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Government Expenditure**

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Abstract

Macroeconomic literature has traditionally regarded public expenditure as yielding no utility *per se* to any agent in the economy. In line with a few previous contributions (Linneman and Schabert 2004, Bouakez and Rebei 2007) in this paper, we build a New Keynesian DSGE model with real and nominal rigidities and distortionary fiscal policy rules, calibrated on the Euro-area (1990:1-2008:4), where part of public spending is allowed to either Edgeworth complement or substitute private consumption by affecting its marginal utility. We show that the interaction between the share of usefulness of public spending and the specification of fiscal and monetary policy rules is able to deliver private consumption multipliers which are in line with the empirical findings for the Euro-Area.

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1 Introduction

How does the standard analysis on fiscal policy multipliers change when government spending directly affects private consumption? In this paper we evaluate the ability of DSGE models to generate positive consumption multipliers in line with those found by empirical analysis on the Euro-zone. The hypothesis we made is that public expenditure flow - financed by distortionary taxation - Edgeworth complements or substitutes private consumption by directly affecting its marginal utility. We present a simple DSGE model able to account for the positive effects on consumption following a government expenditure shock without the role of credit constrained agents, as described in Galí *et al.* (2007). Our model shows that with a proper definition of the degree of complementarity between consumption and public expenditure, and by explicitly considering distortionary taxation as mean of financing, we obtain fiscal policy multipliers in line with empirical evidence for the Euro area. This shows a more general and less 'ad hoc' framework to shed light on the fiscal policy transmission mechanism.

Following the debate on the implementation of the 2009 massive fiscal stimulus plan, there has recently been a renewed interest on the size of government spending multipliers. In an official document of the US administration attempting to assess the employment impact of the American Recovery and Reinvestment Plan, Romer and Bernstein (2009) declare a GDP multiplier of public expenditure equal to 1.24 after two quarters, and 1.44 after a year for the US economy. That kind of magnitude seemed greatly optimistic under the light of existing econometric evidence.¹ Galí *et al.* (2007) report an overview of estimated short-run multipliers generated by Structural Vector Autoregressive (SVAR) models: although they do not seem to be stable across time, they show fiscal multipliers vary between 0.5 and 1 one year after the impact (a range confirmed by Hall 2009). Nevertheless, the debate on the output multiplier of a government spending shock is "merely" quantitative; theoretical models² along with empirical analysis and policy notes all agree on the (positive) sign of the output multiplier, even though they disagree considerably on its magnitude.

The government expenditure multiplier on private consumption constitutes an even more controversial issue, as the disagreement regards both magnitude and sign. Standard neoclassical models predict a decrease in private consumption after a positive government spending shock, as the result of negative wealth effect inducing a decrease in normal goods demand (consumption and leisure). A lower consumption demand generates a negative consumption multiplier, while a lower leisure demand shifts out labor supply schedule, thereby reducing real wage and increasing output. In contrast with such theoretical predictions, a great deal of empirical evidence (see Perotti 2007 for a comprehensive review) reports the existence of a positive consumption multiplier, along with the usual

¹Among the many contributions, Blanchard and Perotti 2002, Ramey and Shapiro 1997, Romer and Romer 2007, Ramey 2008, Mountford and Uhlig 2008.

²Baxter and King (1993), Barro and King (1994).

debate on magnitudes. Efforts aimed at reconciling such evidence with theoretical modelling has followed two broad approaches, whose dividing line is the use of nominal rigidities.

The first approach includes theoretical frameworks firmly grounded in the flexible price Real Business Cycle tradition. Particularly, one direction explores non-walrasian labor market (Shimer 2005, Hall 2009), and shows that a more realistic modelling of labor's demand and supply can lead to non-negative consumption multipliers (along with an output multiplier close to 2). A second set of contributions inserts complementarity between labor effort and private consumption in the utility function, in order to overcome the decrease in aggregate demand for private consumption emerging from negative wealth effect (Linneman 2006, Hall and Milgrom 2008). However, Bilbie (2009) demonstrated that complementarity between consumption and labor implies a negative sloped labor supply curve and that aggregate consumption is an inferior good.

The second approach explicitly considers the presence of nominal rigidities, who however are not sufficient *per se* to generate positive consumption multiplier. Under price stickiness, in fact, business cycle fluctuations are demand-driven; therefore a government spending's exogenous shock raises labor demand and - if this movement outweighs the labor supply shift triggered by the negative wealth effect - the public spending shock results in a real wage increase. This is the starting point to obtain a positive effect on private consumption: in order to achieve it, the literature has so far employed two alternative approaches. The first one adopts non-standard utility function specifications in order to strengthen the substitution effect after the increase in real wage (which substitutes leisure with consumption) at the expenses of the negative income effect behind the labor supply movement. Ravn *et al* (2007) use deep habits into the utility function, Perotti and Monacelli (2008) employ the preferences specifications pioneered by Greenwood, Hercowitz and Huffman (1988) - the so-called *GHH preferences* - so to minimize the labor supply shift after the government spending shock. The second mechanism based on price rigidity is the well known credit-constrained agents approach (Galì *et al* 2007, Lopez-Salido and Rabal 2006, Coenen and Straub 2005), where a fraction of consumers is not allowed to optimize over the life cycle and is therefore forced to consume exclusively out of their current income (that's why the increase in real wage is a necessary condition). However, a widely recognized drawback of this approach is the excessive reliance on the exogenous fraction of credit-constrained agents in order to obtain a non-negative consumption multiplier; moreover, often the required share of liquidity constrained agents is close to half of the total population.

In this paper, we consider an alternative approach focusing on the presence of a non-wasteful flow of government expenditure able to *per se* affect private consumption through modifications of its marginal utility. Our motivation is based on the belief that the usual assumption of public expenditure's total wastefulness is less justifiable as we observe the implementation of massive recovery plans after the 2009 recession³. There have been attempts to explic-

³Few papers (Aschauer 1985, Karras 1994, Ni 1995, Amano and Wirjanto 1998, Okubo

itly consider Edgeworth complementarity/substitutability between private and public consumption into DSGE models. Linnemann and Schabert (2004) use a New Keynesian framework with sticky prices and formally derive the parametric conditions under which government expenditure complements private consumption. By contrast, Bouakez and Rebei (2007) employ a standard RBC model, augmented with habit formation to improve the empirical fit, and estimate the parameters using U.S.data, finding a strong degree of complementarity between public and private consumption⁴.

Our paper builds on those two contributions, by extending their analysis in three directions: first, we employ a fully-fledged New Keynesian general equilibrium model calibrated on the Euro-area with real and nominal rigidities, monetary policy and fiscal rules with distortionary tax rates targeting the stock of government debt. Second, we do not limit ourselves to the derivation of the parametric conditions for complementarity/substitutability, but rather explore the general equilibrium effects particularly regarding government spending multipliers on output and consumption. Third, we explicitly investigate the relationship between multipliers' magnitude and the specification of fiscal and monetary policy rules.

Our main results show can be summarized as follows.

First, the ability of the model to generate positive consumption multipliers under Edgeworth complementarity is preserved after the introduction of distortionary fiscal rules; indeed, a more aggressive stabilization stance on the fiscal side reduces multipliers' magnitudes.

Second, conditioning on the presence of at least half of useful government spending, monetary policy does not need to be trapped into zero nominal interest rate lower bound for the output multiplier to be large; all is needed is a zero output response, as the public spending shock is no longer completely inflationary. Analogously, such a situation delivers a positive and empirically plausible consumption multipliers, in line with the econometric evidence presented in the paper.

The remainder of this paper is organized as follows. Section 2 recalls empirical evidence for the Euro-area recently collected by Marattin and Salotti (2010). Then, we move to the model aims at explaining it: section 3 outlines our baseline theoretical framework, section 4 defines equilibrium and calibrates the model on EU economy (1990-2008), section 5 presents our results. In section 6, we test the basic intuition on multipliers' sizes by comparing different varieties of our theoretical framework. Finally, concluding remarks are contained in section 7.

2003) tried to estimate the degree of substitutability between private consumption and public spending, with largely mixed and inconclusive evidence. Fiorito and Kollinztas (2004) linked the analysis on the distinction between public expenditure on "merit" goods Vs "public" goods in 12 EU countries.

⁴Leeper *et al* (2009) consider the impact of productive government investment, rather than consumption, under alternative sources of fiscal financing. They find that the expansionary effect of public investment is maximized when it is financed by reducing lump-sum transfers, and minimized when using the tax rate on capital income.

