Fiscal policy in open economy: estimates for the euro area*

L. Forni

International Monetary Fund

M. Pisani†

Bank of Italy

December 19, 2010

*We thank Cristina Badarau, Giancarlo Corsetti, Filippo Ferroni, Andrea Gerali, Ricardo Mourinho Félix, Evi Pappa, Michel Strawczynski. We also thank participants in seminars at Bank of Italy (2009), European University Institute (2009), University La Sapienza (2010) and participants in the following workshops and conferences: "Second Bank of Italy Conference on Macro modeling in the policy environment" (2009), Bank of Finland "6th Dynare Conference" (2010), Bank of Israel "Central Bank Macroeconomic Modeling Workshop" (2009), Ceis-University Tor Vergata "Recovery after the crisis: perspectives and policies Workshop" (2010), Bank of France "Structural Analysis in Times of Crisis International Conference"(2010). We thank Fabio Coluzzi for excellent research assistance. All errors are ours. Usual disclaims hold.

†Lorenzo Forni. E-mail: lforni@imf.org. Fiscal Affairs Department, International Monetary Fund, 700 19th Street, NW Washington, DC, 20431, US. Tel: +1 (202) 623 76 27. Massimiliano Pisani. E-mail: massimiliano.pisani@bancaditalia.it. Research Department, Banca d'Italia. Via Nazionale 91, 00184 Rome, Italy. Tel: +39 06 4792 3452.

Abstract

We estimate a dynamic general equilibrium model of an open economy to measure the effects of alternative expansionary fiscal shocks on the trade balance in the euro area. We do find that expansionary fiscal shocks - both those on the expenditure and revenue side - induce a joint deterioration of the public sector balance and trade balance. The output multipliers are always below one, while the deterioration of the trade balance and the trade leakages are relatively small. The largest value of trade deficit is equal to -0.1 percent of output and is obtained conditionally to a public consumption or a consumption tax shocks. The deficit is generally driven by the increase in imports and decrease in exports, partially compensated by the improvement in the terms of trade. Only in the case of the expansionary labor tax shock, higher imports and the deterioration in the terms of trade are partially compensated by higher exports The monetary policy stance and the type of fiscal financing do not greatly affect the size of trade balance deterioration, even if they magnify the impact of fiscal shocks on gross imports and international relative prices.

JEL codes: E32, E62, E63, F32, F41, H30

Keywords: Fiscal policy, distortionary taxation, DSGE modeling, Bayesian estimation, Real exchange rate, Twin deficits, budget deficits, trade deficits, openness, crowding out, international transmission of fiscal policy.

1 Introduction

The worldwide recession of 2008–09, the implemented fiscal stimuli and the more recent debate on fiscal exit strategies have renewed interest on the size of fiscal multipliers in open economy, the size of the trade leakages, the sign and the size of the effects of fiscal stimuli on net exports and international relative prices.

The conventional prediction of theoretical models is that (discretionary) fiscal expansions should have negative effect on the trade balance (twin deficit hypothesis) and on the real exchange rate. Insofar as a fiscal expansion appreciates the domestic currency, net exports fall, causing the twin deficits. As such, the fiscal multiplier is predicted to be inversely related to the trade leakages. The precise effect on trade variables and, hence, on the size of fiscal multipliers, depends however on several factors, as many transmission mechanisms characterize an open economy perturbed by a fiscal shock. Among the others, the type of implemented fiscal measures (public spending or tax rate shock), their persistence, the way and the speed that characterize public debt stabilization, the type of behavior followed by households (if fully Ricardian or not), the structural characteristics of the economy (its degree of openness, the exchange rate pass-through into consumer prices, the degree of substitutability between domestic and foreign goods) and last, but not least, the reaction of monetary policy (more or less accommodative) and the relates exchange rate dynamics.

To evaluate these issues, we develop and estimate on euro area data a new-Keynesian open economy model along the lines of Adolfson et al. (2007). On the theoretical ground, consistently with our goal, we enrich the model by Adolfson et al. (2007) with several fiscal features that, by relaxing the Ricardian equivalence assumption, allow nontrivial effects of fiscal shocks on the trade balance and international relative prices. Specifically, we break the Ricardian equivalence in two ways. First we introduce Keynesian effects of public expenditure through non-Ricardian households, that in each period consume all the available income as in Gali et al. (2007).[1] Second, we introduce multiple fiscal rules, assuming that distortionary (on labor income, capital income and consumption) tax rates, public consumption and public transfers to households can be appropriately and simultaneously modified by the fiscal authority to stabilize public debt.[2] In this way we can assess in a rather exhaustive way how the evolution of fiscal balance affects the

[1] Devereux et al. (2009) and Kollman (2009) exploit rule-of-thumb households to explain the the consumption-real exchange rate anomaly.

[2] See Leeper et al. (2010).

external balance of the economy. On the empirical side, we estimate the model with Bayesian methods using the Area Wide Model database and, more importantly, a rich dataset on euro fiscal variables (public expenditure and taxation) from Forni et al. (2009).

The model includes all the features commonly used in the open economy literature for characterizing the dynamics of trade balance and international relative prices. We allow for asymmetric home bias in final consumption and investment goods, for local currency pricing as a source of international price discrimination and short-run incomplete pass-through, for international incomplete markets to have a non trivial role for current account and trade balance. The open economy is specialized in the production of a tradable good, produced under monopolistic competition regime using domestic labor and physical capital. Furthermore, we assume that the open economy imports a tradable good from the rest of the world. We formalize the latter, consistently with Adolfson et al. (2007), by assuming that foreign inflation, output and interest rate are exogenously given.[3] A riskless bond, denominated in foreign currency, is internationally traded while a bond denominated in domestic currency is traded in the euro area. As such, the uncovered interest parity condition, linking the nominal interest rate differential to the expected nominal exchange rate depreciation, holds in the euro area. For Ricardian households standard Euler equations determining interest-rate sensitive consumption and saving hold (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. Last, but not least, the monetary authority sets the nominal interest rate according to a standard Taylor rule.

