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ON THE RELATIONSHIP BETWEEN PRIVATE CONSUMPTION AND GOVERNMENT SPENDING: EVIDENCE FROM MICRO AND MACRO DATA

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Contents

Acknowledgements **4**

Introduction **5**

1 The Relation between Government and Private Consumption: Evidence from Micro Data **8**

1.1 Introduction 9

1.2 Model 12

1.3 Data 13

1.4 Estimation 15

1.4.1 Model with Non-separabilities 15

1.4.2 Permanent Income Model 18

1.4.3 Discussion of the Estimation Results 19

1.4.4 Accounting for Individual Heterogeneity 20

1.5 Conclusions 21

1.6 References 22

1.7 Appendix 24

1.7.1 Data 24

2 The Effect of Government Consumption on Private Consumption: Macro Evidence from Micro Estimates **25**

2.1 Introduction 26

2.2 The effects of government consumptions shocks: Accounting for General Equilibrium Effects . . . 27
2.2.1 Representative Agent Model . . . 28
2.2.2 Calibration . . . 30
2.2.3 Impulse Response Function Analysis . . . 32
2.3 Conclusions and Extensions . . . 34
2.4 References . . . 36

3 The Effects of Government Spending on Private Consumption: Evidence from an Estimated New Keynesian Model for the US 38
3.1 Introduction . . . 40
3.2 Review of the empirical evidence . . . 42
3.3 The model . . . 45
3.3.1 Households . . . 45
3.3.2 Firms . . . 49
3.3.3 Final-Good Sector . . . 49
3.3.4 Intermediate-goods Firms . . . 49
3.3.5 Fiscal and Monetary authorities . . . 51
3.3.6 Market clearing . . . 52
3.3.7 The substitutability/complementarity mechanism . . . 53
3.4 Estimation . . . 53
3.4.1 Methodology . . . 54
3.4.2 Data and prior distributions . . . 55
3.4.3 Estimation Results . . . 56
3.4.4 Impulse-response analysis . . . 57
3.5 Conclusions and Extensions . . . 58
3.6 References . . . 61
3.7 Tables . . . 64
3.8 Figures . . . 65
3.9 Appendix . . . 67
3.9.1 Bayesian inference . . . 67

3.9.2 The linearized model 68
3.9.3 The Data 71

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Introduction

In this thesis we investigate on the relation between private and government consumption, and, specifically, we address the issue concerning the response of private consumption to government spending shocks.

Assessing the effect of a government spending shock is a long-standing issue in macroeconomics. In particular, the sign of the empirical response of private consumption to government spending shocks has been suggested as a crucial discriminant between the validity of the Neoclassicals versus the Keynesians models.

All this existing empirical evidence is based on aggregate data within various framework of analysis like general equilibrium models or vector autoregressions. However, it's worth noting that the literature has not reached yet a common view on the effects produced of government spending shocks.

We investigate on the reaction of private consumption to various government spending shocks by considering a new identification strategy, which uses individual data for private consumption. This is done in Chapter 1 and 2. Furthermore, we focus on one particular channel of transmission. That is, we investigates how the "externalities" produced by government spending affect the response of private consumption to various government spending shocks. The exploration of the role of these externalities are at the base of all the three Chapters of thesis.

In Chapter 1, we estimate the degree of the relation between different categories of government consumption and private consumption. First, we build a unique panel dataset which links household's private consumption to the government consumption of the region where the household lives, for Italy. Then, we use regional variability of government consumption and measure

its direct effect on individual consumption for different categories of government expenditures. We find that individual's consumption expenditure increases as government consumption increases in the region. This positive relation is driven by publicly provided private goods (e.g. education, health). Health care government consumption has the strongest impact on households' consumption. The results can be interpreted in the light of complementarity between goods.

Up to our knowledge, this paper constitutes the first attempt to estimate the relation of interest, using individual data. As we describe in the Chapter, using our dataset provides several identification advantages over standard datasets based on aggregate data.

In Chapter 2, we estimate the effect of different government consumption shocks on private consumption. We use our estimates from micro data (from Chapter 1) to calibrate an otherwise standard RBC model. We find that government consumption shocks are able to generate a positive response for private consumption, even considering wealth and general equilibrium effects in a dynamic framework with fully flexible prices. Interestingly, the composition of government consumption is important for the impulse response of private consumption; a public health shock has a more significant impact on private consumption than an aggregate government consumption shock of equal size.

In Chapter 3, we address the issue concerning the response of private consumption to government spending shocks by exploiting a different framework of analysis with respect to the one in the previous two Chapters. In particular, we aim at investigating how the externalities produced by public expenditures on the private sector affect this response. To this end, we build a New Keynesian dynamic stochastic general equilibrium model which takes into account two important features. First, it allows government consumption to directly affect the welfare of agents. Second, it allows public capital to influence the productivity of private factors. Results, carried out using bayesian inference on US data, indicate that government and private consumption are unrelated in preferences. On the other hand, our estimates show that public capital enhances the productivity of private factors. As a consequence, a government investment shock generates a positive response of private consumption. Interestingly, the latter shock generates a mild decrease in inflation and a tiny increase in private investment.

Note that Tables and Figures of Chapter 1 and 2 are at the end of the thesis, while those of Chapter 3 are within the Chapter itself.

Chapter 1

The Relation between Government and Private Consumption: Evidence from Micro Data

Abstract[1]

We estimate the degree of the relation between different categories of government consumption and private consumption. First, we build a unique panel dataset which links household's private consumption to the government consumption of the region where the household lives, for Italy. Then, we use regional variability of government consumption and measure its direct effect on individual consumption for different categories of government expenditures. We find that individual's consumption expenditure increases as government consumption increases in the region. This positive relation is driven by publicly provided private goods (e.g. education, health). Health care government consumption has the strongest impact on households' consumption. The results can be interpreted in the light of complementarity between goods.

JEL classification: E21, E32, E62

Keywords: Consumption, Government Purchases, Individual Data

[1] This Chapter is coauthored with Nicola Pavoni (University College London)

1.1 Introduction

Over past years, the relationship between private consumption and government spending has been at the heart of the economics and government policy debates.

Most of the debate is based on the implicit assumption that private consumption and government consumption enter in an additive separable way in the utility function (e.g. Baxter and King (1993)). Other authors have allowed government consumption to directly affect the welfare of agents. Among others, Bailey (1971) and Barro (1981) argue that a general model of consumption should allow for the direct effect of government purchases of goods services on a consumer's utility. In this case, the response of private consumption to public spending is affected, ceteris paribus, by the degree of substitutability (complementarity) between the two items of interest.

The aim of this paper is to provide new evidence on the sign and on the magnitude of the relation between private consumption and several categories of government consumption, exploiting micro data. Up to our knowledge, this paper constitutes the first attempt to estimate the relation of interest, using individual data. Moreover, our approach will provide a structural economic explanation for these effects.

We exploit information from two datasets: The Survey of Households Income and Wealth (SHIW) from Bank of Italy, and The Regional Economic Accounts (REA) from ISTAT. The first dataset provides information on households, such as private consumption, wealth, demographic characteristics and so on. REA delivers data on government consumption consolidated at a regional level. Moreover, for each region, REA disaggregates government consumption along a functional scheme based on COFOG classification (defense, justice, health, education, economics services and so on).

We construct an intertemporal model that allows public and private consumption to enter in a non-separable way into the agent's utility function. The resulting Euler equation contains the parameter identifying the relation of complementarity/substitutability between items. This parameter is estimated using our dataset.

We obtain two main results. First, we estimate a positive relationship between public and private consumption, which indicates a complementarity between the two goods. This relation is driven by publicly provided private goods (e.g., education, health).

Second, we interestingly find that health care positively affects households' private consumption. In reality, there can be motives for both substitutability and complementarity between private consumption and health care provided by government. Public health care services might appear as substitutes for private spending in basic medical treatments; people may prefer to exploit public services to heal pneumonia or to fix a broken arm. On the other hand, public health care services can act as complements for private spending in non-standard medical treatments; after a medical check in a public hospital, people discover that they need a treatment which is not provided by government, so that they need to go privately. Complementarity can also manifest itself between public health services and other categories of private consumption which are not necessarily related to health. The more government provides health services, the more individuals may exploit them[2], and as such the likelihood that individuals are healthy is higher. This may lead them to consume more as shown by Olsho (2006).

Finally, we also study the possibility of heterogeneous responses across households. Preliminary results indicate that the effect of public health care on private consumption increases as the number of elderly people increases within the household. Moreover, the positive relationship between health care and private consumption is quantitatively more important for the regions in the south of Italy.

The existing evidence is all based on aggregate data. A number of studies analyze the complementarity/substitutability between public and private consumption following a partial equilibrium-approach based on Euler equations. Auscher (1985) finds a significant degree of substitutability between the two variables of interest for the US, while, Amano and Wirjanto (1998), for the same country, find a weak complementarity. Fiorito and Kollitznas (2004) split government consumption in two groups named as 'public goods' and 'merit goods'. The first includes spending for defense, public order and justice, the second contains health, education and other services that could have been provided privately. They show that, for twelve European Countries, public goods substitute while merit goods complement private consumption. Finally, Bouakez and Rebei (2007) estimate the parameter governing complementarity within a general-equilibrium framework, they find a strong complementarity between private and public spending

[2]The underling hypothesis is that the quality of public services is non-decreasing in the aumount spent by government to provide these services. However, in the empirical analysis we control for possible geographical heterogeneity in the quality of public services.

in US aggregate data.

The use of individual data has several advantages. First of all, since Attanasio and Weber (1993) it is well known that aggregation problems might cause biased estimates of individual parameters based on Euler equation defined on aggregate data. Second, few important endogeneities that are well known issues at the aggregate level, are more credibly excluded when using individual data. For example, it is realistic to suppose that government consumption may affect the consumption of a single household, but the contrary is unlikely to occur. Third, we can see how heterogeneity among households can affect the relation between private and government consumption. Indeed, in principle, the response of private consumption to a government consumption shock could depend on the composition of the population when some items of public consumption affect more heavily certain groups of individuals. Fourth, we can explain part of the mechanism underlying the relation of interest. Finally, the regional dimension of public consumption considerably improves the identification scheme over existing ones. Indeed, the distribution of the general government expenditure is not homogenous across the Italian territory, so that using a regional measure of government spending could be a good proxy for the quantity and the quality of public services exerted in that specific area[3]. The use of cross-sectional variability of consumption expenditure permits us to identify the parameters of interest while remaining agnostic about the determinants of the business cycle.

The use of individual data makes our paper somewhat related to the extensive microeconometric literature on the evaluation of *specific* policy interventions (e.g., see the summary by Heckman et al. (1999)). Unlike them, we are interested in quantifying the effect of general government spending changes on private consumption in normal times.

The paper is structured as follows. In Section 2 we outline the model while the data is described in Section 3. In Section 4, we describe our empirical strategy and present the estimation results. Some preliminary results on households heterogeneity are also presented. Section 5 concludes.

[3]The underlying hypothesis is the households tend to utilize the great part of public services in the region where they live.

1.2 Model

The framework is a standard consumption saving problem under uncertainty with inelastic labor supply. We assume that households, indexed by i, derive utility from both private consumption (C^i) and public consumption (G). The latter can be decomposed into various (n) categories. We assume that households have isoelastic preferences of the following form[4]:

$$u\left(C_t^i, G_t\right) = v(G_t) + \frac{\left(C_t^i \prod_{j=1}^{n} (G_t^j)^{\xi_j}\right)^{1-\sigma}}{1-\sigma} \exp(\psi Z_t^i + \upsilon_t^i), \tag{1.1}$$

where $\frac{1}{\sigma}$ is the intertemporal elasticity of substitution and $v(G_t)$ is a term which ensures the concavity of the utility function with respect to G. The term Z_t^i represents a set of demographics while υ_t^i represents an individual component which is unobservable (preference shocks). Interpreting G as a single category, we have $u_{cg} = (C_t^i)^{-\sigma}(1-\sigma)\xi G_t^{\xi(1-\sigma)-1}$ which is positive (negative) whenever $(1-\sigma)\xi > 0$ (< 0)[5]. Accordingly, C^i and G are defined to be complements (substitutes).

The individual budget constraint at each node is:

$$C_t^i + qB_t^i = Y_t^i + B_{t-1}^i, \tag{1.2}$$

where Y^i is disposable income[6] and q is the price of the risk-less bond B. If the subjective discount factor is δ, the resulting Euler equation for individual i is:

$$\mathbf{E}_t \left[\left(\frac{C_{t+1}^i}{C_t^i} \right)^{-\sigma} \prod_{j=1}^{n} \left(\frac{G_{t+1}^j}{G_t^j} \right)^{\xi_j(1-\sigma)} \exp(\psi Z_t^i + \upsilon_t^i) \right] = \frac{q}{\delta}, \tag{1.3}$$

[4] Agents however are subject to labor market costs that either force them to take leisure or allow them to work at cost v. The full specification of preferences is hence:

$$u\left(C_t^i, G_t\right) - v l_t,$$

where $l_t \in \left\{0, \bar{l}\right\}$ and $\bar{l}$ coresponds to a full time job.

[5] Imposing the usual restriction on σ ($\sigma > 1$), u_{cg} is positive (negative) whenever $\xi < 0$ (> 0).

[6] Individuals are hence subject to both wage shocks and non labor income shocks. Y includes all such shocks and includes taxes and transfers to and from the public authorities.

if the distribution of C^i and G_t^j is jointly log-normal, than the Euler equation (in logs) takes the following form:

$$\Delta c_{t+1}^i = \frac{\ln\left(\frac{\beta}{q}\right)}{\sigma} + \Gamma + \sum_{j=1}^{n} \alpha_j \Delta g_{t+1}^j + \psi \Delta Z_t^i + \Delta v_t^i + \varepsilon_{t+1}^i, \tag{1.4}$$

where small letters indicate the log of the original variable, and $\alpha_j := \frac{(1-\sigma)}{\sigma}\xi_j$. A positive α hence implies that C^i and G^j are complements. The parameter Γ summarizes the second order moments which we assume as being constant (both over time and across households), while ε_{t+1}^i represents the individual forecast error which, under rational expectations, satisfies $\mathbf{E}_t(\varepsilon_{t+1}^i) = 0$.

If we use the sequence of individual budget constraints[7], an extended permanent income equation of the following form can be obtained:

$$\Delta c_t^i + \alpha \Delta g_t = \Delta y_t^p + \alpha \Delta g_t^p, \tag{1.5}$$

where Δy_t^p and Δg_t^p are the permanent innovations to disposable income and government expenditure. The agent not only reacts to income shocks. The agent also reacts to shocks to his marginal utility. Equation (1.5) takes into account both effects.

1.3 Data

Individual data, such as private consumption and disposable income, are taken by the SHIW of Bank of Italy. We take into account four waves of data (1995-'98-'00-'02). For more information regarding the way of treating data, see Appendix.

Regional data, government consumption in particular, are taken by REA issued by ISTAT. REA follows the general principles of the European System of National Account (ESA '95). Government consumption is the sum of the spending of the Central Government, Regions, Provinces, and Towns. REA consolidates government consumption at a regional level. Specifically, government consumption contains purchases of goods and services, transfers in kind and

[7] Actually we use an approximated budget constraint in logs (see Cambpell (1993) and Naleweik (2006) for details).

wages. Moreover, this dataset provides a functional classification of the government consumption following the COFOG scheme. It divides public consumption in ten categories, such as, general services, defense, economic affairs, public order, education, health, social security and some other minor items. The period covered from REA goes from 1995 to 2002[8].

