Fiscal policy in open economies: estimates for the Euro area

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Abstract

This paper reconsiders the economic effects of fiscal policy using an estimated small open economy dynamic stochastic general equilibrium model for the Euro area. We try to estimate the size of fiscal multipliers obtained in an open economy model and the effects of fiscal shocks on the Euro area trade balance and real exchange rate.

We show that estimated GDP fiscal multipliers of public expenditures - we consider government purchases, wage bill and transfers - never exceed one on a yearly basis. On the revenue side, tax cuts on labor income and consumption have similar expansionary effects on GDP. We show also that expansionary fiscal policy shocks - both those on the expenditure and revenue side - tend to deteriorate the trade balance and to depreciate the real exchange rate.

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1 Introduction

The analysis of the effects of fiscal shocks has recently attracted a vivid attention as the recent collapse of private demand has revived the use of discretionary fiscal policy in order to support aggregate demand. At the same time, there is still an open debate on the effectiveness of spending increase or tax cut in supporting private activity. Typically VAR analyses tend to provide evidence consistent with the new-keynesian view that fiscal multipliers can be significant (Perotti, 2007; Mountford and Uhlig, 2005), while event studies (Ramey, 2008) are more for negligible multipliers and therefore bring support to the neoclassical side. These estimates have been made mainly on US data, as quarterly fiscal data for other countries are scarce, and with reference to closed economy models.

The uncertainty on the effects of fiscal shocks extend to the trade balance and the real exchange rate. On this latter issues a number of studies on the US find some conflicting results. Kim and Roubini (2008) support the view that following a fiscal shock the real exchange rate depreciate (a result found also by Kollmann (2009) for G7 countries) and the trade balance improve. On the other, Monacelli and Perotti (2009), Ravn, Smitt-Groe and Uribe (2007) and, to a certain extent, Corsetti and Muller (2009) present evidence in favour of a worsening of the trade balance. Guerrieri et al (2005) using an open economy DSGE model calibrated to the US and the rest of the world, suggest that a fiscal expansion has a limited effect on the trade deficit as private sector consumption and investment (and therefore import) fall after the shock, partially compensating for the public stimulus. The evidence regarding European or Euro area countries is more scarce. A recent contribution by Beetsma, Giuliodori and Klaassen (2008) present evidence on a panel of European countries using annual data. Their findings are in support of a worsening of the trade balance and a real exchange rate appreciation after a government expenditure shock. Moreover, the effect on the trade balance is relevant: they estimate that an increase in public expenditures of 1% of GDP leads to a deterioration of the trade balance of between 0.5 and 1% in the first year.

Part of the uncertainty on the effectiveness of discretionary fiscal policy as a counter-cyclical device is due to the fact that its effects depend on a variety of elements: on the type of intervention (i.e. on the expenditure or revenue side), on how it is financed, on how long it is expected to last, on the interaction with the monetary policy, on the degree of openness to trade of the country, and so on. General equilibrium models are well suited to capture all these elements; many international institutions and central banks have recently produced analysis of fiscal stimulus based on such models.

This paper reconsiders the economic effects of fiscal policy using an estimated small open economy dynamic stochastic general equilibrium model for the Euro area. Therefore we provide empirical evidence for an economic area different from the US and we explicitly consider the open economy dimension. Our goal is to estimate the size of fiscal multipliers obtained in an open economy model and the effects of fiscal shocks on the Euro area trade balance and real exchange rate. To this end we build a new Keynesian small open economy model that blends most of the elements of both the small open economy model of the Euro area of Adolfson et al. (2008) and the closed economy version rich in terms of fiscal details.
of Forni et al. (2008). In particular, the model features non-Ricardian agents that in each period consume all the available income, so to potentially account for Keynesian effects of public expenditure, as in Gali et al. (2007). It considers also multiple fiscal rules, assuming that labor income tax rate, public consumption and public transfers to households can be appropriately and simultaneously modified by the fiscal authority to stabilize public debt. The range of tax rates includes also those on capital income and consumption, that follow a standard autoregressive process. To estimate the model we use the database on euro area fiscal variables (public expenditure and taxation) from Forni et al. (2009), while data for main aggregate variables are, consistently with similar contributions, from the Area Wide Model database.

Other features of the setup are standard. The small open economy is specialized in the production of a tradable good, produced under monopolistic competition regime using domestic labor and physical capital. We assume that the small open economy imports a tradable good from the rest of the world. Price of imports and exports are sticky in the currency of the destination market (we assume local currency pricing), so that the pass-through of nominal exchange rate into import prices is incomplete in the short-run. The small open economy trades a riskless bond, denominated in foreign currency, with the rest of the world. So the uncovered interest parity condition, linking the nominal interest rate differential to the expected nominal exchange rate depreciation, holds in the small open economy. For Ricardian households standard Euler equations determining interest-rate sensitive consumption and saving holds (Ricardian households accumulate physical capital and buy domestic and internationally traded bonds). As in Adolfson et al. (2007), we include all real and nominal frictions needed to guarantee a good fit of the data. We assume habit in consumption and adjustment costs on investment change, stickiness and indexation for nominal wage and prices. Finally, the monetary authority sets the nominal interest rate according to a standard Taylor rule.


Our results are the following. We show that estimated GDP fiscal multipliers of public expenditures - we consider government purchases, wage bill and transfers - never exceed one on a yearly basis. On the revenue side, tax cuts on labor income and consumption have similar expansionary effects on GDP. We show also that expansionary fiscal policy shocks - both those on the expenditure and revenue side - tend to deteriorate the trade balance and to depreciate the real exchange rate.

The remainder of this paper is organized as follows. Section 2 presents our basic open economy model. Data and calibration are discussed in Section 3. Section 4 reports our estimation results. Section 5 reports impulse response analysis. Section 6 discusses sensitivity analysis. Section 7 concludes.
2 The Model

We develop a standard small open economy model, similar to recent contributions by Adolfson et al. (2007) and Coenen et al. (2008).\footnote{1} Differently from them, we follow Corsetti et al. (2009) and Forni et al. (2009) by including non-Ricardian households and multiple fiscal policy rules on both expenditures and revenues. Ricardian households maximize an intertemporal utility function with respect to consumption and leisure. Non-Ricardian households, instead, in each period consume all the available income. Consumption and investment baskets consist of domestic and imported goods. Pass-through of nominal exchange rate to import and export prices is incomplete in the short-run because of the local currency pricing assumption (nominal prices are sticky and set in the currency of the destination market). Financial markets are incomplete, as we assume that only riskless bonds are traded domestically and at international level. In what follows, we initially describe the problems solved by firms and households and then the behavior of the central bank, the fiscal authority, and the foreign economy. We label the small open economy as Home and the rest of the world as Foreign.

2.1 Firms

Firms in the final goods sector produce three different types of nontradable goods under perfect competition. One type of good is used for private consumption, the other two for private investment and public sector consumption, respectively.