2 An empirical perspective on the EU area

Most of the empirical literature on the effects of government expenditure on private consumption is based on US economy (among others, Fatas and Mihov 2001, Blanchard and Perotti 2002, Galì and Perotti 2003, Ramey 2007, Monacelli and Perotti 2008). Marattin and Salotti (2010) use data on 14 Euro member states (1970:2006) and estimate the following structural Panel VAR model:

$$A_0 Z_{it} = A(L) Z_{i,t-1} + e_{it} \quad (1)$$

where A_0 is the matrix capturing the contemporaneous relationship between endogenous variables, $A(L)$ is a polynomial in the lag operator, and e_{it} is the vector of structural disturbances. The endogenous variables vector Z is:

$$Z_{it} = [B_{it}, G_{it}, P_{it}, T_{it}, I_{it}, C_{it}] \quad (2)$$

where B indicates the stock of government gross financial liabilities, G is government consumption, P is the price level, T net tax revenue, I private investment, and C private consumption. All variables are real, in logs, per capita and deflated by their own deflator⁵. The reduced form which is actually taken to estimation is obtained pre-multiplying (1) by A_0^{-1} so to have:

$$Z_{it} = B(L) Z_{i,t-1} + u_{it} \quad (3)$$

where $B(L) = A_0^{-1} A(L)$ and $u_{it} = A_0^{-1} e_{it}$ is the residual form vector.

Identification is achieved applying a lower triangular Cholesky decomposition with the ordering as in (2)⁶. Individual country's heterogeneity is accounted for by introducing fixed effects. The system is estimated via GMM method (Love and Zicchino, 2006).

Figure 1 shows the impulse response functions related to a one per cent increase in government consumption. Focusing on the upper-right panel, we notice a positive and significant effect on private consumption.

FIGURE 1 ABOUT HERE

Table 1 reports point estimates in order to better assess the size of private consumption multiplier:

Table 1: estimated consumption multipliers

⁵Data sources are OECD Economic Outlook n.84, Main Economic Indicators (published by the European Commission) and the World Development Indicators (published by the World Bank).

⁶See the paper for a thorough discussion of the identification strategy.

period	$\frac{dC}{dG}$
0	0.26***
1	0.21***
2	0.11***
3	0.05**
4	0.02
5	0.01
6	-0.01

***=significant at 1%, **: significant at 5%.

Next section develops a theoretical framework able to account for the above-reported multipliers without assuming credit-constrained agents or consumption habits.

3 The model

Our baseline specification considers a cashless New Keynesian DSGE model with costly capital accumulation, price stickiness *a-là-Rotemberg* and a considerable degree of real distortions such as monopolistic competition in the intermediate good sector and distortionary tax rates on labor and capital income. Monetary policy follows a standard Taylor rule and fiscal policy finances a non-wasteful flow of public expenditure following debt-pegging tax rules. Next three subsections describe the behaviour of, respectively, the households sector, firms and policy authorities.

3.1 Households

Demand side is approximated by the presence of a representative infinitely-lived consumer whose preferences are defined over a composite consumption basket (\tilde{C}_t) to be defined below, and labor effort (N_t), according to the utility function:

$$E_0 \sum_{t=0}^{\infty} \beta^t U(\tilde{C}_t, N_t) \quad (4)$$

where E_t denotes the mathematical expectations operator conditional on the time- t information set, $\beta \in (0,1)$ is the discount factor. The period utility function $U(\bullet)$ is assumed to be strictly increasing in its first argument, strictly decreasing in the second, and strictly concave, according to the following functional form

$$U(\tilde{C}_t, N_t) = \frac{\tilde{C}_t}{1-\gamma} - \frac{a_n}{1+\gamma_n} N_t^{1+\gamma_n} \quad (5)$$

where $\gamma > 0$ is the intertemporal elasticity of consumption, $\gamma_n > 0$ is the inverse of the Frisch elasticity of labor supply and $a_n > 0$ a constant indicating the relative disutility of labor effort. \tilde{C}_t denotes a consumption bundle defined as a Constant Elasticity of Substitution (CES) aggregator of public and private consumption as in Linneman and Schabert (2004) and Bouakez and Rebei (2007)⁷:

$$\tilde{C}_t = \left[\theta C_t^{\frac{v-1}{v}} + (1-\theta) (zG_t)^{\frac{v-1}{v}} \right]^{\frac{v}{v-1}} \quad (6)$$

with G_t being total public expenditure and $0 < z < 1$ is the non-wasteful fraction which - alternatively - complements or substitutes private consumption. Parameter $v > 0$ denotes the intertemporal elasticity of substitution between private and (useful) public consumption and is the relative weight of the two variables in the CES aggregator. When $v = 0$, C_t and G_t are perfect complements, when $v \rightarrow \infty$ they are perfect substitutes.

In our framework, public expenditure complements or substitute private consumption to the extent it affects its marginal utility. By differentiating (5) with respect to C_t we obtain the expression for the marginal utility of private consumption:

$$\frac{\partial U}{\partial C_t} = \theta C_t^{-\frac{1}{v}} \left[\theta C_t^{\frac{v-1}{v}} + (1-\theta) G_t^{\frac{v-1}{v}} \right]^{\frac{-\gamma v + 1}{v-1}} \quad (7)$$

The cross-derivative with respect to G_t amounts to:

$$\frac{\partial U}{\partial C_t \partial G_t} = \theta (1-\theta) \frac{-\gamma v + 1}{v} G_t^{-\frac{1}{v}} \left[\theta C_t^{\frac{v-1}{v}} + (1-\theta) G_t^{\frac{v-1}{v}} \right]^{\frac{-\gamma v - v + 2}{v-1}} \quad (8)$$

It is easily verifiable that:

$$\text{sign} \frac{\partial U}{\partial C_t \partial G_t} = \text{sign} \frac{-\gamma v + 1}{v} = \text{sign}(-\gamma v - 1)$$

Therefore, C_t and G_t are complements whenever $v < \frac{1}{\gamma}$, substitutes if $v > \frac{1}{\gamma}$. If, on the other hand, $v = \frac{1}{\gamma}$ government spending does not affect the marginal utility of consumption and the model collapses to the standard case of wasteful government consumption.

The household's flow budget constraint in real terms is given by:

$$\frac{B_t}{P_t} + C_t + I_t + T_t^0 = (1 - \tau_t^w) w_t N_t + (1 - \tau_t^k) R_t K_t + \frac{i_{t-1} B_{t-1}}{P_t} + \Psi_t \quad (9)$$

where B is the nominal stock of one-period riskless government bonds, I_t denotes investment, T_t^0 lump-sum taxes, w_t the real wage, R_t the rental rate

⁷ A very similar specification is also used in Forni *et al* (2010).

at which households lend capital to firms, i is the gross nominal interest rate, τ_t^i (with $i = w, k$) the distortionary tax rate on, respectively, labor and capital income, and Ψ_t is the economic profits deriving from ownership of monopolistically competitive firms.

Capital stock K_t depreciates at the constant rate $0 < \delta < 1$ and its accumulation is subject to convex adjustment costs, so that evolution of capital is given by:

$$K_{t+1} = (1 - \delta)K_t + I_t - \frac{\psi}{2} \left(\frac{I_t}{K_t} - \delta \right)^2 K_t \quad (10)$$

denoting that a marginal increase in the investment/capital ratio with respect to its steady-state level is penalized in terms of ψ unit of capital which gets lost in the process. The representative household is also constrained by the usual transversality condition ruling out Ponzi schemes.

The household's problem consists in choosing the levels of consumption, labor effort, investment, capital stock and nominal bond holdings in order to maximize the intertemporal utility function (4) subject to (9), (10) and the transversality condition. Optimality conditions are:

$$\theta \tilde{C}_t^{-\gamma + \frac{1}{\psi}} C_t^{-\frac{1}{\psi}} = \lambda_t \quad (11)$$

$$\lambda_t (1 - \tau_t^w) w_t = a_n N_t^{\gamma n} \quad (12)$$

$$\lambda_t = \mu_t \left[1 - \psi \left(\frac{I_t}{K_t} - \delta \right) \right] \quad (13)$$

$$\begin{aligned} \mu_t = & \beta \lambda_{t+1} (1 - \tau_{t+1}^R) R_{t+1} + \\ & + \beta \mu_{t+1} \left[(1 - \delta) + \frac{\psi}{2} \left(\left(\frac{I_{t+1}}{K_{t+1}} \right)^2 - \delta^2 \right) \right] \end{aligned} \quad (14)$$

$$\lambda_t = \beta E_t \lambda_{t+1} \frac{P_t}{P_{t+1}} i_t \quad (15)$$

where λ_t and μ_t denote the Lagrange multipliers associated with, respectively, constraints (13) and (14).