In Table 1, we present government consumption as a share of GDP for each region. Furthermore, following the national accounts (ESA '95), we disaggregate government consumption in two categories: the collective goods and services and the individual goods and services. The first category groups goods which are provided simultaneously to all members of the community or all households living in a particular region. They are public goods, such as, defense, public order, bureaucracy, etc. The second category is represented by goods that are provided to households for which is possible to observe and record its acquisition by an individual household. These goods are referred to as publicly provided private goods or merit goods (e.g. education and health).

The share of the government consumption for Italy is around 20% of GDP, in particular, it ranges from 13.5% of Lombardia to 30% of Sicily. Moreover, we see that individual goods (merit goods) are the lion's share of the government consumption, indeed they are roughly twice as much as collective goods (public goods). Importantly, the distribution of government consumption is not uniform across regions.

[insert Table 1 here]

Table 2 represents the share of each category of spending on total government consumption for Italy from 1995 to 2002. Important to say is that education and health represent the largest items among merit goods.

[insert Table 2 here]

Figure 1 represents the residuals of the regression of the logarithm of government consumption on time dummies, pooled by regions. Figure 2 represent the residuals of the regression of

[8]It is worth noting that similar datasets don't exist for US. In fact, on the one hand the definition of consumption taken from PSID covers just food. On the other hand, CEX does not have detailed information on the location of households. Finally, US does not have measures of government consumption consolidated at a federal level.

the first difference of the logarithm of government consumption on time dummies, pooled by regions. The implication we draw from these figures is that government consumption shows a certain degree of variability within and across regions despite we control for common macro shocks.

[**insert Figure 1 here**]

[**insert Figure 2 here**]

1.4 Estimation

The main aim of this section is to obtain an estimate for α, the parameter stating the degree of complementarity/substitutability between private and government consumption. First, we take to the data the Euler equation described in Section 2. Second, we estimate a permanent income model to check whether we obtain results which are similar with the previous ones.

1.4.1 Model with Non-separabilities

We want to estimate equation (1.4). In fact, we take to the data an equation which has a more flexible structure than (1.4); this allows us to control for possible non unit root preference shocks and some forms of habit. The regression we perform is the following:

$$\Delta c^i_{t+1} = \phi_0 + \phi_1 \Delta c^i_t + \alpha \Delta g^r_{t+1} + d_t + Z^r_{t+1} + \psi \Delta Z_t + \varepsilon^i_{t+1} + \Delta u^i_{t+1} + \Delta u^i_t, \qquad (1.6)$$

for ease of notation, we consider government consumption as a single category, so that g^r is the log of the government consumption for region r. The variable Z^r_{t+1} includes regional controls such as GDP, a proxy for public wages, and total government expenditure[9]. The variables d_t represent time dummies which are supposed to capture common macro shocks (like interest rate shocks). The regressor Z_t includes age, age squared and the level of education of the head of family. The values Δu^i_{t+1} and Δu^i_t represent measurement errors associated to Δc^i_{t+1} and Δc^i_t, respectively. Importantly, our dataset links household's private consumption to the

[9] All these variable but total government expenditure, are taken by ISTAT. Total government expenditure is drawn from Italian Treasury (CPT dataset) and is the sum of the current part of government spending (less government consumption) plus public investment.

government consumption of the region where the household lives. The underlying hypothesis is that households tend to utilize the great part of public services in the area (region) where they live. This is a reasonable hypothesis if we think to several categories of public consumption, such as, primary and secondary education, public order, and health care. Finally, it is worth noting to say that the cross-sectional variability of government consumption permits us to identify the α parameter.

Next, we estimate a process for government consumption at a regional level, that is assumed to follow:

$$\Delta g^r_{t+1} = \beta_0 + \beta_1 \Delta g^r_t + \beta_2 \Delta c^r_{t+1} + \beta_3 \Delta y^r_{t+1} + d_t + Z^r + \varepsilon^r_{t+1}, \tag{1.7}$$

where c^r is the log of regional private consumption and y^r is the log of regional GDP which is included as a regional control. Then, Z^r represent regional dummies which have been included to control for differential rate of growth in government consumption across regions. The motivation for which we estimate a process like (1.7) is that a feedback effect of private consumption to government consumption may arise. Indeed, there could be preference shocks that increase private consumption. As a consequence of these shocks, individuals consume more of any kind of goods and services, on average. Thus, they can ask more even for those services which are freely provided by government (e.g. medical treatments), inducing government to increase the expenditures for these services.

The identification strategy we use to estimate (1.6) and (1.7) is the one typical of simultaneous equation models. In (1.6) Δg^r_{t+1} is instrumented with g^r_t and earlier lags, while Δc^i_t is instrumented with c^i_{t-2} because of measurement errors. In (1.7) Δc^r_{t+1} is instrumented with Δc^r_t and earlier lags. We use GMM techniques applied to panel data, as such we use lagged instruments of any variables in the equations.

The estimation results of (1.6) and (1.4) are in Table 3 and 4, respectively. In both columns of Table 3 the coefficient of the autoregressive term of government consumption is estimated to be around -0.3, and is highly significant. Specifically, the first column does not contain neither Δy^r_t nor Δc^r_t in the estimation. Instead, the second column contains both Δy^r_t and Δc^r_t. Interestingly, regional private consumption has no effect on government consumption, that is the potential feedback effect of private consumption to government consumption does not seem to be important empirically.

[**insert Table 3 here**]

Table 4 represents the results for the Euler equation having total private consumption as dependent variable. In column 1, government consumption is treated as a single item. The coefficient related to Δg^r_{t+1} is estimated to be large and positive, significant at 5%. In column 2, we split government consumption into two categories, public and merit goods. Merit goods have a positive coefficient, significant at 2%. Public goods have no effect on private consumption. In column 3, we split merit goods into three categories, which are education (edu), health and social protection (health), recreation, culture and religion (cult). The coefficient associated with health is positive and significant at 1%. Column 4 presents the results for the excess sensitivity test, private consumption is not sensitive to predictable changes in individual income. Passing this test is somewhat important as it can be seen as validation of our estimation strategy based on the Euler equation. It is well known that this test tend to be rejected when aggregate data is used instead (e.g., Attanasio and Weber (1993)).

[**insert Table 4 here**]

Table 4bis presents some robustness analysis for the estimate of the Euler equation in which government consumption is considered as being disaggregated. In column 1, we estimate (1.6) without habit. The coefficient related to public health care is the same as the one estimated in the specification with habit, however, in the case of no habit the Sargan test rejects the null hypothesis that the moment conditions are equal to zero. In column 2, we take out from our sample people that work in the government sector, to control for a possible direct effect of public wages on government employees. In the last one, we control for individual fixed effect (e.g. heterogeneity in the coefficient of relative risk aversion). In all these cases, the coefficient of health remains positive and significant, at least at 1.5%.

[**insert Table 4bis here**]

Table 4ter represents the results of the estimate of (1.6), having non-durable consumption as dependent variable. The coefficients of interest have the same sign of the ones in Table 4. However, they are significant at a lower level.

[**insert Table 4ter here**]

1.4.2 Permanent Income Model

The aim of this section is to check that the empirical results obtained from the Euler equation in Section 4.1 do not contradict with those of the permanent income approach.

Next to the permanent income equation, developed in Section 2, we assume a process for both government consumption and individual income. The resulting system has the following form:

$$\begin{aligned} \Delta g_t^r &= \beta_0 - \rho \Delta g_{t-1}^r + \beta_2 \Delta c_t^r + d_t + Z_t^r + Z^r + \varepsilon_t^g \\ \Delta y_t^i &= \theta_0 + \theta_1 \Delta y_{t-1}^i + \theta_2 \Delta g_t^r + \theta_3 \Delta g_{t-1}^r + d_t + Z_t^r + \varepsilon_t^{y^i} \\ \Delta c_t^i &= \gamma_0 + \gamma_1 \Delta y_t^i + \gamma_2 \Delta y_{t-1}^i + \gamma_3 \Delta g_t^r + \gamma_4 \Delta g_{t-1}^r + d_t + Z_t^r + \varepsilon_t^{c^i}, \end{aligned} \tag{1.8}$$

where Z_t^r are regional controls.

The form of system (1.8) subsumes the following assumptions. First, government consumption is potentially affected by private consumption through preference shocks (as explained in Section 4.1). Second, individual disposable income is affected by government consumption[10]. Third, private consumption is affected by both government consumption and individual income (permanent income equation).

The estimation results of the first row of (1.8) are visible in Table 3, and have been commented on already in Section 4.1.

Table 5 reports the estimation for the income process, that is the second row of (1.8). Current government consumption tends to positively affect disposable income. However, the coefficient related to government consumption is not highly significant especially in the last two columns, that is, when we augment the specification with geographical dummies and when we do not consider government employees in the sample.

[insert Table 5 here]

Table 6 reports the estimation for the permanent income equation, that is the third row of (1.8). The coefficient related to government consumption happens to be positive and significant

[10] This assumption can find evidence from the fact that government consumption and labor income could be related in a standard government budget constraint.

at 5%, even when the specification is augmented with geographical dummies.

[insert Table 6 here]

We now relate the analysis of the coefficients estimated in (1.8) with the parameter α estimated in the Euler equation (1.6). If we combine (1.8) with the equation for the permanent government consumption process ($\Delta g_t^p = \varphi(q)\varepsilon_t^g$), we recover that $\gamma_3 = \alpha(1-\varphi(q))$ and $\gamma_4 = -\alpha\varphi(q)\rho$. Given $\rho > 0$, and $\varphi(q) < 1$, then:

$$\alpha = \gamma_3 - \frac{\gamma_4}{\rho} \tag{1.9}$$

Given the estimates for γ_3 and γ_4 (see Table 6), although the resulting α is lower than that estimated from the Euler equation (see Table 4), it is unambiguously positive, fully in line with the Euler equation estimates.

1.4.3 Discussion of the Estimation Results

We have estimated a positive relationship between public and private consumption, which indicates a complementarity between the two goods. This relation is driven by publicly provided private goods (e.g., education, health). Interestingly, health care positively affects households' private consumption. In reality, there can be motives for both substitutability and complementarity between private consumption and health care provided by government. Public health care services might appear as substitutes for private spending in basic medical treatments; people may prefer to exploit public services to heal pneumonia or to fix a broken arm. On the other hand, public health care services can function as complements for private spending in non-standard medical treatments; after a medical check in a public hospital, people discover that they need a treatment which is not provided by government, so that they need to go privately. Complementarity can also manifest itself between public health services and other categories of private consumption which are not necessarily related to health. The more government provides health services, the more individuals may exploit them. Thus, the probability that individuals are healthy can increase, and they may consume more (e.g. trips, social events, foods). Actually, some studies in health economics (e.g. Palumbo (1999), Smith (1999), and Olsho (2006)) find a correlation between the individual health status and the economic status.

In particular, Olsho (2006) finds that rational agents consume at higher levels when they are healthier.

The hypothesis that has to hold in our estimates is that the quality of public services is non-decreasing in the amount spent by government to provide these services. However, in the empirical analysis we have implicitly controlled for possible geographical heterogeneity in the quality of public services by performing an analysis in first differences. Moreover, as a further robustness check, we have applied fixed effect techniques to first differenced variables.

1.4.4 Accounting for Individual Heterogeneity

Our dataset gives us the possibility to study how individual heterogeneity affects the relation between government and private consumption. We perform some preliminary exercises on that. In particular, We use equation (1.6) to pursue this aim. Table 7 presents the results once we split the sample according to certain individual characteristics. In particular, in the first two columns we split the sample into two. The first one contains the estimate for households with a head aged less than 45, the second one with a head over 45. The effect of health on private consumption is not significantly different from the two groups. In column 3, the analysis is more refined. We interact government consumption with the number of the elderly (over 65) within the family. Results show that the effect of health expenditure on private consumption is stronger as the number of the elderly increase within the family. In the fourth and the fifth column we split households according to their level of residence. Consumption by people from the south and islands tends to be affected more by public health care with respect to the one of those living in the north. However, consumption of people in the north is still affected by public health care; the associated coefficient is positive and significant at 1.5%[11].

[insert Table 7 here]

[11] We also investigated whether other individual characteristics, such as, level of education, sex, total wealth, matter but we did not find any (statistically) significant difference in consumption responses. Details are available upon request.

1.5 Conclusions

We have estimated the degree of the relation between different categories of government consumption and private consumption, exploiting micro data. First, we have built a unique panel dataset which links household's private consumption to the government consumption of the region where the household lives, for Italy. Then, we have used regional variability of government consumption and measured its direct effect on individual consumption for different categories of government expenditures.

We obtained two main results. First, we found a positive relationship between public and private consumption, which we interpret structurally as complementarity between the two goods. This relation is driven by publicly provided private goods (e.g., education, health).

Second, We interestingly find that public health care is the only item that positively affects households' private consumption.

Finally, we also studied the possibility of heterogeneous responses across households. Preliminary results indicate that the effect of public health care on private consumption increases as the number of elderly people increases within the household. Moreover, the positive relationship between health care and private consumption is quantitatively more important for the regions in the south of Italy.

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1.7 Appendix

1.7.1 Data

Individual data are treated before to be used in the estimation. We rule out households having negative values on income and consumption, with inconsistent data on age sex and level of education. We consider in the sample households with the age of the head ranging from 25 to 65. We do not consider observations when household's head change. In order to eliminate possible outliers, we rule out individuals having consumption less (above) the 1 (99) percentile of the distribution and those having the rate of growth of consumption less (above) the 1 (99) percentile of the distribution. Furthermore, individual variables (such as consumption and disposable income) are adjusted for the equivalent scale; specifically we refer to the "OECD-modified scale" which assigns a value of 1 to the household head, of 0.5 to each additional adult member, and 0.3 to each child (see Haangenars et al. (1994) for details). Regional data are divided by the number of household of the regions (census information issued by ISTAT). All data are deflated by a national deflator (NIC issued by ISTAT).

Chapter 2

The Effect of Government Consumption on Private Consumption: Macro Evidence from Micro Estimates

Abstract[1]

We estimate the effect of different government consumption shocks on private consumption. We use our estimates from micro data to calibrate an otherwise standard RBC model. We find that government consumption shocks are able to generate a positive response for private consumption, even considering wealth and general equilibrium effects in a dynamic framework with fully flexible prices. Interestingly, the composition of government consumption is important for the impulse response of private consumption; a public health shock has a more significant impact on private consumption than an aggregate government consumption shock of equal size.

JEL classification: E21, E32, E62

Keywords: Consumption, Government Purchases, Calibration.

[1] This Chapter is coauthored with Nicola Pavoni (University College London)

2.1 Introduction

The study of the effects of government consumption has been at the core of the macroeconomics. In particular, the sign of the empirical response of private consumption to government spending shocks has been suggested as a crucial discriminant between the plausibility of the Neoclassical versus the Keynesian models.

The bulk of the debate is based on the implicit assumption that private consumption and government consumption enter in an additive separable way in the utility function. In the standard RBC model (Baxter and King (1993)) - where public spending is assumed to be pure waste - government spending *crowds out* private spending because the tax increase induced by the increase in government spending reduces net present value of disposable income which decreases consumption. In models with nominal rigidities consumption may increase as a consequence of an increase in government spending. In fact, Linnemann and Schabert (2003) show that - although the strength of the demand effect depends on the response of the real interest rate governed by the monetary policy regime - stickiness alone is quantitatively not sufficient to explain a rise in consumption as predicted by Keynesian theory. The negative effect on permanent income tends to dominate the demand effect due to sticky prices. Gali, Lopez-Salido and Valles (2007) strengthen the Keynesian effect due to nominal rigidities by introducing a share of liquidity constrained (and myopic) consumers in the economy, and show that their New-Keynesian model is able to generate a positive reaction of private consumption to public spending.

Other authors have allowed government consumption to directly affect the welfare of agents. Among others, Bailey (1971) and Barro (1981) argue that a general model of consumption should allow for the direct effect of government purchases of goods services on a consumer's utility. In this case, the response of private consumption to public spending is affected, ceteris paribus, by the degree of substitutability (complementarity) between the two items of interest.