Private consumption is a constant elasticity of substitution (CES) function of domestically produced goods ($C_H$) and imported goods ($C_F$):

$$C_t = \left[ \frac{\eta}{a_{HC}} (C_{H,t})^{\frac{\eta-1}{\eta}} + (1-a_{HC})^{\frac{\eta}{\eta}} (C_{F,t})^{\frac{\eta-1}{\eta}} \right]^{\frac{1}{\eta-1}}$$

(1)

where the parameter $0 < a_{HC} < 1$ is the share of domestic goods in consumption and the parameter $\eta$ is the elasticity of substitution between the domestic and the imported good. Bundles $C_{H,t}$ and $C_{F,t}$ are composite of a continuum of, respectively, differentiated domestic ($h$) and imported ($f$) intermediate goods, each supplied by a different firm. They are produced according to the following CES functions:

$$C_{H,t} = \left[ \int_0^n C_{H,t}(h)^{\theta_{H,t}^{-1}} dh \right]^{\theta_{H,t}} \quad \text{and} \quad C_{F,t} = \left[ \int_n^1 C_{F,t}(f)^{\theta_{F,t}^{-1}} df \right]^{\theta_{F,t}}$$

(2)

where $1 < \theta_{H,t}, \theta_{F,t} < \infty$ are the time-varying elasticities of substitution among domestic brands and among foreign brands. The parameter $n$ is the size of the home economy (the size of the rest of the world is $(1-n)$, the world size is normalized to one).\footnote{2} The

\footnote{1}{For a closed economy version of the setup see Christiano et al. (2005).}

\footnote{2}{We assume that the country size is equal to the number of domestic firms in each sector and to the number of domestic households.}
elasticities $\theta_{H,t}$ and $\theta_{F,t}$ are distributed according to the following log-linear autoregressive stochastic processes, respectively:

$$\dot{\theta}_{H,t} = \rho_{\theta_{H}} \dot{\theta}_{H,t-1} + \hat{\varepsilon}_{\theta_{H,t}}, \quad \hat{\varepsilon}_{\theta_{H,t}} \overset{iid}{\sim} N(0, \sigma_{\theta_{H}}^2)$$

$$\dot{\theta}_{F,t} = \rho_{\theta_{F}} \dot{\theta}_{F,t-1} + \hat{\varepsilon}_{\theta_{F,t}}, \quad \hat{\varepsilon}_{\theta_{F,t}} \overset{iid}{\sim} N(0, \sigma_{\theta_{F}}^2)$$

Investment bundles are isomorphic to consumption bundles, but the composition can be different:

$$I_t = \left[ a_{H}^\frac{1}{\eta} (I_{H,t})^{\frac{\eta-1}{\eta}} + (1 - a_{H}) (I_{F,t})^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}$$

For public expenditure, we assume it is fully biased towards domestic goods. The implied basket is:

$$G_t = \left[ \int_0^n G_{H,t}(h) \theta_{H,t}^{\theta_{H,t}-1} dh \right]^{\frac{\theta_{H,t}}{\theta_{H,t}-1}}$$

The production function for the generic intermediate good $h$ is

$$Y_{H,t}(h) = z_{t}^{1-\alpha} \epsilon_t K_{t-1}(h)^\alpha L_t(h)^{1-\alpha}$$

where $z_t$ is a unit-root technology shock capturing world productivity, $\epsilon_t$ is a domestic stationary technology shock. Both shocks are common to all firms. The variable $K_{t-1}(h)$ denotes physical capital stock, rented from domestic households in a competitive market. The stationary technology shock $\epsilon_t$, expressed in log-deviations from its steady state value, is distributed according to the following process:

$$\hat{\varepsilon}_t = \rho_{\epsilon} \hat{\varepsilon}_{t-1} + \hat{\varepsilon}_{\epsilon_t}, \quad \hat{\varepsilon}_{\epsilon_t} \overset{iid}{\sim} N(0, \sigma_{\epsilon}^2)$$

Similarly, the growth rate of the unit-root technology shock is distributed according to the following process:

$$\dot{\mu}_{z,t} = \rho_{z} \dot{\mu}_{z,t} + \hat{\varepsilon}_{z,t}, \quad \hat{\varepsilon}_{z,t} \overset{iid}{\sim} N(0, \sigma_{z}^2)$$

where

$$\mu_{z,t} \equiv \frac{z_t}{z_{t-1}} - 1$$

The variable $L_t(h)$ is a composite of a continuum of differentiated labor inputs, each supplied by a different domestic household under monopolistic competition:

$$L_t(h) = \left[ \int_0^n L_t(i) \sigma_{L,t}^{\frac{\eta_{L,t}-1}{\eta_{L,t}}} di \right]^{\frac{\eta_{L,t}}{\eta_{L,t}-1}}$$

---

3A hat denotes log-deviation from the corresponding steady-state level: $\hat{X}_t = \ln X_t - \ln \bar{X}$.

4We also consider the case of public consumption having the same composition as private consumption. Results are reported in the sensitivity analysis section.
where \(1 \leq \theta_{L,t} < \infty\) is the time-varying elasticity of substitution between labor varieties, which is distributed according to the following log-linear process:

\[
\hat{\theta}_{L,t} = \rho_{\theta} \hat{\theta}_{L,t-1} + \hat{\epsilon}_{\theta_{L,t}}, \quad \hat{\epsilon}_{\theta_{L,t}} \overset{iid}{\sim} N(0, \sigma_{\theta}^2)
\]

Each firm \(i\) minimizes its production costs taking input prices as given. The resulting nominal marginal cost is:

\[
MC_t = \frac{1}{z_t^{1-\alpha} \epsilon_t^\alpha (1-\alpha)^\alpha (R^K_t)^\alpha W_t^{1-\alpha}}
\]

where \(R^K_t\) is the gross nominal rental rate of capital and \(W_t\) the nominal wage rate (corresponding to the price of the bundle \(L_t(h)\)).

Each of the domestic goods is sold domestically and abroad subject to market specific cost of adjusting the price à la Rotemberg (1982). We assume that prices are sticky in the currency of the destination market (local currency pricing assumption). So exchange rate pass-through into import prices is incomplete in the short run. In any period, each intermediate firm can reoptimize its domestic and foreign nominal prices, \(P_{H,t}(i)\) and \(P^*_H,t(i)\) respectively, subject to quadratic adjustment costs in the form of a CES basket of all goods produced in the same (domestic and exporting) sector of the economy:

\[
AC_{H,t}(h) = \frac{\kappa_H}{2} \left( \frac{P_{H,t}(h)}{\pi_H^{\alpha_H} (\pi_t^{1-\alpha_H})} - 1 \right)^2 Y_{H,t}
\]

\[
AC^*_H,t(h) = \frac{\kappa^*_H}{2} \left( \frac{P^*_H,t(h)}{\pi_H^{\alpha^*_H} (\pi^*_t)^{1-\alpha^*_H}} - 1 \right)^2 Y^*_H,t
\]

where \(\kappa_H, \kappa^*_H, \geq 0\) are price adjustment cost parameters in the domestic and foreign economy, respectively. The parameters \(0 \leq \alpha_H, \alpha^*_H \leq 1\) measure the degree of indexation, respectively in the Home and Foreign economy. Specifically, we assume \((1-\alpha_H)\) measures the degree of indexation to the current period central bank time-varying inflation target \((\pi_t)\) and \(\alpha_H\) to last period’s sector-specific gross inflation rate \(\pi_{H,t-1}(\pi_{H,t} = P_{H,t}/P_{H,t-1})\). A similar interpretation holds for \(\alpha^*_H\).

