at the same time, the worsening of the output gap strenghtens the standard responses of the inflation/interest rate channels, so output gap overshoots before going back to the steady state (the extent of the overshooting increases with the degree of pro-ciclicality; in that case, obviously, return to the steady state is more rapid). For the same reason, initial response of government expenditure is more severe the more pro-cyclical fiscal policy is.

This is the basic mechanism at work in the benchmark case, where public consumption does not affect private consumption. Let us see how introducing complementarity/substitutability affects the situation.

The two following figures represent the complementarity case, obtained by lowering the elasticity of substitution ν to 1.5 (figure 1) and then, widening the degree of complementarity, by bringing ν to 0.9 . (figure 2)

FIGURE 2 HERE

FIGURE 3 HERE

As we can see from the graphs (and from the tables) the effects are quantitatively quite small, but still they can give us interesting insights on how the behaviour of economic variables can change if the relationship between private and public consumption changes significantly. As we increase complementarity, the impact of technological shock on potential output is smaller, because of the supply-side effect of complementarity; at the same time, the relative effect on output gap is bigger, and this means that under counter-cyclical fiscal policy government expenditure increases more, whereas under pro-cyclical regime it decreases more and more as we increase the degree of complementarity.

The opposite happens if we induce substitutabilty between private and public consumption by raising the elasticity of substitution ν to 4 (figure 3) and then to 9 (figure 4) :

FIGURE 4 HERE
FIGURE 5 HERE

We can see that output gap decreases less, and so public expenditure has a smaller increase in the counterciclical case and a smaller decrease in the prociclical case.

5.2. Government expenditure shocks

This section analyses what happens in case of shocks to the fiscal policy rule (the i.i.d term ξ_t), a stochastic movement of government expenditure so to capture all the deviations from rationality that policy-makers might be induced to, due for example to political or lobbying pressures.

Here are the results in the benchmark, where public consumption has not effect in households' utility function:

FIGURE 6 HERE

A fiscal shock generates an unexpected rise in public expenditure; in this model, this increases actual output (by increasing aggregate demand) and potential output (through the labour supply-channel), with the former effect being much larger than the latter. Therefore output gap increases, and under counterciclical regime public expenditure decreases, bringing it back to equilibrium. In the pro-cyclical case, public expenditure increases by a much larger extent, since now the feedback rule reinforce the initial increase caused by the shock; as fiscal policy becomes more pro-cyclical, the positive effect on actual output offset the interest-rate and the inflation channels (who pushes towards closing of the output gap), and we observe an overshooting of the output gap itself, whose absorption is anyway quicker the more prociclical fiscal policy is.

Let us see what happens as we introduce complementarity between private consumption and public expenditure, first in a week form (figure 6) and then in a stronger one (figure 7).

FIGURE 7 HERE
FIGURE 8 HERE

Introducing complementarity enhances the response of actual output (because of the parallel increase in private consumption) and potential output (because of the labour market effect), and the relative magnitude of these two effects is such that output gap's positive response is also enhanced. Under counter-cyclical fiscal policy, this dumpens public expenditure initial increase, whereas under prociclical regime initial response of public expenditure is increases, and this in turns widens the fluctuations of the output gap dynamics around equilibrium, that have seen to be typical of the pro-cyclical stance.

What happens in case of substitutability?

Intuitively, output will react less, since the innovation in public expenditure is now matched by a decrease in private consumption, which in turn dumpens the reaction of both actual output (because private consumption decreases) and potential output (since the wedge between marginal utility of consumption and marginal disutility of labour is now reduced). This will also be reflected in a smoother jump of public expenditure as we increase the absolute value of α, both under prociclical and counterciclical regime. These the results for $\nu = 4$ and then for $\nu = 9$:

FIGURE 9 HERE

FIGURE 10 HERE

5.3. Cost push shock

Let us see what is the model's reaction to an exogenous i.i.d.shock to the Phillips curve, mimicking all variations in real marginal costs that are due to factors other than excess demand (oil shocks, but also some forms of labour market power,etc).

Here are the results in the benchmark case:

FIGURE 11 HERE

Increasing the degree of counter-cyclicality increases the initial response of public expenditure, because the feedback response to the arising of the negative output gap (due to the cost push shock) is amplified; for the same reason, the more counter-cyclical fiscal policy is the less negative is the initial impact of the shock on output gap.

In the pro-cyclical case the fiscal feedback rule further increase the negative response of output gap to the cost push shock, with an extent obviously increasing with the level of procyclicality. But as we increase it, the output gap response becomes so severe that the usual channels (interest rate and inflation) forces becomes stronger, and provoke and overshooting (similar, but of opposite sign, to the one observed in the fiscal shock case) which can be quite evident when the fiscal policy coefficient is 1.5.

With complementarity, in the counter-cyclical case the positive response of public expenditure is now coupled with a parallel increase in private consumption which, increasing output, makes output gap response less severe as we increase the degree of complementarity. In the pro-cyclical case, the opposite happens, and this widens the fluctuations of output gap around equilibrium.

FIGURE 12 HERE

FIGURE 13 HERE

With substitutability,the response of private consumption (and thus of actual output) is opposite to the public expenditure movements induced by the arising of the negative output gap; this induces output gap dynamics to be more ambiguous depending on the prevailing effect.

FIGURE 14 HERE

FIGURE 15 HERE

6. Conclusions

This paper is concerned with a more accurate analysis on the effects of the fiscal policy regime when the relationship between private and public consumption is taken into account in a more detailed way. We presented a New Keynesian dynamic stochastic general equilibrium model in which households value both private and public consumption, and in which the latter is governed by a fiscal rule showing pro/counter cyclical stance according to the reaction to output gap movements. Our results can be summarized as follows.

As far as stability properties are concerned, the model delivers determinacy of rational expectation equilibrium mainly for parameters showing counter-cyclicality of fiscal policy rule. However, as we increase the degree of substitutability between private and public consumption, we observe a widening of the range of parameters leading to determinacy, so that also pro-cyclical stance is stable.

We also examined the reaction of the economy to a wide set of stochastic shocks (productivity, fiscal and cost-push). Generally speaking, pro-cyclical stance leads to the emergence of an overshooting reaction of output gap dynamics whose fluctuations are increasing with the degree of pro-cyclicality; as far as public expenditure, its negative reaction is lower in case of productivity shock, it increases more in case of fiscal shock, and it decreases more in case of cost-push shock. A general feature of pro-cyclical cases is that shocks are re-absorbed rather quickly. On the other hand, counter-cyclical stance leads to a well-behaved and more persistent response of economic variables. The more counter-cyclical, the smaller the negative effect on output gap of productivity and cost-push shock but the smaller the positive effect of fiscal shock. Moreover, increasing counter-cyclicality leads to bigger positive response of public expenditure to productivity and cost-push shock, and to a dampening of the fiscal shock. Generally speaking, increasing complementarity between private and public consumption increases the absolute values of the above movements, whereas substitutability reduces them.