The aim of this paper is to provide new evidence on the sign and magnitude of the reaction of private consumption to public consumption changes, using the estimates from micro data obtained in Chapter 1.

We use the coefficient of complementarity, estimated in Chapter 1, as input in an otherwise standard RBC model. This allows us to control for any general equilibrium effects that may

influence the relationship between private and government consumption (e.g., negative wealth effect). Then, we produce an impulse response for private consumption to different government consumption shocks.

We obtain two main results. First, we find that government consumption shocks are able to generate a positive response for private consumption, indeed our results from the calibration exercise are in line with the recent VAR evidence (e.g., Blanchard and Perotti (2002)). Second, we find that the composition of government consumption matters greatly for the impulse response of consumption; a public health shock has a more significant impact on private consumption than an aggregate government consumption shock of equal size.

The existing evidence is all based on aggregate data and uses different methodologies, with contrasting results. Ramey and Shapiro (1997) use a 'narrative' or 'dummy variable' approach and find that private consumption reacts negatively to public expenditure shocks for US. This contrasts to the positive relationship estimated by Blanchard and Perotti (2002) within a SVAR methodology, for the same country. Other studies estimate the response of private consumption to government spending shocks within general equilibrium models. Smets and Wouters (2003) estimate a negative response of consumption, while Forni, Monforte and Sessa (2007) estimate a positive one, both with Euro data.

The paper is structured as follows. In Section 2, we outline an otherwise standard RBC model, we do the calibration exercise, and we produce the impulse response functions for the model variables. Section 3 concludes and outlines our plans to extend both this paper and the one included in Chapter 1.

2.2 The effects of government consumptions shocks: Accounting for General Equilibrium Effects

In Chapter 1, we have found that there is a positive relation between private and government consumption. However, this relation has been estimated within a partial equilibrium framework. To study the total effect of government consumption changes on private consumption we need to take into account even wealth and general equilibrium effects. In particular, the negative wealth effect is a crucial element to be taken into account for studying the relation between private

and government consumption. When a positive government spending shock hits the economy, individuals revise downwards their permanent income so that they decrease their consumption. Thus, to control for general equilibrium effects, we resort to an otherwise standard RBC model and we calibrate it for the Italian economy, using as input our estimates from micro data.

We want to relate our study with those ones in the literature who investigate on the response of private consumption to government spending shocks. All of these studies utilize macro data. Some of them use a VAR analysis (e.g. Ramey and Shapiro (1998), Blanchard and Perotti (2002), and Mountford and Uhlig (2005)). Others estimate the response of private consumption to government spending shocks within general equilibrium models (e.g. Smets and Wouters (2003), Bouakez and Rebei (2007), and Forni, Monforte and Sessa (2007)). The results are mixed even using similar approaches. For example, Ramey and Shapiro (1998) find a negative response of consumption while Blanchard and Perotti (2002) estimate a positive one, both with US data. Moreover, Smets and Wouters (2003) estimate a negative response of consumption while Forni et al. (2007) estimate a positive one, both with Euro data.

2.2.1 Representative Agent Model

We assume that government and private consumption enter non-separable in the utility function. The utility function of the representative agent is the following:

$$u\left(C_t, G_t\right) = \frac{\left(C_t(G_t)^{\xi}\right)^{1-\sigma}}{1-\sigma} - \psi \frac{N_t^{1-\eta}}{1-\eta}, \tag{2.1}$$

where N_t measures hours worked by households, $\frac{1}{\eta}$ is the Frisch elasticity of labor supply, and ψ is a positive constant. Other parameters have the same meaning as in Chapter 1.

In a general equilibrium framework, the model we estimated in Chapter 1 can be seen as a Aiyagari (1994) framework with individual inelastic labor supply. In a complete markets framework where individual shocks are fully insured, Rogerson (1988) shows that the representative agent presents a utility function of consumption which is the same as the individual agents and a linear labor supply margin where movements in hours is interpreted as the number of people actually employed times a fixed number of hours per person. This would imply $\eta = 0$.

Unfortunately, the complete market analysis cannot be directly applied to our framework

with incomplete insurance markets. As we will discuss below, a fuller analysis might be needed to solve a general equilibrium model with heterogeneous agents, especially since the effects of government expenditure might change across different individuals. Nevertheless, we believe that the representative agent model we use in this section is a satisfactory tool to account for general equilibrium effects, at the first order, if effects are homogeneous across the population. In line with the analysis by An, Chang, and Kim (forth.), we perform sensitivity analysis to the value of η (although we retain the values for ξ and σ based on the microeconometric estimates).

The individual budget constraint is:

$$C_t + I_t + B_{t+1} = (1 + r_t)\, B_t + (1 - \tau^w) W_t N_t + r_t K_t - T_t, \tag{2.2}$$

where I_t is private investment, B_t is the stock of public debt at time t, W_t is the wage, r_t is the interest rate, and τ^w is the tax rate on labor income.

The law of motion for capital is the following:

$$K_t = (1 - \delta_k) K_t + I_t, \tag{2.3}$$

where δ_k is the depreciation rate of capital.

The household maximizes its expected lifetime utility, subject to the budget constraint, by choosing C_t, N_t, and K_{t+1} at every node of the decision tree.

The aggregate production function is Cobb-Douglas:

$$Y_t = K_t^{\theta} N_t^{1-\theta}, \tag{2.4}$$

and firms maximize profits by choosing labor and capital inputs taking factor prices W_t and r_t as given.

The government budget constraint is:

$$G_t + (1 + r_t) B_t = B_{t+1} + \tau_t^w W_t N_t, \tag{2.5}$$

where G_t is assumed to follow a standard autoregressive process (e.g. see Burnside, Eichenbaum,

and Fischer (2003)) :

$$\ln G_t = (1-\varphi)\ln G + \varphi \ln G_{t-1} + u_t \tag{2.6}$$

where G indicates the deterministic steady state for G_t .

To close the model we use a fiscal rule that insures that the intertemporal government budget constraint is satisfied and debt is stabilized over time. Specifically:

$$\frac{\tau_t^w}{\tau^w} = \left(\frac{B_t}{B}\right)^{\phi_b}, \tag{2.7}$$

where ϕ_b is a strictly positive constant and where τ^w and B indicate the deterministic steady state for τ_t^w and B_t, respectively.

The model is log-linearized around the deterministic steady state, then is solved using linear techniques.

2.2.2 Calibration

The model is calibrated at a quarterly frequency for the Italian economy. We need to calibrate 13 parameters. To calibrate these parameters we exploit information from our dataset and resort to previous studies available in the literature. Specifically, the capital share θ is set to 0.42 and is consistent with the labor share calculated with the data (see Censolo and Onofri (2003)). The discount factor δ and the depreciation rate of capital δ_k are set to 0.988 and 0.025, respectively, to imply a steady state for real interest rate of 3.5% (see Chiarini and Piselli (2005)). The steady state government consumption output ratio $g_y := \frac{G}{Y}$ is set to 0.19 and is consistent with the information of our dataset (see Table 1). The steady state consumption output ratio $c_y := \frac{C}{Y}$ and the steady state investment output ratio $i_y := \frac{I}{Y}$ are set to 0.60 and 0.21, respectively, to match the long-run averages computed from Italian National Accounts (see Forni, Gerali and Pisani (2008)). The level of steady state public debt output ratio $b_y := \frac{B}{Y}$ is set to 1.13 on annual basis, to match the average of public debt over GDP ratio for the period covered by our dataset. The steady state tax rate on labor income is calibrated using effective average tax rates estimated for Italy in Eurostat (2007), that is τ^w is set to 0.431. The coefficient of government consumption process φ is estimated to be equal to 0.96, using aggregate data for government consumption for Italy. Specifically, we take the quarterly series of Government final

consumption expenditure for Italy from Eurostat database (1980:q1-2007:q4). Equation (2.6) has been estimated using the (linear) detrended series of the logarithm of the real government final consumption expenditure[2]. The parameter of the fiscal rule ϕ_b is set to 0.07, following estimates for Italy of Gali and Perotti (2003). The bulk of existing literature on calibration for Italy assumes that the intertemporal elasticity of substitution is 1 (see Forni, et al. (2008)). This implies a value for σ equal to 1. Actually, we can't set σ equal to the mentioned value since the channel of complementarity would be ruled out from the model. In line with the micro estimates for other countries (e.g., Attanasio and Weber (1993)), we set σ equal to 1.5, and we do sensitivity analysis on this parameter. We borrow the value for the labor supply elasticity from Pistaferri (2003), that is we set η equal to 1.43[3]. Finally, setting a value of 1 for ψ allows us to match the ratio of hours worked on total available time calculated by Censolo and Onofri (2003) for Italy. Table A summarizes the values used in calibration.

[2]Note that the process for G is estimated at a national level. This is consistent with the representative agent approach of this section. Recall indeed that the coefficients for the regional process of government consumption were estimated in Chapter 1 by using time dummies to partly capture aggregate shocks such as the national G. We use the Eurostat database, instead of our data, in order to exploit a longer time series than the eight waves in our regional panel dataset.

[3]This is a value that is in line with the micro estimates for other countries. In fact, Fuster, Imbrohoroglu and Imbrohoroglu (2007) argue that a plausible value for η equals 1. However, a value which is above the unity dampens a bit the response of labor supply to a government consumption shock, which we will see is going to be relatively large. We perform sensitivity analysis on η.

Table A: parameters calibration		
parameters		values
θ	capital share	0.42
δ	discount factor	0.988
δ_k	depreciation rate of capital	0.025
g_y	government consumption output ratio	0.19
c_y	consumption output ratio	0.60
i_y	investment output ratio	0.21
b_y	public debt output output ratio	1.13
τ^w	tax rate on labor income	0.431
φ	autoregressive coefficient for G_t	0.96
ϕ_b	fiscal rule	0.07
σ	coefficient of relative risk aversion	1.5
η	inverse of the Frisch elasticity	1.43
ψ	preferences	1

2.2.3 Impulse Response Function Analysis

Within our calibrated RBC model, we produce impulse responses of private consumption (and other model variables) to shocks coming from different categories of government consumption.

Figure 3 shows two sets of impulse response functions. Dotted lines describe the impulse responses to a 1% increase in government consumption if we set ξ equal to zero, that is we impose that government and private consumption are unrelated in preferences. Standard results emerge, in particular, private consumption goes down on impact due to the negative wealth effect. Solid lines describe the impulse responses to a 1% increase in government consumption if we set ξ in line with the estimate of α from the first column of Table 4 (Chapter 1). We see that the complementarity effect more than offsets the negative wealth effect produced by the government spending shock, so that, private consumption increases on impact. Interestingly, the response of labor supply is stronger than in the case of non-separability since government consumption positively affects the marginal utility of consumption, as such individuals are

willing to work more the present period. Moreover, the fact that government shocks are quite persistent implies that when the agent observes an increase in G, she forecasts the desire to high consumption levels in future periods as well. This informational shock induces a further increase to N as the agent aims at increasing labor income to sustain the forecasted expensive consumption path. Accordingly, wages decrease by a larger amount in our model than in the standard case.

[**insert Figure 3 here**]

Figure 4 presents three impulse responses for private consumption. The first one is caused by a shock from government consumption considered as a single aggregate, the second one by a shock coming from merit goods, and the third one by a shock from public health care. All shocks have the same size (1% increase in the item of interest), however, their weight on GDP in steady state is obviously different. Using information from Table1 (Chapter 1), we set the steady state values of government consumption, merit goods, and health care (as a share of GDP) to 0.19, 0.13, and 0.06 respectively. Solid lines describe the response of private consumption to the three spending shocks, conditioned on the different estimates of α (Table 4). In accordance to our estimates, we set to zero all other coefficients for $G^{i\prime}$s. The solid line in the upper left panel describes the response of private consumption to aggregate government shock conditioned on the point estimate for α drawn from column 1 of Table 4 (1.94). Dotted lines are drawn conditional on the 90% confidence interval of the coefficient α. The solid line in the upper right panel describes the response of private consumption to a merit goods shock conditioned on the point estimate for α drawn from column 2 of Table 4 (0.9). The solid line in the bottom panel describes the response of private consumption to a health care shock conditioned on the point estimate for α drawn from column 3 of Table 4 (0.72). All three spending shocks generate a positive response of private consumption, conditioned on their respective α's, however, the health care shock is the one that provides a response for private consumption which is clearly positive. The response of private consumption to the health care shock is the smallest one considering solid lines, however, the associated dotted lines always remain in the positive region and are rather shrunk to the solid line. This is not the case when government consumption shock is considered; although the associated solid line is larger than

the other two, the lower dotted line contains the zero value.

[**insert Figure 4 here**]

2.3 Conclusions and Extensions

We estimated the effect of different government consumption shocks on private consumption, exploiting estimates from micro data. First, we have used our estimates from micro data to calibrate an otherwise standard RBC model. Second, we have produced impulse responses for private consumption to government consumption shocks within the RBC framework.

We obtained two main results. First, we studied how various typologies of government consumption shocks affect private consumption even within a RBC framework and we have consistently found a positive effect. Our result from the calibration exercise are in line with the recent VAR evidence (e.g., Blanchard and Perotti (2002)). Second, we find that the composition of government consumption matters greatly for the impulse response of consumption; a public health shock has a more significant impact on private consumption than an aggregate government consumption shock of equal size.

Our calibration exercise has been conducted within a standard representative agent model. On the other hand, the (preliminary) analysis on individual heterogeneity conducted in Chapter 1 has shown that the demographic structure of the population can potentially matters greatly for the relationship between government and private consumption. We plan to perform a similar quantitative exercise within a general equilibrium model which takes into account for the existence of uninsured idiosyncratic shocks as in Aiyagari (1994). The aim will be to study more in detail what is the response of private consumption to various typologies of government consumption shock, taking into account for the demographics and heterogeneity across households.

The fact that public health care is the item that has the strongest impact on private consumption may motivate the existence of additional explanations for the relationship between government and private consumption. In particular, if we believe that government consumption can affect the variability of future consumption, then precautionary saving motive constitutes another channel through which public expenditures may affect private consumption decisions,

which has been neglected so far by the literature. For example, if public spending for health increases, and the process for government expenditure happens to be persistent, individuals have to save less today to insure themselves for future negative health shocks. This may create a future increase in private consumption. The empirical results coming from the heterogeneity analysis (Chapter 1) could reinforce this view. Indeed, as the number of elderly people expands within a family, the likelihood that family is hit by negative health shocks increases. Thus, public health care can act as a form of insurance for these households. These issues are investigated in Ercolani and Pavoni (2008).

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Chapter 3

The Effects of Government Spending on Private Consumption: Evidence from an Estimated New Keynesian Model for the US

Abstract

We address the issue concerning the response of private consumption to government spending shocks. In particular, we aim at investigating how the externalities produced by public expenditures on the private sector affect this response. To this end, we build a New Keynesian dynamic stochastic general equilibrium model which takes into account two important features. First, it allows government consumption to directly affect the welfare of agents. Second, it allows public capital to influence the productivity of private factors. Results, carried out using bayesian inference on US data, indicate that government and private consumption are unrelated in preferences. On the other hand, our estimates show that public capital enhances the productivity of private factors. As a consequence, a government investment shock generates a positive response of private consumption. Interestingly, the latter shock generates a mild decrease in inflation and a tiny increase in private investment.

JEL classification: E32, E62

Keywords: Fiscal Policy, Private Consumption,

Government Consumption, Government Investment, Bayesian Estimation.

3.1 Introduction

Assessing the effect of government spending on private consumption is a long-standing issue in macroeconomics. The controversy on the effects of government spending is both empirical and theoretical (e.g. see Perotti (2006)).