The profit maximization problem yields two standard log-linearized market-specific Phillips curves:

\footnote{Adolfson et al (2007) use a variant of the Calvo (1983) model. It is possible to show that, up to first order, there is a one-to-one mapping between Calvo and Rotemberg models (see [..]). So results are not affected by the choice of the pricing scheme. See also Corsetti, Dedola and Leduc (2008) and Smets and Wouters (2002).}
\[
\hat{\pi}_{H,t} - \alpha_H \hat{\pi}_{H,t-1} - (1 - \alpha_H) \hat{\pi}_t = \beta E_t \left( \hat{\pi}_{H,t+1} - \alpha_H \hat{\pi}_{H,t} + (1 - \alpha_H) \hat{\pi}_{t+1} \right) - \frac{(\theta_H - 1)}{p_H \kappa_H^p} \hat{p}_{H,t} + \frac{(\theta_H - 1)}{\kappa_H^p} \hat{r}_{mC,t} + \lambda \theta_{H,t} \\
\hat{\pi}_{H,t} - \alpha_H \hat{\pi}_{H,t-1} - (1 - \alpha_H) \hat{\pi}_t = \beta E_t \left( \hat{\pi}_{H,t+1}^* - \alpha_H \hat{\pi}_{H,t}^* + (1 - \alpha_H) \hat{\pi}_{t+1}^* \right) - \frac{(\theta_H - 1)}{p_H^* \kappa_H^p} \hat{p}_{H,t}^* + \frac{(\theta_H - 1)}{\kappa_H^p} \hat{r}_{mC,t} - \frac{1}{\kappa_H^p} \hat{r}_{ER,t} + \hat{\theta}_{H,t}
\]

where \(0 < \beta < 1\) is the discount factor of the Home Ricardian representative household (see next section), \(\hat{p}_{H,t}\) (\(\hat{p}_{H,t}^*\)) is the relative price (in terms of local consumption basket) of the Home intermediate good in the Home (Foreign) market, \(\hat{r}_{mC,t}\) is the real marginal cost and \(\hat{r}_{ER,t}\) is the real exchange rate, defined (in levels) as the ratio of consumption prices expressed in the same currency:

\[
RER_t \equiv \frac{S_t P_t^*}{P_t}
\]

where \(S_t\) is the bilateral nominal exchange rate (expressed in Home currency units) and \(P_t\) (\(P_t^*\)) is the Home (Foreign) consumption-based price level.

### 2.2 Ricardian Households

There is a continuum \((0 \leq j \leq (1 - \lambda^{NR}) n, \text{ with } 0 \leq \lambda^{NR} \leq 1)\) of households that maximize utility subject to a standard budget constraint. The preferences of household \(j\) are given by:

\[
E_t \left[ \sum_{k=0}^{\infty} \beta^k \left( \xi^{C}_{t+k} \log (C_{t+k+1} (j) - bC_{t+k+1-1}) - \xi^{L}_{t+k} (L_{t+k+1} (j))^{1+\sigma_L} \right) \right]
\]

where \(C_t(j)\) and \(L_t(j)\) are respectively the \(j\)-th household’s levels of consumption and labor supply in period \(t\). The variables \(\xi^C\) and \(\xi^L\) represent preference shocks to consumption and labor, respectively. The parameter \(b\) (\(0 \leq b \leq 1\)) measures the degree of external habit formation in consumption (\(C_J\) is the consumption level of the Home Ricardian representative agent), while \(1/\sigma_L\) (\(\sigma_L > 0\)) is the labor Frisch elasticity. The two shocks are distributed according to the following autoregressive processes, respectively:

\[
\hat{\xi}^C_t = \rho_{\xi^C} \hat{\xi}^C_{t-1} + \xi_{\xi^C,t} \text{, } \hat{\xi}^C_{t-1} \overset{iid}{\sim} N(0, \sigma^2_{\xi^C}) \\
\hat{\xi}^L_t = \rho_{\xi^L} \hat{\xi}^L_{t-1} + \xi_{\xi^L,t} \text{, } \hat{\xi}^L_{t-1} \overset{iid}{\sim} N(0, \sigma^2_{\xi^L})
\]

Ricardian households can save in domestic and foreign riskless bonds, respectively \(B_{H,t}\) and \(B_{F,t}\) as well as in physical capital \(K_t\). Domestic bonds are denominated in domestic currency and are traded with domestic government, while foreign bonds are denominated
in foreign currency and are traded between domestic Ricardian households and the rest of the world. The resulting budget constraint is:

\[ B_t(j) + S_tB_t^*(j) - B_{t-1}(j) R_{t-1} - S_tB_{t-1}^*(j) R_{t-1}^* \Phi(a_{t-1}, \tilde{\phi}_{t-1}) \]

\[ = (1 - \tau_t^w) W_t(j) N_t(j) + (1 - \tau_t^k) \left( R_{K,t}K_{t-1} - \frac{\Pi_t}{n(1 - \lambda NR)} \right) \]

\[ + TR_t(j) - (1 + \tau_c^t) P_C,t_i(j) - P_I,t_i(j) - \Gamma_W(j) \]

where \( R_t \) and \( R_t^* \) are respectively the gross nominal interest rates on domestic and foreign bonds. The term \( \Phi \) is a premium that depends on the net foreign asset position of the Home economy \( a \) (see below) and ensures a well-defined steady-state.\(^6\) The variables \( \tau_t^w, \tau_t^c, \tau_t^k \), represent taxes on labor income, consumption and capital income. The latter is equal to to the sum of income from renting physical capital, \( R_{K,t}K_{t-1} \) (\( R_k \) is the gross rental rate) and per-capita total profits for ownership of domestic firms, \( (\Pi_t \) represents total profits and we assume ownership is equally distributed across households). The variable \( TR_t(j) \) represents lump-sum transfers from the public sector. The households can invest \( (I_t) \) in additional physical capital \( (K_t) \) undertaking a quadratic adjustment cost. The implied capital accumulation equation is

\[ K_t(j) = (1 - \delta) K_{t-1}(j) + \left( 1 - \frac{\gamma_t}{2} \left( \frac{\Upsilon_tI_t(j)}{I_{t-1}(j)} - 1 \right)^2 \right) I_t(j) \]

(13)

where \( \Upsilon_t \) is a an investment-specific technology shock distributed as follows:

\[ \tilde{\Upsilon}_t = \rho \Upsilon_t + \tilde{\epsilon}_{\Upsilon_t}, \quad \tilde{\epsilon}_{\Upsilon_t} \overset{iid}{\sim} N(0, \sigma_{\Upsilon}^2) \]

Finally, each household is a monopoly supplier of a differentiated labor service. She chooses her own wage given labor demand by domestic firms and public sector and subject to Rotemberg-type wage adjustment costs \( \Gamma_W \):

\[ \Gamma_W(j) = \frac{\kappa_W}{2} \left( \frac{W_t(j)}{W_{t-1}(j)} - 1 \right)^2 L_t \]

where \( \kappa_W \geq 0 \) is the wage adjustment cost parameter, \( \alpha_W \) (0 \leq \alpha_W \leq 1) is a parameter that measures indexation to the wage inflation rate in the previous period and to the current inflation target of the central bank, while \( L \) is the bundle of labor varieties (??).

