WORKING PAPERS

N° IDEI-840

November 2014

"In search of the transmission mechanism of fiscal policy in the Euro area"

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IN SEARCH OF THE TRANSMISSION MECHANISM OF FISCAL POLICY IN THE EURO AREA

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ABSTRACT. Hand-to-mouth consumers and Edgeworth complementarity between private consumption and public expenditures are two competing mechanisms that were put forward by the literature to investigate the effects of government spending. Using Bayesian prior and posterior analysis and several econometric experiments, we find that a model with Edgeworth complementarity is a better representation for the transmission mechanism of fiscal policy in the euro area. We also show that a small change in the degree of Edgeworth complementarity has a large impact on the estimated share of hand-to-mouth consumers. These findings are robust to a number of perturbations.

JEL: C32, E32, E62.

Keywords: Fiscal multipliers, DSGE Models, Hand-to-Mouth, Edgeworth Complementarity, Euro Area, Bayesian Econometrics.

1. INTRODUCTION

Due to concerns about high levels of public debt, many European countries have engaged in drastic consolidation programs in recent years. The question of the evaluation of their effectiveness initiated a vivid debate on the estimates of government spending multipliers. This has resulted in a variety of quantitative models that embed different transmission mechanisms of government spending shocks. Two of them were particularly put forward by the literature.[1] The first one relies on the presence of *hand-to-mouth* (HtM) consumers in the population, i.e. households that do not have access to financial markets and simply consume their disposable income in each and every period. Gali, Lopez-Salido and Valles (2007) and Forni, Monteforte and Sessa (2009) show that the interaction of such agents with both real and nominal rigidities increases the government spending multiplier. Using prior predictive analysis, Leeper, Traum and Walker (2011) point out that the fraction of HtM consumers is the most influential parameter for obtaining both an output multiplier that exceeds unity and a positive response of private consumption. The second transmission mechanism allows government spending

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[1]Other propagation mechanisms include non-separable preferences, externality in utility and/or production, deep habits and productive government spending. See the technical appendix of Fève *et al.* (2013) for their respective effects in an economy without capital accumulation.

to enter –in a non-separable way– in the household's utility function (GiU). Bouakez and Rebei (2007), Fève, Matheron and Sahuc (2013) and Coenen, Straub and Trabandt (2013) show that when private consumption and public expenditures display a sufficient amount of Edgeworth complementarity, households have incentives to work and to consume more, generating larger fiscal multipliers.

In this paper, we use a Bayesian approach to evaluate *(i)* how these two transmission mechanisms of government spending improve the fit of a baseline dynamic stochastic general equilibrium (DSGE) model of the euro area, *(ii)* their relative contributions to the size of estimated fiscal multipliers and *(iii)* how they interplay at the estimation stage. To address these issues, we include the two competing mechanisms in a medium-scale DSGE *à la* Smets-Wouters and we perform several econometric experiments. Since each competing model nests the baseline version, one can vary the magnitude of the parameter summarizing one of the mechanisms to understand how government spending shocks propagate into the model economy.

We find that a model with non-separable government spending in the utility outperforms a model with hand-to-mouth consumers both in terms of fit and size of fiscal multipliers. This result is all the more striking that a Bayesian prior predictive analysis points out that the presence of HtM consumers helps the model to yield more likely output multipliers that exceed unity. However, when taking seriously to the data, this specification generates short-run output multipliers lower than unity (around 0.8) and close to those obtained in a model excluding the two competing mechanisms (labelled *baseline*). Conversely, a version with Edgeworth complementarity provides a multiplier around 1.6. In addition, in this version, government spending shock accounts for 15% of output fluctuations to be compared to 5% in the HtM specification. Using posterior estimates from a model including both mechanisms, we draw the relationship between the share of HtM consumers and the degree of Edgeworth complementarity. Interestingly, we obtain that small changes in the degree of Edgeworth complementarity have a large impact on the estimated fraction of non-savers, making the explanatory power of this latter mechanism very weak. In order to provide some "model-free" evidence for the euro area, we also apply the DSGE-VAR methodology for each model version (Del Negro and Schorfheide, 2004, Del Negro, Schorfheide, Smets, and Wouters, 2007). The DSGE-VAR framework allows us to know if the fiscal multipliers obtained in a constrained DSGE model are far from those obtained in a more flexible DSGE-VAR model. We obtain a sizeable increase in the estimated value of the multiplier in the baseline and HtM versions, while it remains very similar in the GiU specification and in the model including both mechanisms. This supports our claim that Edgeworth complementarity is a better representation of the transmission mechanism of fiscal policy in the euro area. All the previous findings are robust to a number of perturbations (sub-samples, news shocks in government spending, government spending rule, an additional observable and alternative specification of technology shocks).

The paper is organized as follows. In the next section, we expound the baseline DSGE model and the two competing propagation mechanisms. In section 2, we present our quantitative results and we compare the different model versions. In section 3, we evaluate the robustness of our findings. A last section concludes.

2. Medium-scale models for the euro area

In this section we describe the DSGE models of the euro area economy with distinct transmission mechanisms for government spending shocks. All these models have a common core which is close to Smets and Wouters (2007) and Justiniano, Primiceri and Tambalotti (2010). In particular, each model includes features such as habit formation, investment adjustment costs, variable capital utilisation, monopolistic competition in goods and labour markets, and nominal price and wage rigidities. This setup is extended in two directions: *(i)* the introduction of a share of the households being hand-to-mouth consumers and *(ii)* the introduction of government spending in the household utility function in a non-separable way.

2.1. **Baseline model.**

The economy is populated by five classes of agents: producers of a final good, intermediate goods producers, households, employment agencies and the public sector (government and monetary authorities).

2.1.1. *Household sector.*

Employment agencies–. Each household indexed by $j \in [0,1]$ is a monopolistic supplier of specialised labour $N_{j,t}$. At every point in time t, a large number of competitive "employment agencies" combine households' labour into a homogenous labour input N_t sold to intermediate firms, according to $N_t = \left[\int_0^1 N_{j,t}{}^{\frac{1}{\varepsilon_{w,t}}} \mathrm{d}j\right]^{\varepsilon_{w,t}}$. Profit maximization by the perfectly competitive employment agencies implies the labour demand function $N_{j,t} = \left(\frac{W_{j,t}}{W_t}\right)^{-\frac{\varepsilon_{w,t}}{\varepsilon_{w,t}-1}} N_t$, where $W_{j,t}$ is the wage paid by the employment agencies to the household supplying labour variety j, while $W_t \equiv \left(\int_0^1 W_{j,t}{}^{\frac{1}{\varepsilon_{w,t}-1}} \mathrm{d}j\right)^{\varepsilon_{w,t}-1}$ is the wage paid by intermediate firms for the homogenous labour input sold to them by the agencies. The exogenous variable $\varepsilon_{w,t}$ measures the substitutability across labour varieties and its steady-state is the desired steady-state wage mark-up over the marginal rate of substitution between consumption and leisure.

Household's preferences–. The preferences of the jth household are given by

$$\mathrm{E}_t \sum_{s=0}^{\infty} \beta^s \varepsilon_{b,t+s} \left(\log\left(C^*_{t+s} - hC^*_{t+s-1}\right) - \frac{N_{j,t+s}^{1+\nu}}{1+\nu} + \mathcal{V}\left(G_{t+s}\right) \right),$$

where E_t denotes the mathematical expectation operator conditional upon information available at t, $\beta \in (0,1)$ is the subjective discount factor, $h \in [0,1]$ denotes the degree of habit formation, and $\nu > 0$

is the inverse of the Frisch labour supply elasticity. C_t^* is a consumption measure ($C_t^* = C_t$ in the baseline version), $N_{j,t}$ is labour of type j, and $\varepsilon_{b,t}$ is a preference shock.

As we explain below, households are subject to idiosyncratic shocks about whether they are able to re-optimise their wage. Hence, the above described problem makes the choices of wealth accumulation contingent upon a particular history of wage rate decisions, thus leading to the heterogeneity of households. For the sake of tractability, we assume that the momentary utility function is separable across consumption, real balances and leisure. Combining this with the assumption of a complete set of contingent claims market, all the households will make the same choices regarding consumption and money holding, and will only differ by their wage rate and supply of labour. This is directly reflected in our notations. Finally, $\mathcal{V}(G_t)$ is a positive concave function, meaning that agents do not necessarily feel worse off when public expenditures increase. Notice that this term has no effect on the equilibrium.

Household j's period budget constraint is given by

$$P_t\left(C_t + I_t\right) + T_t + B_t \leq R_{t-1}B_{t-1} + A_{j,t} + D_t + W_{j,t}N_{j,t} + \left(R_t^k u_t - P_t\vartheta\left(u_t\right)\right)\bar{K}_{t-1},$$

where I_t is investment, T_t denotes nominal lump-sum taxes (transfers if negative), B_t is the one-period riskless bond, R_t is the nominal interest rate on bonds, $A_{j,t}$ is the net cash flow from household's j portfolio of state contingent securities, D_t is the equity payout received from the ownership of firms. The capital utilisation rate u_t transforms physical capital $\bar{K}_t$ into the service flow of effective capital K_t according to $K_t = u_t\bar{K}_{t-1}$, and the effective capital is rented to intermediate firms at the nominal rental rate R_t^k. The costs of capital utilization per unit of capital is given by the convex function $\vartheta\left(u_t\right)$. We assume that $u = 1$, $\vartheta(1) = 0$, and we define $\eta_u \equiv \left[\vartheta''(1)/\vartheta'(1)\right]/\left[1 + \vartheta''(1)/\vartheta'(1)\right]$.[2] The physical capital accumulates according to

$$\bar{K}_t = (1-\delta)\,\bar{K}_{t-1} + \varepsilon_{i,t}\left(1 - S\left(\frac{I_t}{I_{t-1}}\right)\right)I_t,$$

where $\delta \in [0,1]$ is the depreciation rate of capital, and $S(.)$ is an adjustment cost function which satisfies $S(\gamma_z) = S'(\gamma_z) = 0$ and $S''(\gamma_z) = \eta_k > 0$, γ_z is the steady-state (gross) growth rate of technology, and $\varepsilon_{i,t}$ is an investment shock. Households set nominal wages according to a staggering mechanism. In each period, a fraction θ_w of households cannot choose its wage optimally, but adjusts it to keep up with the increase in the general wage level in the previous period according to the indexation rule $W_{j,t} = \gamma_z\pi^{1-\gamma_w}\pi_{t-1}^{\gamma_w}W_{j,t-1}$, where $\pi_t \equiv P_t/P_{t-1}$ represents the gross inflation rate, π is steady-state (or trend) inflation and the coefficient $\gamma_w \in [0,1]$ is the degree of indexation to past wages. The remaining fraction of households chooses instead an optimal wage, subject to the labour demand function $N_{j,t}$.

[2]Later, we estimate η_u rather than the elasticity $\vartheta''(1)/\vartheta'(1)$ to avoid convergence issues.