The main result of this paper is that it really seems to make little sense to discuss pro-cyclicality or counter-cyclicality of fiscal policy without distinguish between the different categories of the government expenditure and their properties.For example, according to our simplified framework government expenditure on a public good (which can maybe be considered complementary to private consumption) is consistent with counter-cyclical fiscal policy and amplifies the response of output to shocks and their persistance; on the other hand, financing a merit good (which seems to be featured by substitutability) delivers stability under a prociclical stance but leads to overshooting dynamics for output gap but quicker re-absorptions. This remark obviously call for a more conclusive investigation of the properties of the different public expenditure's categories and the way they affect private consumption dynamics, an issue that, as shown in the introduction, has not yet found a clear solution in the literature.

Future extensions on the theoretical side include addressing some of the shortcomings of the present framework, before turning to a possible open-economy model in which to better analyse some of the issues discussed in the introduction. For example, a more detailed analysis is needed not only on the way public expenditure interacts with private consumption (distinguishing across different types of expenditure), but also on the way it is financed. An extended model should include distorsionary taxation (possibly on multiple sources, as in Forni, Monteforte, Sessa 2006) and debt emission. With such modifications, maybe some interesting conclusions on the macroeconomic consequences of fiscal policy could been drawn in a more adequate way.

References

Amano,R.A., Wirjanto T.S. (1997), "*Intertemporal Substitution and Government Spending"* The Review of Economics and Statistics 1, 605-09

Ashauer, D. (1985) "Fiscal Policy and Aggregate Demand" *American Economic Review,* 75 (1) 117-127

Balassone F., Monacelli D. (2000), EMU Fiscal Rules: Is There a Gap? *Bank of Italy Research Department Working Papers 375*

Barro, R.J. (1979) On the Determination of Public Debt *Journal of Political Economy*, 87, 940-971.

Baxter,M., King,R. (1993), "*Fiscal Policy in General Equilibrium"* American Economic Review 83, 315-334.

Bouakez,H, Rebei N. (2003), "Why Does Private Consumption Rises After a Government Spending Shock?" *Bank of Canada Research Paper*

Campbell,J.Y., Mankiw,G.W., (1990), "*Permanent Income, Current Income and Consumption"* Journal of Business and Economic Statistics 8, 265-279.

Chari,V.V., Kehoe,P. (2004),"On the Desiderability of Fiscal Constraints in a Monetary Union" *NBER Working Papers* 12476

Christiano,L.J., Eichenbaum,M. (1992), "*Current Real Business Cycle Theories and Aggregate Labour Market Fluctuations"* American Economic Review 82, 430-450.

Coricelli,F., Ercolani, V. (2002), "Cyclical and Structural Deficits on the Road to Accession: Fiscal Rules for an Enlarged European Union" *CEPR Discussion Paper* 3672

Deveraux,M.B., Head,A.C.Lapham,B.J., (1996) "*Monopolistic Competition, Increasing Returns and the Effects of Government Spending"* Journal of Money, Credit and Banking 28, 233-254.

Fiorito, R., Kollintzas T., (2004), "Public Goods, Merit Goods and the Relation between Private and Government Consumption" *European Economic Review* 48 1367-1398

Forni, L., Monteforte, L., Sessa, L. (2006), "*Revisiting the Effects of Fiscal Policy in an Estimated DSGE model for the Euro Area"* Bank of Italy- Working paper

Galì,J, Monacelli, T.(2005), "Optimal Monetary and Fiscal Policy in a Monetary Union" *UPF Working paper*

Ganelli, G. (2001), "Useful Government Spending, Direct Crowding-Out and Fiscal Policy Interdependence" *Journal of International Money and Finance*

Graham, F.C., (1993), "Fiscal Policy and Aggregate Demand : Comment" *American Economic Review* 83,659-666.

Graham,F.C, Himarios, D. (1991), "Fiscal Policy and Private Consumption: Instrumental Variables Tests of the Consolidation Approach" *Journal of Money, Credit and Banking* 23 (1), 53-67

Ni,S. (1995),"An Empirical Analysis on the Substitutability between Private Consumption and Government Purchases",*Journal of Monetary Economics* 36, 593-605.

Karras,G., "Government Spending and Private Consumption: Some International Evidence" *Journal of Money, Credit and Banking* 26,9-22.

Okubo,M.(2003), Intratemporal Substitution between Private and Government Consumption: the Case of Japan*" Economics Letters* 79: 75-81