From the two first order conditions with respect to the two bond positions \( B_t(j) \) and \( B_t^*(j) \) we get a modified uncovered interest parity condition. The latter links the interest rate differential, comprehensive of the premium \( \Phi(a_{t-1}, \tilde{\phi}_{t-1}) \) on the foreign bond

\(^6\)See Benigno (2009) and Schmitt-Grohé and Uribe (2001). The cost implies that domestic households are charged a premium over the foreign interest rate \( R_t^* \) if the net foreign asset position of the country is negative, and receive a lower remuneration if the net foreign asset position is positive.
holdings, to the next period expected exchange rate variation. The premium \( \Phi(a_t, \tilde{\phi}_t) \) is given by

\[
\Phi(a_t, \tilde{\phi}_t) = \exp\left(-\tilde{\phi}_a(a_t - \bar{a}) + \tilde{\phi}_t\right)
\]

where \( a_t \equiv S_t B_t^*/(P_t z_t) \) is the stationary component of net foreign asset position, \( \bar{a} \) the correspondent constant steady state level and \( \tilde{\phi}_t \) is a shock to the risk premium distributed as:

\[
\hat{\tilde{\phi}}_t = \rho_{\xi C} \tilde{\phi}_t + \hat{\varepsilon}_{\xi C, t}, \quad \hat{\varepsilon}_{\xi C, t} \sim iid N(0, \sigma_{\xi C}^2)
\]

### 2.3 Non-Ricardian Agents

We assume a share of Home households \((1 - \lambda_{NR}) \) are non-Ricardian. Non-Ricardian households are modeled in various ways in the literature, leading to different responses of their consumption to changes in their current disposable income. Some authors assume that non-Ricardian households cannot participate in capital markets, but they can still smooth consumption by adjusting their holding of money (consumption smoothing will be less than complete as the return from money holding has a negative real return). In this case, Coenen, McAdam and Straub (2008) show it is very difficult to get a non negative response of private consumption to a government expenditure shock as the response of non-Ricardian consumers is very similar to that of Ricardian households. Other authors show that assumptions implying stronger responses of non-Ricardian agent’s consumption to variations in disposable income are necessary to obtain a positive response of private consumption to government expenditure shocks. In particular, following Campbell and Mankiw (1989), Gali’ et al. (2007) assume that in each period non-Ricardian agents consume their current income. In their work, the strong response of non-Ricardian consumption to disposable income variations is a necessary condition (but not sufficient) to obtain a positive response of total consumption to government spending shocks. In this paper we follow the latter approach and assume that non-Ricardian households consume their after-tax disposable income, as originally proposed by Campbell-Mankiw (1989), which consists of (net of wage taxes) labor income plus net lump-sum transfers from the government:

\[
P_tC_t(j') = (1 - \tau_t^W)W_t(j')L_t(j') + TR_t(j')
\]

Note that this modeling of non-Ricardian households does not impose a positive response of total private consumption to government expenditure shocks. The response will depend, among other things, on the value of the share of non-Ricardian households, \( \lambda_{NR} \) (see the below robustness section for a discussion of this point). The composition of the consumption bundle is the same as in equation (12). The non-Ricardian households set their wage to be the average wage of the optimizing households. Since non-Ricardian households face the same labor demand schedule as the optimizing households, each non-Ricardian household works the same number of hours as the average for optimizing households.
2.4 Central bank

The monetary policy specification is in line with Smets and Wouters (2003) and assumes that the central bank follows an augmented Taylor interest rate feedback rule characterized by a response of the nominal rate $R_t$ to its lagged value, to the gap between lagged gross consumer price inflation inflation $\pi_t^c (\pi_t^c \equiv P_t/P_{t-1})$ and targeted inflation $\bar{\pi}_t$, to the gap between contemporaneous (detrended) output $y_t$ and its steady state value, to changes in inflation $\Delta \pi_t^C = \pi_t^c/\pi_{t-1}^c$ and to (stationary) output growth $\Delta y_t = y_t/y_{t-1}$. In log-linearized form we have:

$$
\hat{R}_t = \rho_R \hat{R}_{t-1} + (1 - \rho_R) \left( \hat{\pi}_t^c + r_x (\hat{\pi}_{t-1}^c - \hat{\pi}_t^c) + r_y \hat{y}_t \right) 
+ r_{\Delta x} \Delta \hat{\pi}_t^C + r_{\Delta y} \Delta \hat{y}_t + \varepsilon_{R,t}
$$

where $\varepsilon_{R,t}$ is an uncorrelated monetary policy shock with variance $\sigma_R^2$ and $\hat{\pi}_t^c$ is a shock to the monetary authority target, distributed as:

$$
\hat{\pi}_t^c = \rho_x \hat{\pi}_t^c + \varepsilon_{\pi,t}, \quad \varepsilon_{\pi,t} \sim iid N(0, \sigma_{\pi}^2)
$$

2.5 Fiscal Policy

We consider the following budget constraint:

$$
[B_t^G - B_{t-1}^G R_{t-1}] = P_{H,t} \left( 1 + \tau_t^C \right) G_t + W_t L_t^G + TR_t - T_t
$$

where $B_t^G > 0$ is the public debt. We assume it is traded with domestic Ricardian agents only. The variable $G_t$ is government purchases of goods and services (we assume that the public sector buys only domestic goods and that pays the related consumption tax rate $\tau_t^C$), $w_t L_t^G$ is the expenditure for wage of public employees, $TR_t$ are transfers to households and $T_t$ are taxes. We assume that the stationary components of government purchases and transfers expressed in real terms (deflated by domestic consumer prices), respectively $g$ an $tr$, follows the rules below:

$$
\hat{g}_t = \rho_g \hat{g}_{t-1} + (1 - \rho_g) \eta_g \hat{B}_t + \varepsilon_{g,t}, \quad \varepsilon_{g,t} \sim iid N(0, \sigma_g^2)
$$

$$
\hat{tr}_t = \rho_{tr} \hat{tr}_{t-1} + (1 - \rho_{tr}) \eta_{tr} \hat{B}_t + \varepsilon_{tr,t}, \quad \varepsilon_{tr,t} \sim iid N(0, \sigma_{tr}^2)
$$

where $\hat{B}_t = (\ln B_t^G/P_t - \ln(B_t^G/P))$ is the (stationary component of) public debt expressed in real terms, the parameters $0 \leq \rho_g \leq 1$ and $0 \leq \rho_{tr} \leq 1$ measure the inertia in changing the correspondent fiscal variables and both $\varepsilon_{g,t}$ and $\varepsilon_{tr,t}$ are i.i.d. innovations. Finally, the parameters $\eta_g > 0$ and $\eta_{tr} > 0$ measure the response of, respectively, government consumption and public transfers to public debt.