2.1.2. *Business sector.*

Final good producers–. At every point in time t, a perfectly competitive sector produces a final good Y_t by combining a continuum of intermediate goods $Y_t(\varsigma)$, $\varsigma \in [0,1]$, according to the technology $Y_t = \left[\int_0^1 Y_{\varsigma,t}{}^{\frac{1}{\varepsilon_{p,t}}} \mathrm{d}\varsigma\right]^{\varepsilon_{p,t}}$. Final good producing firms take their output price, P_t, and their input prices, $P_{\varsigma,t}$, as given and beyond their control. Profit maximization implies $Y_{\varsigma,t} = \left(\frac{P_{\varsigma,t}}{P_t}\right)^{-\frac{\varepsilon_{p,t}}{\varepsilon_{p,t-1}}} Y_t$ from which we deduce the relationship between the final good and the prices of the intermediate goods $P_t \equiv \left[\int_0^1 P_{\varsigma,t}{}^{\frac{1}{\varepsilon_{p,t}-1}} \mathrm{d}\varsigma\right]^{\varepsilon_{p,t}-1}$. The exogenous variable $\varepsilon_{p,t}$ measures the substitutability across differentiated intermediate goods and its steady state is then the desired steady-state price markup over the marginal cost of intermediate firms.

Intermediate-goods firms–. Intermediate good ς is produced by a monopolist firm using the following production function

$$Y_{\varsigma,t} = K_{\varsigma,t}{}^{\alpha}\left[Z_t N_{\varsigma,t}\right]^{1-\alpha} - Z_t \Phi,$$

where $\alpha \in (0,1)$ denotes the capital share, $K_{\varsigma,t}$ and $N_{\varsigma,t}$ denote the amounts of capital and effective labour used by firm ς, Φ is a fixed cost of production that ensures that profits are zero in steady state, and Z_t is an exogenous labour-augmenting productivity factor whose growth-rate is denoted by $\varepsilon_{z,t} \equiv Z_t/Z_{t-1}$. In addition, we assume that intermediate firms rent capital and labour in perfectly competitive factor markets.

Intermediate firms set prices according to a staggering mechanism. In each period, a fraction θ_p of firms cannot choose its price optimally, but adjusts it to keep up with the increase in the general price level in the previous period according to the indexation rule $P_{\varsigma,t} = \pi^{1-\gamma_p}\pi_{t-1}^{\gamma_p} P_{\varsigma,t-1}$,where the coefficient $\gamma_p \in [0,1]$ indicates the degree of indexation to past prices. The remaining fraction of firms chooses its price $P^{\star}_{\varsigma,t}$ optimally, by maximizing the present discounted value of future profits

$$\mathrm{E}_t \sum_{s=0}^{\infty} \left(\beta\theta_p\right)^s \frac{\Lambda_{t+s}}{\Lambda_t} \left\{\Pi^p_{t,t+s} P^{\star}_{\varsigma,t} Y_{\varsigma,t+s} - \left[W_{t+s} N_{\varsigma,t+s} + R^k_{t+s} K_{\varsigma,t+s}\right]\right\},$$

where

$$\Pi^p_{t,t+s} = \begin{cases} \prod_{\nu=1}^{s} \pi^{1-\gamma_p}\pi_{t+v-1}^{\gamma_p} & s > 0 \\ 1 & s = 0, \end{cases}$$

subject to the demand from final goods firms and the production function. Λ_{t+s} is the marginal utility of consumption for the representative household that owns the firm.

2.1.3. *Public sector.* Real (unproductive) government purchases G_t is set according to

$$\frac{G_t}{Z_t} = g\varepsilon_{g,t},$$

where g denotes the deterministic steady–state value of G_t/Z_t. $\varepsilon_{g,t}$ is a government spending shock.

The monetary authority follows a generalized-Taylor rule by gradually adjusting the nominal interest rate in response to inflation, the output gap and a change in the output gap:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\varphi_r} \left[\left(\frac{\pi_t}{\pi}\right)^{\varphi_\pi} \left(\frac{Y_t}{Y_{f,t}}\right)^{\varphi_y} \left(\frac{Y_t Y_{f,t-1}}{Y_{t-1} Y_{f,t}}\right)^{\varphi_{\Delta y}}\right]^{(1-\varphi_r)} \varepsilon_{r,t},$$

where R is the steady state of the gross nominal interest rate and $\varepsilon_{r,t}$ is a monetary policy shock. The output gap is defined as the ratio of actual to potential output $Y_{f,t}$ (i.e. the level of output that would prevail under flexible prices and constant elasticity of substitution among intermediate goods and labor types). The parameter φ_r captures the degree of interest-rate smoothing.

2.1.4. *Market clearing and stochastic processes.* Market clearing conditions on final goods market are given by

$$Y_t = C_t + I_t + G_t + \vartheta\left(u_t\right) \bar{K}_{t-1},$$
$$\Delta_{p,t} Y_t = \left(u_t \bar{K}_{t-1}\right)^{\alpha} \left(Z_t N_t\right)^{1-\alpha} - Z_t \Phi,$$

where $\Delta_{p,t} = \int_0^1 \left(\frac{P_{\varsigma,t}}{P_t}\right)^{-\frac{\varepsilon_{p,t}}{\varepsilon_{p,t-1}}} \mathrm{d}\varsigma$ is a measure of the price dispersion.

Regarding the properties of the stochastic variables, productivity and monetary policy shocks evolve according to $\log\left(\varepsilon_{x,t}\right) = \zeta_{x,t}$, with $x \in \{z, r\}$. The remaining exogenous variables follow an AR(1) process $\log\left(\varepsilon_{x,t}\right) = \rho_x \log\left(\varepsilon_{x,t-1}\right) + \zeta_{x,t}$, with $x \in \{b, i, g, p, w\}$. In all cases, $\zeta_{x,t} \sim i.i.d.N\left(0, \sigma_x^2\right)$.

2.2. **Model with hand-to-mouth consumers.** As in Gali *et al.* (2007), we assume *(i)* that a fraction ω of households, called hand-to-mouth consumers, do not have access to financial markets and simply consume their disposable income in each and every period, *(ii)* the employment agencies do not discriminate between household types in their labour demands, such that the number of hours worked N_t is the same for all households. It follows that, in a symmetric equilibrium, all households have the same wage rate W_t. Therefore, the hand-to-mouth consumers set nominal consumption expenditure $C_{r,t}$ equal to their disposable wage income less lump-sum taxes. This results in the following period-by-period budget constraint:

$$P_t C_{r,t} \leq W_t N_t - T_{r,t}$$

The consumption of households who have access to financial markets is denoted $C_{0,t}$. Accordingly, total consumption is then defined as $C_t = (1-\omega) C_{o,t} + \omega C_{r,t}$.

2.3. **Model with government spending in the utility function.** As in Bouakez and Rebei (2007), we allow for complementarity/substitutability between private consumption and public expenditures. Formally, the consumption bundle C_t^* is now defined as

$$C_t^* = C_t + \alpha_g G_t,$$

where the parameter α_g measures the degree of complementarity/substitutability between private consumption and public expenditures. The specification adopted here follows Christiano and Eichenbaum (1992), McGrattan (1994), Finn (1998), among others.[3] If $\alpha_g > 0$, government spending substitutes for private consumption, with perfect substitution if $\alpha_g = 1$, as in Christiano and Eichenbaum (1992). In this case, a permanent increase in government spending has no effect on output and hours but reduces private consumption, through a perfect crowding-out effect. In the special case $\alpha_g = 0$, we recover the standard business cycle model, with government spending operating through a negative wealth effect on labor supply (see Aiyagari *et al.*, 1992, Baxter and King, 1993). When the parameter $\alpha_g < 0$, government spending complements private consumption. Then, it can be the case (depending on the labor supply elasticity) that private consumption will react positively to an unexpected increase in government spending. There exist many concrete examples for which private consumption and public expenditures are complements or substitutes (health care, education, etc.). As discussed in Fiorito and Kollintzas (2004), the complementarity may reveal relative inefficiency in the provision of public goods.

3. Quantitative analysis

In this section, our formal econometric procedure is first expounded. We then present government spending multiplier probabilities implied by a prior predictive analysis. Finally, we discuss the estimation results of a Smets and Wouters type model (denoted by '*baseline*') and several augmented versions: *(i)* a model with hand-to-mouth consumers (denoted by '*HtM*'), *(ii)* a model with government spending in the utility function (denoted by '*GiU*') and *(iii)* a model with both hand-to-mouth consumers and government spending in the utility function (denoted by '*Full*').

3.1. **Data and econometric approach.**

The quarterly euro area data run from 1980Q1 to 2007Q4 and are extracted from the AWM database compiled by Fagan *et al.* (2005), except hours worked and the working age population. The reason for ending in 2007 is not to blur the results with the zero lower bound episode in the aftermath of the financial crisis. Inflation is measured by the first difference of the logarithm of GDP deflator (YED), the short–term nominal interest rate is a three month rate (STN), and real wage growth is the first difference of the logarithm of nominal wage (WRN) divided by GDP deflator. Private consumption growth is constructed by multiplying real private consumption (PCR) times the private consumption deflator (PCD), divided by GDP deflator and transformed into first difference of the logarithm; private investment growth is defined as the aggregate euro area total economy gross investment minus general government investment, scaled by GDP deflator and transformed into first difference of the logarithm; government spending growth is defined as the sum

[3] An alternative specification is a CES function between C_t and G_t (see McGrattan *et al.*, 1997, Bouakez and Rebei, 2007, Coenen *et al.*, 2013). Note that these two specifications yield exactly the same log–linearised equation for the marginal utility of consumption.

of nominal general government final consumption expenditure (GCN) and nominal government investment (GIN), scaled by GDP deflator and transformed into first difference of the logarithm. Real variables are divided by the working age population, extracted from the OECD Economic Outlook. Ohanian and Raffo (2012) have build a new dataset of quarterly hours worked for 14 OECD countries. We have then made a weighted (by country size) average of their series of hours worked for France, Germany and Italy to obtain a series of total hours for the euro area. Interestingly, the series thus obtained is very close to that provided by the ECB on the common sample, i.e. 1995–2007. Total hours worked are taken in logarithm. Before taking the model to the data, we induce stationarity by getting ride of the stochastic trend component Z_t and we log–linearised the resulting system in the neighborhood of the deterministic steady state.

We follow the Bayesian approach to estimate various versions of the model (see An and Schorfheide, 2007, for an overview). Let $\mathbf{X}_T \equiv \{\mathbf{x}_t\}_{t=1}^T$ denote the sample of observable data, where

$$\mathbf{x}_t = 100 \times [\Delta \log C_t, \Delta \log I_t, \Delta \log G_t, \Delta \log (W_t/P_t), \log N_t, \pi_t, R_t].$$

Conditional on a given model specification $\mathcal{M}_i$, the prior distribution for the vector of structural parameters to be estimated $\boldsymbol{\theta}$ is $p(\boldsymbol{\theta}|\mathcal{M}_i)$ and the likelihood function associated with the observable variables is $\mathcal{L}(\mathbf{X}_T|\boldsymbol{\theta}, \mathcal{M}_i)$. Then, from Bayes theorem, the posterior distribution of $\boldsymbol{\theta}$ is given by

$$p(\boldsymbol{\theta}|\mathbf{X}_T, \mathcal{M}_i) \propto \mathcal{L}(\mathbf{X}_T|\boldsymbol{\theta}, \mathcal{M}_i)\, p(\boldsymbol{\theta}|\mathcal{M}_i). \tag{1}$$

This posterior distribution is evaluated numerically using the Metropolis–Hastings algorithm with 1,000,000 draws. For the sake of comparing different model versions, we resort to the following two standard criteria. First, from $p(\boldsymbol{\theta}|\boldsymbol{X}_T, \mathcal{M}_i)$, one can compute the marginal likelihood of specification $\mathcal{M}_i$, which is defined as

$$\mathcal{L}(\mathbf{X}_T|\mathcal{M}_i) = \int_{\boldsymbol{\theta}} \mathcal{L}(\mathbf{X}_T|\boldsymbol{\theta}, \mathcal{M}_i)\, p(\boldsymbol{\theta}|\mathcal{M}_i)\, \mathrm{d}\boldsymbol{\theta}. \tag{2}$$

Second, given a prior probability p_i on a given model specification $\mathcal{M}_i$, the posterior odds ratio is defined as

$$\mathcal{P}_{i,T} = \frac{p_i \mathcal{L}(\mathbf{X}_T|\mathcal{M}_i)}{\sum_{j=0}^{M-1} p_j \mathcal{L}(\mathbf{X}_T|\mathcal{M}_j)} \text{ with } \sum_{j=0}^{M-1} p_j = 1, \tag{3}$$

where M is the number of competing models.