Our results are the following ones. First, expansionary fiscal policy shocks - both those on the expenditure and revenue side - induce a joint deterioration of the public sector balance and trade balance as well as output multipliers below one. Second, the deterioration of the trade balance is relatively small. The largest value, equal to -0.1 percent of output, is obtained conditionally to public spending shock (equal to one percent of output) in the first year after the shock. The deterioration is due to the decrease in gross exports. For other fiscal shocks (to transfers and tax rates), the trade balance deterioration is relatively low and it is driven by the increase in gross

[3] Adolfson et al. (2007) provide substantial evidence in favor of this assumption of small spillover effects from the euro area to the rest of the world. Their findings are also supported by de Walque et al. (2005) and Gomes et al. (2010) who find small spillover effects in a joint structural analysis of business cycles in the euro area and the rest of the world.

imports, which are partially compensated by the improvement in the terms of trade. Only in the case of the labor income tax shock exports increase and partially compensate for the increase in imports and the deterioration of the terms of trade. Third, an accommodative monetary policy stance and a public consumption-based consolidation do amplify the impact of expansionary fiscal shocks on gross imports and terms of trade. Also in these cases the effects on the trade deficit are not extremely large, because the two variables partially offset each other. For similar reasons, this our fourth result, a fiscal consolidation based on public spending reduction does not greatly modify, when the monetary policy rate hits the zero lower bound, the effects of the fiscal shock on the trade balance. Fifth, results are rather robust to alternative and values of key parameters, such as the home bias, the elasticity of substitution and, to a lower extent, the share of non-Ricardian households (given the large effect of the parameters on gross imports).

Our main results are in line with the evidence provided by Beetsma et al. (2008) 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 Erceg et al. (2005), using an open economy new-Keynesian DSGE model calibrated to the US and the rest of the world, find 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.[4]

The remainder of this paper is organized as follows. Section 2 presents our basic open economy model. The calibration is 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 open economy model, similar to Adolfson et al. (2007) and Christoffel et al. (2008).[5] Differently from them, we include in the model non-Ricardian households, public debt and multiple fiscal policy rules on both expenditures and revenues, along the lines of Forni et al. (2009). Ricardian households maximize intertemporally their utility by appropriately choosing consumption and leisure. Non-Ricardian households, to the contrary, simply consume all their available income in each period. Consumption and investment baskets consist

[4]Kollmann (2010) systematically analyses under which conditions an increase in public spending can induce a real exchange rate depreciation in a standard open economy model.

[5]Adolfson et al (2007) extend the DSGE model of Christiano et al. (2005) by incorporating open economy features.

of domestically produced and imported goods. The pass-through of nominal exchange rate to export and import prices is incomplete in the short-run because we assume local currency pricing (nominal prices are sticky in the currency of the destination market). Financial markets are incomplete, because we assume that there are only two riskless bonds. One is traded inside the considered economy and is denominated in domestic currency. The other is traded with the rest of the world and is denominated in the rest of the world's currency. In what follows, we initially describe firms, households, the central bank and the fiscal authority in the "Home" economy. Subsequently we describe the rest of the world (we call it "Foreign").

2.1 Firms

Firms in the final goods sector produce three different types of goods under perfect competition, namely a private consumption good, a private investment good, a public consumption good. Private consumption is a constant elasticity of substitution (CES) aggregator of domestically produced goods (C_H) and imported products (C_F):

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

where the parameter $0 < a_{HC} < 1$ is the share of domestic goods in the consumption basket and the parameter $\eta > 0$ is the elasticity of substitution between domestic and imported goods. Consumption baskets C_H and C_F are composite of a continuum of, respectively, differentiated domestic (h) and imported (f) intermediate goods (brands), each supplied by a different firm. They are produced according to the following functions, respectively:

$$C_{H,t} = \left[\int_0^1 C_{H,t}\left(h\right)^{\frac{\theta_{H,t}-1}{\theta_{H,t}}} dh \right]^{\frac{\theta_{H,t}}{\theta_{H,t}-1}}, \quad C_{F,t} = \left[\int_0^1 C_{F,t}\left(f\right)^{\frac{\theta_{F,t}-1}{\theta_{F,t}}} df \right]^{\frac{\theta_{F,t}}{\theta_{F,t}-1}}, \tag{2}$$

where $1 \leq \theta_{H,t}, \theta_{F,t} < \infty$ are the time-varying elasticities of substitution among domestic brands and among foreign brands, respectively. The elasticities $\theta_{H,t}$ and $\theta_{F,t}$ are distributed according to the following log-linear autoregressive stochastic processes, respectively:[6]

$$\begin{aligned} \hat{\theta}_{H,t} &= \rho_{\theta_H} \hat{\theta}_{H,t-1} + \hat{\varepsilon}_{\theta_{H,t}}, \quad \hat{\varepsilon}_{\theta_{H,t}} \overset{iid}{\sim} N(0, \sigma^2_{\theta_H}), \\ \hat{\theta}_{F,t} &= \rho_{\theta_F} \hat{\theta}_{F,t-1} + \hat{\varepsilon}_{\theta_{F,t}}, \quad \hat{\varepsilon}_{\theta_{F,t}} \overset{iid}{\sim} N(0, \sigma^2_{\theta_F}). \end{aligned} \tag{3}$$