FIGURES AND TABLES

Figure 1: response to technological shock in the benchmark

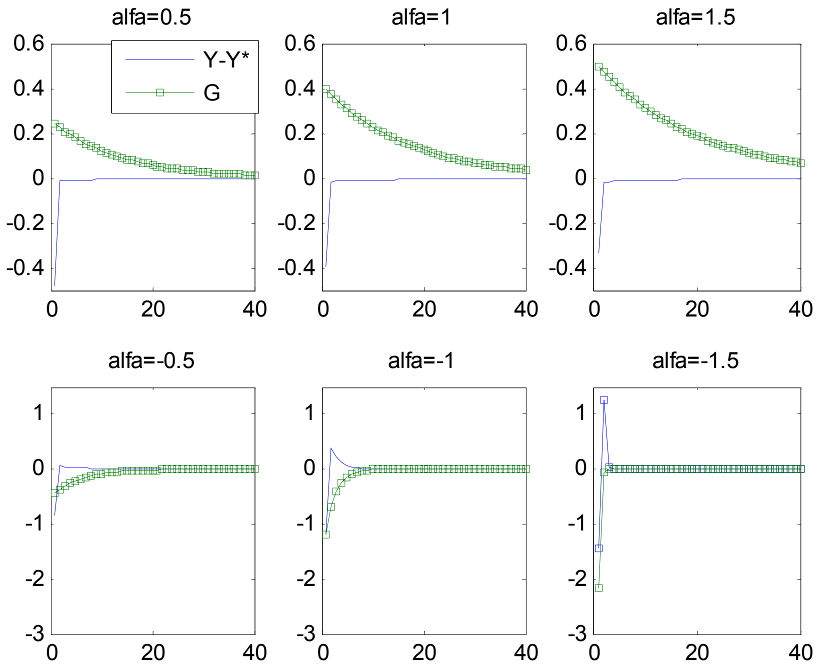

Figure 2: response to technological shock with complementarity

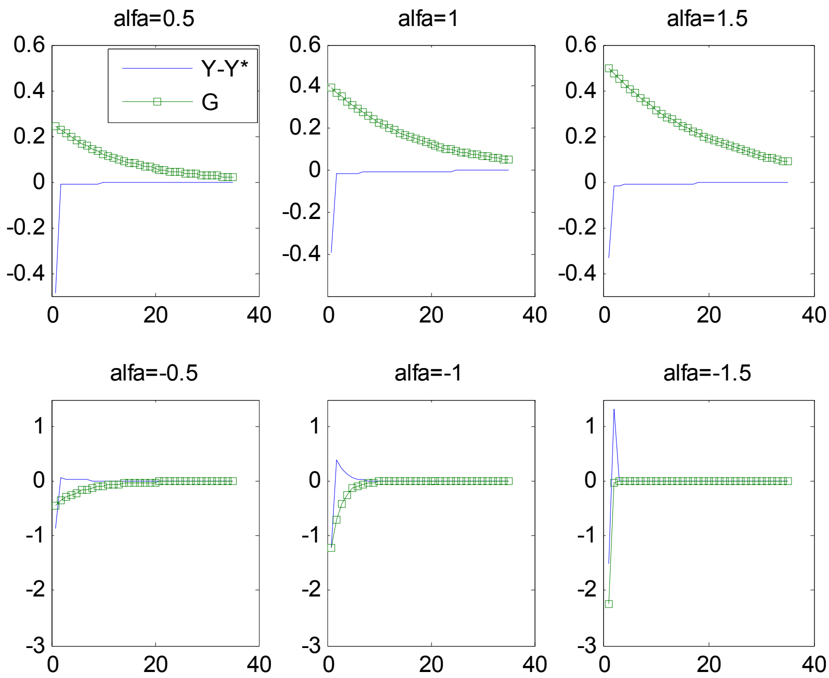

Figure 3: response to technological shock with more complementarity

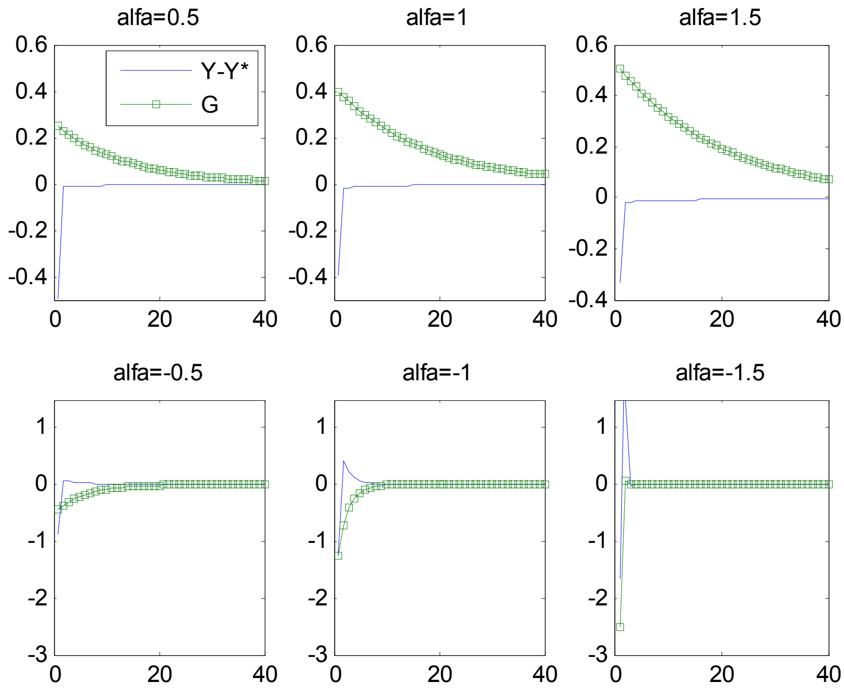

Figure 4: response to technological shock with substitutability

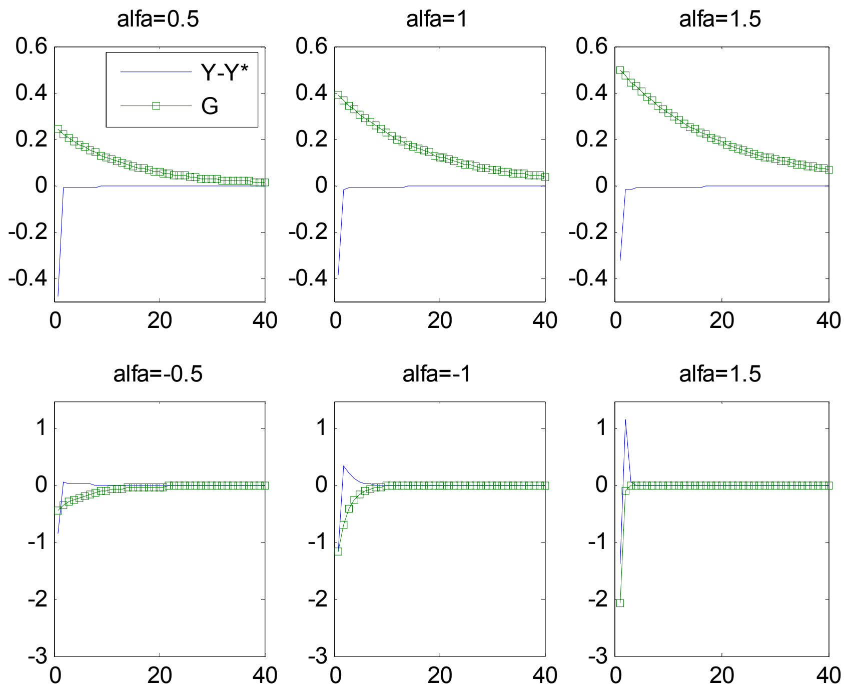

Figure 5: response to technological shock with more substitutability

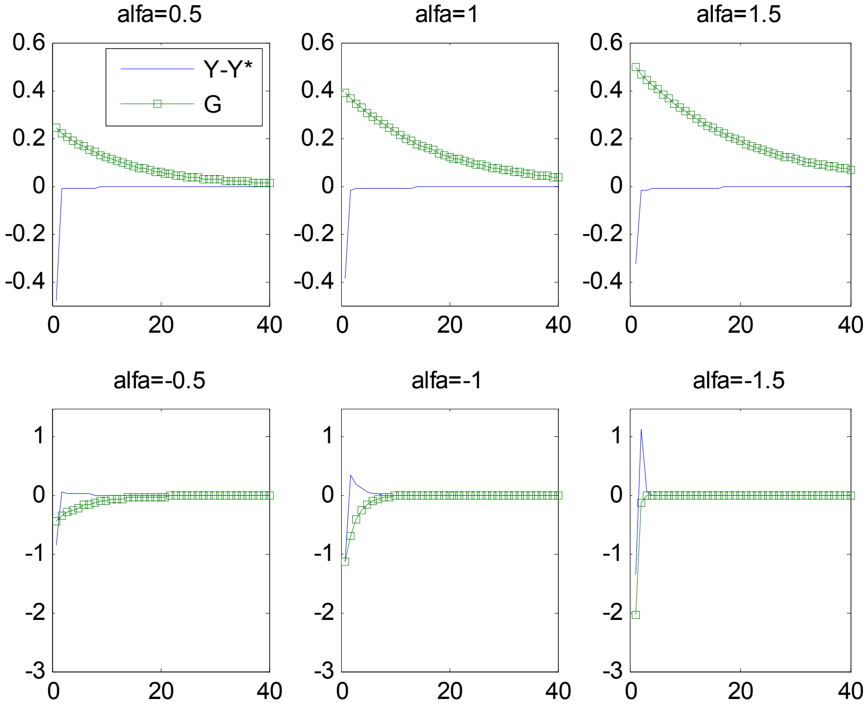

Figure 6: response to fiscal shock in the benchmark

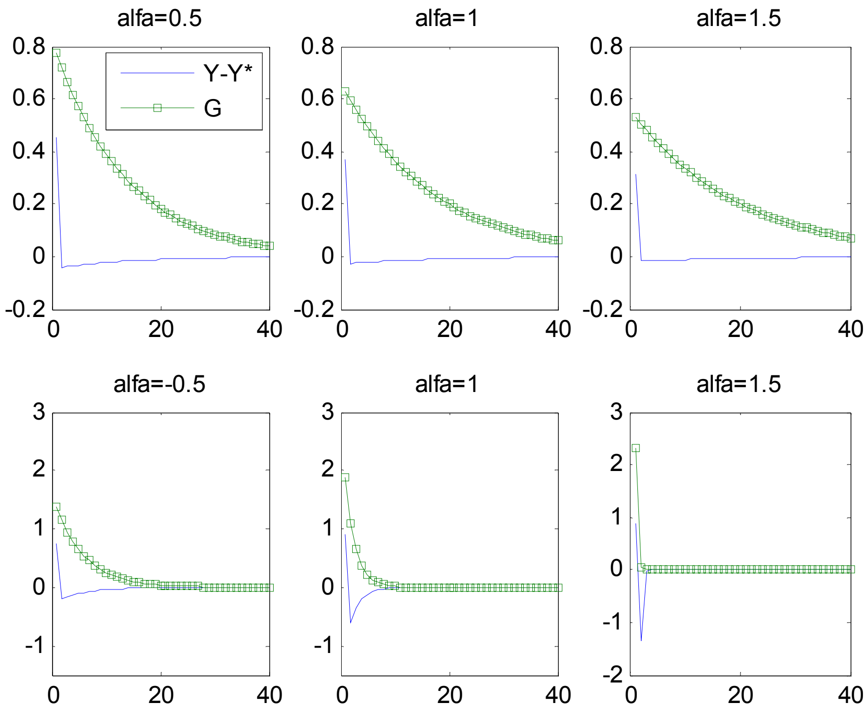

Figure 7: response to fiscal shock with complementarity

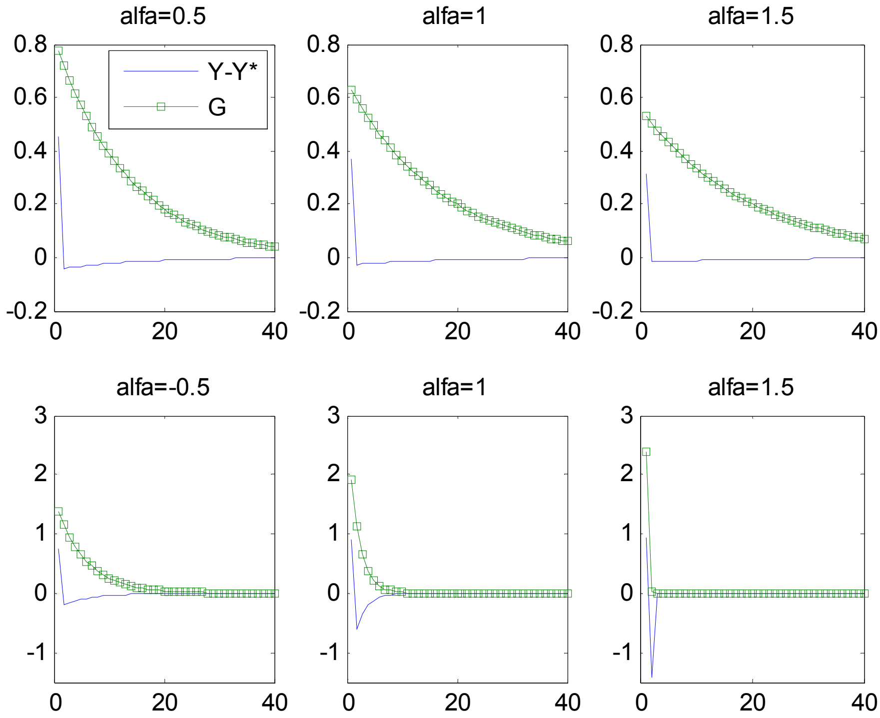

Figure 8: response to fiscal shock with more complementarity

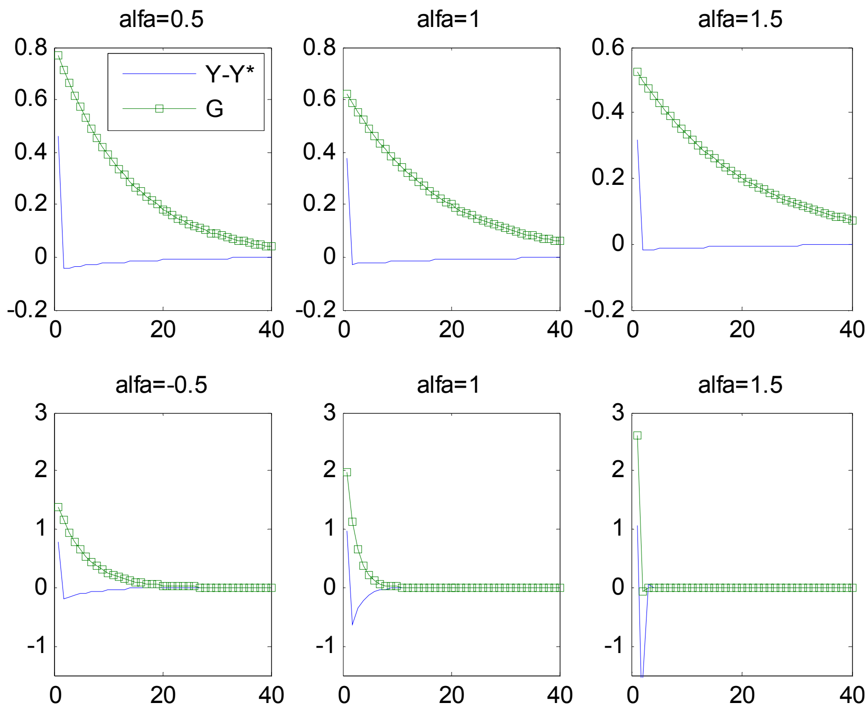

Figure 9: response to fiscal shock with substitutability