3.2. **Prior predictive analysis.** Regardless of how the conditional distribution of observables and the prior distribution of unobservables are formulated, together they provide a distribution of observables with density

$$\mathcal{L}(\tilde{\mathbf{X}}_T|\mathcal{M}_i) = \int_{\boldsymbol{\theta}} \mathcal{L}(\tilde{\mathbf{X}}_T|\boldsymbol{\theta}, \mathcal{M}_i)\, p(\boldsymbol{\theta}|\mathcal{M}_i)\, \mathrm{d}\boldsymbol{\theta}. \tag{4}$$

known as the *prior predictive density*. It summarizes the whole range of phenomena consistent with the complete model and is very easy to access by means of simulations. The prior predictive distribution summarizes the substance of the model and emphasizes the fact that the prior distribution and the conditional distribution of observables are inseparable components, a point forcefully argued by Box (1980). $\tilde{\mathbf{X}}_T$ denotes the vector of *ex ante* observables. Notice that evaluating this density at the *ex post* realized observables (*i.e.* $\tilde{\mathbf{X}}_T = \mathbf{X}_T$) yields the posterior density (2).

As explained by Lancaster (2004) and Geweke (2005), prior predictive analysis is a powerful tool to shed light on complicated objects that depend on both the joint prior distribution of parameters and the model specification. In our context, this Bayesian analysis delivers the possible range of the government spending multiplier conditional on a specific model. As our alternative versions only differ by a parameter, prior predictive analysis gives precise statements about how a particular mechanism affects the multiplier.

Table 1. Prior Distributions for Parameters

HtM share, ω	Edgeworth compl., α_g	Habit in consumption, h
$\mathcal{U}$[0.50,0.28]	$\mathcal{U}$[0.00,1.30]	$\mathcal{B}$[0.50,0.20]
Capital utilisation cost, η_u	Investment adj. cost, η_k	TFP growth rate, $\log(\gamma_z)$
$\mathcal{B}$[0.50,0.10]	$\mathcal{G}$[4.00,1.00]	$\mathcal{G}$[0.40,0.10]
Calvo parameters, θ_p, θ_w	Indexation parameters, γ_p, γ_w	MP–smoothing, φ_r
$\mathcal{B}$[0.66,0.10]	$\mathcal{B}$[0.50,0.15]	$\mathcal{B}$[0.75,0.10]
MP–inflation, φ_π	MP–output gap, $\varphi_y, \varphi_{\Delta y}$	Shocks persistence, $\rho_w, \rho_b, \rho_i, \rho_p, \rho_g$
$\mathcal{G}$[2.00,0.30]	$\mathcal{G}$[0.125,0.10]	$\mathcal{B}$[0.50,0.20]
Shocks volatility, $\sigma_w, \sigma_b, \sigma_i, \sigma_p, \sigma_r$	Shocks volatility, σ_z, σ_g	
$\mathcal{IG}$[0.25,2.00]	$\mathcal{IG}$[1.00,2.00]	

In all model specifications, we calibrate few parameters: The discount factor β is set to 0.99, the inverse of the Frisch labor supply elasticity $\nu = 2$, the capital depreciation rate δ is equal to 0.025, the parameter α in the Cobb–Douglas production function is set to 0.30 to match the average capital share in net (of fixed costs) output (McAdam and Willman, 2013), the steady–state price and wage markups ε_p and ε_w are set to 1.20 and 1.35 respectively (Everaert and Schule, 2008), and the steady–state share of government spending in output is set to 0.20 (the average value over the sample period).

Table 1 lists the priors used in our analysis. Our choice of priors is in line with the literature, especially with Smets and Wouters (2007), Sahuc and Smets (2008) and Justiniano *et al.* (2010). We impose $\mathcal{B}$eta distributions for all the parameters the theoretical support of which is the compact [0,1]. We use $\mathcal{G}$amma distributions for positive parameters. Finally, we use $\mathcal{I}$nverse $\mathcal{G}$amma distributions for the standard errors of shocks. Importantly, we are agnostic about the share of non Ricardian households (ω) and the degree of complementarity/substitutability (α_g) between private consumption and public expenditures. We assume $\mathcal{U}$niform priors for these two parameters: ω is distributed on $[0,1]$ and α_g is centered on 0 with a standard error of 1.30.[4] We take 1,000 draws from our priors and calculate the resulting government spending multipliers from the prior distributions. Fiscal multipliers are defined as the present value multipliers:

$$\frac{\mathrm{E}_t \sum_{i=0}^{s} \tilde{\beta}^i \Delta \Psi_{t+i}}{\mathrm{E}_t \sum_{i=0}^{s} \tilde{\beta}^i \Delta G_{t+i}},$$

where $\tilde{\beta} \equiv \beta/\gamma_z$ is the inverse of the steady-state real interest rate, s is the selected horizon, and $\Psi_t = Y_t, C_t, I_t$. At $s = 0$, the present value multiplier equals the impact multiplier. As in Leeper *et al.* (2011), Table 2 compares the multiplier p-values at various horizons across the four model specifications.[5] The top panel of the table reports the probability that multipliers for output exceed unity at various horizons. Middle and lower panels report the probabilities that multipliers for consumption and investment, respectively, are positive at various horizons.

First we observe that all models can generate output impact multipliers greater than one, even the baseline specification. It comes from the fact that greater price stickiness implies that more firms respond to higher government spending by increasing production rather than prices, so markups respond more strongly. However, it is impossible for the baseline model to produce positive consumption multipliers at any horizon. The negative wealth effect is indeed strong since households decrease their consumption and work more. At the same time, real wages increase to offset other price effects that generate negative substitution effects (the degree of wage rigidities has a strong effect on consumption multipliers). This decline in private demand offsets most of the increased public demand, causing output to increase by less than the increase in government consumption.

Fiscal multipliers raise substantially when introducing hand-to-mouth consumers or Edgeworth complementarity/substitutability. Intuitively, since non-ricardians households automatically consume their entire income, they ignore the wealth effects of future taxes and then increase their consumption when government expenditures rise. The larger the share of these agents, the lower the overall negative wealth effect on consumption. If wages are sticky, so that real wages increase in the very short run, then non-savers consumption increases as well. With enough non-savers in the economy, the increase

[4]The value of the standard error has been set such that the minimum value of α_g does not imply a negative value of the marginal utility around the deterministic steady state.

[5]In the context of the prior predictive analysis, we follow Leeper *et al.* (2011) in choosing a prior density for ρ_g defined as $\mathcal{B}$[0.70,0.20].

in their consumption can cause total consumption to increase, leading to larger output multipliers as well. The version including Edgeworth complementarity/substitutability yields multipliers in the line with the HtM consumers version, although smaller. This result originates in our choice of priors for ω and α_g. Indeed, the prior mean for ω implies a sizeable share of hand-to-mouth consumers allowing for a positive response of consumption. Conversely, the prior uniform distribution for α_g is centered in zero (*i.e.* the value of the baseline model version), meaning that our prior does not favor this version. Edgeworth complementarity/substitutability allows to cover a large range of situations for which consumption reacts positively and output multipliers are above one.

Table 2. Government Spending Multiplier Probabilities Implied by Prior Predictive Analysis with Informative Priors

	$\text{Prob}\left(\frac{\Delta Y}{\Delta G} > 1\right)$				
	Impact	4 quart.	10 quart.	25 quart.	∞
$\mathcal{M}_0$: Baseline	0.269	0.016	0.002	0.001	0.001
$\mathcal{M}_1$: HtM	0.871	0.593	0.397	0.322	0.332
$\mathcal{M}_2$: GiU	0.494	0.428	0.385	0.356	0.345
$\mathcal{M}_3$: Full	0.704	0.640	0.560	0.529	0.523
	$\text{Prob}\left(\frac{\Delta C}{\Delta G} > 0\right)$				
	Impact	4 quart.	10 quart.	25 quart.	∞
$\mathcal{M}_0$: Baseline	0.000	0.000	0.000	0.000	0.000
$\mathcal{M}_1$: HtM	0.780	0.630	0.524	0.441	0.354
$\mathcal{M}_2$: GiU	0.472	0.442	0.426	0.407	0.373
$\mathcal{M}_3$: Full	0.691	0.641	0.608	0.579	0.545
	$\text{Prob}\left(\frac{\Delta I}{\Delta G} > 0\right)$				
	Impact	4 quart.	10 quart.	25 quart.	∞
$\mathcal{M}_0$: Baseline	0.040	0.042	0.055	0.063	0.076
$\mathcal{M}_1$: HtM	0.067	0.070	0.075	0.085	0.091
$\mathcal{M}_2$: GiU	0.332	0.332	0.331	0.332	0.337
$\mathcal{M}_3$: Full	0.163	0.167	0.178	0.182	0.190

Note: Baseline: Smets-Wouters type model; HtM: Model with hand-to-mouth consumers; GiU: Model with government spending in the utility function; Full: Model with both hand-to-mouth consumers and government spending in the utility function.

3.3. **Estimation results.** Table 3 reports information on the posterior distribution of the share of hand-to-mouth consumers ω and the degree of complementarity/substitutability between private consumption and government expenditures α_g for each model version: The mean and the 90% confidence interval for each model version. To save space, the rest of the parameters are reported in Appendix B. Several results are worth commenting on.

The first result that stands out is that the two propagation mechanisms considered here are essential as they heavily improve the fit of the model (in comparison with the baseline model). For instance, the marginal likelihood increases from -608 in the baseline model to -599 in the model with hand-to-mouth consumers. The estimated share of hand-to-mouth consumers ω is precisely estimated, with a mean at 0.27 and a 90% confidence interval given by $[0.205; 0.329]$, even though we use a flat (uniform) prior (see the left panel of Figure 1).

Table 3. Posterior Estimates

Parameter	Model			
	$\mathcal{M}_0$: Baseline	$\mathcal{M}_1$: HtM	$\mathcal{M}_2$: GiU	$\mathcal{M}_3$: Full
HtM share, ω	–	0.266 [0.205,0.329]	–	0.161 [0.108,0.215]
Edgeworth compl., α_g	–	–	–1.253 [–1.483,–1.018]	–1.125 [–1.371,–0.882]
Marginal likelihood	–608.584	–599.965	–590.547	–584.742
Posterior odds ratio	0.000	0.000	0.003	0.997
	–	0.001	0.999	–

Note: This table reports the mean and the 90 percent confidence interval (within square brackets) of the estimated posterior distribution of ω and α_g. Baseline: Smets-Wouters type model; HtM: Model with hand-to-mouth consumers; GiU: Model with government spending in the utility function; Full: Model with both hand-to-mouth consumers and government spending in the utility function.