Public sector labor demand is modeled as an autoregressive exogenous stochastic process in logs with i.i.d. error term, of the form:

$$
\hat{L}_t^G = \rho_{Lc} \hat{L}_{t-1}^G + \varepsilon_{Lc,t}, \quad \varepsilon_{Lc,t} \sim iid N(0, \sigma_{Lc}^2)
$$
We assume that the wage rate in the public sector is equal to the one prevailing in the private sector.\footnote{This assumption is not far from reality, as hourly wages in the public sector tend to track private sector ones over medium terms horizons.} Consistently with the existing empirical evidence on euro area, we assume that the labor income tax rate is determined according to the following rule:

\[
\hat{\tau}_w^t = \rho \tau_r \hat{\tau}_{w-1}^t + (1 - \rho \tau_r) \eta_r \hat{B}_t + \hat{\xi}_{w,t}, \quad \hat{\xi}_{w,t} \overset{iid}{\sim} N(0, \sigma_{\xi_{w,t}}^2)
\]  

while tax rates on capital income and consumption follow an exogenous AR(1) process

\[
\hat{\tau}_k^t = \rho \tau_r \hat{\tau}_{k-1}^t + \hat{\xi}_{k,t}, \quad \hat{\xi}_{k,t} \overset{iid}{\sim} N(0, \sigma_{\xi_{k,t}}^2)
\]

\[
\hat{\tau}_c^t = \rho \tau_r \hat{\tau}_{c-1}^t + \hat{\xi}_{c,t}, \quad \hat{\xi}_{c,t} \overset{iid}{\sim} N(0, \sigma_{\xi_{c,t}}^2)
\]

Finally, we assume that the Total taxes \( T \) are given by the following identity:

\[
T_t \equiv \tau_w^t W_t n L_t + \tau_r^t (1 - \lambda NR) n C_t + P_t \lambda NR n C_t + P_{H,t} G_t
\]

\[
+ \tau_k^t R_k^t (1 - \lambda NR) K_{t-1} + \tau_c^t \Pi_t
\]

where \( \Pi_t \) are total profits in the economy. Note we assume that \( \tau_w^t \) is the same for both Ricardian and non-Ricardian households.

### 2.6 Foreign Economy

The setup of the Foreign economy is stylized so to get a parsimonious model. We assume there is a Euler equation for aggregate demand (without making any distinction between consumption and investment), two Philips curves (one holds domestically and the other in the Home country, because we assume that local currency pricing holds also for foreign firms), a Taylor rule reacting to domestic inflation and total output. Finally, we also assume that the foreign aggregate demand is a CES bundle of foreign and home goods, with weights respectively \( a_F \) and \( (1 - a_F) \) and elasticity of substitution \( \eta \). The chosen calibration (see next section) implies that the foreign economy is substantially closed and spillovers from the euro area are small, consistently with the assumption of small open economy.

Specifically, we add the following set of log-linear equations to those holding for the Home economy:

\[
\hat{\lambda}_t^* = \hat{\lambda}_{t+1} + \hat{\eta}_t^* - \hat{\tau}_{t+1}^*
\]

\[
\hat{\lambda}_t^* = \frac{1}{1 - h^* g_z^{-1}} \hat{a}_d^* + \frac{h^* g_z^{-1}}{1 - h^* g_z^{-1}} \hat{a}_d_{t-1} - \frac{h^* g_z^{-1}}{1 - h^* g_z^{-1}} \hat{a}_d_{t} + \hat{\varepsilon}_{d,t}^* - \phi (1 - n) y^*_F \hat{g}_F_{t,t} + \gamma_F \hat{a}_d^* \hat{a}_d_{t}
\]

\[
(1 - n) y_H^* \hat{g}_H_{t,t} = -\phi \eta y^*_H \hat{p}_{H,t} + (1 - \gamma_F) \hat{a}_d^* \hat{a}_d_{t}
\]
\[ R_t^* = \rho_R^* R_{t-1}^* + (1 - \rho_R^*) \left( \hat{\pi}_{t}^{C^*} + r_\pi^* (\hat{\pi}_{t-1}^{C^*} - \hat{\pi}_{t}^{C^*}) + r_\pi^* y_t^* \right) \]
\[ + r_{\Delta}^* \Delta \hat{\pi}_{t}^{C^*} + r_{\Delta}^* \Delta \hat{y}_t^* + \varepsilon_{R,t}^* \]  \hspace{1cm} (28)

The first equation is the Euler condition for foreign aggregate demand (we do not distinguish between foreign consumption and investment). The second equation defines the Lagrange multiplier \( \lambda^* \) in terms of foreign aggregate demand and a shock \( \varepsilon_{t}^{ad} \) following a standard AR(1) process. The parameter \( h^* \) measures habit in aggregate demand. The third and fourth equations are market clearing conditions for foreign and home good in the foreign country, respectively. The fifth equation is the monetary policy rule. Finally, the last two equations are the Phillips curves of the foreign good in the home and foreign market, respectively. We assume that the marginal cost is directly proportional to foreign aggregate demand (the weight of exports to the home country in the total demand of foreign good is negligible) and inversely proportional to the Lagrange multiplier. We assume that the shocks to foreign aggregate demand, to foreign good markup in the home and foreign market and to foreign monetary target follow log-linear AR(1) processes. The monetary policy shock is assumed to be i.i.d.

2.7 The trade balance of the Home economy

The Home trade balance is obtained by consolidating the private sector aggregate budget constraint and the government budget constraint, taking into account that the Home public debt is traded only with domestic Ricardian households and it’s not internationally traded. Assuming that a symmetric equilibrium holds (so there is a representative agent for each type of households, Ricardian and non-Ricardian), the resulting trade balance is:

\[ TB_t = S_t n B_t^* - S_t n B_{t-1}^* - S_t n B_{t-1}^* (j) R_{t-1}^* \Phi \left( a_{t-1}, \phi_{t-1} \right) \]
\[ = P_{H,t} Y_{H,t}^* + S_t P_{H,t} n Y_{H,t}^* - P_t n (1 - \lambda_{NR}^*) C_t - P_{H,t} n (1 - \lambda_{NR}^*) I_t - P_{H,t} G_{t} \]
\[ = S_t P_{H,t} n Y_{H,t}^* - P_{F,t} (1 - n) Y_{F,t} \]

The first equality expresses the trade balance as the result of the change in the net foreign asset position. The second equality as the difference between total aggregate revenues from production and total aggregate expenditures. Finally, the third equality is net exports,
both expressed in domestic currency. The ratio of import-to-export prices, both expressed in Home currency, defines the home terms of trade:

\[ \text{tot}_t = \frac{P_{F,t}}{S_t P^n_{H,t}} = \frac{p_{F,t}}{\text{RER}_t p^n_{H,t}} \]

where \( \text{RER}_t \) is the home real exchange rate (see equation (??)) while \( p_{F,t} \) and \( p^n_{H,t} \) are prices of home imports and exports expressed respectively in terms of home and foreign consumption.

3 Data

We use quarterly Euro area data for the period 1980:1–2005:4 to estimate the model. We match the following twenty one variables: GDP, consumption, investment, government consumption, exports, imports, the real exchange rate, the short-run interest rate, wage inflation, private employment, public employment, the GDP deflator, the consumption deflator, the investment deflator, transfers to families, average effective tax rate on labor, average effective tax rate on capital, average effective tax rate on consumption, foreign output, foreign inflation and the foreign interest rate.