The object of this paper is to shed light on the response of private consumption to government spending shocks focusing on one particular channel. That is, the paper investigates how the "externalities" produced by government spending affect the response of private consumption to two specific government spending shocks, i.e. a government consumption shock and a public investment shock. Externality means that government consumption can affect the households' marginal utility of consumption, and, therefore, the level of consumption itself. This implies that some items of government spending can act as substitutes or complements for private consumption. For example, public health care can reduce the need for private health services, or, public education services can, on the one hand, reduce the need for private tutors, and, on the other hand, increase the demand for textbooks or for personal computers. These potential relations between private consumption and different items of public spending makes government consumption, in aggregate, to be either substitute or complement for private consumption. Thus, omitting *a priori* the potential channel of substitutability/complementarity can produce a bias in the estimate of the response of private consumption to a government consumption shock. Not only the current part of government expenditures but also government investment can create some externalities for the private sector. Specifically, public capital can act as a shifter for the productivity of the private factors, so that an increase of public investments may create a positive wealth effect in the economy which affects the dynamics of private consumption, as well. For example, an efficient system of public highways built in place of an old route can enhance the productivity of private factors for firms operating in that area (e.g. it may foster the transportation for commodities). This creates a positive wealth effect in the economy, ceteris paribus, that in turn can increase private consumption.

The standard hypothesis of the bulk of the neoclassical and New Keynesian models is that private and government consumption are unrelated in preferences, therefore, government consumption is nothing but a pure waste of resources. Moreover, even public capital is often omitted in these models since it is assumed to be "unproductive". Both standard neoclassi-

cal and New Keynesian models predict that positive shocks of government consumption and government investment decrease private consumption. This mechanism works through the so-called *negative wealth effect*. If government spending increases, also the present discounted value of taxes of a representative agent would increase. Individual's permanent income is lower and private consumption as well. In fact, a government spending shock has two effects within standard New Keynesian models. On the one hand, the negative wealth effect which always operates. On the other hand, there is a demand effect which is silent in neoclassical models. Because of the presence of price rigidity, output is partly demand driven so that an increase in government spending boosts labour demand. If labor demand increases more than labor supply, real wage increases. In this case, labor income is higher, and, thus, private consumption can happen to increase. Eventually, even in standard New Keynesian models, government spending negatively causes private consumption because the negative wealth effect dominates the mentioned demand effect (Linnemann and Schabert (2003)).

A number of recent papers have been able to generate a positive comovement between private consumption and government spending. Gali, Lopez-Salido and Valles (2007) introduce in a New Keynesian model a market imperfection, namely, a share of the population cannot borrow or lend. These liquidity constrained individuals consume all labor income at each point in time. Following a government spending shock, as price stickiness operates, a significant increase in labor demand can make real wages higher. Thus, the consumption of the liquidity constrained individuals increase, by definition. If the share of liquidity constrained individuals is sufficiently large in the economy, even aggregate consumption can increase after a government spending shock. Linnermann (2006) builds a neoclassical model in which leisure and consumption enter not separable in the utility function. As leisure falls following the negative wealth effect produced by a government spending shock, the substitutability between consumption and leisure implies the marginal utility of consumption must increase, making the agent want to consume more. Government spending and private consumption covary positively conditional on a government spending shock.

This paper contributes to the literature in the following ways. It estimates the response of private consumption to two spending shocks, a government consumption shock and a public investment shock, within a New Keynesian Dynamic Stochastic General Equilibrium (NK-

DSGE) model. Unlike standard models, the estimation has been performed considering two additional channels in the model. First, the substitutability/complementarity link between private and government consumption. Second, allowing for the possibility that public capital affects the productivity of the private factors. Summing up, the questions we want to answer are the following: does the standard hypothesis of separability between private and government consumption hold in the data? How does the channel of substitutability/complementarity affect the response of private consumption to a government consumption shock? Is there evidence that government capital affects the productivity of the private factors? What is the response of private consumption to a government investment shock?

The estimation of the model is carried out exploiting bayesian techniques, using US data. Our results suggest that the standard hypothesis of separability in preferences between private and government consumption is not rejected by the data. As a consequence, a government consumption shock generates a negative response of private consumption as in standard models. On the other hand, public capital provides positive externalities for private factors. Given that, a government investment shock generates a positive response of private consumption. Interestingly, a government investment shock creates a mild slowdown in inflation through the decrease of real marginal costs. Moreover, it generates a tiny positive response for private investments.

The paper has the following structure. Section 2 describes an overview of the empirical evidence and relates it to our paper. Section 3 outlines the model. Section 4 describes the estimation exercise. In Section 5, both concluding remarks and future extensions are presented.

3.2 Review of the empirical evidence

A number of empirical papers has studied the response of private consumption to government spending shocks. The evidence on private consumption is mixed at best, even within similar approaches.

Among the Vector Autoregression approach, three important papers emerge. Ramey and Shapiro (1997), using the so called "dummy-variable approach", find that during specific episodes of exogenous increases in government spending, private consumption fell. Blanchard

and Perotti (2002) use institutional information to identify fiscal shocks; they find that a government spending shock positively causes private consumption. Finally, Mountford and Uhlig (2005) use a Structural VAR (SVAR) approach with an identification scheme based on sign restrictions. They find a slightly positive effect of government spending shock on private consumption. Our paper does not directly contribute to this class of papers since it does not focus on the issue of identification, but on the channel through which fiscal policy effects manifest themselves.

There are a number of papers which study the channels for the transmission of fiscal policy, specifically, the mechanisms which drive the response of private consumption to a government spending shock. Coenen and Straub (2005) estimate a NK-DSGE model à la Gali et al. (2007) for the Euro area, i.e. allowing for a share of consumers to be liquidity constrained. Despite this extension, the response of private consumption to a government consumption shock is estimated to be negative. Lopez-Salido and Rabanal (2006) estimate a NK-DSGE model for US in which they find that the form of complementarity between private consumption and hours worked helps consumption to increase after a government spending shock. Forni, Monforte and Sessa (2007) estimate a NK-DSGE model for the Euro area with the presence of liquidity constrained individuals. Moreover, the model features both distortionary taxes and the fact that government consumption is a composite aggregate (including purchases of goods and services and compensation for government employes). The final result is that a government expenditure shock *crowds-in* private consumption more than a government employment shock. We contribute to this class of papers, since we address two additional features. One concerns the investigation of the response of private consumption, conditional on the estimated degree of substitutability/complementarity between private and government consumption. The other is the study of the response of private consumption to a government investment shock, conditional of the estimated level of productivity of public capital.

All the estimates of the degree of substitutability/complementarity between private consumption and government consumption, except for Bouakez and Rebei (2007), are obtained within a partial equilibrium model based on Euler equations[1]. Using NK-DSGE models repre-

[1]The empirical evidence obtained by estimating euler-equations is not conclusive. Auscher (1985) finds a significant degree of substitutability between the two variables of interest for US, whereas, Amano and Wirjanto (1998) finds a weak complementarity. Ahmed (1986) finds substitutability for UK. Karras (1994) examines the

sents a contribution for the following two reasons. First, the chosen approach is superior with respect to a partial-equilibrium framework since a relevant omitted variable problem can show up in those models which cannot account for the changing in the agent's permanent income. More precisely, it's likely that the estimate of the degree of substitutability/complementarity could be spoiled by the so-called negative wealth effect if correct instruments are not used in the estimation of Euler equations. Second, using NK-DSGE model can improve the work of Bouakez and Rebei (2007). Although they use a general equilibrium model, they do not account for price stickiness. However, as documented in Section 1, price rigidity can be an additional channel for transmitting fiscal policy because it can somehow dampen the negative wealth effect produced by a government spending shock. Moreover, Bouakez and Rebei (2007) produce estimates within an RBC model which typically fits the data worse than a NK-DSGE model (in term of marginal data density).

The last class of papers focuses attention on the importance of public capital in boosting output growth. Estimating a production function that relates private sector output to private sector labor and capital and to total government capital for the aggregate US economy, Aschauer (1989) finds the output elasticity of government capital is 0.39. Following a similar approach, Finn (1993) estimates the output elasticity of government capital to be 0.16. The implications of these two papers is that public capital is an important explanatory factor for changes in the productivity of the economy. Unlike these papers, we estimate the output elasticity of government capital within a general equilibrium model. As a consequence, we can study the effect of a government investment shock on the economy, controlling for general equilibrium effects. There are virtually no estimates on the effects of a government investment shock within an estimated NK-DSGE model. However, it is worth noting that Coenen and Tchakarov (2007) conduct a calibration exercise for the Euro area within a NK-DSGE framework. They find that both permanent and temporary public investment shocks generate a larger multiplier than exogenous increases in government consumption.

relationship between private and public consumption across thirty countries and finds that the two type of goods are best described as unrelated. Fiorito and Kollitznas (2004) splits government consumption in two groups named as "public goods" and "merit goods". The first includes spending for defense, public order and justice, the second contains health, education and other services that could have been provided privately. They show that, for twelve European Countries, public goods slightly substitute while merit goods complement private consumption.

3.3 The model

The model is an extended version of NK-DSGE model à la Smets and Wouters (2003), henceforth SW (03). The model features four types of economic agents: households, firms, a monetary authority and a fiscal authority. In addition, it is characterized by two sources of nominal frictions and five real rigidities. The nominal frictions include price and wage stickiness à la Calvo (1983) and Yun (1996) with indexation to past inflation. The real rigidities originate from internal habit formation in consumption, monopolistic competition in factor and products markets, investment adjustment costs, and variable costs of adjusting capacity utilization.

The extensions regard the government expenditures side of the fiscal block of SW (03) model. Government consumption is allowed to affect the household's welfare by entering the individuals' utility function. Moreover, the standard production function is augmented with public capital to allow for the possibility that the latter can affect the productivity of private factors. Finally, following Finn (1998) and Forni et al. (2007) we break up government consumption into two items: purchases of goods and services and wage bill.

3.3.1 Households

The economy is populated by a continuum of households. We assume that the representative household derives utility from effective consumption ($\tilde{C}_t$), while, it derives disutility from working.

Effective consumption is assumed to be a CES aggregator of private consumption, C_t, and government purchases of goods and services, G_t:

$$\tilde{C}_t = \left[\phi \left(\varepsilon_t^b C_t\right)^{\frac{v-1}{v}} + (1-\phi)\, G_t^{\frac{v-1}{v}}\right]^{\frac{v}{v-1}}, \tag{3.1}$$

where ϕ is the weight of private consumption in the effective consumption aggregator, and $\nu \in (0;\infty)$ is the elasticity of substitution between C_t and G_t[2]. The aggregator also contains one consumption-preference shock, that is ε_t^b. The shock is assumed to follow a first-order autoregressive process with an i.i.d.-normal error term: $\varepsilon_t^b = \rho_b \varepsilon_{t-1}^b + \eta_t^b$.

[2] When $\nu = 0$, we have a "Leontief" aggregator, i.e. C_t and G_t become perfect complements. When $\nu = 1$, we have a "Cobb-Douglas" aggregator of the form $\tilde{C}_t = C_t^{\phi} G_t^{(1-\phi)}$. As $\nu \to \infty$, we have a linear aggregator of the form $\tilde{C}_t = \phi C_t + (1-\phi)\, G_t$, the two goods are perfect substitutes.

The household maximizes its lifetime utility function by choosing consumption, C_t, labor supply, L_t, next period's financial wealth in form of one period government bonds, B_{t+1}, next period's physical capital stock, K_{t+1}, the level of investment, I_t, and the intensity with which the installed capital stock is utilized, Z_t, given the following lifetime utility function:

$$E_t \left\{ \sum_{k=0}^{\infty} \beta^k \left[\frac{\left(\tilde{C}_{t+k} - h\tilde{C}^A_{t+k-1} \right)^{1-\sigma_c}}{1-\sigma_c} - \frac{1}{1+\sigma_L} \varepsilon^L_t \left(L_{t+k} \right)^{1+\sigma_L} \right] \right\}, \tag{3.2}$$

where σ_c denotes the degree of relative risk aversion, σ_L is the inverse of the Frisch elasticity, i.e. the inverse of the elasticity of work effort with respect to wage. The parameter $h \in (0;1)$ measures the degree of habit formation in consumption. $\beta \in (0;1)$ is the subjective discount factor. $\tilde{C}^A_{t-1}$is the aggregate level of effective consumption at time $t-1$. This creates external habit formation in consumption. Equation (3.2) also contains one preference shock; ε^n_t is a labor supply shock. This shock is assumed to follow a first-order autoregressive process with an i.i.d.-normal error term: $\varepsilon^L_t = \rho_L \varepsilon^L_{t-1} + \eta^L_t$. Note that if $\phi = 1$, $\tilde{C}_t = C_t$ and the standard hypothesis of considering G_t as pure waste of public resources emerges.

The household faces the following budget constraint (expressed in real terms):

$$C_t + I_t + B_{t+1} = R^b_t B_t + W_t N_t + \left[R^k_t Z_t - \Psi\left(Z_t\right) \right] K_t + D_t - T_t, \tag{3.3}$$

where the terms on the left-hand side show how the household uses its resources, while the terms on the right-hand side indicate the resources the household has at its disposal. B_t are riskless government bonds. R^b_t is the riskless return on government bonds. R^k_t is the return from capital. $W_t L_t$ is the labor income. $\Psi\left(Z_t\right)$ represents the cost of using capital at intensity Z_t. D_t are the dividends paid by household-owned firms. T_t are lump-sum taxes.

The capital stock evolves according to the following capital accumulation equation:

$$K_{t+1} = (1-\tau) K_t + I_t \left[1 - S\left(\varepsilon^I_t \frac{I_t}{I_{t-1}} \right) \right], \tag{3.4}$$

where τ is the depreciation rate. The function $S(.)$ introduces investment adjustment costs à la Christiano, Eichenbaum, and Evans (2005). ε^I_t is a shock to the investment cost function which is assumed to follow a first-order autoregressive process with an i.i.d.-normal error term: $\varepsilon^I_t =$

$\rho_I \varepsilon^I_{t-1} + \eta^I_t$. Let Λ_t and $\Lambda_t Q_t$ the Lagrange multipliers associated with the budget constraint (3.3), and the capital accumulation equation (3.4), respectively. Q_t is the Tobin's Q which determine the value of installed capital. The first order condition associated with the optimal choice for C_t, B_{t+1}, K_{t+1}, I_t, and Z_t are:

$$\Lambda_t = \phi \left(\frac{\tilde{C}_t}{\varepsilon^b_t C_t} \right)^{\frac{1}{v}} \left[\left(\tilde{C}_t - \gamma \tilde{C}_{t-1} \right)^{-\sigma_c} \right] \tag{3.5}$$

$$\beta E_t \left[\frac{\Lambda_{t+1}}{\Lambda_t} R^b_t \right] = 1 \tag{3.6}$$

$$Q_t = \beta E_t \left[\frac{\Lambda_{t+1}}{\Lambda_t} (Q_{t+1}(1-\tau) + R^k_{t+1} Z_{t+1} - \Psi\left(Z_{t+1}\right)) \right] \tag{3.7}$$

$$\begin{aligned} & Q_t S' \left(\varepsilon^I_t \frac{I_t}{I_{t-1}} \right) \varepsilon^I_t \frac{I_t}{I_{t-1}} - \beta E_t \left[Q_{t+1} \frac{\Lambda_{t+1}}{\Lambda_t} S' \left(\varepsilon^I_{t+1} \frac{I_{t+1}}{I_t} \right) \left(\varepsilon^I_{t+1} \frac{I_{t+1}}{I_t} \right) \frac{I_{t+1}}{I_t} + 1 \right] \\ = \; & Q_t \left(1 - S \left(\varepsilon^I_t \frac{I_t}{I_{t-1}} \right) \right) \end{aligned} \tag{3.8}$$

$$R^k_t = \Psi'\left(Z_t\right) \tag{3.9}$$

Wage Setting

There is a continuum of monopolistically competitive unions, within the household sector, indexed by $i \in [0;1]$, which act as wage setters for the differentiated labor services supplied by households. Unions take the aggregate wage rate, W_t, and aggregate labor demand, N_t, as given.