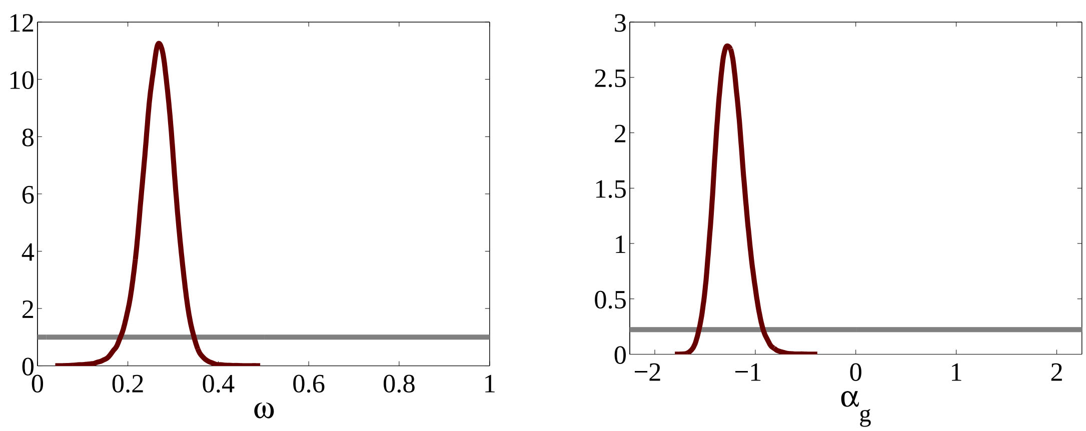
The posterior mean is close to the value obtained by Coenen and Straub (2005, 2013) and is consistent with the values reported in Kaplan, Violante and Weidmer (2014). Using survey data on household portfolios for Germany, France, Italy, and Spain between 2008 and 2010, Kaplan *et al.* (2014) obtain a share of hand-to-mouth consumers between 20% and 32%, according to the country.[6] However, this model version is outperformed by the model with government spending in the utility. This can be directly verified by inspecting the marginal likelihood and posterior odds ratios. Starting from a prior distribution on the two model versions with equal probability (1/2), we obtain that the GiU

[6]They define wealthy hand-to-mouth consumer as the households who hold little or no liquid wealth, despite owning sizable amounts of illiquid assets.

model represents the whole probability mass. The estimated value for α_g is negative suggesting a strong complementarity between private consumption and public expenditures. This result is in line with those obtained in Coenen *et al.* (2013) for the euro area. Using again an uninformative prior with zero mean (see the right panel of Figure 1), we obtain the confidence interval $[-1.43; -1.02]$ for α_g.

When the two mechanisms are combined at the estimation stage (the full model version), we obtain a lower share of hand-to-mouth consumers ($\omega = 0.16$) and a slightly lesser complementarity between private consumption and public expenditures ($\alpha_g = -1.13$). Thus, the estimation of the full model specification on actual data highlights a substitution between these two mechanisms. It is worth noting that the mean value of ω in the HtM specification is outside the 90 percent confidence interval of the full model version. This is not the case when we consider the GiU specification. Therefore, we can infer that a model version with Edgeworth complementarity suffers less that a specification with hand-to-mouth consumers from the presence of a competing propagation mechanism.

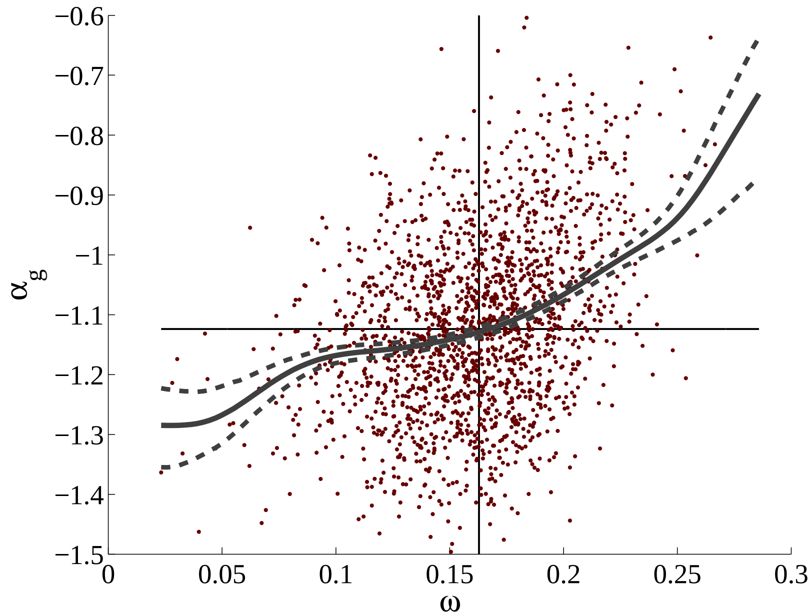
Figure 1. Prior and Posterior Distributions of Parameters ω and α_g



Note: The grey and red lines correspond to the prior and posterior distributions, respectively.

To better illustrate the trade–off between the two transmission mechanisms of fiscal shocks, we plot draws from the posterior distribution of ω and α_g in the full model version. Figure 2 reports the outcome of this exercise. The thick plain line is the nonparametric regression, and the thick dashed lines delineate the 90 percent confidence interval obtained by standard bootstrap techniques. The scatter diagram corresponds to the estimation of the full model . The cross indicates the average parameter values for ω and α_g. This figure clearly reveals, in the neighborhood of the posterior means ($\omega = 0.16$ and $\alpha_g = -1.13$), that the two mechanisms substitute. Importantly, a small variation in α_g has strong implications for the estimated share of hand-to-mouth consumers. For example, moving α_g from -1.13 to -1.16 implies a change in ω from 0.16 to 0.08. In other words, the GiU specification appears more robust to a model's perturbation, i.e. the introduction of a competing transmission mechanism, than the HtM specification.

Figure 2. Empirical Relationship Between ω and α_g



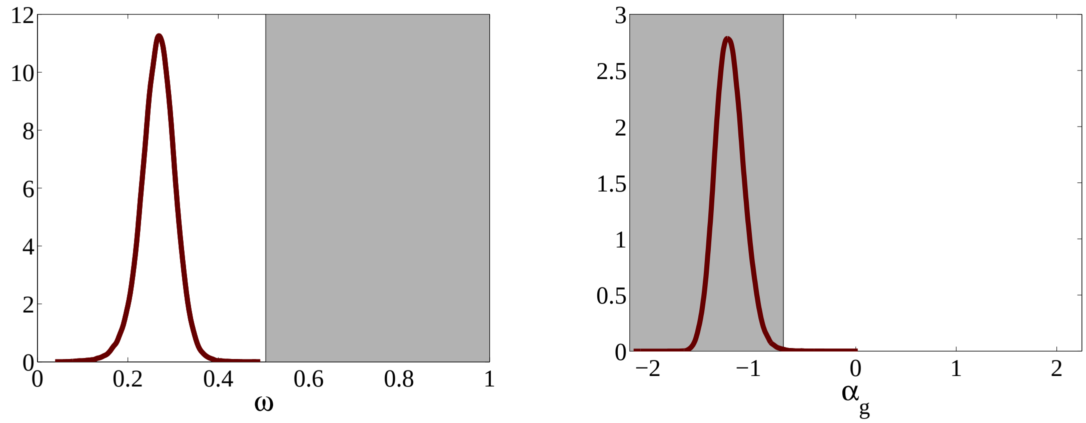
Note: The thick line is the nonparametric regression and the thick dashed lines delineate the 90 percent confidence interval obtained by standard bootstrap techniques. The cross indicates the average parameter values for α_g and ω.

Moreover, the estimated share of hand-to-mouth consumers is too low for generating a positive private consumption multiplier of government consumption shocks in a standard New-Keynesian DSGE model (see *e.g.* Coenen and Straub, 2005; Galí *et al.*, 2007). This is confirmed by the left panel of Figure 3. This figure reports the posterior distribution of ω and a grey area representing the range of values that allow private consumption responding positively to a government spending shock.

One obtains that ω must exceed 0.5 to generate this pattern, a value that is far from its posterior distribution and the empirical evidence reported by Kaplan *et al.* (2014). This means that the posterior estimation dramatically changes the conclusions from the Bayesian prior predictive analysis. Conversely, the GiU model has no difficulty to create a positive response of private consumption (see the right panel of Figure 3): Almost all the posterior distribution lies within the grey area. This findings is also confirmed by the positive and persistent dynamic response of consumption after a government spending shock (see Appendix C). The baseline and HtM models on one side and GiU and Full models on the other side are very close.[7] Consequently, the HtM specification appears to add very little both to the baseline model and to the GiU model.

[7]This is also true for other variables of the model. See Figure C1 in Appendix C.

Figure 3. Posterior Distributions of ω and α_g and Area for a Positive Response of Consumption



Note: The red lines correspond to the posterior distributions; the grey area show the range of values for which the instantaneous response of consumption is positive after a government spending shock.

Table 4. Contribution of the Government Spending Shock (in %)

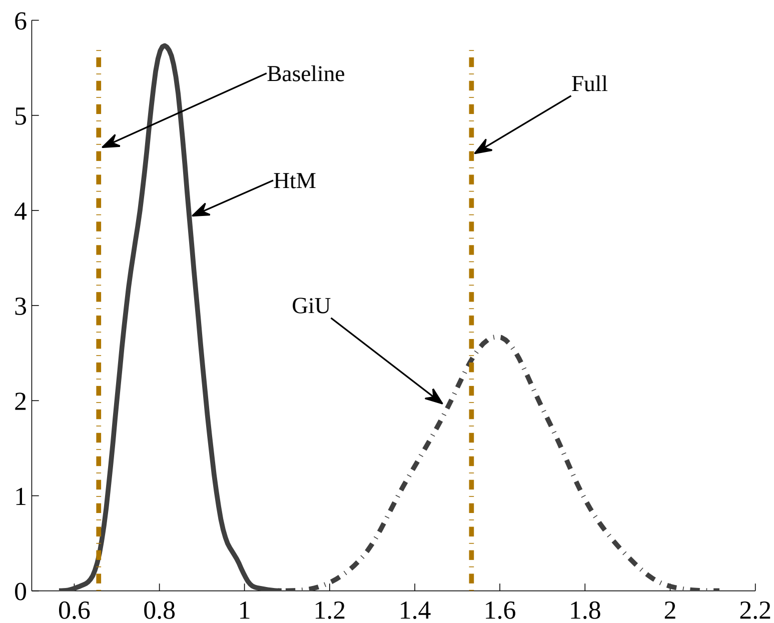
Variable	Model			
	$\mathcal{M}_0$: Baseline	$\mathcal{M}_1$: HtM	$\mathcal{M}_2$: GiU	$\mathcal{M}_3$: Full
Output	3.69	5.37	15.12	14.09
Consumption	3.86	2.64	4.20	3.70
Investment	0.01	0.01	0.07	0.00
Government Spending	59.21	59.58	58.59	58.00
Hours Worked	7.72	11.34	41.11	48.26
Real Wages	0.00	0.00	0.00	0.00
Inflation	0.34	0.54	2.15	1.42
Interest Rate	1.11	1.58	6.96	4.40

Note: Baseline: Smets-Wouters type model; HtM: Model with hand-to-mouth consumers; GiU: Model with government spending in the utility function; Full: Model with both hand-to-mouth consumers and government spending in the utility function.