Data are from the Area Wide Model data set and, for fiscal variables, from Forni et al. (2009).\(^8\) In the AWM data set export and import series include both intra- and extra-area trade and there is no series on aggregate hours worked. The exchange rate is the ECB’s official effective exchange rate for the 12 main trading partners of the Euro area with weights based on 1995–1997 manufactured goods trade.\(^9\) The data set also includes foreign output and prices (weighted average of, respectively, the GDP and GDP deflator series for the U.S., the United Kingdom, Japan and Switzerland). It does not include data on foreign interest rate and euro area hours worked. Regarding the former, the Fed funds rate is used as a proxy. For hours worked we use employment, which we model using a Calvo-rigidity equation:\(^{10}\)

\[ \hat{E}_t = \frac{\beta}{1 + \beta} E_t \left[ \hat{E}_{t+1} \right] + \frac{1}{1 + \beta} \hat{E}_{t-1} + \frac{(1 - \beta \xi_E) (1 - \xi_E)}{(1 + \beta) \xi_E} \left( \hat{N}_t - \hat{E}_t \right) \]

where \( 1 - \xi_E \) is the fraction of firms that can adjust the (log-linear) level of employment \( \hat{E} \) to the preferred amount of total labor input \( \hat{N} \).

Estimates concerning the effects of fiscal policy for the Euro area are usually constrained by the lack of quarterly data on government accounts. Eurostat has recently started to release quarterly data on general government accounts, but only starting from 1999, i.e. a period too short to be used for our purposes. As we use quarterly data for government consumption, transfers to families, public employment and average effective tax rates, we can model the fiscal policy with more detail than previous work. First, we

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\(^8\)For details on the AWM dataset see Fagan et al. (2005).

\(^9\)See Adolfson et al. (2006).

\(^{10}\)See Smets and Wouters (2003).
can distinguish within expenditures and revenues. Moreover, estimating average effective tax rates allows us to use proportional distortionary taxation, a feature that is more realistic, and more appropriate for estimation purposes than assuming lump-sum taxes.

The assumption of non stationary technology shock implies a common stochastic trend in the real variables. We make them stationary by using first log-differences. We remove a linear trend from the employment and public expenditures. We also remove an excessive trend of import and export (with respect to output) series, to make the correspondent shares stationary.\textsuperscript{11} Employment, tax rates, public expenditure and the real exchange rate are measured as percentage deviations around the mean. For all other variables, we use the seasonally adjusted series, without demeaning.

Finally, consumption and investment aggregates in the model are CES composites of domestic and imported goods. This assumption does not hold in the data. We take into account of it when estimating the model by constructing data-consistent consumption and investment variables.\textsuperscript{12}

4 Estimation

In what follows we describe calibrated parameters and the prior distributions of estimated parameters. The model is estimated with Bayesian methods (a posterior distribution of the model is obtained by updating the information contained in the prior distribution with the information in the observed data).

4.1 Calibrated parameters

We calibrate parameters that allow to match the sample mean of observed variables and those that are weakly identified. In Table 1 we report both the calibrated parameters and in Table 2 the implied steady state values of main variables.

Following Coenen et al. (2008), we set private home consumption, investment and government consumption as a ratio to home GDP respectively to 59, 23 and 20 percent. To match the investment-to-GDP ratio, we calibrate the depreciation rate $\delta$ of physical capital to 0.025 and the share $\alpha$ of capital in the production function to 0.31.

The home-bias parameters ($a_H$ in the Home consumption bundle, $a_{HI}$ in the Home final investment bundle and $a_F^*$ in the foreign country) are set to values that allow to match the import content of consumption and investment spending— roughly 10 and 6 percent, expressed as shares of nominal GDP— in line with Coenen et al (2008) and that imply that the foreign country is substantially a closed economy. The elasticity of substitution between domestic and imported goods, $\eta$, is set to 4.5, in line with Adolfson et al (2007). The steady state elasticity of substitution between brands ($\theta_H, \theta_F, \theta_H^*, \theta_F^*$) is set to 6, consistently with a steady state markup equal to 1.2. The substitution elasticity

\textsuperscript{11}See Adolfson et al. (2005).
\textsuperscript{12}See Adolfson et al. (2005) for details.
between labor varieties, $\theta_L$, to 4.33.

We assume that the steady state growth rate of the world economy is 2.0 percent per annum (consistently with the average sample real GDP growth). The steady state trade balance and the net foreign asset position are set to zero. The discount factor $\beta$ is calibrated consistently with an annualized equilibrium real interest rate of 2.0 percent. The monetary authority’s long-run annualized gross inflation objective $\pi$ is set to 2.0 percent. The inverse of the labor supply elasticity, $\sigma^L$, is set to 2, consistently with the existing literature.

On the fiscal side, as for steady state values, based on sample averages we set public expenditures for consumption goods at 20 percent of output, debt at 60 percent (on a yearly basis). Steady state values for tax rates are assumed to be simply the averages over the sample period of our estimates of average effective tax rates (approximately equal to 16 percent for consumption taxes, 19 percent for capital income taxes, 45 percent for labor income taxes). Given these figures, the steady state value for transfers is set residually so as to satisfy the government budget constraint.

### 4.2 Prior distributions of the estimated parameters

Table 3 shows the prior distribution of the estimated parameters (first fourth columns from the left hand side). The location of the prior distribution corresponds to a large extent to that in Adolfson et al (2007) and Forni et al. (2009). Parameters bounded between 0 and 1 are distributed according to a beta distribution (habit persistence $b$, indexation parameters $\alpha$ and coefficients of shock autocorrelation $\rho$). Positive parameter have an inverse gamma distribution (wage and price stickiness parameters $\kappa$, adjustment cost on investment $\gamma_I$, standard deviations of the shocks $\sigma$, tax rate and public expenditure responses to public debt in the fiscal rules $\eta_b$). Finally unbounded parameters are distributed according to the normal distribution (interest rate response to output and output growth in the Taylor rule $\rho_y$ and $\rho_{\Delta y}$).

The (domestic, imported and exported goods) price and wage stickiness parameters are set so that the average length between price, or wage, adjustments is four quarters. The range covered by the prior distributions of both parameters is chosen so as to span approximately from less than one fifth to more than double the mean frequency of adjustment, therefore including very low degrees of nominal rigidity. Parameters measuring the degree of price and wage indexation are set to 0.5. Investment adjustment coefficient has a mean of 7.694 and a standard deviation equal to 1.5. Regarding the monetary policy rule, the prior mean on the the lagged interest rate coefficient is set to 0.8, those on inflation and inflation growth coefficients respectively to 1.7 and 0.3. Finally, the coefficient responding to output (deviation from steady state) and output growth are set respectively to 0.125 and 0.0625. All the autocorelated shocks have an autoregressive coefficient set to 0.85. The prior on the risk premium parameter, $\Phi$, is set to 0.01.

Tax policies are a priori taken to be quite persistent, with autoregressive coefficients having a prior mean set to 0.8 (standard deviation equal to 0.1). Labor income tax rate and public expenditures (for consumption and transfers) elasticities with respect to
debt are all assumed to have a mean equal to 0.02 (standard deviation equal to 0.005). Innovations to all shocks are assumed to be white noise with standard deviation having mean set to 0.1 percent.

4.3 Posterior distributions of the estimated parameters

Given priors, we estimate the posterior distributions of the parameters using the Metropolis–Hastings algorithm with two hundred thousand iterations. Table 3 shows the posterior mode of all the parameters, the posterior standard deviation, the mean along with the 5th and 95th percentiles of the posterior distribution.