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

A similar aggregator holds for investment:

$$I_t = \left[a_{HI}^{\frac{1}{\eta}} \left(I_{H,t} \right)^{\frac{\eta-1}{\eta}} + \left(1 - a_{HI} \right)^{\frac{1}{\eta}} \left(I_{F,t} \right)^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \tag{4}$$

where $0 < a_{HI} < 1$ is the share of domestic goods while I_H and I_F are:

$$I_{H,t} = \left[\int_0^1 I_{H,t} \left(h \right)^{\frac{\theta_{H,t}-1}{\theta_{H,t}}} dh \right]^{\frac{\theta_{H,t}}{\theta_{H,t}-1}}, \ I_{F,t} = \left[\int_0^1 I_{F,t} \left(f \right)^{\frac{\theta_{F,t}-1}{\theta_{F,t}}} df \right]^{\frac{\theta_{F,t}}{\theta_{F,t}-1}}. \tag{5}$$

For the public expenditure, we assume it is fully biased towards domestic intermediate goods. The implied basket is:[7]

$$G_t = \left[\int_0^1 G_{H,t} \left(h \right)^{\frac{\theta_{H,t}-1}{\theta_{H,t}}} dh \right]^{\frac{\theta_{H,t}}{\theta_{H,t}-1}}. \tag{6}$$

The production function for the generic intermediate good h is

$$Y_{H,t} \left(h \right) = z_t^{1-\alpha} \epsilon_t K_{t-1} \left(h \right)^{\alpha} L_t \left(h \right)^{1-\alpha}, \tag{7}$$

where z_t is a unit-root technology shock capturing world productivity and ϵ_t is a domestic stationary technology shock. Both shocks are common to all firms in the intermediate sector. The variable $K(h)$ denotes physical capital stock, rented from domestic households in a competitive market. We do not include capacity utilization of capital as Adolfson et al. (2007) find that this feature deteriorates the fit of the open economy model.[8] The stationary technology shock ϵ, expressed in log-deviations from its steady state value, follows an autoregressive process:

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

The growth rate of the unit-root technology follows a similar log-linear process:

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

where:

$$\hat{\mu}_{z,t} \equiv \frac{z_t}{z_{t-1}} - 1.$$

[7]Evidence discussed in Corsetti and Muller (2006) suggests that the import content in government spending is generally less than half the import content in private spending. We thus assume, as a first approximation, that the import content in government spending is zero.

[8]Christoffel et al. (2008) find the same result.

The variable $L(h)$ is a composite of a continuum of differentiated labor inputs, each supplied by a different domestic household j:

$$L_t(h) = \left[\int_0^1 L_t(j)^{\frac{\theta_{L,t}-1}{\theta_{L,t}}} dj \right]^{\frac{\theta_{L,t}}{\theta_{L,t}-1}}, \tag{8}$$

where $1 \leq \theta_{L,t} < \infty$ is the time-varying elasticity of substitution among labor varieties, which is distributed according to the following log-linear autoregressive process:

$$\hat{\theta}_{L,t} = \rho_{\theta_L} \hat{\theta}_{L,t-1} + \hat{\varepsilon}_{\theta_{L,t}}, \quad \hat{\varepsilon}_{\theta_{L,t}} \overset{iid}{\sim} N(0, \sigma^2_{\theta_L}).$$

Each firm h minimizes its production cost. The resulting nominal marginal cost is:

$$MC_t = \frac{1}{z_t^{1-\alpha} \epsilon_t \alpha^\alpha (1-\alpha)^\alpha} \left(R_t^K \right)^\alpha W_t^{1-\alpha}, \tag{9}$$

where R_t^k is the gross nominal rental rate of capital and W_t the nominal wage rate (corresponding to the price of the labor bundle $L_t(h)$).

Each of the domestically produced goods is sold domestically and abroad subject to market specific cost of adjusting the price à la Rotemberg (1982).[9] Prices are sticky in the currency of the destination market (the local currency pricing assumption holds) and, as such, the exchange rate pass-through into export prices is incomplete in the short run.[10] In any period, each Home firm can reoptimize its domestic and foreign prices, $P_{H,t}(h)$ and $P^*_{H,t}(h)$ respectively, subject to quadratic adjustment costs in the form of a CES aggregator of all goods domestically sold and exported ($Y_{H,t}$ and $Y^*_{H.t}$ respectively):

$$AC_{H,t}(h) \equiv \frac{\kappa_H}{2} \left(\frac{P_{H,t}(h) / P_{H,t-1}(h)}{\pi_{H,t-1}^{\alpha_H} \bar{\pi}_t^{1-\alpha_H}} - 1 \right)^2 Y_{H,t}, \tag{10}$$

$$AC^*_{H,t}(h) \equiv \frac{\kappa^*_H}{2} \left(\frac{P^*_{H,t}(h) / P^*_{H,t-1}(h)}{\left(\pi^*_{H,t-1} \right)^{\alpha^*_H} \left(\bar{\pi}^*_t \right)^{1-\alpha^*_H}} - 1 \right)^2 Y^*_{H.t}, \tag{11}$$

where $\kappa_H, \kappa^*_H, \geq 0$ are price adjustment cost parameters in the Home and Foreign economy, respectively. Similarly, the parameters $0 \leq \alpha_H, \alpha^*_H \leq 1$ measure the degree of indexation respec-

[9]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.

[10]See also Smets and Wouters (2002). A similar assumption holds for import prices, as shown later.

tively 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 (gross) inflation target ($\bar{\pi}_t$) and α_H to last period's sector-specific (gross) inflation rate $\pi_{H,t-1}$ ($\pi_{H,t} \equiv P_{H,t}/P_{H,t-1}$). Similar interpretations hold for $(1-\alpha_H^*)$, α_H^*, $\bar{\pi}_t^*$, $\pi_{H,t-1}^*$.