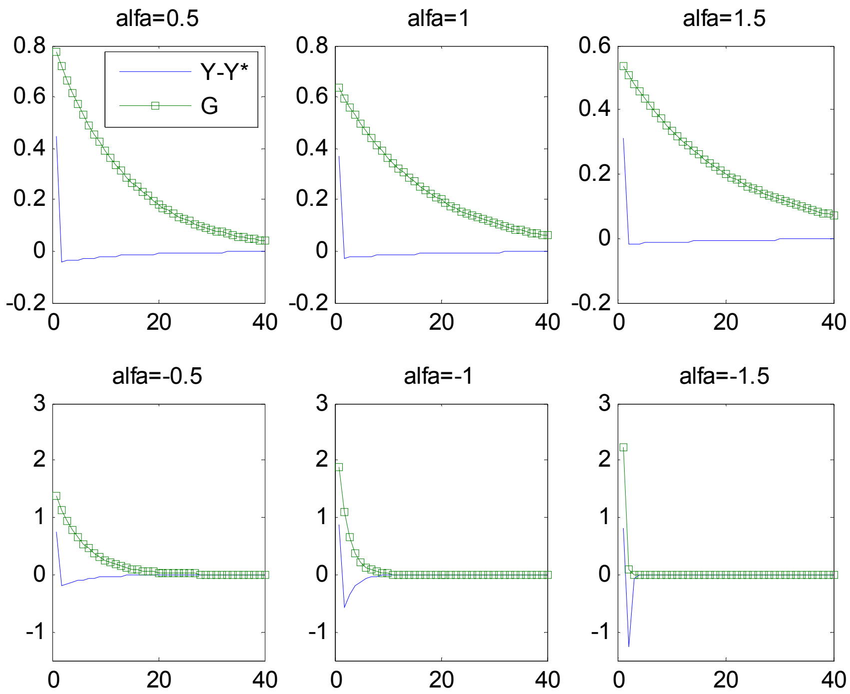

Figure 10: response to fiscal shock with more substitutability

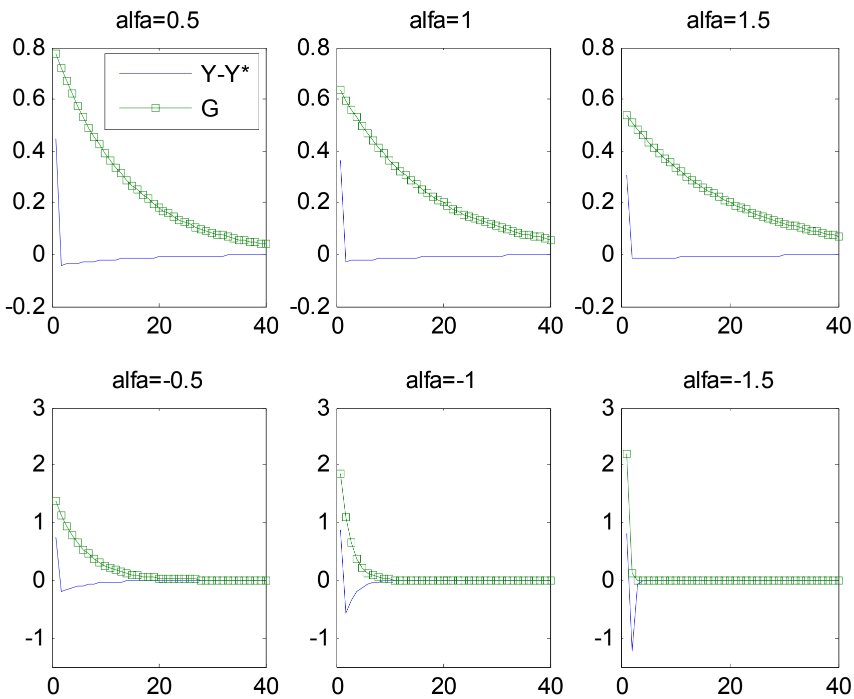

Figure 11: response to cost-push shock in the benchmark

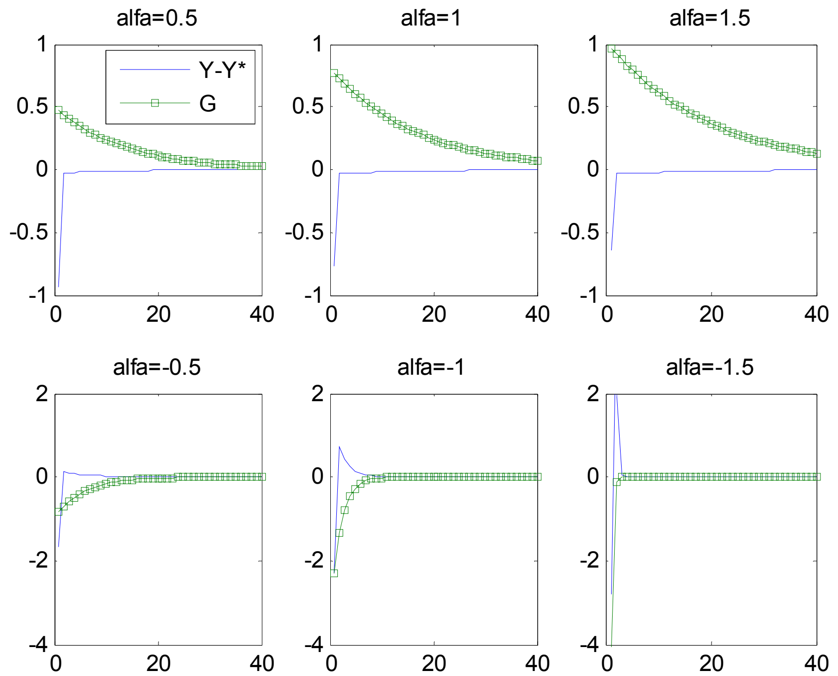

Figure 12: response to cost-push shock with complementarity

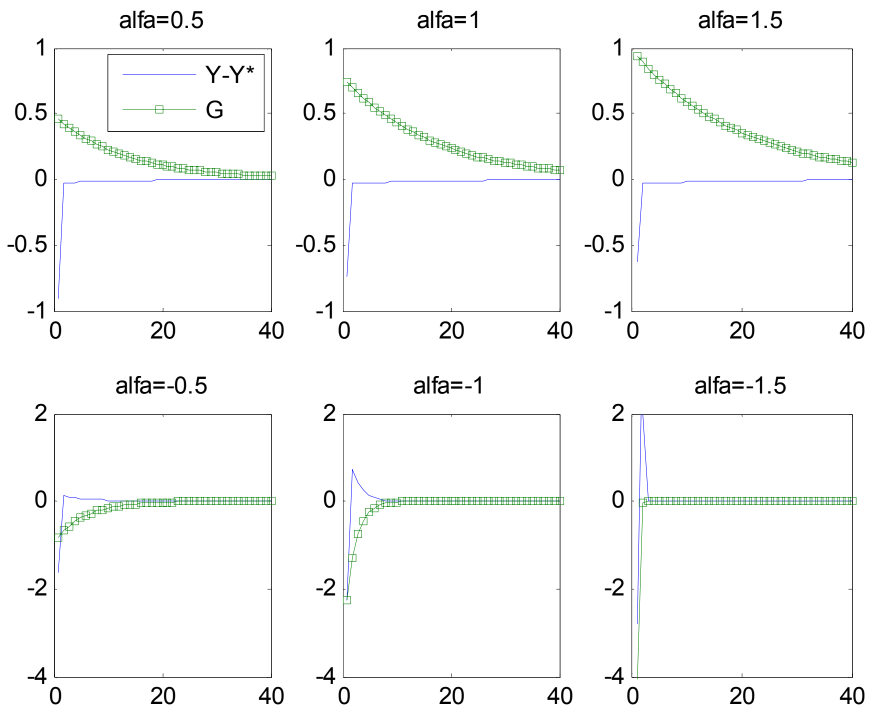

Figure 13: response to cost-push shock with more complementarity

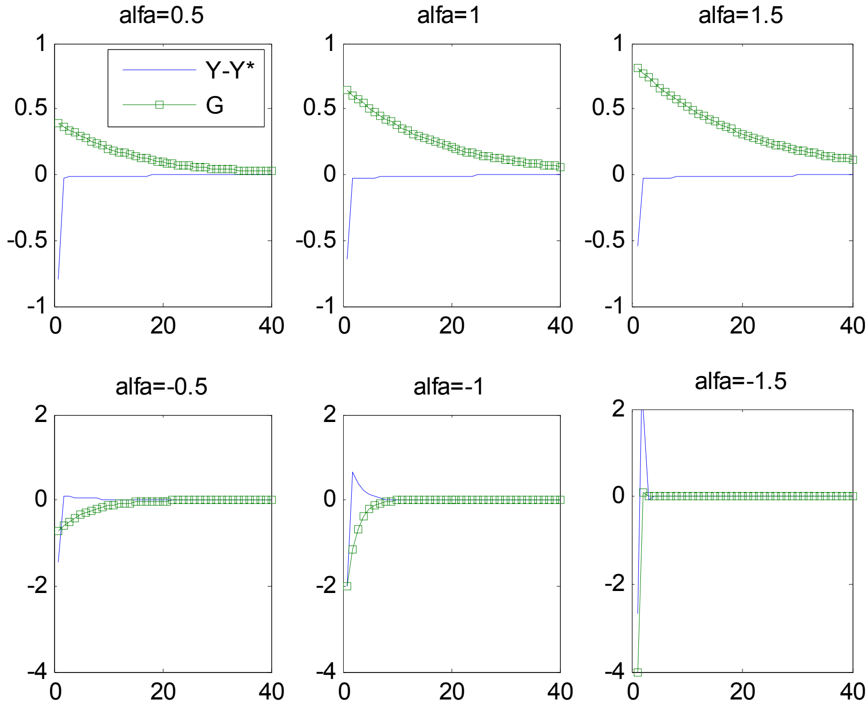

Figure 14: response to cost-push shock with substitutability

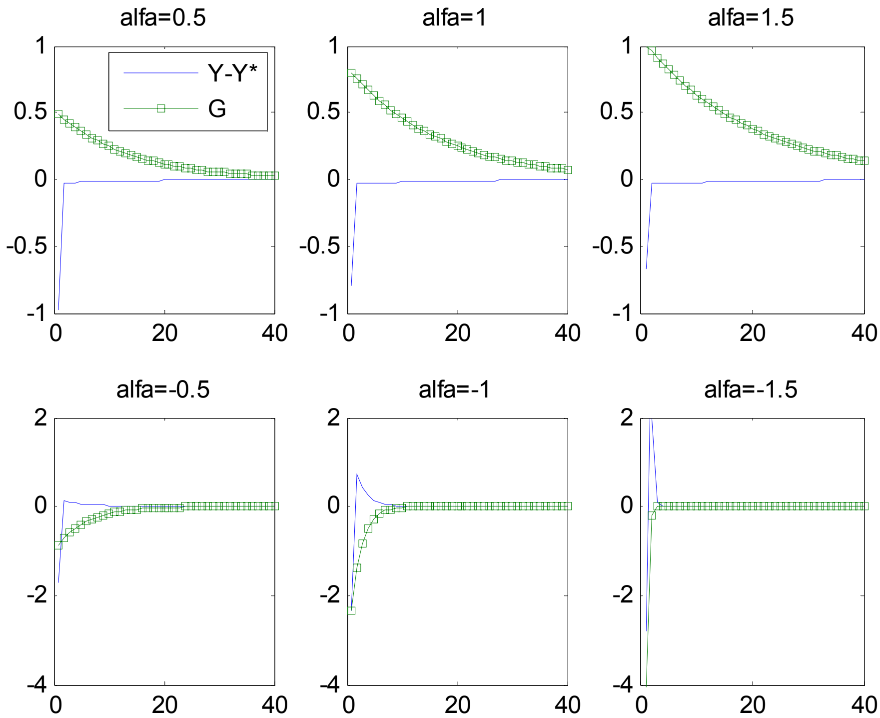

Figure 15: response to cost-push shock with more substitutability

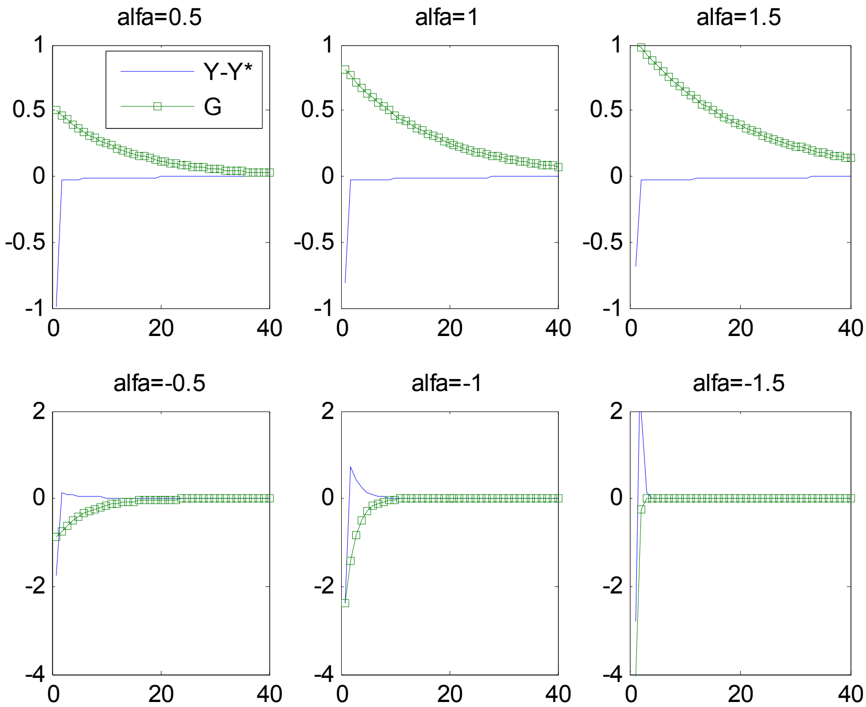

Table 1: baseline calibration

Parameter	Value	Description
β	0,99	subjective discount factor
ζ	0,75	prob.of keeping prices fixed in a given period
θ	0,75	preference parameter (weight in the CES)
γ	0,75	risk adversion coefficient
γ(n)	1,50	inverse of labour supply elasticity