On the fiscal policy side, tax rate processes appear to be highly persistent. The autoregressive parameter for government purchases, and transfers to households are estimated at respectively 0.984 and 0.986, pointing to a high persistence of fiscal policy innovations.

The estimate for price stickiness suggests that in the euro area prices are more sticky than wages (a similar result is obtained by Adolfson et al. (2007). Habit parameter is estimated to be relatively low

The posterior mode of the persistence parameter in the unit-root technology process is estimated to be 0.99. We find a similar value for the stationary technology shock. For other shocks, the persistence coefficients are substantially lower.

In Figure 1 we report the data and the correspondent fitted values obtained from the benchmark model estimated at the mode. The in-sample fit of the model appears to be satisfactory.

5 Impulse response Functions

5.1 Public expenditure shocks

We now discuss the implications of our estimates for the effects of government spending shocks on the economy. Fig. 2 shows impulse responses with respect to a shock to real detrended government purchases of goods and services, Fig. 3 with respect to real detrended transfers, while Figure 4 with respect to real detrended government outlays for public employment. The solid line shows median values, while the dotted ones the 5th and 95th percentile based on posterior distributions. The magnitude of the shocks is set in order to have an increase in expenditures equal to one percent of steady state output. Impulse responses are expressed as percent deviation from steady state values. The exceptions are the interest rate and the inflation rate, expressed as annualized percentage points, and fiscal and trade balance reported as a ratio to domestic steady state output (percentage points from steady state).

The shock to public government purchases (Figure 2) increases employment by increasing the demand for goods and services which, in turn, brings about an increase in labor income. This sustains consumption of non-Ricardian households, to an extent that,
however, is barely enough (also in view of their share) to compensate for the decrease in Ricardian consumption due to the negative wealth effect of debt-financed spending and the higher real interest rates (that crowds out also investment). On impact, the government spending multiplier does not exceeds unity.

The higher GDP, sustained by public demand, leads to an increase in the government budget deficit as a share of GDP of about 0.6 per cent of the initial shock. After the initial period, the deficit gradually decreases, because labor income taxes and transfer adjust to make the public debt stable.

Imports rise, following the increase in the home private demand. The public expenditure is fully biased towards the domestic good, so its increase induces an improvement in the home terms of trade.\textsuperscript{13} The increase in the home goods relative prices favors a decrease in export. The trade deficit-to-GDP ratio deteriorates by about 0.4 percentage points in the first quarter (the peak level). Overall, the effect of public deficit on the external balance is rather strong.

Figure 3 reports the effects of a shock to transfers to households. It has a significant and persistent impact on consumption as it translates one to one into an increase in disposable income of non-Ricardian households. Demand-driven output and employment also increase, while real wages are substantially unchanged. The GDP response however is about 0.25 percentage points on impact, therefore substantially lower than the response to a public purchase or employment shock (for this latter see below) that - differently from transfers - are included in aggregate output. Consumption and capital accumulation by Ricardian agents decrease, mainly because of the negative wealth effect of debt-financed spending (due to distortionary taxation) and to the higher long term real interest rate (not shown). The higher public transfer implies an initial increase in the government budget deficit by about 0.9 percentage point of GDP on impact. Subsequently, the deficit decreases very slowly.

Higher private consumption favors higher demand for domestic goods and higher imports. The trade balance-to-output ratio response is instead, differently from the case of the shock to government purchases, rather muted (around 0.1 percent). The higher private aggregate demand induces, on top of the increase in imports, an improvement in the terms of trade.

Figure 4 shows impulse responses to an increase in public employment that brings about an increase in expenditure (at steady state values) equal to 1% of GDP. The higher labor income leads to an increase in non Ricardian consumption, while for Ricardian ones the usual negative wealth effect due to the increase in public expenditures applies. The increase in public employment also leads to an increase in real wages, that in turn crowd out employment in the private sector (which becomes negative starting from the second quarter after the shock). Together with the reduction in private employment, also investment contracts. Output is supported by the public component, as the expenditure for

\textsuperscript{13}We have estimated a version of the model where the composition of government purchases is the same as the one of private consumption and therefore not fully biases toward domestic production. Quantitative results regarding the macroeconomic effects are not substantially different. Specifically, the GDP multiplier is slightly lower, as it is the improvement of the terms of trade.
public employees is included in the measure of GDP (in fact public services are computed at their production costs).

The terms of trade appreciates, imports increase and export decrease. This leads to a worsening of the trade balance of about 0.4 percentage points on impact. Due to the increase in GDP, the primary balance increase by about half of the initial shock.

5.2 Shocks to tax rates

Next we look at the effects of tax rates innovations. Figures 5-7 plot the impulse responses of a shock to the tax rate on, respectively, labor income, capital income and consumption, all calibrated in order to achieve a decrease in revenues equal to 1% of steady state output.

The reduction in labor income tax rate leads to an outward shift of labor supply, higher consumption and accumulation of physical capital by Ricardian agents. Also non-Ricardian agents increase consumption, given the higher available income (lower taxes and higher number of hours worked more than compensate for the reduction in real wage). In the first period the public deficit increases by 0.8% of GDP. Higher aggregate demand drives up imports. The real exchange rate and terms of trade depreciate because of higher supply of home goods, whose production is driven up by higher labor supply. Exports increase, contributing to reduce the high supply of home goods. The trade balance deteriorates by about 0.2 points in the first quarter and continues to deteriorate thereafter, up to a maximum value of 0.3 percentage points in the 10th quarter.

Figure 6 reports the effects of a decrease in capital income tax rate. Ricardian intertemporal choice starts favoring investment rather than consumption. Labor moves mildly, given the incentive to substitute capital for labor. Consumption of non-Ricardian agents remain stable, because their disposable income is relatively constant. Overall, aggregate consumption falls. On impact the public deficit increases by 0.9 percent point of GDP. Higher aggregate demand for investment favors higher imports, while exports initially slightly decrease and subsequently gradually increase, following the smooth increase in domestic good supply. The trade balance slightly deteriorates, up to -0.05 percentage points in the 3rd year.

Figure 7 shows that a decrease in consumption tax rate brings about a one time decrease in inflation (around 5% on annual terms). The lower tax rate stimulates households to increase consumption, while investment in physical capital increases only slightly. Firms increase output to meet the additional demand and they do so by increasing employment. The strong increase in economic activity limits the loss of public revenues. The deterioration is rather the same in the following periods, given the extremely high persistence of the negative consumption tax shock. Higher aggregate demand favors the improvement of the home terms of trade (which is computed net of consumption taxes, that is consumption taxes do not enter in the computation of import prices) and higher imports. Higher aggregate supply is absorbed mainly through the higher domestic demand. Overall, the trade balance after an initial deterioration, moves quickly to a persistent surplus.
5.3 Fiscal multipliers

To summarize the quantitative effects of our six fiscal shocks we report in Table 4 the fiscal multipliers on output, consumption, investment, imports, exports, real exchange rate and inflation implied by our estimates. We report the average effects in the first 1 and 4 quarters (first two lines) and from 4th to 8th quarters (third line) respectively, expressed in percentage points (annualized in the case of inflation).