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

$$
\begin{aligned}
& \hat{\pi}_{H,t} - \alpha_H \hat{\pi}_{H,t-1} - (1-\alpha_H)\,\widehat{\bar{\pi}}_t \\
= \quad & \beta E_t \left(\hat{\pi}_{H,t+1} - \alpha_H \hat{\pi}_{H,t} + (1-\alpha_H)\,\widehat{\bar{\pi}}_{t+1}\right) \\
& -\frac{(\theta_H - 1)}{p_H \kappa_H^p}\widehat{p}_{H,t} + \frac{(\theta_H - 1)}{\kappa_H^p}\widehat{rmc}_t + \hat{\theta}_{H,t},
\end{aligned} \tag{12}
$$

$$
\begin{aligned}
& \hat{\pi}_{H,t}^* - \alpha_H^* \pi_{H,t-1}^* - (1-\alpha_H^*)\,\widehat{\bar{\pi}}_t^* \\
= \quad & \beta E_t \left(\hat{\pi}_{H,t+1}^* - \alpha_H^* \hat{\pi}_{H,t}^* + (1-\alpha_H^*)\,\widehat{\bar{\pi}}_{t+1}^*\right) \\
& -\frac{(\theta_H^* - 1)}{p_H^* \kappa_H^{p*}}\widehat{p}_{H,t}^* + \frac{(\theta_H^* - 1)}{\kappa_H^{p*}}\widehat{rmc}_t - \frac{(\theta_H^* - 1)}{\kappa_H^{p*}}\widehat{rer}_t + \hat{\theta}_{H,t}^*,
\end{aligned} \tag{13}
$$

where $0 < \beta < 1$ is the discount factor of the Home Ricardian representative household (we illustrate the households' setup in the next section), $\widehat{p}_{H,t}$ ($\widehat{p}_{H,t}^*$) is the relative price, with respect to the local consumption basket, of the Home tradable in the Home (Foreign) market, $\widehat{rmc}_t$ is the real marginal cost and $\widehat{rer}_t$ is the (pre-consumption tax) real exchange rate. The latter is defined (in levels) as the ratio of consumption prices expressed in the same currency:

$$
RER_t \equiv \frac{S_t P_t^*}{P_t}, \tag{14}
$$

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. The term $\hat{\theta}_{H,t}^*$ in equation 13 represents a markup shock in the Foreign market and it is distributed as follows:

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

2.2 Ricardian households

There is a continuum ($0 \leq j \leq \left(1-\lambda^{NR}\right)$, 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:

$$E_t \left[\sum_{k=0}^{\infty} \beta^k \left(\xi_{t+k}^C \log \left(C_{t+k}(j) - bC_{J,t+k-1} \right) - \frac{1}{1+\sigma_L} \left(L_{t+k}(j) \right)^{1+\sigma_L} \right) \right], \tag{15}$$

where $0 < \beta < 1$ is the intertemporal discount factor, $C(j)$ and $L(j)$ are respectively the j-th household's levels of consumption and labor supply.[11] The former is subject to an autoregressive preference shock, ξ^C. 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 household).[12] The inverse of the parameter σ_L is the labor Frisch elasticity. The shock ξ^C is distributed according to the following autoregressive process:

$$\hat{\xi}_t^C = \rho_{\xi^C} \hat{\xi}_t^C + \hat{\varepsilon}_{\xi^C,t}, \quad \hat{\varepsilon}_{\xi^C,t} \overset{iid}{\sim} N(0, \sigma_{\xi^C}^2).$$

Ricardian households can save in domestic and foreign riskless bonds, respectively B_t and B_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 Home Ricardian households and the rest of the world. The resulting budget constraint is as following:

$$\begin{aligned} & B_t(j) + S_t B_t^*(j) - B_{t-1}(j) R_{t-1} - S_t B_{t-1}^*(j) R_{t-1}^* \Phi \left(a_{t-1}, \tilde{\phi}_{t-1} \right) \\ = \; & \left(1-\tau_t^w\right) W_t(j) N_t(j) + \left(1-\tau_t^k\right) \left(R_{K,t} K_{t-1}(j) + \frac{\Pi_t}{\left(1-\lambda^{NR}\right)} \right) \\ & + TR_t(j) - \left(1+\tau_t^c\right) P_{C,t} C_t(j) - P_{I,t} I_t(j) - \Gamma_W(j), \end{aligned}$$

where R and R^* are respectively the gross nominal interest rates on domestic and foreign bonds. The term Φ is a premium that depends on the net foreign asset position of the Home economy (a, see below). It ensures that the net foreign asset position is stationary and, hence, that the steady-state is well defined. The variables τ_t^w, τ_t^c, τ_t^k represent taxes respectively on labor income ($W_t N_t$), consumption expenditure ($P_{C,t} C_t$) and capital income. The latter is equal to the sum

[11] As is done in much of the recent literature, we consider a cashless limit economy.

[12] Habit depends on lagged aggregate consumption that is unaffected by any one household's decisions. See Abel (1990).

of $R_{K,t}K_{t-1}$ (R_k is the gross rental rate of capital, K is amount of physical capital) and Π_t (per-capita total profits from ownership of domestic firms, equally distributed across Ricardian households).The variable TR_t represents (net) lump-sum transfers from the public sector. The household can invest (I_t) in additional physical capital (K_t) undertaking a quadratic adjustment cost. The implied capital accumulation equation is:

$$K_t(j) = (1-\delta) K_{t-1}(j) + \left(1 - \frac{\gamma_I}{2}\left(\frac{\Upsilon_t I_t(j)}{I_{t-1}(j)} - 1\right)^2\right) I_t(j), \tag{16}$$

where $0 < \delta < 1$ is the depreciation rate of capital, $\gamma_I > 0$ is the investment adjustment cost parameter and Υ_t is a stationary autoregressive investment-specific technology shock. Finally, each household supplies under monopolistic competition a differentiated labor service. It chooses its own wage given labor demand by domestic firms and subject to Rotemberg-type wage adjustment costs Γ_W, whose functional form is:

$$\Gamma_W(j) \equiv \frac{\kappa_W}{2}\left(\frac{W_t(j)/W_{t-1}(j)}{\pi_{W,t-1}^{\alpha_W}\bar{\pi}_t^{1-\alpha_W}} - 1\right)^2 W_t, \tag{17}$$

where $\kappa_W \geq 0$ is the wage adjustment cost parameter , α_W ($0 \leq \alpha_W \leq 1$) is a parameter that measures indexation to the (gross) wage inflation rate in the previous period and $(1-\alpha_W)$ measures indexation to the current period's inflation target of the central bank. The variable W is the wage paid to L, the bundle of labor varieties (8).[13]