v	2	elasticity of substitution between priv. cons. and gov.expend.
G/Y	0,25	ratio between gov.expend. and output in steady state
C/Y	0,75	ratio between priv.expend and output in steady state
φ(x)	0,5	output coefficient in Taylor rule
ρ	0,95	AR(1) parameter of technological shock
ρ(g)	0,9	AR(1) parameter of the fiscal shock
φ(i)	0,5	interest rate inertia in Taylor rule

Table 2: equilibrium determinacy increasing complementarity

γ	**v**	**φ(π)**	**stability parameter for fiscal rule**
0,5	2	1,5	$-1 < \alpha < 3$
0,5	2	2,5	$-1 < \alpha < 3$
0,5	2	0,7	none
0,5	*1,5*	1,5	$-1 < \alpha < 3$
0,5	*1,5*	2,5	$-1 < \alpha < 3$
0,5	*1,5*	0,7	none
0,5	*0,9*	1,5	$-1 < \alpha < 3$
0,5	*0,9*	2,5	$-1 < \alpha < 3$
0,5	*0,9*	0,7	none

Table 3: equilibrium determinacy increasing substitutability

γ	**v**	**φ(π)**	**stability parameter for fiscal rule**
0,5	2	1,5	$-1< \alpha < 3$
0,5	2	2,5	$-1 < \alpha < 3$
0,5	2	0,7	no one