3.2 Firms

The supply-side of the model economy is represented by two sectors.

A perfectly competitive final good sector assembles the final output Y_t , which can be used for internal absorption (private consumption C_t , investment I_t or government expenditure G_t), according to the CES production function:

$$Y_t = \left[\int_0^1 Y_{it}^{\frac{\eta-1}{\eta}} di \right]^{\frac{\eta}{\eta-1}} \quad (16)$$

where Y_{it} (with $i \in (0, 1)$) is the i -th variety of the intermediate goods produced by firm i , and $\eta > 1$ is the constant elasticity of substitution between any two varieties. Cost minimization by final good firms lead to the following negative sloped demand schedule for intermediate products::

$$Y_{it} = \left(\frac{P_{it}}{P_t} \right)^{-\eta} Y_t \quad (17)$$

where P_{it} is the price of good i set by the corresponding monopolistically competitive firm- i , P_t is the general price index given by the Dixit-Stiglitz aggregator $P_t = \left[\int_0^1 P_{it}^{1-\eta} di \right]^{\frac{1}{1-\eta}}$ and Y_t denotes aggregate demand.

Intermediate goods firms produce according to the following Cobb-Douglas production function:

$$Y_{it} = A_t K_{it}^\alpha N_{it}^{1-\alpha} - \Phi \quad (18)$$

where K_{it} and N_{it} are, respectively, capital and labor services employed by firm i , Φ is a fixed cost of production whose role is to soak up steady-state profits, and A_t is an aggregate productivity following an AR(1) stochastic process such as:

$$\log \frac{A_t}{\bar{A}} = \rho_A \log \frac{A_{t-1}}{\bar{A}} + \varepsilon_t^A \quad (19)$$

where \bar{A} denotes steady-state technology, $0 < \rho_A < 1$ the autoregressive parameter, and $\varepsilon_t^A \sim (0, \sigma_A^2)$ a stochastic shock.

The intermediate good sector features a nominal rigidity through the presence of quadratic adjustment costs (Rotemberg 1982) in nominal price-setting, of the form:

$$AC^P = \frac{\phi_p}{2} \left(\frac{P_{it}}{P_{it-1}} - \bar{\pi} \right)^2 Y_t \quad (20)$$

meaning that every deviation of good- i gross inflation rate from steady-state general price index inflation costs ϕ_p units of output.

Each intermediate producers charge the optimal price \tilde{P}_{it} , which is set so to maximize the expected present discounted value of nominal profits, subject to production (equation 18) and demand (equation 17) constraints. Formally:

$$\max_{P_{it}} \Pi_{i0} = E_0 \left[\sum_{t=0}^{\infty} \Lambda_t P_t \Pi_{it} \right] \quad (21)$$

where real profits Π_{it} are given by:

$$\Pi_{it} = \frac{P_{it}}{P_t} Y_{it} - R_t K_{it} - w_t N_{it} - AC^P \quad (22)$$

subject to:

$$\begin{aligned}
Y_{it} &= A_t K_{it}^\alpha N_{it}^{1-\alpha} - \Phi_t \\
Y_{it} &= \left(\frac{P_{it}}{P_t} \right)^{-\varepsilon} Y_t \\
AC^P &= \frac{\phi_p}{2} \left[\frac{P_{jt}}{P_{i,t-1}} - \bar{\pi}_t \right]^2 Y_t
\end{aligned}$$

and Λ_t is the stochastic discount factor.

Maximization leads to the following factor prices:

$$R_t = \alpha \left(1 - \frac{1}{\varepsilon_{it}^Y}\right) \left(\frac{Y_{jt} + \Phi}{K_{it}} \right) \quad (23)$$

$$w_t = (1 - \alpha) \left(1 - \frac{1}{\varepsilon_{it}^Y}\right) \left(\frac{Y_{jt} + \Phi}{N_{it}} \right) \quad (24)$$

with ε_{it}^Y , being the output demand elasticity:

$$\frac{1}{\varepsilon_{it}^Y} = \eta^{-1} \left[\begin{aligned} &1 - \phi_p \left(\frac{P_{it}}{P_{i,t-1}} - \bar{\pi} \right) \frac{P_t}{P_{i,t-1}} \frac{Y_t}{Y_{it}} \\ &+ \beta E_t \phi_p \frac{\Lambda_{t+1}}{\Lambda_t} \left(\frac{P_{i,t+1}}{P_{i,t}} - \bar{\pi} \right) \frac{P_{t+1}}{P_{it}} \frac{P_{i,t+1}}{P_{it}} \frac{Y_{t+1}}{Y_{it}} \end{aligned} \right] \quad (25)$$

With perfect price flexibility ($\phi_p = 0$) or in steady-state ($\pi_t = \pi_{t+1} = \bar{\pi}$) expression (25) simplifies to $\varepsilon_{it}^Y = \eta$, so that the mark-up is a decreasing function of the elasticity of substitution across intermediate goods. In such situation, stochastic shocks do not change the mark-up, with the only differences being that technological or fixed-cost shocks affect real variables, whereas demand shocks do not. With price stickiness, mark-up becomes a transmission channel for the business cycle, through its own cyclicity whose direction relies on the source of the shock (Kim 1998): production function shocks leading to a reduction of marginal costs increase output and the mark-up, whereas demand side shocks (shifting upward the profit-maximizing equality between marginal and revenue and marginal costs) increase output but lead to a cut in the mark-up.

3.3 The policy side

Public sector consists of central bank and government. The central bank is in charge of monetary policy, implemented by setting nominal interest rate according to a standard Taylor rule such as:

$$\ln \frac{i_t}{\bar{i}} = \phi_\pi \ln \left(\frac{\pi_t}{\bar{\pi}} \right) + \phi_y \ln \left(\frac{y_t}{\bar{y}} \right) \quad (26)$$

where $\bar{\pi}$ and \bar{y} indicate, respectively, the steady-state levels of inflation and output.

The government is in charge of fiscal policy; flow budget constraint in nominal terms is given by:

$$B_t = i_{t-1}B_{t-1} + P_t(zG_t + (1-z)G_t) - P_tT_t \quad (27)$$

where zG_t and $(1-z)G_t$ are, respectively, the useful and wasteful share of public expenditure.

The overall amount G_t evolves according to a AR(1) stochastic process:

$$\log \frac{G_t}{\bar{G}} = \rho_g \log \frac{G_{t-1}}{\bar{G}} + \varepsilon_t^G \quad (28)$$

where \bar{G} denotes steady-state technology, $0 < \rho_g < 1$ the autoregressive parameter, and $\varepsilon_t^G \sim (0, \sigma_g^2)$ a stochastic shock. In (27) T_t denotes real total tax revenue, made of distortionary taxation and a residual lump-sum revenue T^0 so that:

$$T_t = T^0 + \tau_t^w w_t N_t + \tau_t^R R_t K_t \quad (29)$$

By expressing nominal budget constraint (28) in real terms we obtain the dynamics of real government debt:

$$b_t = \frac{i_{t-1}}{\pi_t} b_{t-1} + zG_t + (1-z)G_t - T_t \quad (30)$$

where b_t denotes the real stock of public debt and π_t is the inflation rate at time t .

The government conducts fiscal policy by setting the two distortionary tax rates on both capital and labor income according to a simple feedback rule on deviations of last period real stock of public debt from its steady-state level:

$$\tau_t^w = \bar{\tau}^w + \phi^w (b_{t-1} - \bar{b}) \quad (31)$$

$$\tau_t^R = \bar{\tau}^R + \phi^R (b_{t-1} - \bar{b}) \quad (32)$$

Note that (31) and (32) differ from similar specifications (such as Schmitt-Grohè and Uribe 2007) where the overall tax revenue is the fiscal policy instrument and reacts to debt deviations. Indeed, we believe that using the actual tax rate (on labor or capital income) as the variable directly under government's control constitutes a more accurate representation of real world fiscal policy decisions. Under this respect, we believe that this adds a more realistic structure to the fiscal side of the model, not previously considered in the literature.