Fiscal multipliers on output and consumption are quite sizeable, although generally smaller than one. The average effect on output in the first quarter is, as expected, greatest for a shock to purchases of good and services and to the public wage bill (these being part of aggregate demand; note that these two cases are the only ones delivering a GDP multipliers not smaller than one on impact); the other shocks all have GDP multipliers between zero and 0.6. In general, on a yearly basis, we never have multipliers grater than one. The effect on private consumption is higher for innovations to consumption taxes, labor taxes and transfers. The effect, in all cases, works through an increase in household real income (this is true in particular for non-Ricardian agents). For Ricardian agents an intertemporal substitution effect, favoring an increase in consumption, is at work in the case of consumption and labor taxes.

The fiscal multipliers on imports mimics the multiplier on consumption and investment, depending on the considered fiscal shock. The highest value is reached in correspondence of shocks to labour income tax, consumption tax and transfer (that stimulates private consumption), somewhat smaller for capital income (that stimulate private investment). The effects on the real exchange rate and inflation are generally mild. The only notable exception are the innovations in consumption taxes, as they translate one to one to prices and therefore affect strongly the real exchange rate.

6 Sensitivity Analysis

We have performed sensitivity by looking at the impulse responses to our fiscal shocks allowing one single parameter to move at a time while leaving the other parameters set at their estimated values. We focused on the following parameters: among calibrated ones, the share of non-Ricardians and the elasticity of intratemporal substitution between domestic and imported goods; among estimated one, the parameters of the fiscal and monetary rules (in particular, the persistence of the Fiscal rules). These are the parameters that most can impact on private consumption, and therefore imports, and on the composition of final demand in domestically produced and imported goods.

Overall results are robust to variations in these parameters within reasonable bounds. Two relevant cases, that we discuss below, are the effect of the share of non-Ricardian consumers on domestic consumption and imports (and therefore trade balance) and the response of the real exchange rate for values of the elasticity of intratemporal substitution between domestic and imported goods higher than the one we assume. We will discuss these two cases with reference to a government expenditure shock.
Figure 8 reports the impact responses of total private consumption, investment, imports and the trade balance (upper panel), and of the terms of trade and real exchange rate (lower panel) following a government expenditure shock for values of \( \lambda^\text{NR} \) between zero and one. The response of consumption and imports is significantly increasing in the share of non-Ricardian agents. The consumption response becomes positive for values of \( \lambda \) around 0.4 (note that for this exercise we use the parameter values at the mode, while the solid line of the impulse response functions was the median value, so that the results are not exactly comparable). Consistently with the response of domestic consumption, that induce a stronger increase in demand for domestic goods, the terms of trade appreciates to a bigger extent and the real exchange rate appreciates less.

Figure 9 shows the response to a government expenditure shock of the same variables, now moving the value of the elasticity of substitution between domestic tradables and imported goods. The impact responses highlight that real variables (consumption, investment and imports) tend to remain relatively stable, while the relative prices (terms of trade and real exchange rate) move significantly.

Figure 10 shows the responses to a spending shock for values of the persistence of the fiscal shock (\( \rho_G \)) between 0.8 and 1. A more persistent process produces a stronger negative wealth effect on Ricardian agents that drives down consumption and imports. The real exchange rate appreciate more.

Finally the response of variables is inversely proportional to the tightness of monetary policy. These effects however are not very strong and therefore we do not show any particular figure on this point. Higher consumption and import responses are obtained when the coefficient of response to CPI inflation in the Taylor rule is low and there is a lower reaction of the nominal interest rate to the fiscal stimulus (so that the increase in the real interest rate is lower, and the implied depressing effect on Ricardian aggregate effect is lower as well).

7 Conclusions

This paper reconsidered the economic effects of fiscal policy using an estimated small open economy dynamic stochastic general equilibrium model for the Euro area. In particular we estimated the size of fiscal multipliers obtained in an open economy setting and the effects of fiscal shocks on the Euro area trade balance and real exchange rate. To this end, we have developed a standard small open economy model, similar to recent contributions by Adolfson et al. (2007) and Coenen et al. (2008). Differently from them, we follow Corsetti et al. (2009) and Forni et al. (2009) by including non-Ricardian households and multiple fiscal policy rules on both expenditures and revenues.

Our results points to annual GDP fiscal multipliers of public expenditures not bigger than one. On the revenue side, tax cuts on labor income and consumption have expansionary effects on GDP similar to the ones of expenditure shocks. We have shown also that expansionary fiscal policy innovations - both those on the expenditure and revenue side - tend to deteriorate the trade balance and to depreciate the real exchange rate.
References


Table 1 Calibrated parameters

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<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Value</th>
</tr>
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<tr>
<td>(\beta)</td>
<td>Discount factor</td>
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<td>(\alpha)</td>
<td>Capital share in production</td>
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<td>(\eta)</td>
<td>Substitution elasticity btw tradables</td>
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<td>(\sigma^L)</td>
<td>Labor supply elasticity</td>
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<td>(\delta)</td>
<td>Depreciation rate of capital</td>
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<td>(\theta_i (i = H, F, H^<em>, F^</em>))</td>
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<td>(\theta^L)</td>
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<td>(1 - a_{HI})</td>
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<td>(1 - a_{H})</td>
<td>Imported consumption share</td>
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<td>(\lambda^{NR})</td>
<td>Share of rule-of-thumb agents</td>
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<td>(\tau^w)</td>
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<td>(n)</td>
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Table 2 Steady state relationships

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<td>(gr)</td>
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<td>(R)</td>
<td>Nominal interest rate</td>
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<td>(I/(pyY))</td>
<td>Investment-to-output ratio</td>
<td>0.23</td>
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<td>(M(X)/(pyY))</td>
<td>Imports (Exports)-to-output ratio</td>
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<td>(BF/(pyY))</td>
<td>Net foreign asset</td>
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<td>Rev. on capital income tax-to-output ratio</td>
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Table 4. Fiscal multipliers

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*Note:* Fiscal multipliers are computed as averages of percent responses over the specified number of quarters. Expenditure innovations are set equal to 1% of steady state output. Tax rates innovations are such that the reduction of revenues is equal to 1% of steady state output. The change in inflation is expressed in annualized percentage points.
Fig. 1 Data (thick) and one-sided predicted values from the model (thin)
Figure 2 Increase in public purchases

- Private Hours
- Gov. Cons./GDP
- Real exc. rate
- Cons. RoT
- Gov. Exp. Shock

- Terms of trade
- Gov. Rev./GDP
- Nominal rate
- Cons. Ric.
- Real wage

- Trade bal./GDP
- Gov. Tran./GDP
- Import
- Cons. Consumption
- Labor tax rate

- Prim def./GDP
- Infl. (ann)
- Export
- GDP
- Investment
Figure 3: Increase in public transfers
Figure 4 Increase in public employment
Figure 5. Reduction of wage income tax rate.
Figure 7 Reduction of consumption tax rate
Figure 8 Sensitivity - Impact responses to a public expenditure shock of main variables for different values of the non-Ricardian households share
Figure 9 Sensitivity - Impact responses to a public expenditure shock of main variables for different values of the elasticity of substitution between domestic and imported goods.
Figure 10 Sensitivity - Impact responses to a public expenditure shock of main variables for different values of the shock persistence