0,5	*4*	1,5	$-2 < \alpha < 3$
0,5	*4*	2,5	$-2 < \alpha < 3$
0,5	*4*	0,7	no one
0,5	*9*	1,5	$-2.5 < \alpha < 3$
0,5	*9*	2,5	$-2,5< \alpha < 3$
0,5	*9*	0,7	no one

Table A1: initial responses to technological shock

		alfa=0.5	alfa=1	alfa=1.5	alfa=-0.5	alfa=-1	alfa=-1.5
BENCHMARK	y-y*	-0,4833	-0,3933	-0,3313	-0,8587	-1,184	-1,4452
	g	0,2417	0,39333	0,4969	-0,4293	-1,184	-2,1679
		alfa=0.5	alfa=1	alfa=1.5	alfa=-0.5	alfa=-1	alfa=-1.5
COMPL.	y-y*	-0,4864	-0,3953	-0,3327	-0,8686	-1,207	-1,5019
	g	0,2432	0,3953	0,499	-0,4343	-1,207	-2,2528
MORE COMPL.		alfa=0.5	alfa=1	alfa=1.5	alfa=-0.5	alfa=-1	alfa=-1.5
	y-y*	-0,4923	-0,3993	-0,3355	-0,8871	-1,2554	-1,6656
	g	0,2462	0,3993	0,5033	-0,4435	-1,2554	-2,4984
		alfa=0.5	alfa=1	alfa=1.5	alfa=-0.5	alfa=-1	alfa=-1.5
SUBST.	y-y*	-0,4793	-0,3907	-0,3294	-0,8456	-1,1551	-1,3801
	g	0,2396	0,3907	0,4941	0,4228	-1,1551	-2,0701
		alfa=0.5	alfa=1	alfa=1.5	alfa=-0.5	alfa=-1	alfa=-1.5