4 Equilibrium and calibration

4.1 Definition of equilibrium

We assume the existence of a complete and competitive market for contingent claims, so that firms discount their future profits the same way households dis-

count their future consumption flows $\left(\beta \frac{\lambda_{t+1}}{\lambda_t} = \frac{\Lambda_{t+1}}{\Lambda_t}\right)$. A symmetric competitive rational expectations equilibrium is defined as a sequence of prices:

$$\{\mathbf{P}_t\}_0^\infty = \{P_t^*, R_t^*, i_t^*, w_t^*\}_{t=0}^\infty,$$

quantities

$$\{\mathbf{Q}_t\}_{t=0}^\infty = \{Y_t^*, C_t^*, I_t^*, G_t^*, N_t^*, K_{t+1}^*, T_t^*, B_t^*, \tau_t^*\}_{t=0}^\infty$$

and stochastic shocks

$$\{\boldsymbol{\varepsilon}_t\}_{t=0}^\infty = \{\varepsilon_t^A, \varepsilon_t^g\}_{t=0}^\infty$$

bounded in a neighbourhood of the deterministic steady state, such that given initial stocks of capital and public debt the optimality conditions for households and firms are satisfied in each period t , goods, capital, labor and bond markets clear, transversality conditions hold, government budget constraints and policy rules are satisfied, aggregate resource constraints ($Y_t = C_t + I_t + G_t + AC_t^P$) holds. The complete set of equilibrium conditions can be found in Appendix A.

4.2 Calibration

The model is calibrated on European Union economy from 1990 to 2008. Time unit is chosen to be one quarter, and deep parameters are picked up accordingly. Steady-state annual inflation rate is assumed to be 3.02 per cent, and the discount factor β is set at 0.9902. We assume that households devote one third of their total amount of time to labor effort ($N = 0.33$); steady-state government debt is set to be 60 per cent of real GDP. In setting the value for steady-state \bar{G} , we sum up government consumption and investment so to have a ratio of 32.08 per cent of GDP. In the benchmark calibration we assume that $z = 1$ (all spending is either substitute or complement to private consumption). Private investment share of GDP is 11.29 and total tax revenue/GDP ratio is 31.66.

Structural parameters of the model are set according to Table 2.

Table 2: Structural Parameter calibration and description

Parameter	Value	Description
γ	2	risk adersion coefficient
θ	0.8	preference parameter
γ_n	0.55	inverse of Frisch elasticity
β	0.9902	discount factor
δ	0.025	depreciation rate
α	0.33	capital share
ϕ_k	2.48	capital adjustment cost
η	5	price elasticity of demand
ρ_A	0.95	serial correlation of productivity
ρ_G	0.90	serial correlation of govt spending
σ_A	0.07	standard deviation of A -shock
σ_G	0.01	standard deviation of G -shock

Parameter θ , denoting the relative weight of private and public consumption in the utility function, is set at the same value used by the only paper which - to the best of our knowledge - has employed and calibrated this utility function specifications before us (Bouakez and Rebei 2007). The price elasticity of demand η is set equal to 5 so to be consistent with a steady-state net mark-up of 25 per cent. The value of the capital adjustment cost parameter ($\phi_k = 2.48$) is taken from Christiano *et al* (2005). Parameter ϕ_p denoting the degree of nominal price rigidity is set equal to 100, as in Ireland (1997).

Finally, first and second moments of the stochastic shocks are in line with current business cycle literature.

In developing our results we carry out counterfactual exercises along two dimension sets. The first one involves the nature of public expenditure (the Edgeworth complementarity/substitutability and the share of non-wastefulness), the second is concerned with policy (monetary and fiscal policy feedback parameters (ϕ^w, ϕ^R, ϕ_y)).

As mentioned in section 2.1, (equation 9) the nature of the relation between government expenditure and public consumption is given by sign of the expression $v - \frac{1}{\gamma}$; having fixed the risk adersion coefficient at the standard value of 2, we determine the Edgeworth complementarity or substitutability of public expenditure by varying the elasticity of substitution v . At the reference value of 0.5, the flow of government spending does not affect private consumption at all ("benchmark"); at $v = 0.8$ (> 0.5) there will be substitutability, and at $v = 0.2$ (< 0.5) there will be complementarity.

Monetary policy parameter ϕ_π and ϕ_y are set at the conventional values of, respectively, 1.5 and 0.5. Steady-state tax rates on capital and labor income are set such that $\bar{\tau}^w = 0.40$ and $\bar{\tau}^R = 0.20$ as average in our sample.

The model is solved through first-order approximation around the deterministic steady-state by using Sims (2001) algorithm.

5 Results

In this section we present our results, which are mainly concerned with the response of the relevant endogenous variables to a one-standard deviation government spending shock. Particular attention is devoted to the quantitative side of the implied output and consumption multipliers. Subsection 4.1. develops our basic intuition, while the following two illustrate our results under - respectively- wasteful and non-wasteful government spending. Subsection 4.4 strenghtens the intuition on the underlying mechanism by comparing results obtained under different versions of the theoretical model.

5.1 The intuition

By elaborating on Hall (2009a), we provide an intuitive representation of the driving forces at work in our setting, in order to facilitate the interpretation of results. If we combine first order conditions on consumption (equation 12) and leisure (equation 13) we obtain a static general equilibrium condition for the optimal mix of consumption and hours worked:

$$U'(N_t) = (1 - \tau_t^w)w_t U'(C_t) \quad (33)$$

with the usual concavity and convexity assumptions $U'(N) > 0, U''(N) > 0$ and $U'(C) > 0, U''(C) < 0$.

Equation (33) states the equality between the marginal cost of supplying a time unit of work (left-hand-side) and the net marginal benefits in utility terms (right-hand-side).

An impulse in G raises left-hand-side via the income-effect and the convexity assumption with respect to the labor effort argument. In the right-hand side, although gross real wage w_t increases because of price stickiness, the fiscal policy rule trying to stabilize debt increases τ_t^w and thus decreases the net real wage. Since condition (33) must hold during the transitional dynamics, then $U'(C_t)$ must increase, meaning that the consumption level must decrease due to concavity assumption of the utility function with respect to the consumption argument.

The analysis of optimal condition (33) allows us to understand the transmission mechanism of fiscal policy along both dimensions of revenue (the effects of the distortionary wage taxation) and expenditure (whenever public expenditure is "non-wasteful" and therefore affects $U'(C_t)$ positively or negatively).

On the revenue side, given the left-hand-side increase, the higher the response of the labor income tax rate (τ_t^w), the higher the increase in marginal utility of consumption that is needed in order to remain on the optimal path, and the higher the required drop in consumption.

On the expenditure side, a shock in G can either increase or decrease $U'(C)$, depending on whether the elasticity of substitution between public and private consumption ν is - respectively - lower or higher than the intertemporal elasticity of substitution given by the inverse of risk aversion parameter ($\frac{1}{\gamma}$). If public

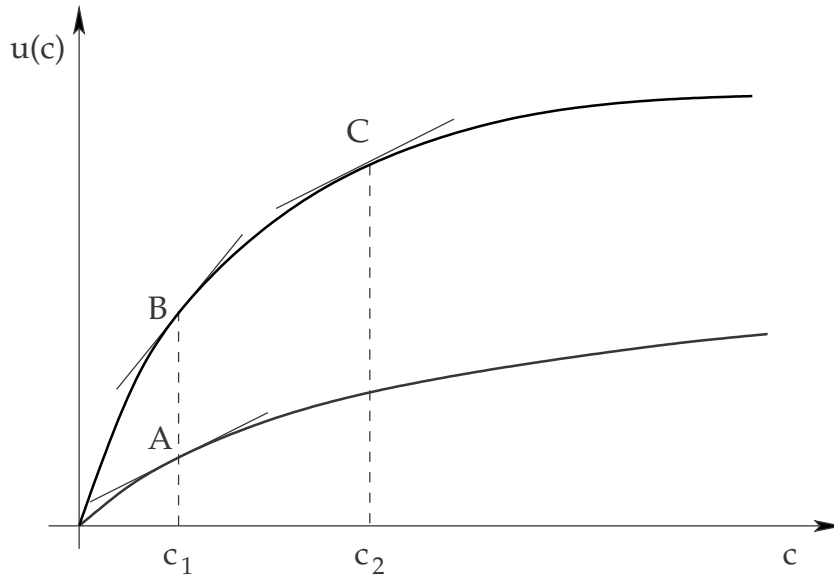


Figure 1:

expenditure complements private consumption, this produces an impact raise in $U'(C)$ according to equation (9); by keeping constant the movement of τ_t^w (given by the fiscal rule), this results in a higher labor supply's outward shift and thus an higher output multiplier. This is why under Edgeworth complementarity we expect higher consumption and output multipliers: the former by construction, the latter through general equilibrium effects given by (33).