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 nominal interest rate differential, comprehensive of the premium $\Phi\left(a_{t-1}, \tilde{\phi}_{t-1}\right)$ on the foreign currency-denominated bond holdings, to the expected exchange rate changes in nominal terms. The premium $\Phi\left(a_t, \tilde{\phi}_t\right)$ is defined as:

$$\Phi\left(a_t, \tilde{\phi}_t\right) \equiv \exp\left(-\tilde{\phi}_a(a_t - \bar{a}) + \tilde{\phi}_t\right),$$

where $a_t \equiv S_t B_t^*/(P_t z_t)$ is the net foreign asset position (deflated by the Home consumption deflator P_t and divided by the stochastic technology trend z_t), $\tilde{\phi}_a > 0$ is parameter.[14] The

[13]For the Calvo variant of nominal wage stickiness, see Erceg et al. (2000).

[14]See Benigno (2009b), Schmitt-Grohé and Uribe (2001) and Turnovsky (1985). The cost implies that the 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.

variable $\tilde{\phi}_t$ is a shock to the risk premium, distributed as follows:[15]

$$\widehat{\tilde{\phi}}_t = \rho_{\tilde{\phi}} \widehat{\tilde{\phi}}_{t-1} + \hat{\varepsilon}_{\tilde{\phi},t}, \quad \hat{\varepsilon}_{\tilde{\phi},t} \overset{iid}{\sim} N(0, \sigma^2_{\tilde{\phi}}).$$

2.3 Non-Ricardian households

We assume that a share of Home households $(\left(1-\lambda^{NR}\right) < j' \leq 1)$ 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 have assumed 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, however, less than complete as the return from money holding has a negative real return).[16] Other authors have shown that assumptions implying stronger responses of non-Ricardian agent's consumption to variations in disposable income are necessary in order to allow for the possibility of obtaining 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 households 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 simply consume their after-tax disposable income, as originally proposed by Campbell-Mankiw (1989), which consists of labor income plus net lump-sum transfers from the government:

$$P_t C_t(j') = (1-\tau_t^W) W_t(j') L_t(j') + TR_t(j'). \tag{18}$$

Note that this modeling of non-Ricardian households does not impose a positive response of total private consumption to government expenditure shocks. The response depends, among other things, on the value of the share of non-Ricardian households, λ_t^{NR}. The composition of the consumption bundle is the same as in equation (1). The non-Ricardian households set their wage to be the average wage of the Ricardian households. Since non-Ricardian households face the same labor demand schedule as the Ricardian households, each non-Ricardian household

[15] For the use of such shock to fit the wide real exchange rate fluctuations, see, among the others, Adolfson et al. (2007), Christoffel et al. (2008), Devereux and Engel (2002), Duarte and Stockman (2005).

[16] In the latter case, Coenen and Straub (2005) 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.

works the same number of hours as the average for Ricardian households.

2.4 Central bank

The monetary policy specification is in line with Smets and Weuters (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 after-consumption tax price inflation and steady state (or targeted) inflation $\bar{\pi}_t^c$, to the gap between contemporaneous (detrended) output y_t and its steady state value, to changes in inflation $\Delta\pi_t^C \equiv \pi_t^c/\pi_{t-1}^c$ and to output growth $\Delta y_t \equiv y_t/y_{t-1}$.[17] In log-linearized form we have:

$$\begin{aligned} \hat{R}_t &= \rho_R \hat{R}_{t-1} + (1-\rho_R)\left(\widehat{\bar{\pi}}_t^c + r_\pi\left(\hat{\pi}_{t-1}^c - \widehat{\bar{\pi}}_t^c\right) + r_y \hat{y}_t\right) \\ &\quad + r_{\Delta\pi}\Delta\hat{\pi}_t^C + r_{\Delta y}\Delta\hat{y}_t + \varepsilon_{R,t}, \end{aligned} \tag{19}$$

where $\varepsilon_{R,t}$ is an uncorrelated monetary policy shock with zero mean and variance σ_R^2 while $\widehat{\bar{\pi}}_t^c$ is a shock to the monetary authority target, distributed according to the following autoregressive process:

$$\widehat{\bar{\pi}}_t^c = \rho_{\bar{\pi}^C}\widehat{\bar{\pi}}_t^c + \hat{\varepsilon}_{\bar{\pi}^C,t}, \quad \hat{\varepsilon}_{\bar{\pi},t} \overset{iid}{\sim} N(0, \sigma_{\bar{\pi}^C}^2).$$

2.5 Fiscal policy

The public sector budget constraint is defined as follows:

$$\tilde{B}_t - \tilde{B}_{t-1}R_{t-1} = P_{H,t}\left(1+\tau_t^C\right)G_t + TR_t - T_t, \tag{20}$$

where $\tilde{B}_t > 0$ is the public debt level. We assume it is a riskless bond denominated in Home currency and traded with domestic Ricardian households only. The variable G_t is government consumption (see equation 6). We assume that the public sector buys only domestic goods and that pays the related consumption tax rate τ_t^C. The variable TR_t represents lump-sum transfers to (Ricardian and non-Ricardian) households and T_t are total taxes. Assuming that a symmetric equilibrium holds (so that there is a representative agent for each type of households, Ricardian and non-Ricardian, and a representative firm for each production sector), total taxes are equal