MORE SUBST.	y-y*	-0,4776	-0,3895	-0,3286	-0,8402	-1,1432	-1,3548
	g	0,2388	0,3895	0,4929	0,4201	-1,1432	-2,0322

Table A2: initial response to fiscal shock

		alfa=0.5	alfa=1	alfa=1.5	alfa=-0.5	alfa=-1	alfa=-1.5
BENCHMARK	y-y*	0,4505	0,3695	0,3127	0,7528	0,898	0,8778
	g	0,7747	0,6305	0,531	1,3764	1,898	2,3167
		alfa=0.5	alfa=1	alfa=1.5	alfa=-0.5	alfa=-1	alfa=-1.5
COMPL.	y-y*	0,4535	0,3715	0,314	0,7619	0,9189	0,9251
	g	0,7733	0,6285	0,5289	1,381	1,9189	2,3877
MORE COMPL.		alfa=0.5	alfa=1	alfa=1.5	alfa=-0.5	alfa=-1	alfa=-1.5
	y-y*	0,4587	0,375	0,3166	0,7771	0,9651	1,0714
	g	0,7706	0,625	0,5252	1,3885	1,9651	2,6071
		alfa=0.5	alfa=1	alfa=1.5	alfa=-0.5	alfa=-1	alfa=-1.5
SUBST.	y-y*	0,4505	0,3695	0,3127	0,7528	0,898	0,8778
	g	0,7747	0,6305	0,531	1,3764	1,898	2,3167

		alfa=0.5	alfa=1	alfa=1.5	alfa=-0.5	alfa=-1	alfa=-1.5
MORE SUBST.	y-y*	0,4466	0,3669	0,3108	0,7407	0,8719	0,8243
	g	0,7767	0,6331	0,5338	1,3703	1,8719	2,2362