Following Calvo (1983), unions receive permissions to optimally reset their wage rate in a given period t with probability $(1 - \xi_w)$. All unions that receive permission to reset their wage rate choose the same wage rate $\tilde{w}_t$. Those unions that do not receive permission are allowed to adjust their wage rate at least partially according to the following scheme:

$$W_{i,t} = W_{i,t-1}\left(\frac{P_{t-1}}{P_{t-2}}\right)^{\gamma_w}, \tag{3.10}$$

where $\gamma_w \in (0;1)$ measures the degree of indexation to past changes in the aggregate price index P_t.

Each union i that receives permission to optimally reset its wage rate in period t, is assumed to maximize household lifetime utility, as represented by equation (3.2), taking into account the wage-indexation scheme and the demand for labor services, the latter being given by:

$$N_{i,t} = \left(\frac{W_{i,t}}{W_t}\right)^{\frac{1+\lambda_{w,t}}{\lambda_{w,t}}} N_t, \tag{3.11}$$

where the stochastic parameter $\lambda_{w,t} = \lambda_w + \eta_t^w$ represents the wage mark-up in the unionized labor market.

Thus, we obtain the following first-order condition for the union's optimal wage-setting choice in period t:

$$E_t\left[\sum_{k=0}^{\infty}\xi_w^k\beta^k N_{i,t+k}\left(\Lambda_{t+k}\frac{W_{i,t}}{P_{t+k}}\left(\frac{P_{t+k-1}}{P_{t-1}}\right)^{\gamma_w} - (1+\lambda_{w,t+k})\varepsilon_{t+k}^L N_{i,t+k}\right)\right] = 0 \tag{3.12}$$

Aggregate labor demand, N_t, and aggregate nominal wage, W_t, are determined by the following Dixit-Stiglitz indices:

$$N_t = \left[\int_0^1 (N_{i,t})^{\frac{1}{1+\lambda_{w,t}}} di\right]^{1+\lambda_{w,t}} \tag{3.13}$$

$$W_t = \left[\int_0^1 (W_{i,t})^{-\frac{1}{\lambda_{w,t}}} di\right]^{-\lambda_{w,t}} \tag{3.14}$$

The equilibrium real wage reflects the fact that, at each time t, some unions are allowed to reoptimize their wages, and some are not. For this reason the aggregate real wage must satisfy the following rule:

$$W_t = \left((1-\xi_w)(W_{i,t})^{-\frac{1}{\lambda_{w,t}}} + \xi_w\left(\frac{P_{t-1}}{P_{t-2}}\right)^{\gamma_w}(W_{i,t-1})^{-\frac{1}{\lambda_{w,t}}}\right)^{-\lambda_{w,t}} \tag{3.15}$$

3.3.2 Firms

We assume that there is a continuum of monopolistically competitive firms indexed by $j \in [0,1]$ each of which produces a single variety of final goods, $Y_{j,t}$. Moreover, there is a set of competitive firms which combine all the intermediate goods into a single final good, Y_t.

3.3.3 Final-Good Sector

The final-good firms combine the differentiated intermediate goods $Y_{j,t}$ using a standard Dixit-Stiglitz aggregator of the following form:

$$Y_t = \left[\int_0^1 (Y_{j,t})^{\frac{1}{1+\lambda_{p,t}}} dj\right]^{1+\lambda_{p,t}}, \tag{3.16}$$

where the stochastic parameter $\lambda_{p,t} = \lambda_p + \eta_t^p$ represents the wage mark-up in the intermediate-goods market.

The cost minimization conditions in the final goods sector can be written as a function of the price $P_{j,t}$ relative to the price of the final good P_t:

$$Y_{j,t} = \left(\frac{P_{j,t}}{P_t}\right)^{-\frac{1+\lambda_{p,t}}{\lambda_{p,t}}} Y_t \tag{3.17}$$

where P_t can be written as:

$$Y_t = \left[\int_0^1 (P_{j,t})^{-\frac{1}{\lambda_{p,t}}} dj\right]^{-\lambda_{p,t}} \tag{3.18}$$

3.3.4 Intermediate-goods Firms

We assume that there is a continuum of monopolistically competitive firms indexed by $j \in [0,1]$ each of which produces a single variety of final goods, $Y_{j,t}$, using as inputs capital services, $K_{j,t}$ and labor services, $N_{j,t}$. Moreover, we augment the standard production function by inserting public capital, K_t^G. The production function is given by:

$$Y_{j,t} = \varepsilon_t^a K_{j,t}^{\alpha} N_{j,t}^{1-\alpha} (K_t^G)^{\theta_g} - \Phi, \tag{3.19}$$

where the variable $\varepsilon_t^a = \rho_a \varepsilon_{t-1}^a + \eta_t^a$ is a serially correlated technology shock, and the parameter Φ represents fixed cost of production. $\theta_g \in (0; \infty)$ is a parameter stating the level of the productivity of the public capital, that is the output elasticity of government capital. The higher it is, the more effective public capital is in boosting the firm's output, ceteris paribus. If $\theta_g = 0$, the standard production function pops up again, and public capital has no effect on output.

Following Baxter and King (1993), public capital is assumed to evolve according to:

$$K_{t+1}^G = \left[(1 - \tau_{K^G}) K_t^G + I_t^G\right], \tag{3.20}$$

where I_t^G is the level of government investment and τ_{K^G} is the depreciation rate of public capital.

The existence of an economy-wide competitive factor market implies that all firms pay the same rental rate R_t^k and the same real wage W_t. Hence, cost minimization subject to the production technology (3.19) yields first order conditions for inputs which can be expressed as relative factor demands, and real marginal cost:

$$\frac{K_t}{N_t} = \frac{\alpha}{1-\alpha} \frac{W_t}{R_t^k} \tag{3.21}$$

$$MC_t = \frac{\left(R_t^k\right)^{\alpha} W_t^{1-\alpha}}{\varepsilon_t^a \alpha^{\alpha} (1-\alpha)^{1-\alpha}} * \frac{1}{(K_t^G)^{\theta_g}} \tag{3.22}$$

Note that marginal costs are affected by public capital, provided that θ_g is different from zero.

Price setting

Following Calvo (1983), at each period t a firm receives permission to optimally reset its price with probability $1 - \xi_p$. The firms which receive permission to reset their prices chose the same price $\tilde{P}_{j,t}$. Those firms, which cannot optimally reset their price, index their price to past price inflation according to the following rule:

$$P_{j,t} = \left(\frac{P_{t-1}}{P_{t-2}}\right)^{\gamma_p} P_{t-1}, \tag{3.23}$$

where the parameter γ_p measures the degree of indexation to past changes in the aggregate price index P_t.

All firms that can reset their price in period t, maximize the expected present discounted value of profits:

$$E_t \left\{ \sum_{k=0}^{\infty} \xi_p^k \beta_{t,t+s} D_{j,t+s} \right\}, \tag{3.24}$$

subject to the demand for its output (3.17), and the price indexation scheme (3.23), and where:

$$D_{j,t} = P_{j,t} Y_{j,t} - MC_t \left(Y_{j,t} + \Phi \right), \tag{3.25}$$

are period t nominal profits distributed as dividends to households.

The first order condition with respect to $\tilde{P}_t$ is:

$$E_t \left\{ \sum_{k=0}^{\infty} \xi_p^k \beta_{t,t+k} Y_{j,,t+k} \left(\tilde{P}_{j,t} \left(\frac{P_{t+k-1}}{P_{t-1}} \right)^{\gamma_p} - 1 + \lambda_{p,t} (MC_{t+k}) \right) \right\} = 0 \tag{3.26}$$

Like the aggregate real wage, the equilibrium price reflects the fact that, at each time t, some firms are allowed to reset their prices, some are not. For this reason the aggregate price index must satisfy the following rule:

$$P_t = \left(\left(1 - \xi_p \right) \tilde{P}_{j,t}^{-\frac{1}{\lambda_{p,t}}} + \xi_p \left(\frac{P_{t-1}}{P_{t-2}} \right)^{\gamma_p} P_{j,t-1}^{-\frac{1}{\lambda_{p,t}}} \right)^{-\lambda_{p,t}} \tag{3.27}$$

3.3.5 Fiscal and Monetary authorities

The government budget constraint is the following:

$$G_t + I_t^G + W_t L_t^{gov} = T_t, \tag{3.28}$$

where L_t^{gov} is the labor in the government sector and, accordingly, $W_t L_t^{gov}$ is the wage bill. The wage paid to public employees is determined in the private sectors. From a theoretical point of view, this can be achieved by assuming that hours can be moved costlessy between the two sectors and thus L_t^{priv} and L_t^{gov} are perfect substitutes in the utility function. Indeed, in the utility function the labor supply is meant to be total labor supply, $L_t = L_t^{gov} + L_t^{priv}$. T_t are

lump-sum taxes.

Government investment, government consumption and government labor are assumed to evolve exogenously following a standard log-linear autoregressive process:

$$\begin{aligned} i_t^G &= \rho_{I^G} i_t^G + \eta_t^{I^G} \\ g_t &= \rho_g g_{t-1} + \varepsilon_t^g \\ l_t^{gov} &= \rho_{\lg ov} l_{t-1}^{gov} + \eta_t^{\lg ov}, \end{aligned} \tag{3.29}$$

where lower case letters indicate that variables are expressed in log deviations from their respective steady state values. Then, $\eta_t^{I^G}$, ε_t^g , and $\eta_t^{\lg ov}$ represent serially uncorrelated shock.

Finally, the monetary authority follows the usual log-linear Taylor-type rule:

$$r_t = \rho r_{t-1} + (1-\rho)\left[r_\pi(\pi_t) + r_y(y_t - y_t^P)\right] \tag{3.30}$$

$$+ r_{\Delta\pi}(\pi_t - \pi_{t-1}) + r_{\Delta y}(y_t - y_t^P - (y_t - y_{t-1}^P)) + \eta_t^R, \tag{3.31}$$

where, again, lower-case letters for model variables indicate log deviations from steady state values. Specifically, r_t is the nominal interest rate ($r_t = r_t^b + E_t(\pi_{t+1})$), π_t is the inflation rate. y_{t-1}^P is the potential output, that is the output that would prevail under flexible prices and wages. Accordingly, $y_t - y_{t-1}^P$ represents the output gap at time t. The rule embeds one policy shock: a temporary i.i.d. normal interest rate shock (η_t^R), that is denoted by a monetary policy shock.

3.3.6 Market clearing

The labor market is in equilibrium when the labor demand of firms equals the differentiated labor services supplied by households at the wage rates set by unions. The market for capital is in equilibrium when the demand for capital services by the firms equals the capital services supplied by households at the market rental rate. The market for government bonds is in equilibrium when the outstanding government bonds are held by households at the market

interest rate.

Finally, the good market is in equilibrium when the supply by firms equals the demand by households and government:

$$Y_t = C_t + I_t + G_t + I_t^G + a\left(u_t\right) K_t \tag{3.32}$$

3.3.7 The substitutability/complementarity mechanism

In this section, we want to clarify how the mechanism of substitutability/complementarity actually manifests itself in the model. For a given level of consumption, we represent the effect of a change in government spending on the marginal utility of consumption (in a log-linearized form):

$$U_{cg} = (1-\phi)\left(\frac{G}{\tilde{C}}\right)^{\frac{v-1}{v}}\left(\frac{1}{v} - \frac{\sigma_c}{(1-h)}\right), \tag{3.33}$$

where G and $\tilde{C}$ are the steady state level of government consumption and effective consumption, respectively. They are supposed to be positive values. The parameters which are important in giving the sign to U_{cg} are the elasticity of substitution between private and government consumption, v, the coefficient of relative risk aversion, σ_c, and the level of habit persistence, h. When U_{cg} is greater than 0, private and government consumption are defined to be complements, whereas, when U_{cg} is less than 0, private and government consumption are defined to be substitutes. When U_{cg} is equal to 0, private and government consumption are not related in preferences. It is easy to see that we set ϕ equal to 1, this model completely nests a standard NK-DSGE model in which government consumption is not supposed to enter the utility function of households. In this case, the right-hand side of equation (3.33) collapse to zero. For values of ϕ which are less than one, U_{cg} could be either positive or negative depending on the other parameters within equation (3.33).

3.4 Estimation

Before proceeding to the estimation, we linearize the model equations described above around the deterministic steady state (see the Appendix). Then, we adopt bayesian techniques to es-

timate the model. We want to gather two pieces of information from this empirical exercise. First, we want to estimate the elasticity of substitution between private and government consumption and see how the latter affects the response of private consumption to a government consumption shock. Second, we want to estimate the output elasticity of government capital and see how the latter affects the response of private consumption to a government investment shock.

3.4.1 Methodology

Bayesian inference involves obtaining the posterior distribution of the parameters of the model as a combination of two types of information. First, prior information obtained from early studies at both the macro and micro level. Second, information obtained from actual data through the likelihood.

More formally, let $P(\theta|m)$ be the prior distribution of the parameter vector $\theta \in \Theta$ for some model $m \in M$, and let $L(Y_T|\theta, m)$ be the likelihood function for the observed data $Y_T = \{y_t\}_{t=1}^T$, conditional on the parameter vector θ and model m. The likelihood is computed starting from the log-linear state space form representation of the model and by applying the Kalman filter. The posterior distribution of the parameter vector θ for model m is then obtained combining the likelihood function for Y_T with the prior distribution of θ, that is:

$$P(\theta|Y_T, m) \propto L(Y_T|\theta, m)P(\theta|m), \tag{3.34}$$

where "$\propto$" indicates proportionality.

In order to obtain numerically a sequence from this unknown posterior distribution, we follow An and Schorfeide (2007) and employ Markov Chain Monte Carlo methods (see Appendix for details on the estimation procedure).

As discussed in Geweke (1999), Bayesian inference also provide tools to compare the performance of various models. For a given model m, the marginal likelihood is:

$$L(Y_T|m) = \int_{\theta\in\Theta} L(Y_T|m)P(\theta|m)d\theta \tag{3.35}$$

The marginal likelihood gives an indication of the overall likelihood of a model conditional

on observed data.

3.4.2 Data and prior distributions

The model is estimated on quarterly US data which go from 1980 Q1 to 2004 Q4. The set of observables includes GDP, private consumption, hours worked, hourly real wage, inflation, private investment, and nominal interest rate. Furthermore, the series of purchases of goods and services, the one of public investment and the number of employees of the public sector are used to estimate the parameters that govern the processes for G_t, I_t^G and L_t^{gov}, respectively (see Appendix for a detailed description of the dataset).

Concerning the choice of the priors the following is worth noting. Following a common practice in the existing literature (e.g. SW (03)) we fix several parameters throughout the estimation. This includes setting β to 0.99 and $\tau = \tau_{K^G} = 0.025$. The steady state ratios C/Y , I/Y, G/Y, $(WL^{gov})/Y$, and I^G/Y are set to 0.7, 0.19, 0.08, 0.11 and 0.03, respectively. The steady state ratio B/Y are set to 0.6 on annual basis. The share of the government sector labor on the total labor (l_{gov}) is set to 0.2.