[17] The after-consumption tax price inflation is $\pi_t^c \equiv P_t\left(1+\tau_t^c\right)/\left(P_{t-1}\left(1+\tau_{t-1}^c\right)\right)$.

to:

$$
\begin{aligned}
T_t \quad \equiv \quad & \tau_t^w W_t L_t + \tau_t^c \left(P_t \left(1 - \lambda^{NR}\right) C_t + P_t \lambda^{NR} C_t' + P_{H,t} G_t \right) \\
& + \tau_t^k R_t^k \left(1 - \lambda^{NR}\right) K_{t-1} + \tau_t^k \Pi_t,
\end{aligned} \tag{21}
$$

where Π are total profits in the economy and C_t' is the consumption of the representative non-Ricardian household. We assume that τ^w, τ^c and per-capita transfers are the same for both Ricardian and non-Ricardian households.

Tax rates and public expenditure items are set according to (feedback) fiscal rules. Specifically, instead of specifying government spending and taxes as series of autocorrelated, exogenous shocks, we explicitly allow for endogenous dynamics reflecting debt- and output-stabilization motives. For public spending, we assume that the stationary components of government purchases and transfers expressed in real terms (deflated by domestic consumer prices), respectively g an tr, follow the log-linear rules below:

$$
\hat{g}_t \quad = \quad \rho_g \hat{g}_{t-1} + \eta_{g\tilde{b}} \widehat{\tilde{b}}_t + \eta_{gy} \widehat{y}_t + \varepsilon_{g,t}, \quad \hat{\varepsilon}_{g,t} \overset{iid}{\sim} N(0, \sigma_g^2), \tag{22}
$$

$$
\widehat{tr}_t \quad = \quad \rho_{tr} \widehat{tr}_{t-1} + \eta_{tr\tilde{b}} \widehat{\tilde{b}}_t + \eta_{try} \widehat{y}_t + \varepsilon_{tr,t}, \quad \hat{\varepsilon}_{tr,t} \overset{iid}{\sim} N(0, \sigma_{tr}^2), \tag{23}
$$

where $\widehat{\tilde{b}}_t$ is the log-deviation of the (stationary component of) public debt expressed in real terms from its steady state value, the parameters $0 \leq \rho_g, \rho_{tr} \leq 1$ measure the inertia in changing the corresponding expenditure items and both $\varepsilon_{g,t}$ and $\varepsilon_{tr,t}$ are i.i.d. innovations, aimed at capturing discretionary changes in public spending. The parameters $\eta_{g\tilde{b}}, \eta_{tr\tilde{b}} < 0$ measure the response of, respectively, government consumption and public transfers to public debt. As the latter increases (decreases), the former decrease (increase). In this way we capture the use of public spending for stabilizing public debt. Finally, the parameters η_{gy} and η_{try} measure the response of the two types of public spending to output, so as to capture the endogenous response of public spending to business cycle fluctuations. Similar rules hold for labor income tax rate, capital income tax rate and consumption tax rate. Specifically:

$$
\hat{\tau}_t^l \quad = \quad \rho_{\tau^l} \hat{\tau}_{t-1}^l + \eta_{\tau^l \tilde{b}} \widehat{\tilde{b}}_t + \eta_{\tau^l y} \widehat{y}_t + \hat{\varepsilon}_{\tau^l,t}, \quad \hat{\varepsilon}_{\tau^w,t} \overset{iid}{\sim} N(0, \sigma^2_{\varepsilon_{\tau^l},t}), \tag{24}
$$

$$
\hat{\tau}_t^k \quad = \quad \rho_{\tau^k} \hat{\tau}_{t-1}^k + \eta_{\tau^k \tilde{b}} \widehat{\tilde{b}}_t + \eta_{\tau^k y} \widehat{y}_t + \hat{\varepsilon}_{\tau^k,t}, \quad \hat{\varepsilon}_{\tau^k,t} \overset{iid}{\sim} N(0, \sigma^2_{\varepsilon_{\tau^k},t}), \tag{25}
$$

$$
\hat{\tau}_t^c \quad = \quad \rho_{\tau^c} \hat{\tau}_{t-1}^c + \eta_{\tau^c \tilde{b}} \widehat{\tilde{b}}_t + \eta_{\tau^c y} \widehat{y}_t + \hat{\varepsilon}_{\tau^c,t}, \quad \hat{\varepsilon}_{\tau^c,t} \overset{iid}{\sim} N(0, \sigma^2_{\varepsilon_{\tau^c},t}). \tag{26}
$$

Our assumption find support in empirical estimates of policy rules, which indicate a statistically significant adjustment of both spending and taxes in response to higher debt and output.[18]

2.6 Foreign economy

Consistently with Adolfson et al. (2007), foreign inflation π_t^*, output y_t^*, and the interest rate R_t^* are exogenously given by an identified VAR model with four lags. Morover, we have the following equations:

$$
\begin{aligned}
\hat{y}_{H,t}^* &= -\eta \hat{p}_{H,t}^* + \widehat{y}_t^*, && (27) \\
& \hat{\pi}_{F,t} - \alpha_F \hat{\pi}_{F,t-1} - (1-\alpha_F)\,\widehat{\overline{\pi}}_t && (28) \\
&= \beta E_t \left(\hat{\pi}_{F,t+1} - \alpha_F \hat{\pi}_{F,t} + (1-\alpha_F)\,\widehat{\overline{\pi}}_{t+1}\right) \\
& \quad - \frac{(\theta_F - 1)}{\kappa_F^p} \widehat{p}_{F,t} + \frac{(\theta_F - 1)}{\kappa_F^p} \widehat{rer}_t + \hat{\theta}_{F,t}
\end{aligned}
$$