The contribution of the government spending shock to the short-run aggregate volatility illustrates the previous findings. Table 4 reports this contribution to the variance of observables for the four model versions. As it is clear from this table, the contribution of the government spending shock to output volatility is small for the baseline and HtM model versions (less or equal to 5%), while it is around 15% for the GiU specification. The discrepancy is even larger when it comes to the volatility of hours worked: 11% for the HtM specification and 41% for the GiU version. Introducing government expenditures in the utility directly affects the marginal rate of substitution between consumption and hours worked and thus acts as a labor wedge. This government spending based labor wedge then impacts output in the short-run.

The value of the government spending multiplier inherits from the estimated values of ω and α_g. Figure 4 reports the empirical distribution of the output impact multiplier for the HtM and GiU specifications, and the average value of this multiplier for the baseline and full models. The figure makes clear that the estimated multiplier differs a lot between the two model versions. In presence of hand-to-mouth consumers, the average output multiplier is around 0.8, while it is twice larger (around 1.6) when government expenditures enter in the households utility. The estimated multiplier in the HtM case slightly exceeds that obtained in the baseline model (around 0.66). At the same time, the GiU and full models yield similar multiplier values.

Figure 4. Empirical Distributions of the Output Impact Multiplier



Note: Baseline: Smets-Wouters type model; HtM: Model with rule of thumb consumers; GiU: Model with government spending in the utility function; Full: Model with both rule of thumb consumers and government spending in the utility function.

Furthermore, the four model versions display almost identical estimated values of the common structural parameters. Most of the parameter estimates are in line with previous results (Smets and Wouters, 2003, Sahuc and Smets, 2008, Coenen *et al.*, 2013). Neither the parameters related to real rigidities nor those related to nominal rigidities are affected by the presence of ω and α_g (see Appendix

B). In addition, the parameters that govern the driving force and those describing the monetary policy are left unaffected. This means that our additional features improve the fit of a standard DSGE model without altering its own propagation mechanisms. For example, the effects of monetary policy shocks are the same for each model version.

Finally, in order to provide some "model-free" evidence for the euro area, we apply the DSGE-VAR methodology for each model version.[8] The DSGE-VAR approach has been suggested as a tool for studying misspecification of a DSGE model and allowing the cross-equation restrictions of the DSGE model to be relaxed in a flexible manner (See Del Negro and Schorfheide, 2004, Del Negro, Schorfheide, Smets, and Wouters, 2007, for instance). The basic idea is to *(i)* use a VAR model as an approximating model for the DSGE model and *(ii)* construct a mapping from the DSGE model to the VAR parameters, leading to a set of cross-restrictions for the VAR model. Deviations from these restrictions may be interpreted as evidence for DSGE model misspecification. In a Bayesian framework, one can specify a prior distribution for deviations from the DSGE model restrictions, whose tightness is scaled by a single hyperparameter. By varying this parameter from infinity to zero we create a continuum of models with the VAR approximation of the DSGE model at one end and an unrestricted VAR at the other end. The marginal likelihood function of this parameter provides then an overall assessment of the DSGE model restrictions that is more robust and informative than a comparison of the two polar cases (unconstrained VAR model *vs.* DSGE model).

Table 5. Government spending multiplier in DSGE-VAR models

Model	DSGE	DSGE-VAR	$\frac{\text{DSGE-VAR}}{\text{DSGE}}$
$\mathcal{M}_0$: Baseline	0.663	1.021	1.540
$\mathcal{M}_1$: ROT	0.810	1.131	1.396
$\mathcal{M}_2$: GIU	1.585	1.675	1.057
$\mathcal{M}_3$: Full	1.512	1.630	1.078

Note: This table reports the output impact multiplier. Baseline: Smets-Wouters type model; HtM: Model with hand-to-mouth consumers; GiU: Model with government spending in the utility function; Full: Model with both hand-to-mouth consumers and government spending in the utility function. The VAR model includes two lags.

In our context, this approach allows to know if the fiscal multipliers obtained in a constrained DSGE model are far from those obtained in a more flexible DSGE-VAR model. If they are close, this means that the features incorporated in the DSGE model is consistent with empirical evidence. Table 5 reports the estimated government spending multiplier in both the DSGE case and the DSGE-VAR

[8]We choose two lags for the VAR model. We investigate the robustness of our results to other lag selections. None of our results is altered.

case for each model version. The estimated value of the multiplier sizeably increases in the baseline and HtM versions, while it remains very similar in the GiU and full model versions. For example, the estimated multiplier in the DSGE-VAR model increase by 40% relative to the constrained HtM model version. This is in contrast with the GiU specification for which the relative change is only 6%. This finding supports our claim that Edgeworth complementarity is a better representation of the transmission mechanism of fiscal policy in the euro area.

4. Robustness

In this section, we investigate the robustness of our findings to a number of perturbations: Sub-samples, news shocks in government spending, government spending rule, an additional observable and alternative specification of technology shocks.[9] All the results are reported in Table 6. For all experiments, we use the same prior distributions for the parameters (see Table 1), except special comments. To save space, we only report the parameter values for ω and α_g and the marginal likelihood.

We first investigate whether our results still hold if we re-estimate the four model versions over different sub-samples. In the period between the mid-1990s and 2007, European countries enjoyed one of the greatest economic growth periods, known as the Great Moderation due to the low volatility of growth rates in those years. The mid-1990s also corresponds to the progressive realisation of Economic and Monetary Union. It seems then natural to split the overall sample in the following two parts: 1980Q1-1993Q4 and 1994Q1-2007Q4. The results are reported in Panel a of Table 6. All our previous findings are robust to this sub-sample analysis: The GiU model version outperforms the HtM one, the HtM specification adds very little to both the baseline model and the GiU model versions, the share of hand-to-mouth consumer decreases when this specification is considered together with Edgeworth complementarity.

Second, as emphasized by Ramey (2011) and Schmitt-Grohé and Uribe (2012), the expected component in public expenditures constitutes an important element of government policy. We accordingly modify our benchmark specification to allow for news shocks in the government spending rule. The stationary component of government spending still follows an AR(1) but the innovation $\zeta_{g,t}$ rewrites

$$\zeta_{g,t}^{(0)} + \zeta_{g,t-4}^{(4)} + \zeta_{g,t-8}^{(8)},$$

where $\zeta_{g,t}^{(0)}$, $\zeta_{g,t-4}^{(4)}$, and $\zeta_{g,t-8}^{(8)}$ are two independent random variables that follow a normal distribution with zero mean and variance equals to $\sigma_{g,0}^2, \sigma_{g,4}^2$ and $\sigma_{g,8}^2$, respectively. All variances have the same prior distribution, i.e. an inverse gamma $\mathcal{IG}[1.00,2.00]$.

[9]One can legitimately wonder why the model with hand-to-mouth consumers differs so much from the model with Edgeworth complementarity at the estimation stage. The two propagation mechanisms can equally fit the data, as they both have the potential to yield a positive response of private consumption to a government spending shock (see Table 2). Appendix D addresses this issue in considering the effect of data on the estimation of the share ω.

Table 6. Robustness Analysis: Posterior Estimates

Parameter	Model			
	$\mathcal{M}_0$: Baseline	$\mathcal{M}_1$: HtM	$\mathcal{M}_2$: GiU	$\mathcal{M}_3$: Full
Panel a. Sub–Samples (1980Q1–1993Q4 / 1994Q1–2007Q4)				
ω	–	0.216 / 0.338 (0.067) (0.005)	–	0.103 / 0.265 (0.065) (0.051)
α_g	–	–	–1.188 / –1.386 (0.192) (0.206)	–1.090 / –1.119 (0.210) (0.228)
$\mathcal{L}$	–342.943 / –263.266	–342.021 / –256.396	–333.606 / –256.055	–334.880 / –253.384
Panel b. News Shocks				
ω	–	0.265 (0.039)	–	0.167 (0.034)
α_g	–	–	–1.194 (0.157)	–1.088 (0.155)
$\mathcal{L}$	–613.056	–606.490	–600.771	–596.093
Panel c. Government Spending Rule				
ω	–	0.284 (0.036)	–	0.127 (0.003)
α_g	–	–	–1.552 (0.127)	–1.450 (0.136)
$\mathcal{L}$	–597.829	–588.032	–564.026	–561.891
Panel d. Additional Observables				
ω	–	0.288 (0.039)	–	0.164 (0.034)
α_g	–	–	–1.283 (0.136)	–1.173 (0.144)
$\mathcal{L}$	–657.401	–648.271	–638.822	–632.076
Panel e. Stationary Productivity Shock				
ω	–	0.431 (0.056)	–	0.216 (0.041)
α_g	–	–	–1.336 (0.144)	–1.051 (0.172)
$\mathcal{L}$	–605.021	–593.567	–586.660	–581.519

Note: This table reports the mode and the standard error (within parentheses) of HtM share ω and Edgeworth complementarity α_g. $\mathcal{L}$ denotes the marginal likelihood. Baseline: Smets-Wouters type model; HtM: Model with hand-to-mouth consumers; GiU: Model with government spending in the utility function; Full: Model with both hand-to-mouth consumers and government spending in the utility function.

We obtain that government spending shocks explain around 20% of output variance, among which the expected components represent more than 30%. The estimation results are reported in Panel b of Table 6. As in the previous case, none of our main results are modified.

Third, in the previous section, we follow the DSGE literature with fiscal shocks and we specify an exogenous process for government spending. However, as shown in Fève *et al.* (2013), omitting a stabilizing component in the government spending rule can bias the estimation of a relevant transmission mechanism of government spending shocks. To assess the existence of a potential bias, we assume that the stationary component of government spending is given by

$$\frac{G_t}{Z_t} = g\tilde{G}_t\varepsilon_{g,t},$$

where the endogenous component of the policy $\tilde{G}_t$ is assumed to follow the simple rule

$$\tilde{G}_t = \left(\frac{Y_t}{\gamma_z Y_{t-1}}\right)^{\varphi_g}.$$

The parameter φ_g is the policy rule parameter linking the stationary component of government policy to demeaned output growth. If $\varphi_g > 0$, the policy rule contains a procyclical component that triggers an increase in government expenditures whenever output growth is above its average value. In contrast, if $\varphi_g < 0$, the policy rule features a countercyclical component, and thus reflects automatic stabilizers. We specify for φ_g an uniform prior centered on 0 and with a standard deviation of 1.00, to reflect again our agnostic view concerning this parameter. We include this augmented rule in each model version and re-estimate the model accordingly. The results are reported in Panel c of Table 6. For each model version, we obtain a counter-cyclical policy and the estimated parameter of the government spending rule is very similar ($\varphi_g \approx -0.65$). The estimated share of HtM consumers increases slightly. This reflects the two opposite forces at work in the model. On one hand, the presence of hand-to-mouth consumers tends to amplify the propagation of government spending shocks. On the other hand, the counter-cyclicality of government policy tends to weaken it. If fiscal policy is truly stabilizing, a larger share of hand-to-mouth consumers is then required. However, the increase of ω remains very small, indicating that this mechanism adds little to the transmission of government spending shocks. This is in sharp contrast with what we obtain in the GiU version. When an endogenous government spending policy is considered, the model displays more complementarity between private consumption and public expenditures. The new estimated value of α_g yields a larger output multiplier (1.71). This is another piece of evidence that Edgeworth complementarity is a useful propagation mechanism.