The choice of the prior for the parameters that enter the CES aggregator, ϕ and v, deserves particular attention. Concerning the parameter $\nu \in (0; \infty)$, we note the following. For a very large portion of its parameter space government and private consumption are always substitutes, no matter what the values are of the other parameters within U_{cg}. On the contrary, only for values of ν which are really close to zero, the two items happen to be complements. Hence, we decide to reparametrize ν such that $\nu = \exp(\nu_b)$. Now, the parameter space of the elasticity of substitution is unbounded, $\nu_b \in (-\infty; \infty)$. Then, in assigning prior to ν_b we want to be as agnostic as possible[3]. We decide for a normal distribution centered at -1.5. This is the value which makes U_{cg} equal to zero, given standard prior means for the other parameters within U_{cg}. The assigned standard deviation for the distribution is 2. We decide to have a loose prior so that we do not force the posterior estimates of ν_b to be around the prior mean. We set the prior mean of ϕ to be equal to 0.8, which is the calibrated value chosen by Bouakez and Rebei (2007).

[3]The underlined aim is to avoid providing prior information in favour either of substitutability or of complementarity .

Regarding the choice for the prior mean of the output elasticity of government capital, θ_g, we set it to be equal to 0.16 which is the estimated value by Finn (1993) for US. Since $\theta_g \in (0; \infty)$, we decide for an inverted gamma distribution with mean equal to 0.16 and standard deviation equal to 2. Within the production function, we even estimate the output elasticity of private capital, that is α. We follow Smets and Wouters (2007) in setting the prior for the latter parameter.

The priors for the remaining parameters are set on the basis of the existing literature, in particular we follow SW (03). Table I presents the prior distributions for selected parameters.

3.4.3 Estimation Results

We present the results for three different specifications. *Model A*, the benchmark model, shuts down a priori the two channels of interest, that is ϕ and θ_g are set to 1 and 0, respectively. *Model B* lets the two channels be opened, that is we estimate ν_b, ϕ and θ_g. *Model C* shuts down the channel of substitutability/complementary ($\phi = 1$) and allows for the estimate of θ_g.

Table I contains the estimation results for the three specifications. Analyzing Panel A for *Model B* emerges that the posterior mean of ν_b, σ_c, and h are equal to -1.21, 1.54 and 0.56, respectively. These results makes U_{cg} approximately equal to zero, as such government and private consumption are unrelated in preferences.

Looking at Panel B of both *Model B* and *Model C*, similar results emerge. The posterior mean of θ_g is 0.12 in *Model B*, while it is 0.13 in *Model C*. The 80% posterior intervals for this parameter is $[0.04; 0.26]$ in *Model B*, while it is $[0.04; 0.29]$ in *Model C*. Importantly, in both specifications the zero value is not contained in the interval. To investigate further on the latter argument, we estimate the model imposing a normal distribution centered at 0 (with variance equal to 2) for θ_g. The posterior mean is now 0.16 with a 80% posterior interval as $[0.06; 0.45]$.

In Panel B, we can see that the output elasticity of private capital, α, is estimated to be 0.26 in all the three models. Note that all the estimates for the other parameters are in line with the results of SW (03) and Smets and Wouters (2007)[4].

Panel C indicates the marginal data density for the three specification proposed. Interestingly, *Model C*, the one with government capital, fits the data at best. The benchmark model,

[4]The complete set of the estimated parameters is available upon request.

Model A, beats *Model B*, which is the richest model among the three.

The estimation of the univariate processes for g_t, i_t^G, and l_t^{gov} delivers the following results. The autoregressive coefficients for the process of g_t, i_t^G, and l_t^{gov} are 0.61, 0.81 and 0.64, respectively. The regression standard errors are 1.80, 0.36, and 0.96, respectively.[5].

[**insert Table I here**]

3.4.4 Impulse-response analysis

In this section we focus on the effect of a government investment shock on the model variables, especially on private consumption.

Figure Ia, Ib, and II depict the estimated response of the selected variables to a government investment shock. All dynamic responses are plotted as percentage point deviations from the steady state. Solid lines plot the responses computed using the mean of the posterior distribution of the structural parameters. Dashed lines plot the corresponding $10th$ and $90th$ percentiles.

Figure Ia describes the impulse responses of private consumption obtained under the benchmark model, *Model A*, shutting down *a priori* the channel of substitutability/complementarity and the possibility that government capital affects output growth. Standard results emerge; private consumption falls noticeably on impact before gradually returning to the steady state. In this version of the model the negative wealth effect dominates the demand effect, so that government investment causes negatively private consumption. Figure Ib depicts the response of private consumption obtained under *Model B*[6]. Private consumption moves hardly on impact, but then it increases. This is due by the fact that θ_g is greater than zero. Indeed, a government investment shock contributes to enhance the productivity of private factors creating a positive wealth effect in the economy, ceteris paribus. The latter contrasts the negative wealth effect induced by the fact that government investment has to be financed. If the positive wealth effect dominates the negative one, private consumption can increase as our results actually show.

[**insert Figure Ia and Ib here**]

[5] These coefficients are used as calibrated values in the bayesian estimation of our NK-DSGE model.
[6] *Note that the results are robust even under Model C.*

Figure II depicts the impulse response of the remaining variables conditional on *Model B*.

Especially two impulse responses are worthy of interest. First, inflation shows a mild negative response to a government spending shock. In fact, a public investment shock can have a double effect for inflation. On the one hand, it creates a deflationary response in the economy through a negative impact on the real marginal cost[7]. On the other hand, it creates a standard positive effect on inflation due to the fact that public investment is also an aggregate demand component. Our estimates show that the first channel dominates the second so that a public investment shock is able to generate a tiny negative response for inflation. Note that the response of inflation under *Model A*, the benchmark model, is unambiguously positive. Second, private investment responds mildly positive to a government investment shock because the productivity of private capital is now higher. The standard crowding-out effect of private investment disappears.

As theory predicts, the response of output is positive on impact. Furthermore, output tends to remain at a higher level with respect to its steady state since public capital builds up and directly sustains output growth.

Finally, real wage increases on impact. This is due to the fact that labor supply has increased less than labor demand because of price stickiness (see Linnemann and Schabert (2003)).

It is worth saying that the impulse response functions of the model variables to the government consumption shock mimic those obtained by SW (03). This happens because the channel of complementarity is estimated to be unimportant in our model.

[**insert Figure II here**]

3.5 Conclusions and Extensions

The paper has posed attention on the potential externalities produced by public expenditures on the private sector, and, specifically, how these externalities affect the response of private consumption to two government spending shocks, i.e. a government consumption shock and a government investment shock.

[7] Note that this negative effect on marginal costs emerges whenever θ_g is strictly greater than 0.

We have built a NK-DSGE model which takes into account two important features. First, it allows government consumption to affect the welfare of agents, by directly entering the households' utility function. Second, it allows public capital to affect the productivity of the private factors, by entering in the firm's production function.

Results show that the standard hypothesis of separability between private and government consumption does hold in the data. The response of private consumption to a government consumption shock is negative, as it happens to be in models where government investment is considered as pure waste (e.g. SW (03)).

On the other hand, we do find that public capital enhances the productivity of private factors. The output elasticity of government capital is estimated to be equal to 0.12-0.13 and it is in line with the previous estimates of Finn (1993), obtained under a production function-regression based approach. Conditioned on that, we have three main results which contrast with those of standard NK-DSGE models without government capital. First, we estimate that a public investment shock creates a positive response for private consumption. Second, a government investment shock creates a mild negative response for inflation via a negative impact on the real marginal cost. Thirdly, the same shock generates a tiny positive response for private investments.

The present work calls for two extensions at least. First, the fact that we do not find evidence of complementarity between government and private consumption can be due to the fact that we are considering government consumption as an aggregate. Unlike this, Ercolani and Pavoni (2008) show that relations of complementarity can manifest themselves between private consumption and some specific categories of government consumption. In principle, there could be items of government consumption that are substitutes while others that are complements, and others which are unrelated to private consumption. This may create a zero effect of aggregate government consumption on private consumption. To investigate this "composition" effect for the US, we want to resort to yearly aggregate data from 1947 onwards (Bureau of Economic Analysis), which disaggregate government consumption following a functional classification: administrative services, justice, health, education and so on. It would be interesting to see what are the categories that affect private consumption the most. Then, it would also be worth noting to check if these potential relations vary over time and over the cycle.

The second extension hinges upon the conclusions of Justiniano, Primiceri and Tambalotti (2008). They estimate a DSGE model with several shocks and (nominal and real) frictions. They find that shocks to the marginal efficiency of investment are the most important drivers of business cycle fluctuations in US output and hours. Thus, we want to provide a comparison between a neutral technology shock, an investment specific shock and a public investment shock. It would be interesting to see how these shocks diversely affect the model variables. Furthermore, we would investigate on the importance of public investment shock in driving the business cycles fluctuations. It could be the case that part of the output variance that seems explained by (private) investment shocks is instead driven by public investment shocks.

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3.7 Tables

Table I: Priors and Posteriors of selected parameters

Parameter	PRIOR			POSTERIOR (mean)		
	Distr.	Mean	St. Dev.	*Model A*	*Model B*	*Model C*
A. Utility function						
σ_c	*Normal*	1	0.37	1.51	1.54	1.49
h	*Beta*	1	0.37	0.57	0.56	0.58
ν_b	*Normal*	-1.5	2	*n.a.*	1.21	*n.a.*
ϕ	*Beta*	1	0.37	$1*$	0.87	$1*$
σ_L	*Normal*	2	0.75	2.42	2.45	2.42
B. Production function						
α	*Normal*	0.3	0.05	0.26	0.26	0.26
θ_g	*Inv.Gamma*	0.16	2	$0*$	0.12	0.13
C. Marginal Likelihood				-283.47	-282.51	-278.89

$*$ means that the parameter is calibrated to that value

3.8 Figures

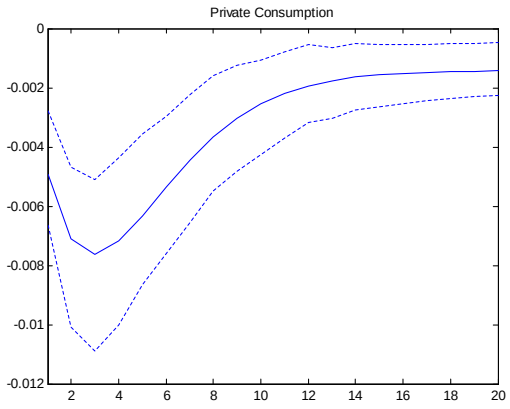

Figure Ia. Consumption's impulse response to a government consumption shock, within 80% posterior intervals (Model A).

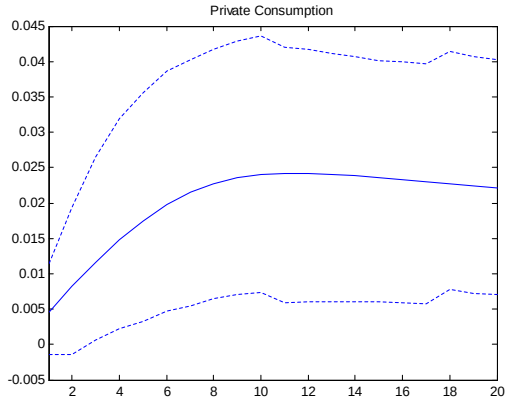

Figure Ib. Consumption's impulse response to a government investment shock, within 80% posterior intervals (Model B).

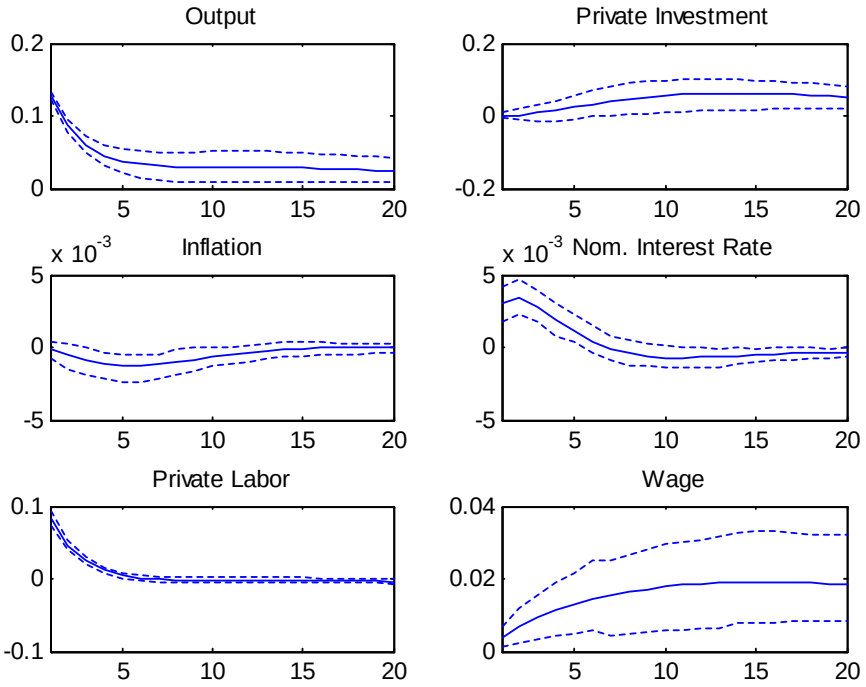

Figure II. Selected IRFs to a government investment shock, within 80% posterior intervals (Model B).

3.9 Appendix

3.9.1 Bayesian inference

The following description characterizes the estimation procedure. The model is solved up to a log-linear approximation around the deterministic steady state. Once the solution is obtained, the model can be cast in state-space form, and the likelihood function can be computed using the Kalman filter. The posterior distributions can be computed once independent priors are specified for each on of the structural parameters in the model.

To obtain the posterior distributions, we use the Random-Walk Metropolis (RWM) algorithm. The RWM algorithm belongs to the more general class of Metropolis-Hastings algorithms. This class of algorithms generate Markow chains with stationary distributions that corresponds to the posterior distribution of interest. The RWM works in this way:

1. Use a numerical optimization routine to maximize $\ln L(Y_T|\theta) + \ln P(\theta/Y_T)$[8]. Denote with θ_M the posterior mode

2. Let $\sum_M$ the inverse of the Hessian computed at θ_M

3. Draw $\theta^{(0)}$ from $N(\theta_M, c_o^2 \sum_M)$[9]

4. For $s = 1, ..., n_{sim}$, draw $\theta^{(s)}$ from the proposal distribution $N(\theta^{(s-1)}, c_o^2 \sum_M)$. The jump from $\theta^{(s-1)}$ is accepted ($\theta^{(s)} = \theta$) with probability $min\left\{1, r(\theta^{(s-1)}, \theta^{(s)}/Y_T)\right\}$ and rejected otherwise ($\theta^{(s)} = \theta^{(s-1)}$). Here

$$r(\theta^{(s-1)}, \theta/Y_T) = \frac{L(\theta|Y_T)P(\theta)}{L(\theta^{(s-1)}|Y_T)P(\theta^{(s-1)})} \tag{3.36}$$

5. Approximate the posterior expected value of a function $h(\theta)$ by $\frac{1}{n_{sim}} \sum_{s=1}^{n_{sim}} h(\theta^{(s)})$

Under fairly general regularity conditions, e.g. Walker (1969), the posterior distribution of θ will be asymptotically normal.

[8] The maximization of the posterior density kernel is carried out with a version of quasi-Newton algorithm proposed by Sims.

[9] In reality, we start from our prior mean.

The draws we take are 200000. The acceptation rate is around 35%.