The first equation is the foreign demand for Home tradeables (we assume that the elasticity of substitution between Home and Foreign goods, η, is the same in both the Home and Foreign economy, see equation 1). The second equation is the Phillips curve of the Home imports. The shock to the markup, $\hat{\theta}_{F,t}$, follows a log-linear AR(1) process (see equation 3)

2.7 The trade balance of the Home economy

The trade balance is obtained by consolidating the private sector aggregate budget constraint and the government budget constraint, taking into account that the public debt is traded only with Home Ricardian households and it's not internationally traded. Assuming that a symmetric equilibrium holds, the resulting trade balance is as follows:

$$
\begin{aligned}
TB_t &= S_t B_t^* - S_t B_{t-1}^* - S_t B_{t-1}^* R_{t-1}^* \Phi\left(a_{t-1}, \tilde{\phi}_{t-1}\right) \\
&= P_{H,t} Y_{H,t} + S_t P_{H,t}^* Y_{H,t}^* - P_t\left(1-\lambda^{NR}\right) C_t - P_t \lambda^{NR} C_t' - P_{I,t}\left(1-\lambda^{NR}\right) I_t - P_H G_t \\
&= S_t P_{H,t}^* Y_{H,t}^* - P_{F,t} Y_{F,t}.
\end{aligned}
$$

The first equality expresses the trade balance as the result of the change in the net foreign asset position and the related interest payments. The second equality is the difference between

[18] Galì and Perotti (2003), for responses to public debt, report estimates ranging from -0.04 to 0.03 in the case of government spending, and from 0 to 0.05 in the case of taxes, in a panel of OECD members. See also Forni et al. (2009) for evidence on tax-based rules in the euro area and Canova and Pappa (2004) for the stabilizing response of government spending to the debt-output ratio across U.S. states.

total aggregate revenues from production and total aggregate expenditures. Finally, the third equality is the difference between gross exports and gross imports, both expressed in domestic currency. As said in the introduction, we use the trade balance (or net exports) instead of the current account to abstract from issues related to structure of international financial markets such as valuations effects or international payment flows.[19] Consistently, we use the public sector primary deficit to measure the fiscal position of the economy (as such, we do not consider interest payments on public debt).

The ratio of import-to-export prices, both expressed in Home currency terms, defines the Home (pre-consumption tax) terms of trade:

$$TOT_t \equiv \frac{P_{F,t}}{S_t P^*_{H,t}} \equiv \frac{p_{F,t}}{RER_t p^*_{H,t}},$$

where RER_t is the home real exchange rate (see equation 14) while $p_{F,t}$ and $p^*_{H,t}$ are prices of Home imports and exports expressed respectively in terms of Home and Foreign consumption.[20]

3 Data

We use quarterly Euro area data for the period 1980:1–2005:4 to estimate the model. The sample ends in 2005 as fiscal variables are available only up to that year. We match the following twenty variables: GDP, consumption, investment, government consumption, exports, imports, the real exchange rate, the short-run interest rate, wage inflation, employment, the GDP deflator, the consumption deflator, the investment deflator, transfers to families, tax rate on labor, tax rate on capital, tax rate on consumption, foreign output, foreign inflation and the foreign interest. We include the foreign variables to identify parameters driving the propagation of the foreign shocks to the Euro area economy.[21] Data are from the Area Wide Model data set and, for fiscal variables, from Forni et al. (2009).[22] In the AWM data set export and import series include both intra- and extra-area trade. The exchange rate is the ECB's official effective exchange rate for the 12 main trading partners of the euro area. The data set also includes foreign output

[19]Baxter (1995) shows that at business cycle frequencies, the current account and the trade balance tend to move closely. For an analysis of the valuation effects (changes in the value of the net external position of a country associated with the nominal exchange rate fluctuations), see Benigno (2009a).

[20]An increase (decrease) corresponds to a deterioration (improvement).

[21]The parameters of the (preestimated) Foreign VAR are kept fixed at their estimated mean during the estimation of the DSGE model. The dynamics of the Foreign variables is driven by three shocks (to the Foreign interest rate, output, inflation).

[22]For details on the AWM dataset see Fagan et al. (2005).

and prices (weighted average of, respectively, the GDP and GDP deflator series for the major euro area trade partners). It does not include data on foreign interest rate and euro area hours worked. Regarding the former, we use the Fed funds rate as a proxy. For hours worked we use employment, which we model using a Calvo-rigidity equation:[23]

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

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 and average effective tax rates, we can model the fiscal policy block with more detail than previous work. First, we 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.[24] 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.[25]

4 Estimation

In what follows we initially describe calibrated parameters and the prior distributions of estimated parameters. We then report the obtained estimates. The model is estimated with Bayesian

[23] See Smets and Wouters (2003).

[24] See Adolfson et al. (2007).

[25] We include measurement errrors in the variables. The only exceptions are the Home and Foreign interest rates. We calibrate the variances of the uncorrelated measurement errors to rather small values. Overall, the fundamental shocks explain about 90-95% of the variation in most of the variables. As such, the measurement errors capture some of the high frequency movements in the data but not fluctuations related to the business cycle.

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 the calibrated parameters and in Table 2 the implied steady state values of main variables.