Table A3: initial responses to cost-push shock

		alfa=0.5	alfa=1	alfa=1.5	alfa=-0.5	alfa=-1	alfa=-1.5
BENCHMARK	y-y*	-0,9439	-0,7681	-0,647	-1,677	-2,3124	-2,8226
	g	0,472	0,7681	0,9704	-0,8385	-2,3124	-4,2338
		alfa=0.5	alfa=1	alfa=1.5	alfa=-0.5	alfa=-1	alfa=-1.5
COMPL.	y-y*	-0,9112	-0,7406	-0,6233	-1,6274	-2,2612	-2,8137
	g	0,4556	0,7406	0,935	-0,8137	-2,2612	-4,2206
MORE COMPL.		alfa=0.5	alfa=1	alfa=1.5	alfa=-0.5	alfa=-1	alfa=-1.5
	y-y*	-0,795	-0,6447	-0,5417	-1,4324	-2,0271	-2,6894
	g	0,3975	0,6447	0,8126	-0,7162	-2,0271	-2,6894
		alfa=0.5	alfa=1	alfa=1.5	alfa=-0.5	alfa=-1	alfa=-1.5
SUBST.	y-y*	-0,9802	-0,7989	-0,6736	-1,7293	-2,3622	-2,8222
	g	0,4901	0,7989	1,0104	-0,8646	-2,3622	-4,2333
		alfa=0.5	alfa=1	alfa=1.5	alfa=-0.5	alfa=-1	alfa=-1.5
MORE SUBST.	y-y*	-0,994	-0,8107	-0,6839	-1,7486	-2,3793	-2,8197
	g	0,497	0,8107	1,0258	-0,8743	-2,3793	-4,2295

Appendix A: Quantitative results of impulse responses: initial impact

TABLE A1 HERE
TABLE A2 HERE
TABLE A3 HERE

Appendix B - the system in matrix form

The system is in the form:

$$AE_tY_{t+1} = BY_t + CX_t$$

with the vector Y_t being:

$$Y_t = [y_t, \pi_t, y_t^*, x_t, g_t, i_{t-1}, a_{t-1}]$$

The system in a explicit form:

$$\begin{aligned}
E_t y_{t+1} + \frac{\bar{C}}{\bar{Y}}\Phi E_t \pi_{t+1} - \left[\frac{\bar{G}+\bar{C}\Omega}{\bar{Y}}\right] E_t g_{t+1} - \frac{\bar{C}}{\bar{Y}}\Phi i_t &= y_t - \left[\frac{\bar{G}+\bar{C}\Omega}{\bar{Y}}\right] g_t \\
\beta E_t \pi_{t+1} &= \pi_t - kx_t - \mu_t \\
\frac{\gamma_n + 1}{\left((\gamma - \frac{1}{v})\theta\left(\frac{C}{\tilde{C}}\right)^{\frac{v-1}{v}}\frac{\bar{Y}}{\bar{C}} + \frac{1}{v}\frac{\bar{Y}}{\bar{C}} + \gamma_n\right)} a_t &= y_t^* - \frac{\left[(\gamma - \frac{1}{v})\theta\left(\frac{C}{\tilde{C}}\right)^{\frac{v-1}{v}}\frac{\bar{G}}{\bar{C}} + (-\gamma + \frac{1}{v})(1-\theta)\left(\frac{G}{\tilde{C}}\right)^{\frac{v-1}{v}} + \frac{1}{v}\frac{\bar{G}}{\bar{C}} \right.}{\left((\gamma - \frac{1}{v})\theta\left(\frac{C}{\tilde{C}}\right)^{\frac{v-1}{v}}\frac{\bar{Y}}{\bar{C}} + \frac{1}{v}\frac{\bar{Y}}{\bar{C}} + \gamma_n\right)} \\
0 &= g_t + \alpha x_t - \rho_g h_t - \xi_t \\
a_t &= \rho a_{t-1} + \varepsilon_t \\
i_t &= \phi_i i_{t-1} + \phi_\pi \pi_t + \phi_x x_t \\
0 &= x_t - y_t + y_t^* \\
h_{t+1} &= g_t
\end{aligned}$$

In matrix form:

$$
\left\{\begin{array}{cccccccc}
1 & \frac{\bar{C}}{\bar{Y}}\Phi & 0 & 0 & -\left[\frac{\bar{G}+\bar{C}\Omega}{\bar{Y}}\right] & -\frac{\bar{C}}{\bar{Y}}\Phi & 0 & 0 \\
0 & \beta & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & \frac{\gamma_n+1}{\left((\gamma-\frac{1}{\nu})\theta\left(\frac{C}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}}\frac{\bar{Y}}{\bar{C}}+\frac{1}{\nu}\frac{\bar{Y}}{\bar{C}}+\gamma_n\right)} & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1
\end{array}\right\} E_t \left\{\begin{array}{c}
y_{t+1} \\ \pi_{t+1} \\ y^*_{t+1} \\ x_{t+1} \\ g_{t+1} \\ i_t \\ a_t \\ h_{t+1}
\end{array}\right\} =
$$

$$
\left\{\begin{array}{cccccccc}
1 & 0 & 0 & 0 & -\left[\frac{\bar{G}+\bar{C}\Omega}{\bar{Y}}\right] & 0 & 0 & 0 \\
0 & 1 & 0 & -k & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & \frac{\left[(-\gamma+\frac{1}{\nu})\theta\left(\frac{C}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}}\frac{\bar{G}}{\bar{C}}+(\gamma-\frac{1}{\nu})(1-\theta)\left(\frac{G}{\bar{C}}\right)^{\frac{\nu-1}{\nu}}-\frac{1}{\nu}\frac{\bar{G}}{\bar{C}}\right]}{\left((\gamma-\frac{1}{\nu})\theta\left(\frac{C}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}}\frac{\bar{Y}}{\bar{C}}+\frac{1}{\nu}\frac{\bar{Y}}{\bar{C}}+\gamma_n\right)} & 0 & 0 & 0 \\
-1 & 0 & 1 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & \alpha & 1 & 0 & 0 & -\rho_g \\
0 & \phi_\pi & 0 & \phi_x & 0 & \phi_i & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & \rho \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & 0
\end{array}\right\} \left\{\begin{array}{c}
y_t \\ \pi_t \\ y^*_t \\ x_t \\ g_t \\ i_{t-1} \\ a_{t-1} \\ h_t
\end{array}\right\} + \left\{\begin{array}{c}
0 \\ 0 \\ 0 \\ 0 \\ -1 \\ 0 \\ 1 \\ 0
\end{array}\right\} \varepsilon_t
$$

$$\frac{\nu}{\left[1-(1-\gamma\nu)\theta\left(\frac{C}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}}\right]}=\Phi$$

$$\frac{\left[(1-\gamma\nu)(1-\theta)\left(\frac{G}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}}\right]}{\left[1-(1-\gamma\nu)\theta\left(\frac{C}{\tilde{C}}\right)^{\frac{\nu-1}{\nu}}\right]}=\Omega$$