The RWM generates a sequence of dependent draws from the posterior distribution of θ that can be averaged to approximate posterior moments. Geweke (1999), and Brooks and Gelman (1998) reviews regularity conditions that guarantee the convergence of the Markow Chain generated by the Metropolis Hastings algorithm to the posterior distribution of interest and the convergence of $\frac{1}{n_{sim}} \sum_{s=1}^{n_{sim}} h(\theta^{(s)})$ to the posterior expectations $E\left[h(\theta)/Y_T\right]$. In our specific case, we use the diagnostics computed by Brooks and Gelman (1998). Their intuition is the following. Let $\theta^{(0,i)}$ denote m initial values which are taken from very different regions of the parameter space, for $i = 1, ..., m$. Let $\theta^{(s,i)}$ denote S RWM draws from *ith* starting values, for $s = 1, ..., S$. Intuitively, if the effect of the starting value has been removed, each of the m sequences should be the same as one another. Hence, the variance calculated across the sequences should not be too large relative to the variance within a sequence (for the exact expression of these two variances see Koop (2003)). Using the rule-of-thumb that the two variances are equal, up to a difference of 20%, should ensure convergence. If this is not the case, either the effect of the initial replication has not worn off, or the number of taken draws is too low. Our number of draws is sufficient to achieve convergence.

3.9.2 The linearized model

All the first order conditions have been linearized by taking log-linear approximations around the deterministic steady state. The linearized version of the presented model is summarized below. Again, note that lower-case letters for model variables indicate log deviations from steady state values. Moreover, a variable without subscript t denotes that it is in steady state.

- *the aggregator (consumption):*

$$\tilde{c}_t = \phi \left(\frac{c}{\tilde{c}}\right)^{\frac{v-1}{v}} c_t + (1-\phi) \left(\frac{g}{\tilde{c}}\right)^{\frac{v-1}{v}} g_t \tag{3.37}$$

- *the consumption equation:*

$$c_t = \left(\tilde{c}_t - \tilde{c}_{t+1} + c_{t+1} - \varepsilon_t^b\right) + \frac{\sigma_c \nu}{(1-h)}\left(h\tilde{c}_{t-1} - h\tilde{c}_t + \tilde{c}_{t+1} - \tilde{c}_t\right) + \\ -\nu\left(r_t - E_{t+1}\pi_{t+1}\right) \tag{3.38}$$

- *the investment equation:*

$$i_t = \frac{1}{1+\beta} i_{t-1} + \frac{\beta}{1+\beta} E_{t+1} i_{t+1} + \frac{\varphi}{1+\beta} q_t - \frac{\beta E_{t+1}\varepsilon_t^I - {}_{t+1}\,\varepsilon_t^I}{1+\beta} \tag{3.39}$$

  where $\varphi = 1/S^{''}$ governs the adjustment cost of investment.

- *the Q equation:*

$$q_t = -\left(r_t - E_t\pi_{t+1}\right) + \left(1 - \beta\left(1-\tau\right)\right) r_{t+1}^k + \beta\left(1-\tau\right) q_{t+1} \tag{3.40}$$

- *the capital (private) accumulation equation:*

$$k_t = (1-\tau)k_{t-1} + \tau i_t \tag{3.41}$$

- *the capital (public) accumulation equation:*

$$k_t^G = (1-\tau_k)k_{t-1}^G + \tau_k i_t^G \tag{3.42}$$

- *the inflation equation:*

$$\pi_t = \left(\frac{1}{1+\beta\gamma_p}\right)\left(\beta E_t\pi_{t+1} + \gamma_p\pi_{t-1} + \frac{(1-\xi_p)(1-\beta\xi_p)}{\xi_p} mc_t\right) + \varepsilon_t^P \tag{3.43}$$

- *the marginal cost:*

$$mc_t = \alpha r_t^k + (1-\alpha)w_t - \varepsilon_t^a - \theta_g k_t^G \tag{3.44}$$

- *the wage equation:*

$$
\begin{aligned}
w_t &= \left(\frac{1}{1+\beta}\right)(\beta E_t w_{t+1} + w_{t-1}) + \left(\frac{\beta}{1+\beta}\right)\pi_{t+1} - \left(\frac{1+\beta\gamma_w}{1+\beta}\right)\pi_t \\
&\quad + \left(\frac{\gamma_w}{1+\beta}\right)\pi_{t-1} - \left(\frac{1}{1+\beta}\right)\frac{(1-\beta\xi_w)(1-\xi_w)}{(1+\frac{(1+\lambda_w)\sigma_L}{\lambda_w})\xi_w} \\
&\quad *(w_t - \sigma_L l_t - \frac{\sigma_C}{1-h}(\tilde{c}_t - h\tilde{c}_{t-1}) + \frac{1}{\nu}(\tilde{c}_t - c_t) + \varepsilon_t^L) + \eta_t^W
\end{aligned} \tag{3.45}
$$

- *the labor demand equation:*

$$
l_t^{priv} = (1+\Psi)r_t^k - w_t + k_{t-1} \tag{3.46}
$$

where $\Psi = \Psi'(1)/\Psi''(1)$ is the inverse of the elasticity of the capital utilization cost function.

- *the aggregator (labor):*

$$
l_t = (1-l_{gov})l_t^{priv} + l_{gov}l_t^{gov} \tag{3.47}
$$

where l_{gov} is the share of government sector labor on total labor.

- *the goods market equilibrium condition:*

$$
y_t = c_y c_t + i_y i_t + g_y g_t + i_y^G i_t^G + i_y\left(\frac{\frac{1}{\beta}+\tau-1}{\tau}\right)\Psi r_t^k \tag{3.48}
$$

where c_y, i_y, g_y, i_y^G are the share of consumption, private investment, government purchases of goods and services and public investment on output, respectively.

- *the production function:*

$$
Y = \Phi_y\left(\alpha k_{t-1} + \alpha\Psi r_t^k + (1-\alpha)l_t^{priv} + \varepsilon_t^a + \theta_g k_t^G\right) \tag{3.49}
$$

where Φ_y is 1 plus the share of the fixed cost in production.

- *the monetary rule:*

$$\begin{aligned} r_t &= \rho r_{t-1} + (1-\rho)\left[r_\pi(\pi_t) + r_y(y_t - y_t^P)\right] \\ &\quad + r_{\Delta\pi}(\pi_t - \pi_{t-1}) + r_{\Delta y}(y_t - y_t^P - (y_t - y_{t-1}^P)) + \eta_t^R \end{aligned} \tag{3.50}$$

- *the autoregressive processes:*

$$\begin{aligned} \varepsilon_t^b &= \rho_b \varepsilon_{t-1}^b + \eta_t^b \\ \varepsilon_t^L &= \rho_L \varepsilon_{t-1}^L + \eta_t^L \\ \varepsilon_t^I &= \rho_I \varepsilon_{t-1}^I + \eta_t^I \\ \varepsilon_t^a &= \rho_a \varepsilon_{t-1}^a + \eta_t^a \\ i_t^G &= \rho_{I^G} i_t^G + \eta_t^{I^G} \\ g_t &= \rho_g g_{t-1} + \varepsilon_t^g \\ l_t^{gov} &= \rho_{\lg ov} l_{t-1}^{gov} + \eta_t^{\lg ov} \end{aligned} \tag{3.51}$$

3.9.3 The Data

We follow Smets and Wouters (2007) in treating the data. GDP, private consumption, private investment, government purchases of goods and services, and government gross investment are taken from the US Department of Commerce - Bureau of Economic Analysis databank. Real Gross Domestic Product is expressed in Billions of Chained 1996 Dollars. Nominal personal consumption expenditures, fixed private domestic investment, nominal government purchases of goods and services, and nominal government gross investment are deflated with the GDP-deflator. Hours and wages come from the Bureau of Labor and Statistics (hours and hourly compensation for the Non Farm Business sector for all persons). Hourly compensation is divided by the GDP price deflator in order to get the real wage variable. Hours are adjusted to take into account the limited coverage of the Non Farm Business sector compared to GDP (the index of average hours for the NFB sector is multiplied with the Civilian Employment (16 years

and over)). The series for the number of employees in the government sector are taken from the Bureau of Labor and Statistics, and are converted from monthly to quarterly frequency. Consumption, private investment, GDP,purchases of goods and services, public investment, number of employees in the government sector, wages and hours are expressed in 100 times log. Inflation is the first difference of the log of the Implicit Price Deflator of GDP. The interest rate is the Federal Funds Rate.

All series are seasonally adjusted. The aggregate real variables are expressed per capita by dividing with the population over 16.The interest rate and inflation rate are expressed on a quarterly basis corresponding with their appearance in the model.

Detrending method. Our model does not display any trend. Once the model is log-linearized around the deterministic steady state, all variables are expressed as deviations around the steady state. Thus, to make the data comparable with the model-generated series, a detrending procedure must be chosen. We HP-filter each variables but inflation and the nominal interest rate which are detrended by the same trend in inflation.

Table1: government consumption (% of GDP), year 2002

Regions	**government consumption**	**collective goods** (public goods)	**individual goods** (merit goods)
Piemonte	15.9	6.1	9.8
Valle d'Aosta	26.1	14.6	11.5
Lombardia	13.5	5.1	8.4
Trentino-Alto Adige	20.9	8.4	12.5
Veneto	15.4	5.8	9.6
Friuli-Venezia Giulia	18.2	7.2	11.04
Liguria	17.8	6.8	11.0
Emilia Romagna	14.7	5.5	9.2
Toscana	17.4	6.5	10.9
Umbria	21.3	8.1	13.2
Marche	19.0	7.0	12.0
Lazio	18.5	6.1	12.4
Abbruzzo	22.6	8.1	14.5
Molise	25.6	9.6	16.0
Campania	27.7	9.9	17.8
Puglia	25.0	8.7	16.3
Basilicata	28.3	10.7	17.6
Calabria	31.5	11.6	19.9
Sicilia	30.0	12.0	18.0
Sardegna	27.2	10.6	16.6
Italy	**19.0**	**6.0**	**13.0**

Source: author's compilation using REA

Table 2: percentage of each category on total government consumption (Italy)

	categories	1995	1996	1997	1998	1999	2000	2001	2002	**mean**
public	**General public services**	12.0	12.8	12.3	12.3	12.2	12.2	12.3	12.3	**12.4**
	Defence	6.3	6.0	5.6	5.6	5.9	5.7	5.7	5.7	**5.8**
	Public order and safety	11.1	11.5	11.2	11.2	10.9	10.5	10.0	9.8	**10.8**
	Economic affairs	7.7	7.5	7.4	7.3	7.1	6.7	6.7	6.7	**7.1**
	Environmental protection	0.7	0.6	0.8	1.0	1.3	1.4	1.4	1.4	**1.1**
	Housing and community amenities	1.3	1.2	1.3	1.3	1.4	1.3	1.3	1.3	**1.3**
merit	**Health**	28.8	28.8	29.6	29.7	29.9	31.4	32.2	32.6	**30.4**
	Recreation, culture and religion	2.3	2.3	2.4	2.4	2.3	2.2	2.1	2.2	**2.3**
	Education	25.3	25.6	25.6	25.6	25.2	24.7	24.0	23.8	**25.0**
	Social protection	3.8	3.8	3.7	3.7	3.7	3.9	4.2	4.2	**3.9**

Authors' calculation based on REA

Table 3: government consumption process

	(1)	(2)
	ols	**gmm**
	Δg	Δg
Δg(-1)	**-0.32****	**-0.30****
	[0.001]	**[0.001]**
Δc_reg		-1.04
		[0.276]
Δy_reg		0.34+
		[0.068]
const	0.03**	0.03**
	[0.000]	[0.000]
Obs	120	120

Data are in logs. p values in brackets (+ significant at 10%; * significant at 5%; ** significant at 1%). Associated standard errors are robust. The overidentification test does not reject the null that the moments conditions are equal to zero.

Table 4: euler equation - total consumption

	(1)	(2)	(3)	exc. Sens.
	Δc	Δc	Δc	Δc
Δage	0.33*	0.32*	0.30*	0.22
	[0.026]	[0.029]	[0.037]	[0.303]
Δage^2	-0.00*	-0.00*	-0.00*	-0.00*
	[0.017]	[0.022]	[0.023]	[0.025]
Δeducation	-0.01	0	0	0.01
	[0.822]	[0.926]	[0.960]	[0.876]
Δc(-1)	0.24	0.16	0.08	0.3
	[0.207]	[0.360]	[0.513]	[0.157]
Δg	**1.94***			2.88*
	[0.047]			[0.019]
Δmerit		**0.90***		
		[0.019]		
Δpubl		**0.45**	**0.36**	
		[0.572]	**[0.562]**	
Δedu			**0.26**	
			[0.367]	
Δhealth			**0.72****	
			[0.003]	
Δcult			**0.01**	
			[0.948]	
Δy(-1)				-0.29
				[0.409]
const	-0.72*	-0.66+	-0.66+	-0.43
	[0.044]	[0.059]	[0.054]	[0.398]
Obs	4218	4218	4218	4174
sargan (pval)	0.443	0.72	0.293	0.161

Data are in logs. p values in brackets (+ significant at 10%; * significant at 5%; ** significant at 1%). Associated standard errors are robust. Regional controls and time dummies are added.

Table 4bis: euler equation - robusteness

	(1)	(2)	(3)
	no habit	**no PA**	**FE**
	Δc	Δc	Δc
Δage	0.09	0.26	0
	[0.315]	[0.114]	[0.921]
Δage^2	0	-0.00+	0
	[0.108]	[0.064]	[0.893]
Δeducation	0.03	-0.04	0.01
	[0.363]	[0.350]	[0.626]
Δc(-1)		0.09	-0.47*
		[0.531]	[0.011]
Δpubl	-0.02	-0.77	-0.4
	[0.974]	[0.260]	[0.615]
Δedu	-0.1	-0.22	-0.28
	[0.728]	[0.483]	[0.659]
Δhealth	**0.73****	**0.69***	**0.97***
	[0.002]	**[0.014]**	**[0.015]**
Δcult	-0.05	0.07	0.05
	[0.711]	[0.651]	[0.819]
cons	-0.21	-0.57	-0.04
	[0.331]	[0.148]	[0.237]
Obs	6265	3181	1811
Sargan (pval)	0.03	0.472	0.304

Data are in logs. p values in brackets (+ significant at 10%; * significant at 5%; ** significant at 1%). Associated standard errors are robust. Regional controls and time dummies are added.

Table 4ter: euler equation - non durables

	(1)	(2)	(3)
	Δc	Δc	Δc
Δage	0.28*	0.27+	0.26+
	[0.049]	[0.053]	[0.059]
Δage^2	-0.00*	-0.00*	-0.00*
	[0.018]	[0.021]	[0.027]
Δeducation	0	0	0
	[0.920]	[0.989]	[0.958]
Δc(-1)	0.18	0.11	0.05
	[0.363]	[0.568]	[0.750]
Δg	**1.66***		
	[0.049]		
Δmerit		**0.90+**	
		[0.068]	
Δpubl		**0.51**	**0.28**
		[0.476]	**[0.633]**
Δedu			**0.13**
			[0.657]
Δhealth			**0.41+**
			[0.054]
Δcult			**-0.04**
			[0.797]
const	-0.54	-0.49	-0.45
	[0.112]	[0.145]	[0.170]
Obs	4219	4219	4219
sargan (pval)	0.644	0.559	0.09

Data are in logs. p values in brackets (+ significant at 10%; * significant at 5%; ** significant at 1%). Associated standard errors are robust. Regional controls and time dummies are added.

Table 5: disposable income process

	(1)	(2)	(3)
		area	**no PA**
	Δy	Δy	Δy
Δage	0.02	-0.22	-0.03
	[0.944]	[0.651]	[0.924]
Δage^2	0	0	0
	[0.175]	[0.636]	[0.161]
Δeducation	0.03	0.07	0.03
	[0.633]	[0.322]	[0.662]
Δy(-1)	-0.39**	-0.40**	-0.40**
	[0.000]	[0.000]	[0.000]
Δg	**0.67***	**0.65+**	**0.81+**
	[0.046]	**[0.08]**	**[0.090]**
Δg(-1)	-0.36	-0.69+	-0.56
	[0.243]	[0.087]	[0.168]
const	0.08	0.55	0.18
	[0.893]	[0.577]	[0.766]
Obs	2593	2593	2033

Data are in logs. p values in brackets (+ significant at 10%; * significant at 5%; ** significant at 1%). Associated standard errors are robust. Regional controls and time dummies are added.