Fourth, Guerron-Quintana (2010) has already shown that the estimation of a structural model is sensitive to the set of observables and the improper exclusion of some observables may lead to estimated parameters with unexpected outcomes. This is why we now include the output growth as an additional observable as it is the case in most of the empirical DSGE literature. To avoid singularity problems, we add an error term into its measurement equation, with an inverse gamma as a prior distribution for its variance. The results are reported in Panel d of Table 6. This alteration has very little effect on our results, both in terms of model's fit and parameter estimates.

Finally, we consider a stationary version for the productivity shocks. Indeed, one can argue that the presence of a random walk (with a positive drift) specification could affect our results as it implies that government spending growth is affected by technology shocks.[10] We relax this assumption and specify a stationary AR(1) process for the logarithm of total factor productivity (in deviation from a linear trend). Government expenditures are now only explained by their own shocks. We use the same prior as before for the autoregressive parameter and the variance of innovation. The results are reported in Panel e of Table 6. We obtain a larger share of the hand-to-mouth consumers (with an output multiplier around 1), but this model version is still outperformed by the GiU specification (with an output multiplier around 1.8). Even if we obtain different numbers, we reach the same conclusions about the HtM and GiU specifications.

5. Concluding remarks

This paper has assessed two competing transmission mechanisms of government spending shocks in the euro area, namely hand-to-mouth consumers and Edgeworth complementarity. Although a Bayesian prior predictive analysis points out that the presence of hand-to-mouth consumers yields larger multipliers than the introduction of Edgeworth complementarity, our posterior estimates suggest the opposite. A model with Edgeworth complementarity provides a better fit and enriches the propagation mechanism of government spending shocks. Moreover, we show that a small change in the degree of Edgeworth complementarity impacts a lot the estimated share of hand-to-mouth consumers. These findings are robust to a number of perturbations.

In our quantitative assessment, we deliberately abstracted from relevant details in order to concentrate on the two competing mechanisms. However, the relevant literature has pushed forward other modeling and policy issues that might affect and enrich our findings. We mention two of them. First, we only concentrated our analysis on hand-to-mouth consumers and Edgeworth complementarity. There exists other relevant mechanisms (non-separable utility, externality, deep habits, productive government spending) and a systematic evaluation of their relative merits may help to improve our understanding about the effects of government activity. Second, we assumed lump-sum taxes to finance government deficit but a more realistic representation should consider distortionary taxes with feedback rules. This allows us to investigate how the way the government expenditures are financed by distortionary taxes could impact the transmission mechanism of fiscal shocks in the euro area.

[10]We obtain that 42% of the volatility of government spending growth is explained by the permanent technology shock in the short run (see Table 4).

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Appendix A: Model

A.1. Equilibrium Conditions

This section reports the first-order conditions for the agents' optimising problems and the other relationships that define the equilibrium of the baseline model.

Effective capital:

$$K_t = u_t \bar{K}_{t-1}$$

Capital accumulation:

$$\bar{K}_t = (1-\delta)\,\bar{K}_{t-1} + \varepsilon_{i,t}\left(1 - S\left(\frac{I_t}{I_{t-1}}\right)\right) I_t$$

Marginal utility of consumption:

$$\Lambda_t = \frac{\varepsilon_{b,t}}{C_t^* - hC_{t-1}^*} - \beta h \mathrm{E}_t \left\{ \frac{\varepsilon_{b,t+1}}{C_{t+1}^* - hC_t^*} \right\}$$

$$C_t^* = C_t$$

Consumption Euler equation:

$$\Lambda_t = \beta R_t \mathrm{E}_t \left\{ \Lambda_{t+1} \frac{P_t}{P_{t+1}} \right\}$$

Investment equation:

$$\begin{aligned} 1 = {} & Q_t \varepsilon_{i,t} \left[1 - S\left(\frac{I_t}{I_{t-1}}\right) - \frac{I_t}{I_{t-1}} S'\left(\frac{I_t}{I_{t-1}}\right) \right] \\ & + \beta \mathrm{E}_t \left\{ \frac{\Lambda_{t+1}}{\Lambda_t} Q_{t+1} \varepsilon_{i,t+1} \left(\frac{I_{t+1}}{I_t}\right)^2 S'\left(\frac{I_{t+1}}{I_t}\right) \right\} \end{aligned}$$

Tobin's Q:

$$Q_t = \beta \mathrm{E}_t \left\{ \frac{\Lambda_{t+1}}{\Lambda_t} \left[\frac{R_{t+1}^k}{P_{t+1}} u_{t+1} - \vartheta\,(u_{t+1}) + (1-\delta)\, Q_{t+1} \right] \right\}$$

Capital utilisation:

$$R_t^k = P_t \vartheta'\,(u_t)$$

Production function:

$$Y_{i,t} = K_{i,t}{}^{\alpha}\,[Z_t N_{i,t}]^{1-\alpha} - Z_t \Phi$$

Labour demand:

$$W_t = (1-\alpha)\, Z_t \left(\frac{K_t}{Z_t N_t}\right)^{\alpha} MC_t$$

where MC_t is the nominal marginal cost.

Capital renting:

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

Price setting:

$$\mathrm{E}_t \sum_{s=0}^{\infty} \left(\beta\theta_p\right)^s \frac{\Lambda_{t+s}}{\Lambda_t} Y^{\star}_{t,t+s} \left[P^{\star}_t \Pi^{p}_{t,t+s} - \varepsilon_{p,t+s} MC_{t+s}\right] = 0$$

Aggregate price index:

$$P_t = \left[\left(1-\theta_p\right)\left(P^{\star}_t\right)^{1/\left(\varepsilon_{p,t}-1\right)} + \theta_p \left(\pi^{1-\gamma_p}\pi^{\gamma_p}_{t-1}P_{t-1}\right)^{1/\left(\varepsilon_{p,t}-1\right)}\right]^{\left(\varepsilon_{p,t}-1\right)}$$

Wage setting:

$$\mathrm{E}_t \sum_{s=0}^{\infty} \left(\beta\theta_w\right)^s \Lambda_{t+s} N^{\star}_{t,t+s} \left[\frac{W^{\star}_t}{P_{t+s}} \Pi^{w}_{t,t+s} - \varepsilon_{b,t+s}\varepsilon_{w,t+s} \frac{\left(N^{\star}_{t,t+s}\right)^{\nu}}{\Lambda_{t+s}}\right] = 0$$

Aggregate wage index:

$$W_t = \left[\left(1-\theta_w\right)\left(W^{\star}_t\right)^{1/\left(\varepsilon_{w,t}-1\right)} + \theta_w \left(\gamma_z \pi^{1-\gamma_p}\pi^{\gamma_w}_{t-1}W_{t-1}\right)^{1/\left(\varepsilon_{w,t}-1\right)}\right]^{\left(\varepsilon_{w,t}-1\right)}$$

Government spending:

$$G_t = \varepsilon_{g,t}$$

Monetary policy rule:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\varphi_r} \left[\left(\frac{\pi_t}{\pi}\right)^{\varphi_\pi} \left(\frac{Y_t}{Y_{f,t}}\right)^{\varphi_y} \left(\frac{Y_t Y_{f,t-1}}{Y_{t-1} Y_{f,t}}\right)^{\varphi_{\Delta y}}\right]^{(1-\varphi_r)} \varepsilon_{r,t}$$

Resource constraint:

$$Y_t = C_t + I_t + G_t + \vartheta\left(u_t\right)\bar{K}_{t-1}$$

$$\Delta_{p,t} Y_t = \left(u_t \bar{K}_{t-1}\right)^{\alpha}\left[Z_t N_t\right]^{1-\alpha} - Z_t \Phi$$

Model with hand-to-mouth consumers:

$$P_t C_{r,t} = W_t N_t - T_{r,t}$$

$$C_t = \left(1-\omega\right) C_{o,t} + \omega C_{r,t}$$

Model with government spending in the utility function:

$$C^{*}_t = C_t + \alpha_g G_t$$

A.2. Stationary Equilibrium

To find the steady-state, we express the model in stationary form. Thus, for the non-stationary variables, let lower-case denote their value relative to the technology process Z_t:

$$\begin{array}{lllll} y_t \equiv Y_t/Z_t & k_t \equiv K_t/Z_t & \bar{k}_t \equiv \bar{K}_t/Z_t & i_t \equiv I_t/Z_t & c_t \equiv C_t/Z_t \\ g_t \equiv G_t/Z_t & \lambda_t \equiv \Lambda_t Z_t & w_t \equiv W_t/\left(Z_t P_t\right) & w^{\star}_t \equiv W^{\star}_t/\left(Z_t P_t\right) & c^{*}_t \equiv C^{*}_t/Z_t \\ c_{o,t} \equiv C_{o,t}/Z_t & c_{r,t} \equiv C_{r,t}/Z_t & & & \end{array}$$

where we note that the marginal utility of consumption Λ_t will shrink as the economy grows, and we express the wage in real terms. Also, we denote the real rental rate of capital and real marginal cost by

$$r_t^k \equiv R_t^k / P_t \text{ and } mc_t \equiv MC_t / P_t,$$

and the optimal relative price as

$$p_t^\star \equiv P_t^\star / P_t.$$

Then we can rewrite the model in terms of stationary variables as follows.

Effective capital:

$$k_t = \frac{u_t \bar{k}_{t-1}}{\varepsilon_{z,t}}$$

Capital accumulation:

$$\bar{k}_t = (1-\delta) \frac{\bar{k}_{t-1}}{\varepsilon_{z,t}} + \varepsilon_{i,t} \left(1 - S\left(\frac{i_t}{i_{t-1}} \varepsilon_{z,t}\right)\right) i_t$$

Marginal utility of consumption:

$$\lambda_t = \frac{\varepsilon_{b,t}}{c_t^* - h \dfrac{c_{t-1}^*}{\varepsilon_{z,t}}} - \beta h \mathrm{E}_t \left\{ \frac{\varepsilon_{b,t+1}}{\varepsilon_{z,t+1} \left(c_{t+1}^* - h \dfrac{c_t^*}{\varepsilon_{z,t+1}} \right)} \right\}$$

$$c_t^* = c_t$$

Consumption Euler equation:

$$\lambda_t = \beta R_t \mathrm{E}_t \left\{ \frac{\lambda_{t+1}}{\varepsilon_{z,t+1} \pi_{t+1}} \right\}$$

Investment equation:

$$\begin{aligned} 1 = {} & q_t \varepsilon_{i,t} \left[1 - S\left(\frac{i_t}{i_{t-1}} \varepsilon_{z,t}\right) - \frac{i_t}{i_{t-1}} \varepsilon_{z,t} S'\left(\frac{i_t}{i_{t-1}} \varepsilon_{z,t}\right) \right] \\ & + \beta \mathrm{E}_t \left\{ \frac{\lambda_{t+1}}{\lambda_t \varepsilon_{z,t+1}} q_{t+1} \varepsilon_{i,t+1} \left(\frac{i_{t+1}}{i_t} \varepsilon_{z,t+1}\right)^2 S'\left(\frac{i_{t+1}}{i_t} \varepsilon_{z,t+1}\right) \right\} \end{aligned}$$