If, on the other hand, public expenditure Edgeworth substitutes private consumption, we have the opposite effects: $U'(C_t)$ decreases and therefore labor supply shift can be very modest, especially if the response of τ_t^w is particularly strong.

The following figure depicts the "core" of our intuition: starting from point A, a shock to Edgeworth complement public expenditure G shifts both the utility frontier and its slope to point B. It is obvious that the slope's change represents an increase in marginal utility of private consumption according to (9). Therefore, to restore the ex-ante marginal utility, consumption level must increase up to point C, where the slope is same as in point A. It is worth to note that point C represents the impact right after the shock to G . Afterwards - due to the autoregressive structure imposed on the stochastic process driving G - the level of public spending gets period by period lower: this implies further downward shifts of the utility function back to the original position. This, in turn, inserts a transitional dynamics where both consumption and its marginal utility are above the pre-shock starting level.

A general equilibrium condition analogous to (33) can be derived for the capital accumulation process. In fact, combining first order conditions on K_{t+1} (equation 15) and I_t (equation 14) we obtain a dynamic condition stating the equality between the marginal cost of saving (the foregone marginal utility of consumption) and its marginal benefits (in terms of augmented capital stock and factor income) net of adjustment costs:

$$\frac{U'(C_t)}{1 - \psi \left(\frac{I_t}{K_t} - \delta \right)} = \beta U'(C_{t+1})(1 - \tau_{t+1}^R)R_{t+1} + \beta \mu_{t+1} \left[(1 - \delta) + \frac{\psi}{2} \left(\left(\frac{I_t}{K_t} \right)^2 - \delta^2 \right) \right] \quad (34)$$

The analysis on the revenue side of fiscal policy is easy: an increase in the tax rate on capital discourages capital accumulation by diminishing the net marginal benefits of savings (note that, since the equation is dynamic and the relevant tax rate is indexed $t + 1$, a shock in government debt at period t produces only a delayed effect). A shock in Edgeworth complement government expenditure raises the marginal cost of savings and therefore discourages capital accumulation, as it is perfectly intuitive as current aggregate consumption increases⁸. However, as far as overall effect on output multiplier is concerned, we should also remember the different factor shares of capital and labor in the production function (with the former being calibrated at the conventional value of 0.3 against 0.7 for the latter). Therefore, the negative effect on capital accumulation contributes to output multiplier's magnitude less than the positive effect on labor effort.

5.2 Wasteful government expenditure

Figure 2 here below shows the impulse response functions after a one standard deviation shock in wasteful government expenditure ($v = 0.5 = \frac{1}{\gamma}$).

FIGURE 2 ABOUT HERE

Here our model behaves as a standard DSGE with nominal rigidities: an unexpected increase in government spending raises future tax burden (although our fiscal rules ensure a partial increase in distortionary taxation the period after the shock) and therefore increase labor supply. Nominal rigidities shifts also the labor demand curve, and both movements result in a real wage increase. The positive output multiplier ($\frac{dY}{dG} > 0$) results from the increase in labor effort, while the negative consumption multiplier ($\frac{dC}{dG} < 0$) arises from the negative wealth effect. Absent any liquidity constraint (and any complementarity between labor supply and consumption), the increase in real wage is not

⁸However, the marginal utility of consumption's upward shifts does not die out after one period; therefore, also $U'(C_{t+1})$ on the RHS of (30) is higher, so the overall effect is less relevant.

enough to generate a positive consumption response. Multipliers' numerical values after two, four and eight quarters are in line with previous literature but, again, distant from empirical evidence :

Table 3: Fiscal Policy Multipliers with wasteful government expenditure

$\frac{dY}{dG}(Q2)$	$\frac{dY}{dG}(Q4)$	$\frac{dY}{dG}(Q8)$	$\frac{dC}{dG}(Q2)$	$\frac{dC}{dG}(Q4)$	$\frac{dC}{dG}(Q8)$
0.05	0.10	0.10	-0.18	-0.55	-1.28

Investigating the sensitivity of multipliers' magnitude on fiscal and monetary policy parameters, we can find out that the higher the responses of - respectively - tax rates to debt and interest rate to output - the lower multipliers are.

Results are shown in Tables 4 and 5 here below:

Table 4: Sensitivity of Fiscal Policy Multipliers to monetary policy parameter

monetary rule parameters	$\frac{dY}{dG}(Q2)$	$\frac{dY}{dG}(Q4)$	$\frac{dY}{dG}(Q8)$	$\frac{dC}{dG}(Q2)$	$\frac{dC}{dG}(Q4)$	$\frac{dC}{dG}(Q8)$
$\tau^w, \tau^R = 0.1$	0.05	0.10	0.10	-0.18	-0.55	-1.28
$\phi_y = 0$	0.16	0.38	0.56	-0.10	-0.42;	-1.01

Given the fiscal rule outlined in equations (27)-(28), a monetary policy rule with no response to output, by setting $\phi_y = 0$, output reduces the intertemporal substitution effect which, via the increase in the interest rate following the expansionary effect of the government expenditure stimulus, dampens the response of output and consumption.

Table 5: Sensitivity of Fiscal Policy Multipliers to fiscal policy parameter

fiscal rule parameters	$\frac{dY}{dG}(Q2)$	$\frac{dY}{dG}(Q4)$	$\frac{dY}{dG}(Q8)$	$\frac{dC}{dG}(Q2)$	$\frac{dC}{dG}(Q4)$	$\frac{dC}{dG}(Q8)$
$\tau^w, \tau^R = 0.1$	0.05	0.10	0.10	-0.18	-0.55	-1.28
$\tau^w, \tau^R = 0.5$	0.01	0	-0.05	-0.20	-0.62	-1.39
$\tau^w, \tau^R = 0.9$	0	-0.01	-0.07	-0.21	-0.68	-1.47

For a given monetary policy stance (equation (23)), increasing the tax rates response to debt accumulation reduces multipliers' magnitude because of their distortionary effects on labor and capital accumulation, already illustrated in the previous subsection.

The reliance of multipliers' sizes on the exact specification of monetary and fiscal policy rules is a first element worth attention. Recently, Christiano *et al*

(2009) emphasize that the output multiplier can be substantially large (as high as 3.9) when the zero lower bound on the nominal interest rate binds, so that monetary policy reaction to the government expenditure shock is zero. In the next subsection we show that, in presence of non-wasteful government expenditure, monetary policy does not need to be confined in the lower bound for the multipliers to be empirically plausible: all we need is a muted output response in the Taylor rule. By the same token, the magnitude of fiscal policy feedback parameters plays a role (although quantitatively less relevant) in determining multipliers' sizes.

5.3 Non-wasteful government expenditure

First we examine the complementarity case, then we move to the substitutability scenario.

We set the elasticity of substitution between public spending and private consumption (parameter v) equal to 0.2, so that according to equation (5) a government expenditure shock raises the marginal utility of private consumption (since $v < \frac{1}{\gamma}$). Figure 3 reports the corresponding effects on macroeconomic variables:

FIGURE 3 ABOUT HERE

Consistently with the intuition developed in subsection 4.1., we observe an increase in the level of private consumption, caused by the upward shift of the utility function; the resulting increase in the marginal utility - by equation (29) - causes a larger increase in labor supply, which has two effects: on one hand, increases the output multiplier (in spite of a larger decrease in capital accumulation), on the other it offsets the price-rigidity-induced labor demand shifts thereby causing a reduction in the real wage, marginal costs and inflation. Under active monetary policy (obtained by setting $\phi_\pi > 1$ in (23)), this results in a more than proportional decrease in the nominal interest rate and therefore in a further expansionary effect on both output and consumption.