Table 6: perm. income equation - total consumption

	(1)	(2)
		area
	Δc	Δc
Δage	0.07	0.06
	[0.609]	[0.703]
Δage^2	0	0
	[0.660]	[0.676]
Δeducation	0	0.01
	[0.985]	[0.865]
Δy	0.31**	0.31**
	[0.000]	[0.000]
Δy(-1)	0.02	0.02
	[0.266]	[0.220]
Δg	**0.99***	**0.81***
	[0.025]	**[0.048]**
Δg(-1)	0.12	0.25
	[0.769]	[0.536]
const	-0.13	-0.14
	[0.607]	[0.680]
Obs	2679	2679

Data are in logs. p values in brackets (+ significant at 10%; * significant at 5%; ** significant at 1%). Associated standard errors are robust. Regional controls and time dummies are added.

Table 7: individual heterogeneity (euler equation)

	(1)	(2)	(3)	(4)	(5)
	eta<45	**eta>45**	**interaction: # old**	**center-north**	**south-islands**
	Δc	Δc	Δc	Δc	Δc
Δage	-0.06	0.41*	0.30*	0.19	0.37
	[0.779]	[0.014]	[0.033]	[0.163]	[0.119]
Δage^2	0	0	-0.00+	-0.00+	0
	[0.610]	[0.587]	[0.054]	[0.077]	[0.392]
Δeducation	0.06	-0.02	0	0	0.02
	[0.367]	[0.652]	[0.940]	[0.995]	[0.794]
# old			-0.05+		
			[0.062]		
Δc(-1)	-0.19	0.23	0	-0.09	-0.16
	[0.222]	[0.253]	[0.993]	[0.538]	[0.408]
Δpubl	-1	1.35	0.33	-0.96	-1.53*
	[0.356]	[0.117]	[0.600]	[0.200]	[0.030]
Δedu	-0.61	0.84+	0.28	-0.06	-0.45
	[0.230]	[0.056]	[0.348]	[0.808]	[0.542]
Δhealth	**0.88***	**0.58+**	**0.57***	**0.67***	**1.31****
	[0.042]	**[0.089]**	**[0.022]**	**[0.013]**	**[0.001]**
Δhealth*# old			**0.38****		
			[0.008]		
Δcult	-0.39	0.02	-0.08	0.37+	-0.06
	[0.216]	[0.922]	[0.647]	[0.059]	[0.757]
cons	0.26	-1.00*	-0.58+	-0.37	-0.68
	[0.609]	[0.015]	[0.079]	[0.247]	[0.224]
Obs	1220	2998	4218	2655	1563

Data are in logs. p values in brackets (+ significant at 10%; * significant at 5%; ** significant at 1%). Associated standard errors are robust. Regional controls and time dummies are added.

Figure 1: ln(g) residuals - all regions

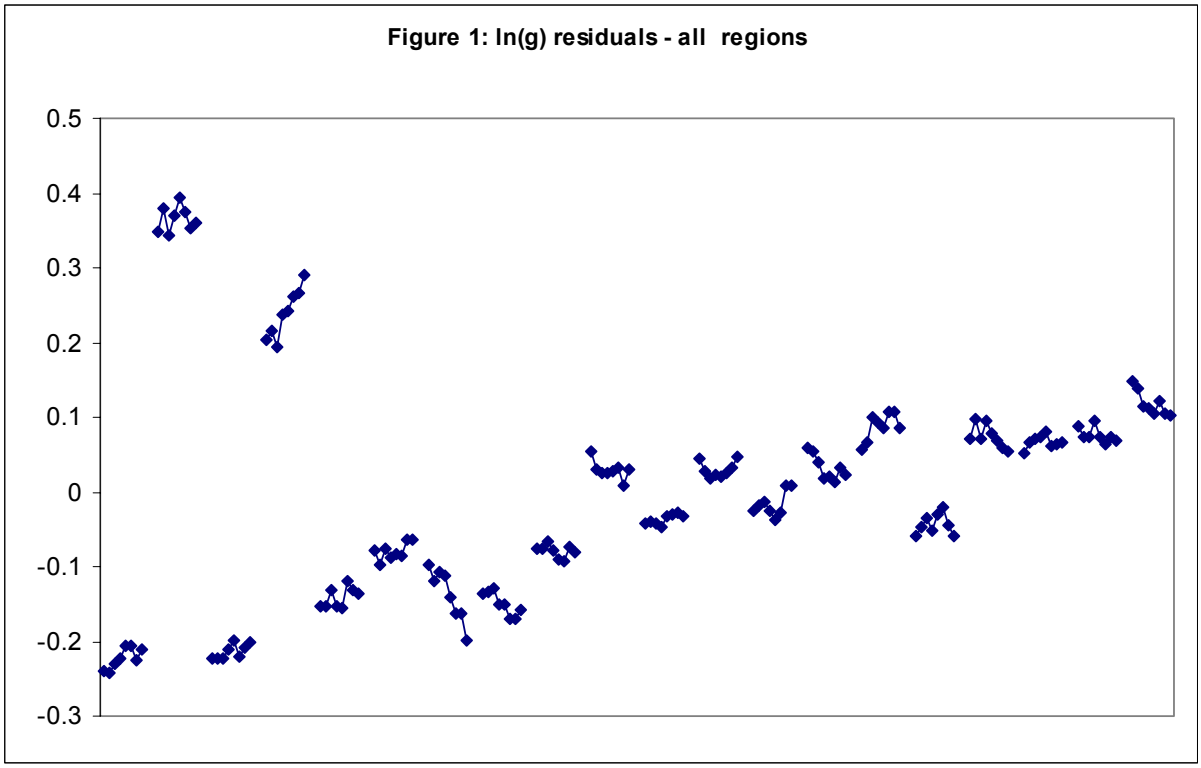

Figure 2: ∆ln(g) residuals - all regions

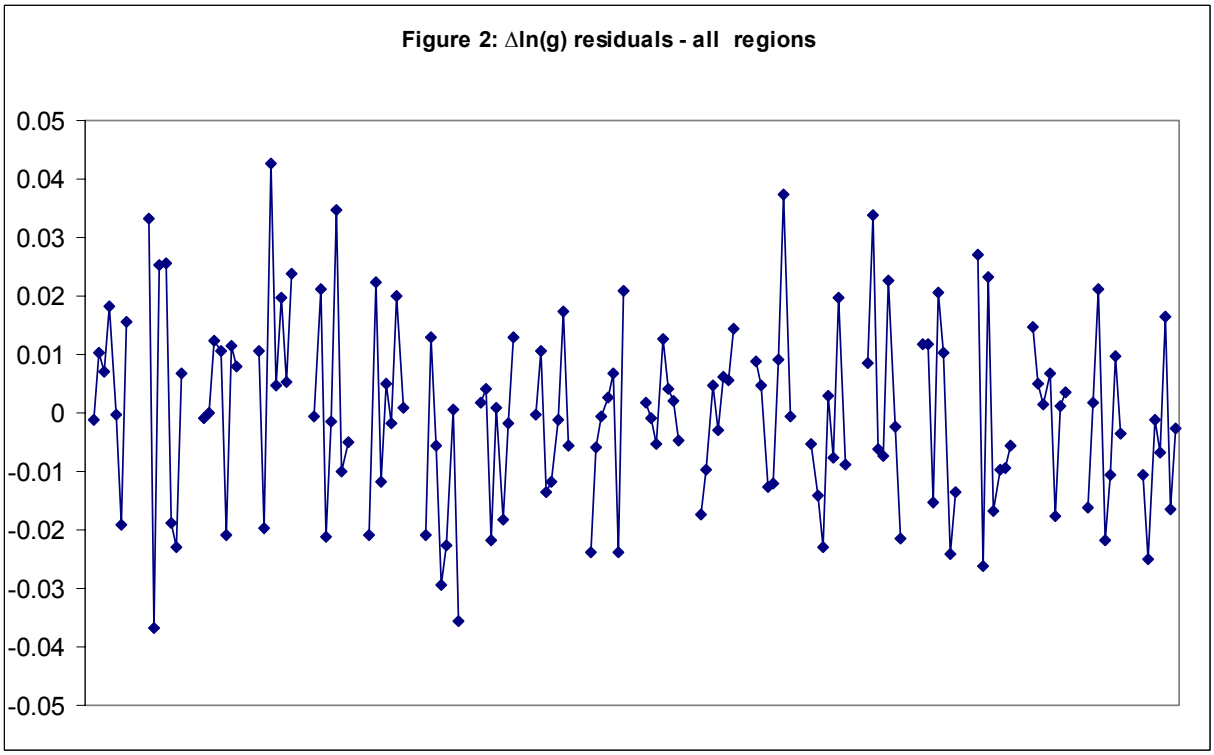

Figure 3: gov. consumption shock

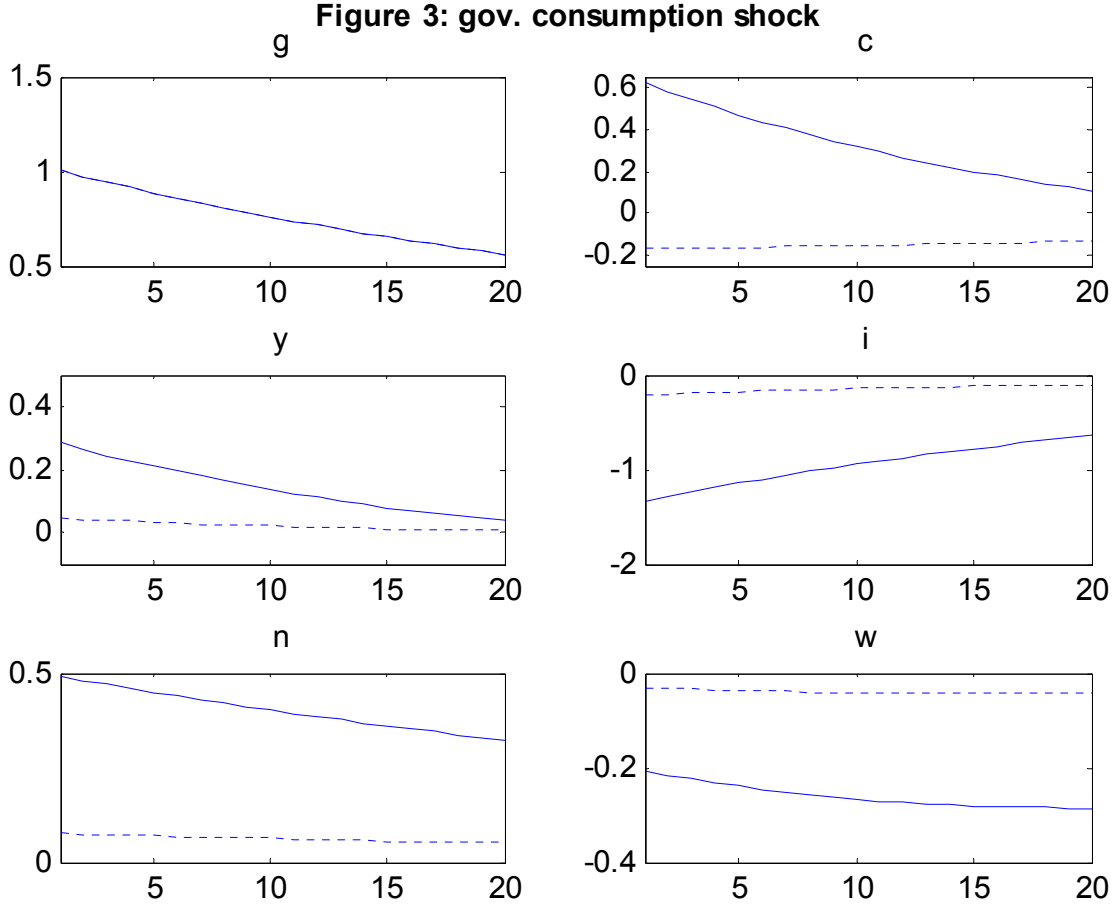
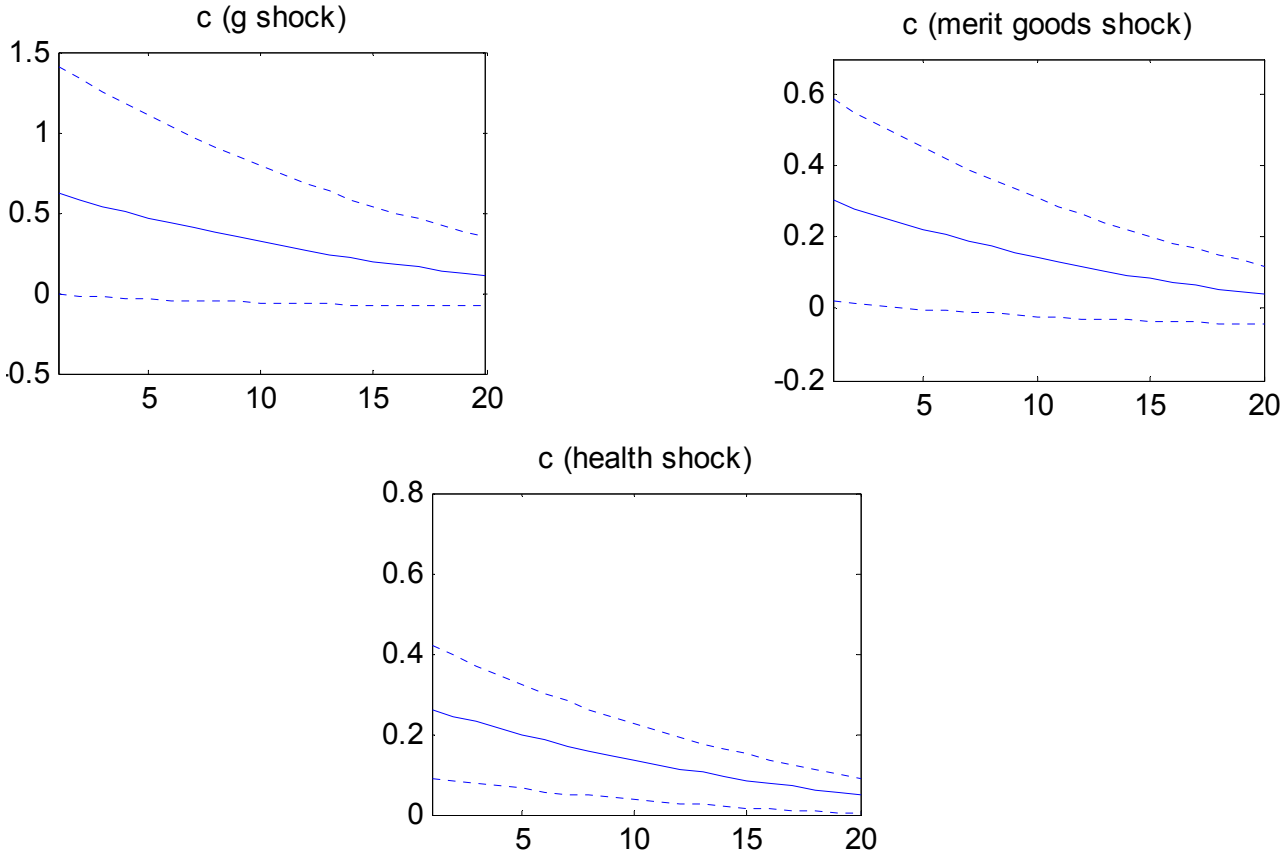
Figure 4: government cons. shock(s)