Tobin's Q:

$$q_t = \beta \mathrm{E}_t \left\{ \frac{\lambda_{t+1}}{\lambda_t \varepsilon_{z,t+1}} \left[r_{t+1}^k u_{t+1} - \vartheta(u_{t+1}) + (1-\delta) q_{t+1} \right] \right\}$$

Capital utilisation:

$$r_t^k = \vartheta'(u_t)$$

Production function:

$$y_{i,t} = k_{i,t}^\alpha N_{i,t}^{1-\alpha} - F$$

Labour demand:

$$w_t = (1-\alpha) \left(\frac{k_t}{N_t}\right)^\alpha mc_t$$

Capital renting:

$$r_t^k = \alpha \left(\frac{k_t}{N_t}\right)^{\alpha-1} mc_t$$

Price setting:

$$\mathrm{E}_t \sum_{s=0}^{\infty} \left(\beta\theta_p\right)^s \frac{\lambda_{t+s}}{\lambda_t} y^{\star}_{t,t+s} \left[p^{\star}_t \frac{P_t}{P_{t+s}} \Pi^p_{t,t+s} - \varepsilon_{p,t+s} mc_{t+s} \right] = 0$$

Aggregate price index:

$$1 = \left[\left(1-\theta_p\right)\left(p^{\star}_t\right)^{1/\left(\varepsilon_{p,t}-1\right)} + \theta_p \left(\pi^{1-\gamma_p} \pi^{\gamma_p}_{t-1} \frac{1}{\pi_t} \right)^{1/\left(\varepsilon_{p,t}-1\right)} \right]^{\left(\varepsilon_{p,t}-1\right)}$$

Wage setting:

$$\mathrm{E}_t \sum_{s=0}^{\infty} \left(\beta\theta_w\right)^s \lambda_{t+s} N^{\star}_{t,t+s} \left[w^{\star}_t \frac{P_t}{P_{t+s}} \frac{Z_t}{Z_{t+s}} \Pi^w_{t,t+s} - \varepsilon_{b,t+s}\varepsilon_{w,t+s} \frac{N^{\nu}_{t,t+s}}{\lambda_{t+s}} \right] = 0$$

Aggregate wage index:

$$w_t = \left[\left(1-\theta_w\right)\left(w^{\star}_t\right)^{1/\left(\varepsilon_{w,t}-1\right)} + \theta_w \left(\gamma_z \pi^{1-\gamma_p} \pi^{\gamma_w}_{t-1} \frac{w_{t-1}}{\pi_t \varepsilon_{z,t}} \right)^{1/\left(\varepsilon_{w,t}-1\right)} \right]^{\left(\varepsilon_{w,t}-1\right)}$$

Government spending:

$$g_t = \varepsilon_{g,t}$$

Monetary policy rule:

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\varphi_r} \left[\left(\frac{\pi_t}{\pi}\right)^{\varphi_\pi} \left(\frac{y_t}{y_{f,t}}\right)^{\varphi_y} \left(\frac{y_t y_{f,t-1}}{y_{t-1} y_{f,t}}\right)^{\varphi_{\Delta y}} \right]^{(1-\varphi_r)} \varepsilon_{r,t}$$

Resource constraint:

$$y_t = c_t + x_t + g_t + \vartheta\left(u_t\right)\bar{k}_{t-1}/\varepsilon_{z,t}$$

$$\Delta_{p,t} y_t = \left(u_t \bar{k}_{t-1}\right)^{\alpha} N_t^{1-\alpha} - \Phi$$

Model with hand-to-mouth consumers:

$$c_{r,t} = w_t n_t - t_{r,t}$$

$$c_t = (1-\omega)\, c_{o,t} + \omega c_{r,t}$$

Model with government spending in the utility function:

$$c^*_t = c_t + \alpha_g g_t$$

A.3. Steady State

We use the stationary version of the model to find the steady state, and we let variables without a time subscript denote steady-state values. First, we have that $R = \left(\gamma_z \pi\right)/\beta$ and the expression for Tobin's Q implies that the rental rate of capital is

$$r^k = \frac{\gamma_z}{\beta} - (1-\delta)$$

and the price-setting equation gives marginal cost as

$$mc = \frac{1}{\varepsilon_p}.$$

The capital/labour ratio can then be retrieved using the capital renting equation:

$$\frac{k}{N} = \left(\alpha \frac{mc}{r^k}\right)^{1/(1-\alpha)},$$

and the wage is given by the labour demand equation as

$$w = (1-\alpha)\, mc \left(\frac{k}{N}\right)^{\alpha}.$$

The production function gives the output/labour ratio as

$$\frac{y}{N} = \left(\frac{k}{N}\right)^{\alpha} - \frac{\Phi}{N},$$

and the fixed cost Φ is set to obtain zero profits at the steady state, implying

$$\frac{\Phi}{N} = \left(\frac{k}{N}\right)^{\alpha} - w - r^k \frac{k}{N}.$$

The output/labour ratio is then given by

$$\frac{y}{N} = w + r^k \frac{k}{N} = \frac{r^k}{\alpha} \frac{k}{N}.$$

Finally, to determine the investment/output ratio, we use the expressions for effective capital and physical capital accumulation to get

$$\frac{i}{k} = \left(1 - \frac{1-\delta}{\gamma_z}\right) \gamma_z \Longrightarrow \frac{i}{y} = \frac{i}{k} \frac{k}{N} \frac{N}{y} = \left(1 - \frac{1-\delta}{\gamma_z}\right) \frac{\alpha \gamma_z}{r^k}.$$

Given the government spending/output ratio g/y, the consumption/output ratio is then given by the resource constraint as

$$\frac{c}{y} = 1 - \frac{i}{y} - \frac{g}{y}.$$

Model with hand-to-mouth consumers:

$$c_r = wn - t_r$$

$$c = c_o = c_r$$

Model with government spending in the utility function:

$$c^* = c + \alpha_g g$$

A.4. Log-Linearised Version

We log-linearise the stationary model around the steady state. Let $\hat{\chi}_t$ denote the log deviation of the variable χ_t from its steady-state level χ: $\hat{\chi}_t \equiv \log(\chi_t/\chi)$. The log-linearised model is then given by the following system of equations for the endogenous variables.

Effective capital:

$$\hat{k}_t + \hat{\varepsilon}_{z,t} = \hat{u}_t + \hat{\bar{k}}_{t-1}$$

Capital accumulation:

$$\hat{\bar{k}}_t = \frac{1-\delta}{\gamma_z}\left(\hat{\bar{k}}_{t-1} - \hat{\varepsilon}_{z,t}\right) + \left(1 - \frac{1-\delta}{\gamma_z}\right)(\hat{\imath}_t + \hat{\varepsilon}_{i,t})$$

Marginal utility of consumption:

$$\begin{aligned}\hat{\lambda}_t = {} & \frac{h\gamma_z}{(\gamma_z - h\beta)(\gamma_z - h)}\hat{c}^*_{t-1} - \frac{\gamma_z^2 + h^2\beta}{(\gamma_z - h\beta)(\gamma_z - h)}\hat{c}^*_t + \frac{h\beta\gamma_z}{(\gamma_z - h\beta)(\gamma_z - h)}\mathrm{E}_t\hat{c}^*_{t+1} \\ & - \frac{h\gamma_z}{(\gamma_z - h\beta)(\gamma_z - h)}\hat{\varepsilon}_{z,t} + \frac{h\beta\gamma_z}{(\gamma_z - h\beta)(\gamma_z - h)}\mathrm{E}_t\hat{\varepsilon}_{z,t+1} \\ & + \frac{\gamma_z}{\gamma_z - h\beta}\hat{\varepsilon}_{b,t} - \frac{h\beta}{\gamma_z - h\beta}\mathrm{E}_t\hat{\varepsilon}_{b,t+1} \\ \hat{c}^*_t = {} & \hat{c}_t\end{aligned}$$

Consumption Euler equation:

$$\hat{\lambda}_t = \mathrm{E}_t\hat{\lambda}_{t+1} + \left(\hat{R}_t - \mathrm{E}_t\hat{\pi}_{t+1}\right) - \mathrm{E}_t\hat{\varepsilon}_{z,t+1}$$

Investment equation:

$$\hat{\imath}_t = \frac{1}{1+\beta}(\hat{\imath}_{t-1} - \hat{\varepsilon}_{z,t}) + \frac{\beta}{1+\beta}\mathrm{E}_t(\hat{\imath}_{t+1} + \hat{\varepsilon}_{z,t+1}) + \frac{1}{\eta_k\gamma_z^2(1+\beta)}(\hat{q}_t + \hat{\varepsilon}_{i,t})$$

Tobin's Q:

$$\hat{q}_t = \frac{\beta(1-\delta)}{\gamma_z}\mathrm{E}_t\hat{q}_{t+1} + \left(1 - \frac{\beta(1-\delta)}{\gamma_z}\right)\mathrm{E}_t\hat{r}^k_{t+1} - (\hat{r}_t - \mathrm{E}_t\hat{\pi}_{t+1})$$

Capital utilisation:

$$\hat{u}_t = \frac{1-\eta_u}{\eta_u}\hat{r}^k_t$$

Production function:

$$\hat{y}_t = \frac{y+\Phi}{y}\left(\alpha\hat{k}_t + (1-\alpha)\hat{n}_t\right)$$

Labour demand:

$$\hat{w}_t = \widehat{mc}_t + \alpha\hat{k}_t - \alpha\hat{n}_t$$

Capital renting:

$$\hat{r}^k_t = \widehat{mc}_t - (1-\alpha)\hat{k}_t + (1-\alpha)\hat{n}_t$$

Phillips curve:

$$\hat{\pi}_t = \frac{\gamma_p}{1+\beta\gamma_p}\pi_{t-1} + \frac{\beta}{1+\beta\gamma_p}\mathrm{E}_t\pi_{t+1} + \frac{(1-\beta\theta_p)(1-\theta_p)}{\theta_p(1+\beta\gamma_p)}\left(\widehat{mc}_t + \hat{\varepsilon}_{p,t}\right)$$

Wage curve:

$$\hat{w}_t = \frac{1}{1+\beta}\hat{w}_{t-1} + \frac{\beta}{1+\beta}\mathrm{E}_t\hat{w}_{t+1} + \frac{(1-\beta\theta_w)(1-\theta_w)}{\theta_w(1+\beta)\left(1+\nu\frac{\varepsilon_w}{\varepsilon_w-1}\right)}\left(\widehat{mrs}_t - \hat{w}_t + \hat{\varepsilon}_{w,t}\right)$$
$$+\frac{\gamma_w}{1+\beta}\hat{\pi}_{t-1} - \frac{1+\beta\gamma_w}{1+\beta}\hat{\pi}_t + \frac{\beta}{1+\beta}\mathrm{E}_t\hat{\pi}_{t+1} - \frac{1}{1+\beta}\hat{\varepsilon}_{z,t} + \frac{\beta}{1+\beta}\mathrm{E}_t\hat{\varepsilon}_{z,t+1}$$