Output and consumption multipliers are:

Table 6: Fiscal policy multipliers with $v = 0.2$

$\frac{dY}{dG}(Q2)$	$\frac{dY}{dG}(Q4)$	$\frac{dY}{dG}(Q8)$	$\frac{dC}{dG}(Q2)$	$\frac{dC}{dG}(Q4)$	$\frac{dC}{dG}(Q8)$
0.18	0.49	0.91	0.32	0.83	1.42

The magnitude of consumption multipliers is considerable; however, it can be brought down by acting on two dimensions: (i) first, the share of non-wasteful government expenditure, (ii) second the fiscal rule parameter on debt. Table 6 shows the value of the consumption multiplier when only half of government expenditure is assumed to Edgeworth complement private consumption ($z = 0.5$) and tax rates response to last-period debt is assumed to be more aggressive ($\phi^w = \phi^R = 0.5$):

Table 7: Private consumption multipliers with $z = 0.5$ and $\phi^w = \phi^R = 0.5$

$\frac{dC}{dG}(Q2)$	$\frac{dC}{dG}(Q4)$	$\frac{dC}{dG}(Q8)$
0.23	0.45	0.68

These results - derived with no need of assuming credit-constrained agents and/or consumption habits - are very similar to the empirical estimates on the Euro-area by Marattin and Salotti (2009) and reported by Table 1 in Section 2: a consumption multiplier equal to 0.26 on impact, 0.47 after one year and 0.57 after two years. This is indeed the central results of our paper: empirical results indicating a positive effect of government spending shock on private consumption can be almost exactly replicated in a DSGE model with no need of assuming deviations from permanent income hypothesis or real rigidities in consumption patterns such as habit formation. All you need is a combination of partially useful government consumption and distortionary taxation targeting the stock of real debt.

As mentioned above, shutting off monetary policy's response to output largely increases multipliers' sizes. Table 7 shows our results with $\phi_y = 0$ and $z = 0.5$ tax rates at their steady-state level:

Table 8: Fiscal policy multipliers with muted monetary policy and complementarity

$\frac{dY}{dG}(Q2)$	$\frac{dY}{dG}(Q4)$	$\frac{dY}{dG}(Q8)$	$\frac{dC}{dG}(Q2)$	$\frac{dC}{dG}(Q4)$	$\frac{dC}{dG}(Q8)$
0.42	1.12	2.08	0.46	1.22	2.24

Therefore, in presence of Edgeworth complementarity- even partial- monetary policy can help achieving positive and significant multipliers with no need of the nominal interest rate's zero lower bound constraint being binding. Since public spending shock is actually deflationary (due to the large response of labor supply after the increase in the marginal utility of consumption), an active and exclusive monetary policy response to inflation reinforces the expansionary effect.

On the other hand, Edgeworth substitutability can probably explain cases where public expenditure stimulus has not succeeded in fulfilling its desired expansionary effect. In fact, as we set $v = 0.8 (> \frac{1}{\gamma})$, these are the corresponding impulse response functions:

FIGURE 3 ABOUT HERE

Consistently with our intuition developed in subsection 4.1., now increase in labor supply is much smaller, and this consistently reduces the magnitude of the output multiplier. While it seems hard to justify the total substitutability between public expenditure and private consumption, a value of $z = 0.5$ can reconcile our predictions with less dramatic - although still negative - consumption multipliers (see Table 9).

Table 9: Private consumption multipliers with $v = 0.8$

	$\frac{dC}{dG}(Q2)$	$\frac{dC}{dG}(Q4)$	$\frac{dC}{dG}(Q8)$
$z = 1$	-0.26	-0.76	-1.66
$z = 0.5$	-0.20	-0.60	-1.39

5.4 Models' comparisons

In this subsection we check the consistency of our intuition by comparing our results with those obtained under two alternative flexible price versions of the model: one with the same fiscal behaviour (debt-pegging tax rules), and the other where the two distortionary tax rates are the only fiscal policy tools to balance the budget. We compare the magnitude of our implied multipliers under all scenarios: wasteful, complementary and substitute government expenditure. Results are showed in Table 10.

Table 10: Fiscal policy multipliers under different versions of the model

	$\frac{dY}{dG}(Q2)$	$\frac{dY}{dG}(Q4)$	$\frac{dY}{dG}(Q8)$	$\frac{dC}{dG}(Q2)$	$\frac{dC}{dG}(Q4)$	$\frac{dC}{dG}(Q8)$
Flexible prices with balanced budget						
$v = 0.5$	-0.03	-0.10	-0.23	-0.22	-0.65	-1.44
$v = 0.2$	0.29	0.79	1.55	0.34	0.89	1.62
$v = 0.8$	-0.08	-0.25	-0.52	-0.30	-0.89	-1.93
Flexible prices with public debt						
$v = 0.5$	0.22	0.55	0.89	-0.14	-0.42	-0.94
$v = 0.2$	0.49	1.31	2.43	0.38	1.01	1.88
$v = 0.8$	0.17	0.42	0.61	-0.24	-0.68	-1.45
Sticky prices						
$v = 0.5$	0.05	0.10	0.10	-0.18	-0.55	-1.28
$v = 0.2$	0.18	0.49	0.91	0.32	0.83	1.42
$v = 0.8$	0.02	0.03	-0.01	-0.26	-0.76	-1.66

Let us first analyse the flexible price framework. Multipliers are lower under balanced budget rule: in fact, neither public debt nor the lump-sum option are available to government. As a result, all the burden of the increase in (wasteful or not) public expenditure must be beared by distortionary tax rates, with the general equilibrium effect highlighted in subsection 4.1. Instead, allowing public debt and lump-sum taxation as means of financing public imbalances the extent of the distortions gets lower and therefore we obtain higher multipliers.

With nominal rigidities - as already observed in section 4.2 - multipliers' sizes are affected by the intertemporal substitution operating through the Euler equation (i.e. the intertemporal allocation of consumption governed by interest rate movements, in turn affected by the inflationary public spending increase and by the positive output movement). This is the reason why under sticky prices both output and consumption multipliers are lower. As already noted, however, if monetary policy's response to output is zero, this effect is reduced and multipliers can be higher (still lower than flexible price case, though).

6 Conclusions

As exit strategies from the massive fiscal stimulus begin to be implemented in most countries - and important government spending cuts are yet to come - it has become increasingly harder to delay the question on which kind of government expenditure we ought to cut (increase) in order to minimize (maximize) the negative (positive) effects on the overall macroeconomic environment. The literature on business cycle fluctuations has traditionally regarded government expenditure as wasteful, meaning that its role is confined to be an exogenous stream of purchases by public authorities which, however, yields no utility whatsoever to any agent in the model economy. It is not uncommon to find expressions such as "the government buys an exogenous amount of output and throws it away".

In this paper, we aimed at exploring the general equilibrium consequences of allowing a full or partial flow non-wasteful public spending, so that it can *per se* increase or decrease marginal utility of private consumption.

Our main conclusion is that the ability of a fully-fledged DGSE model to deliver positive and empirically plausible consumption multipliers does not necessarily rely on specific devices such as deviations from permanent income hypothesis or complementarities between work effort and consumption which are very hard to be empirically tested. The insertion of (even partially) useful government expenditure - through the modification of the optimality conditions for factor supply in the households' problem - allows us to achieve positive consumption multipliers. On top of that, policy rules play a crucial role: we showed that a zero response of monetary policy to output - or, alternatively, a less distortionary fiscal policy mix - combined with a partial degree of Edgeworth complementarity manages to deliver consumption multipliers of the same magnitude of those found for the Euro-Area on the same time span employed for the calibration of our theoretical model. These results are achieved under price stickiness and with no need of assuming real rigidities such as credit-constrained agents or consumption habits.

Naturally, if on one hand this conclusion opens up a new device to reconcile theoretical predictions with empirical findings, on the other presents a number of new questions to be necessarily addressed if the approach has to be employed for policy analysis. How do we empirically identify and quantify the share of

public expenditure which complements private consumption? How can we *a priori* distinguish between wasteful and non-wasteful contributions? Moreover, how do we deal with the situation - not accounted for in this framework - where a government expenditure shock is the combination of Edgeworth complement and Edgeworth substitute components? Finally, an even more interesting issue would be an investigation of welfare properties of alternative fiscal rules under government expenditure complementarity or substitutability.

Nevertheless, the ultimate aim of this contribution was to suggest that even in a very stylized theoretical frameworks we can no longer avoid to consider the quality and not only the quantity of public expenditure whenever we wonder about its general equilibrium effects.