Marginal rate of substitution:

$$\widehat{mrs}_t = \nu\hat{n}_t - \hat{\lambda}_t + \hat{\varepsilon}_{b,t}$$

Government spending:

$$\hat{g}_t = \hat{\varepsilon}_{g,t}$$

Monetary policy rule:

$$\hat{R}_t = \varphi_r\hat{R}_{t-1} + (1-\varphi_r)\left[\varphi_\pi\hat{\pi}_t + \varphi_y\left(\hat{y}_t - \hat{y}_{t-1}\right) + \varphi_{\Delta y}\left(\left(\hat{y}_t - \hat{y}_{f,t}\right) - \left(\hat{y}_{t-1} - \hat{y}_{f,t-1}\right)\right)\right] + \hat{\varepsilon}_{r,t}$$

Resource constraint:

$$\hat{y}_t = \frac{c}{y}\hat{c}_t + \frac{i}{y}\hat{\imath}_t + \frac{g}{y}\hat{g}_t + \frac{r^k k}{y}\hat{u}_t$$

Model with hand-to-mouth consumers:

$$\hat{c}_{r,t} = \frac{wn}{c}\left(\hat{w}_t + \hat{n}_t\right) - \frac{t_r}{c}\hat{t}_{r,t}$$
$$\hat{c}_t = (1-\omega)\hat{c}_{o,t} + \omega\hat{c}_{r,t}$$

Model with government spending in the utility function:

$$\hat{c}_t^* = \frac{c}{c+\alpha_g g}\hat{c}_t + \frac{\alpha_g g}{c+\alpha_g g}\hat{g}_t$$

APPENDIX B: ESTIMATION RESULTS

Table B1. Posterior Estimates

	$\mathcal{M}_0$: Baseline	$\mathcal{M}_1$: HtM	$\mathcal{M}_2$: GiU	$\mathcal{M}_3$: Full
Habit in consumption, h	0.263 [0.158,0.367]	0.203 [0.098,0.305]	0.109 [0.027,0.188]	0.120 [0.039,0.197]
Capital utilisation cost, η_u	0.649 [0.510,0.784]	0.664 [0.529,0.799]	0.671 [0.545,0.799]	0.694 [0.574,0.816]
Investment adj. cost, η_k	4.667 [3.429,5.884]	3.958 [2.649,5.279]	4.087 [2.896,5.302]	3.736 [2.472,4.990]
Growth rate of technology, $\log(\gamma_z)$	0.382 [0.292,0.471]	0.398 [0.308,0.485]	0.393 [0.302,0.483]	0.411 [0.321,0.501]
Calvo price, θ_p	0.946 [0.927,0.968]	0.935 [0.916,0.958]	0.932 [0.915,0.951]	0.926 [0.909,0.942]
Calvo wage, θ_w	0.733 [0.606,0.855]	0.756 [0.560,0.908]	0.693 [0.564,0.825]	0.691 [0.523,0.845]
Price indexation, γ_p	0.221 [0.044,0.425]	0.175 [0.029,0.345]	0.160 [0.032,0.290]	0.146 [0.038,0.248]
Wage indexation, γ_w	0.279 [0.105,0.443]	0.381 [0.163,0.588]	0.288 [0.119,0.454]	0.346 [0.153,0.535]
MP–smoothing, φ_r	0.870 [0.822,0.918]	0.868 [0.815,0.924]	0.879 [0.835,0.925]	0.878 [0.833,0.927]
MP–inflation, φ_π	1.605 [1.252,1.939]	1.576 [1.221,1.931]	1.584 [1.242,1.922]	1.603 [1.247,1.954]
MP–output gap, φ_y	0.019 [0.000,0.039]	0.025 [0.000,0.048]	0.042 [0.001,0.079]	0.058 [0.003,0.109]
MP–output gap change, $\varphi_{\Delta y}$	0.422 [0.327,0.511]	0.416 [0.314,0.515]	0.483 [0.365,0.594]	0.457 [0.345,0.567]
Wage markup shock persistence, ρ_w	0.700 [0.511,0.911]	0.728 [0.564,0.939]	0.844 [0.757,0.934]	0.847 [0.740,0.949]
Intertemporal shock persistence, ρ_b	0.913 [0.874,0.951]	0.795 [0.688,0.905]	0.873 [0.810,0.938]	0.763 [0.653,0.876]
Investment shock persistence, ρ_i	0.431 [0.308,0.553]	0.428 [0.318,0.542]	0.477 [0.351,0.609]	0.504 [0.383,0.625]
Price markup shock persistence, ρ_p	0.412 [0.091,0.665]	0.498 [0.222,0.763]	0.557 [0.353,0.775]	0.595 [0.434,0.773]
Government shock persistence, ρ_g	0.981 [0.969,0.994]	0.982 [0.970,0.993]	0.981 [0.970,0.992]	0.988 [0.980,0.996]

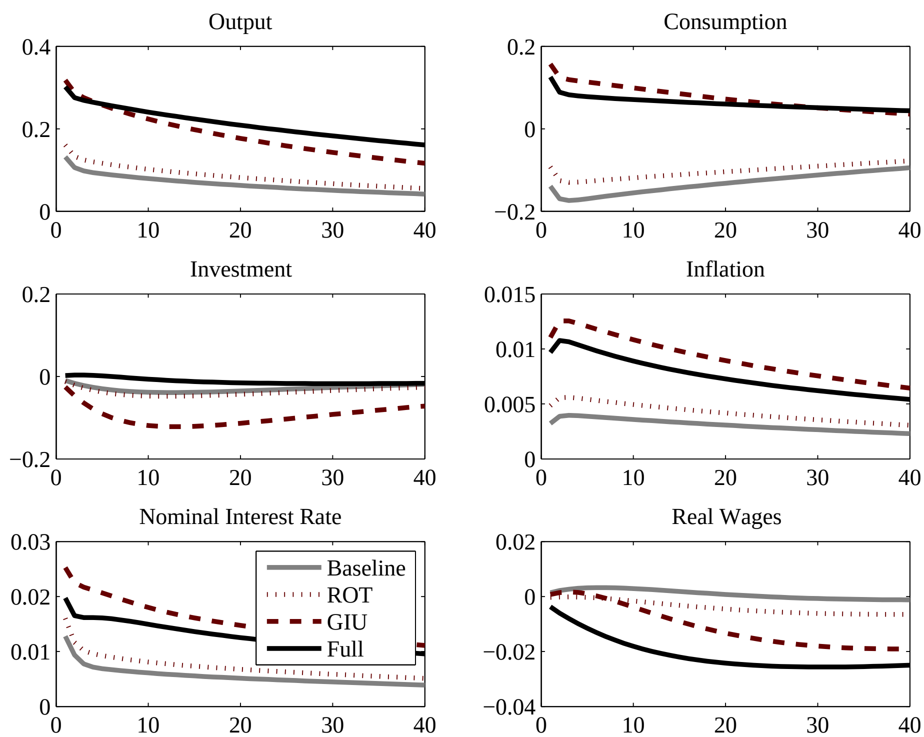
Table B1. Posterior Estimates (cont'd)

	$\mathcal{M}_0$: Baseline	$\mathcal{M}_1$: HtM	$\mathcal{M}_2$: GiU	$\mathcal{M}_3$: Full
Wage markup shock volatility, σ_w	0.108 [0.073,0.143]	0.106 [0.074,0.138]	0.084 [0.064,0.102]	0.087 [0.065,0.108]
Intertemporal shock volatility σ_b	0.045 [0.035,0.054]	0.085 [0.053,0.114]	0.098 [0.058,0.135]	0.136 [0.084,0.184]
Investment shock volatility, σ_i	0.559 [0.465,0.650]	0.591 [0.492,0.686]	0.555 [0.462,0.650]	0.571 [0.472,0.666]
Price markup shock volatility, σ_p	0.137 [0.097,0.177]	0.124 [0.085,0.164]	0.112 [0.077,0.148]	0.106 [0.074,0.137]
Productivity shock volatility, σ_z	0.809 [0.718,0.900]	0.802 [0.713,0.890]	0.812 [0.717,0.901]	0.807 [0.715,0.896]
Government shock volatility, σ_g	0.970 [0.856,1.076]	0.969 [0.859,1.078]	0.962 [0.852,1.071]	0.945 [0.838,1.051]
Monetary policy shock volatility, σ_r	0.194 [0.158,0.228]	0.189 [0.156,0.222]	0.191 [0.155,0.226]	0.183 [0.151,0.215]

Note: This table reports the prior distribution, the mean and the 90 percent confidence interval (within square brackets) of the estimated posterior distribution of the structural parameters. Baseline: Smets-Wouters type model; HtM: Model with hand-to-mouth consumers; GiU: Model with government spending in the utility function; Full: Model with both hand-to-mouth consumers and government spending in the utility function.

Appendix C: Impulse Response Functions

Figure C1. Impulse Response Functions to a Government Spending Shock



Note: Baseline: Smets-Wouters type model; HtM: Model with hand-to-mouth consumers; GiU: Model with government spending in the utility function; Full: Model with both hand-to-mouth consumers and government spending in the utility function.

Appendix D: The Effects of Data on Estimation

In this appendix, we consider the following experiment. We calibrate the DSGE model according to the posterior estimates in the HtM, GiU and Full model versions, respectively. For the GiU and Full models, we set $\alpha_g = 0$, *i.e.* we eliminate the propagation mechanism related to Edgeworth complementarity. In other words, the HtM, GiU and Full versions only reflect a particular calibration of the remaining models' parameters. These three calibrations are considered as simple robustness check. Given a calibration, we only estimate the share of hand-to-mouth consumers for several sets of observables. We start with the smallest relevant set and progressively add observables. The results are reported in Table D1. For comparison purpose, the table includes our benchmark results (i.e. with seven observables). When we consider private consumption and government spending, including or not investment, we obtain a larger estimated value of ω (whatever the calibration) compared to the benchmark estimates. The share ω is now close to 0.5 and the HtM model version can yield more likely an output multiplier larger than one. When we progressively extend the set of observables, the estimated value is reduced, especially if we include real wages, hours worked, inflation or the nominal interest rate.

Table D1. Value of ω Conditional on the Set of Observables

Observables	Calibration		
	$\mathcal{M}_1$: HtM	$\mathcal{M}_2$: GiU	$\mathcal{M}_3$: Full
Benchmark	0.273	0.274	0.308
$\{\Delta c_t, \Delta g_t\}$	0.385	0.488	0.469
$\{\Delta c_t, \Delta g_t, \Delta i_t\}$	0.402	0.511	0.489
$\{\Delta c_t, \Delta g_t, \Delta w_t\}$	0.310	0.365	0.389
$\{\Delta c_t, \Delta g_t, \Delta i_t, n_t\}$	0.336	0.383	0.384
$\{\Delta c_t, \Delta g_t, \Delta i_t, \Delta w_t\}$	0.244	0.315	0.282
$\{\Delta c_t, \Delta g_t, \Delta i_t, \Delta w_t, n_t\}$	0.287	0.336	0.326
$\{\Delta c_t, \Delta g_t, \Delta i_t, \Delta w_t, n_t, \pi_t\}$	0.296	0.353	0.329
$\{\Delta c_t, \Delta g_t, \Delta i_t, \Delta w_t, n_t, R_t\}$	0.265	0.257	0.299

Note: This table reports the mode estimates of ω under three sets of calibration (HtM, GiU and Full). Benchmark refers to the case where the seven observables are used for estimation. HtM: Model with hand-to-mouth consumers; GiU: Model with government spending in the utility function; Full: Model with both hand-to-mouth consumers and government spending in the utility function. In all calibrations, $\alpha_g = 0$.