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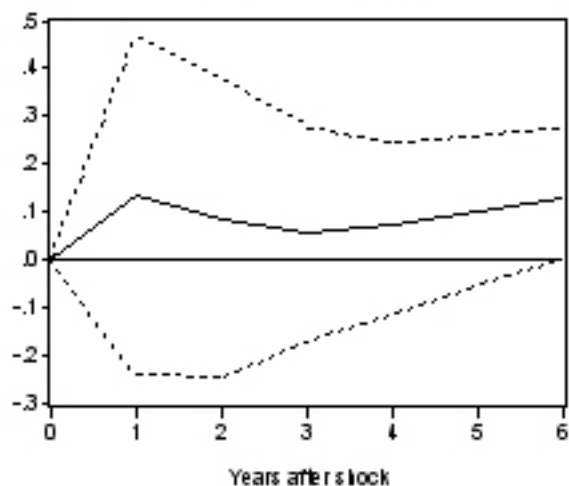
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7 Appendix A

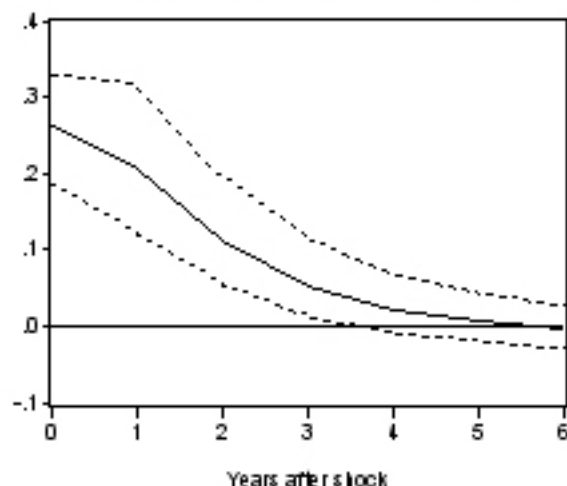
The complete set of equilibrium equations:

$$\begin{aligned}
\theta \tilde{C}_t^{-\gamma + \frac{1}{v}} C_t^{-\frac{1}{v}} &= \lambda_t \\
\tilde{C}_t &= \left[\theta C_t^{\frac{v-1}{v}} + (1-\theta) (zG_t)^{\frac{v-1}{v}} \right]^{\frac{v}{v-1}} \\
\lambda_t (1 - \tau_t^w) w_t &= a_n N_t^{\gamma_n} \\
\lambda_t &= \mu_t \left[1 - \psi \left(\frac{I_t}{K_t} - \delta \right) \right] \\
\mu_t &= \beta \left[\lambda_{t+1} (1 - \tau_{t+1}^R) R_{t+1} + \mu_{t+1} \left[(1-\delta) + \frac{\psi}{2} \left(\left(\frac{I_{t+1}}{K_{t+1}} \right)^2 - \delta^2 \right) \right] \right] \\
\lambda_t &= \beta E_t \lambda_{t+1} \frac{P_t}{P_{t+1}} i_t \\
K_{t+1} &= (1-\delta)K_t + I_t - \frac{\psi}{2} \left(\frac{I_t}{K_t} - \delta \right)^2 K_t \\
Y_{it} &= A_t K_{it}^\alpha N_{it}^{1-\alpha} - \Phi \\
R_t &= \alpha \left(1 - \frac{1}{\varepsilon_{it}^Y} \right) \left(\frac{Y_{jt} + \Phi}{K_{it}} \right) \\
w_t &= (1-\alpha) \left(1 - \frac{1}{\varepsilon_{it}^Y} \right) \left(\frac{Y_{jt} + \Phi}{N_{it}} \right) \\
\ln \frac{i_t}{\bar{i}} &= \phi_\pi \ln \left(\frac{\pi_t}{\bar{\pi}} \right) + \phi_y \ln \left(\frac{y_t}{\bar{y}} \right) \\
\log \frac{A_t}{\bar{A}} &= \rho_A \log \frac{A_{t-1}}{\bar{A}} + \varepsilon_t^A \\
\log \frac{G_t}{\bar{G}} &= \rho_G \log \frac{G_{t-1}}{\bar{G}} + \varepsilon_t^G \\
b_t &= \frac{i_{t-1}}{\pi_t} b_{t-1} + zG_t + (1-z)G_t - T_t \\
T_t &= T^0 + \tau_t^w w_t N_t + \tau_t^R R_t K_t \\
\tau_t^w &= \bar{\tau}^w + \phi^w (b_{t-1} - \bar{b}) \\
\tau_t^R &= \bar{\tau}^R + \phi^R (b_{t-1} - \bar{b}) \\
Y_t &= C_t + I_t + G_t + AC_t^P \\
\varepsilon_{it}^{Y^{-1}} &= \eta^{-1} \left[\begin{aligned} &1 - \phi_p \left(\frac{P_{it}}{P_{i,t-1}} - \bar{\pi} \right) \frac{P_t}{P_{i,t-1}} \frac{Y_t}{Y_{it}} \\ &+ \beta E_t \phi_p \frac{\Lambda_{t+1}}{\Lambda_t} \left(\frac{P_{i,t+1}}{P_{i,t}} - \bar{\pi} \right) \frac{P_{t+1}}{P_{it}} \frac{P_{i,t+1}}{P_{it}} \frac{Y_{t+1}}{Y_{it}} \end{aligned} \right]
\end{aligned}$$

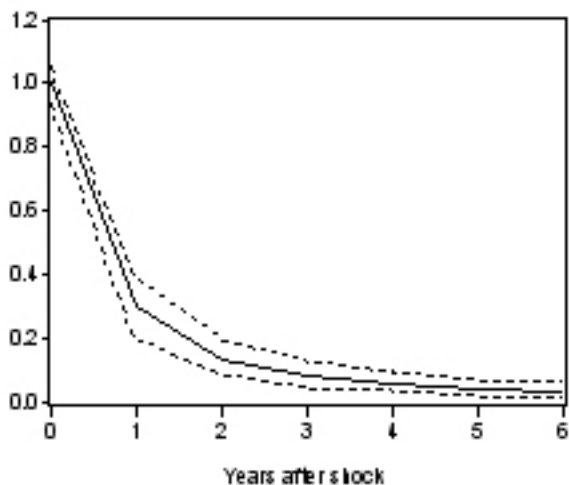
Response of debt



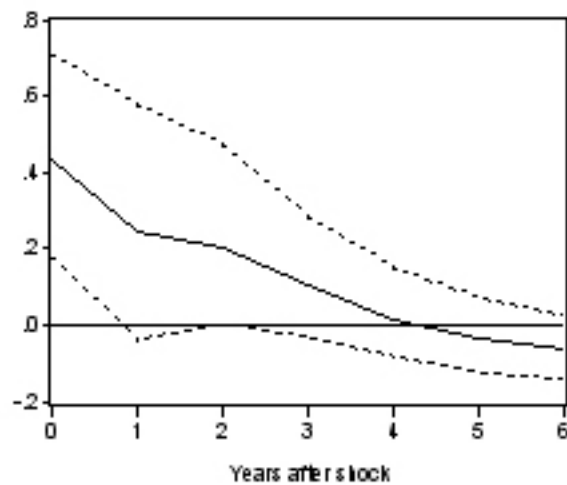
Response of private consumption



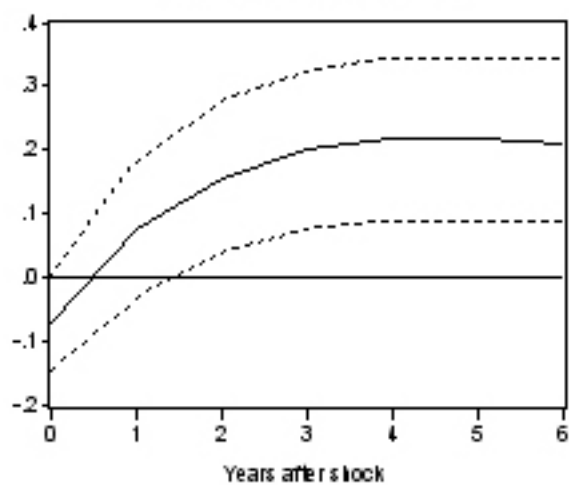
Response of public spending



Response of private investment



Response of price level



Response of net taxes

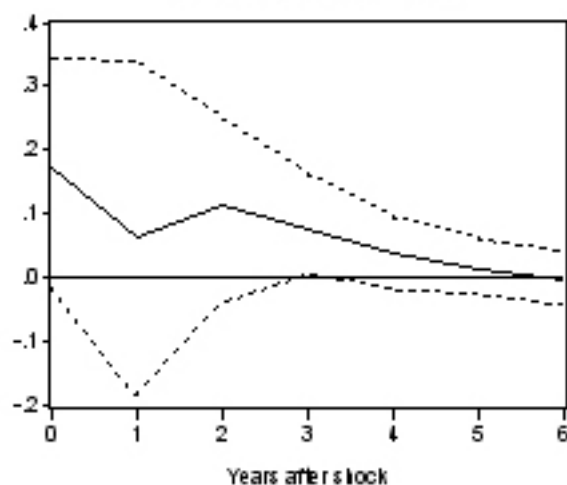


Fig.1: Wasteful Government Expenditure

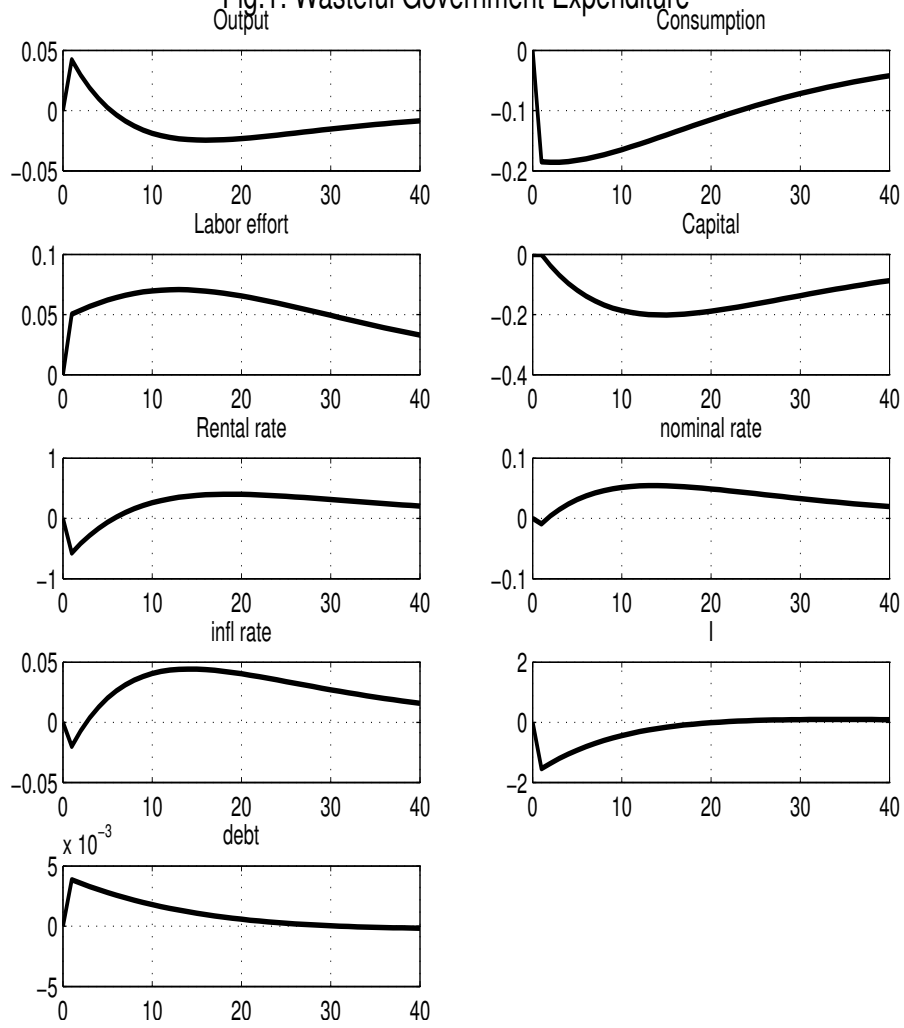


Figure 2:

Fig.2: Edgeworth Complementarity

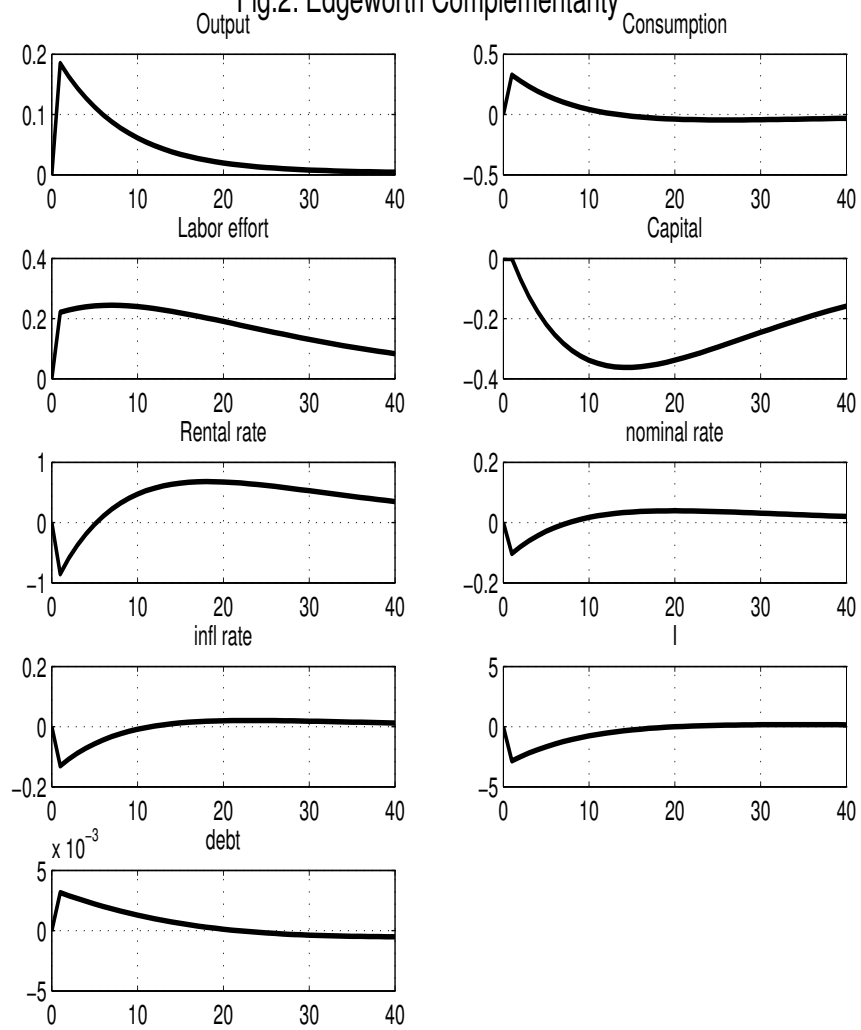


Figure 3:

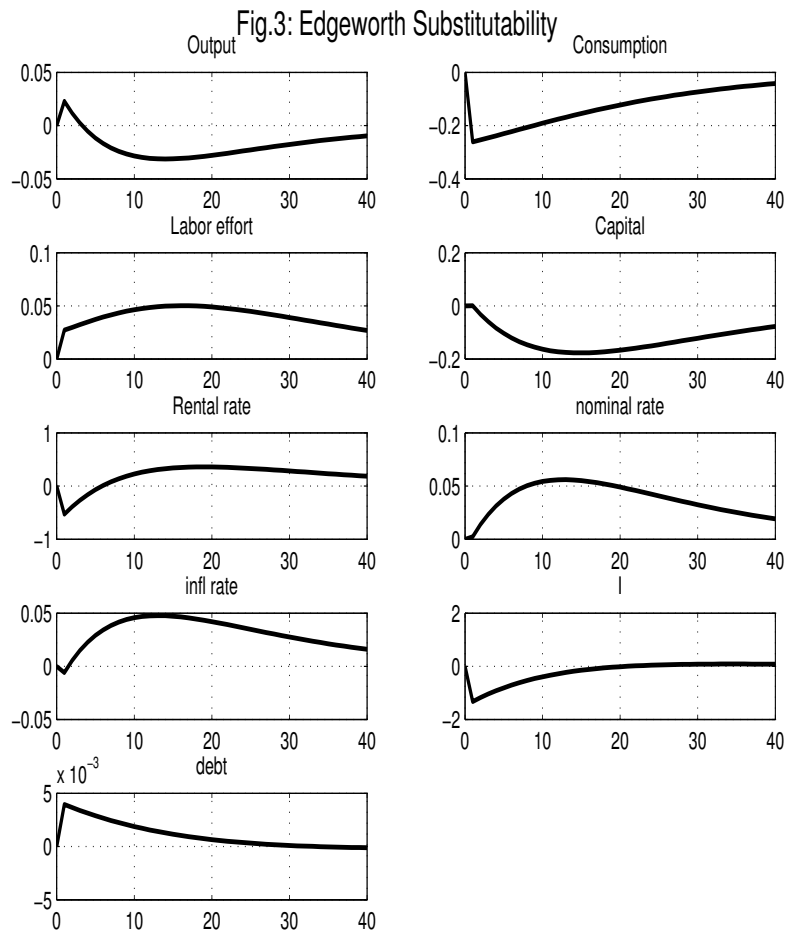


Figure 4:



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