We calibrate the home-bias parameters (a_H in the Home consumption bundle, a_{HI} in the Home final investment bundle) to values that allow to match the import content of consumption and investment spending (Table 1). The elasticity of substitution between domestic and imported goods, η, is set to 3.0, in line with Adolfson et al. (2007). The steady state elasticities of substitution between brands ($\theta_H, \theta_F, \theta_H^{\star}$) are set to 6, consistently with a steady state (gross) markup equal to 1.2. The substitution elasticity between labor varieties, θ_L, to 4.33 (the implied gross steady state markup is 1.3). The inverse of the labor supply elasticity, σ^L, is set to 2, consistently with the existing literature. The depreciation rate δ of physical capital to 0.025 and the share α of capital in the production function to 0.31. We assume values for tax rates 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, 47 percent for labor income taxes). For non-Ricardian households, we set that their share is equal to 35 percent of the Home population, consistently with estimates reported in Forni et al. (2009).[26]

We report the implied steady-state quantities and great ratios in Table 2. Consistently with Christoffel et al. (2008), private Home consumption, investment and government consumption as a ratio to Home output are equal to 60 (for private consumption) and 20 percent (for private investment and public consumption). Consumption and investment imports are roughly 10 and 6 percent (as shares of nominal output). We assume that the steady state growth rate of the world economy is 2.18 percent per annum and the steady-state annualized gross inflation π is 2.18 percent (both values are consistent with corresponding average sample values). We set the steady state net foreign asset position to zero. This implies a zero trade balance, even if the steady state (net) growth rate and inflation are different from zero. The annualized equilibrium real interest rate is equal to 3.0 percent. We set the public debt at 60 percent (on a yearly

[26]Coenen and Straub (2005) report a similar estimated value using euro area data.

basis). Given this figure and those of tax rates and public consumption spending, we set the steady state value for transfers residually so as to satisfy the government budget constraint. The implied steady state public sector deficit is equal to 0.67 (percent of annualized output).

4.2 Prior distributions of the estimated parameters

In Table 3 we show the prior distribution of the estimated parameters. The location of the prior distribution corresponds to a large extent to that in Adolfson et al. (2007) and Forni et al. (2009). Similarly, we set the standard errors so that the domain covers a reasonable range of parameter values, including values estimated by previous studies. Parameters bounded between 0 and 1 are distributed according to a beta distribution (habit persistence b, indexation parameters α and coefficients of shock autocorrelation ρ). Positive parameter have an inverse gamma distribution (wage and price stickiness parameters κ, adjustment cost on investment and net foreign asset position (γ_I and $\tilde{\phi}_a$, respectively), standard deviations of the shocks σ, tax rate and public expenditure responses to public debt and output in the fiscal rules η_b and η_y, respectively). Finally unbounded parameters are distributed according to the normal distribution (in the Taylor rule, the interest rate response to inflation ρ_π, to inflation change $\rho_{\Delta\pi}$, to output ρ_y and output growth $\rho_{\Delta y}$).

The external habit parameter has a mean of 0.65 and a standard deviation of 0.10. The investment adjustment coefficient has a mean equal to 7.694 and a standard deviation of 1.50. The prior mean on the risk premium parameter, $\tilde{\phi}_a$, is set to 0.01 and the standard deviation to 0.05.

We set the (domestic, imported and exported goods) price and wage stickiness parameters so that the average length between price, or wage, adjustments is four quarters. Consistently we set the mean of nominal price rigidities to 60 (standard deviation is 30), the mean of nominal wage rigidity to 40 (the standard deviation is 20).[27] We choose the range covered by the prior distributions of both parameters 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

[27] To match the 4-quarter frequency adjustment we have assume different mean values of Rotemberg parameters for prices and wages, as the elasticity of substitution between labor varieties on the one hand and product varieties on the other hand are different. A typical Calvo price-setting model implies a (log-linearized) stochastic difference equation for inflation of the form $\pi = \beta E_t \pi_{t+1} + \tilde{\lambda} rmc_t$, where rmc_t is the firm's real marginal cost of production, and $\tilde{\lambda} = (1-q)(1-\beta q)/q$ where q is the constant probability that a firm must keep its price unchanged in any given period and β the subjective discount factor. The quadratic adjustment cost model gives a similar (loglinearized) equation for inflation. The difference is in the parameter $\tilde{\lambda} = (\theta - 1)/(\kappa\pi)$. Similar considerations hold for the wage-setting equation.

rigidity. Parameters measuring the degree of price and wage indexation have a mean equal to 0.50 (standard deviation 0.15).

We take tax rate and public spending policies to be quite persistent a priori, with autoregressive coefficients having a prior mean set to 0.80 (standard deviation equal to 0.10). We assume that both the tax rate and public spending elasticities with respect to public debt and to output have a mean equal to 0.04. The corresponding standard deviations are equal to 0.10. We assume a rather loose prior on these parameters, so as to reflect the high uncertainty surrounding their values.

For the monetary policy rule, we set the prior mean on the lagged interest rate coefficient to 0.80, those on inflation and inflation growth coefficients respectively to 1.70 and 0.30 (each of the corresponding distributions has a standard deviation equal to 0.10). We set the coefficient responding to output (deviation from steady state) and output growth to 0.125 and 0.0625, respectively (each distribution has a standard deviation equal to 0.05).

Finally, we assume that all the autocorrelated shocks have an autoregressive coefficient equal to 0.80 (standard deviation equal to 0.10). The corresponding innovations (to shocks) are white noise with standard deviation having mean equal to 0.10 percent (standard deviation equal to 1.00 percent).[28]

4.3 Posterior distribution

In Table 3 we show the posterior mode of all the parameters, the mean along with the 5th and 95th percentiles of the posterior distribution.

We compute them using a posterior sampling algorithm based on a Markov chain with 450,000 draws.[29]

The estimate of the degree of habit formation in consumption is in between that reported by Christoffel et al. (2008) on the one hand, equal to around 0.6, and those reported by Forni et al. (2009) and Adolfson et al. (2007) on the other hand, equal to around 0.7. For the investment adjustment cost parameter, the estimate (8.6) is similar to that reported by Adolfson et al.

[28]We have analyzed the sensitivity of the estimation results to the prior assumptions by increasing the standard errors of the prior distributions of the behavioral parameters by 50 percent. Overall, the estimation results are very similar.

[29]We obtain the joint posterior distribution of all estimated parameters in two steps. First, we obtain the posterior mode and the approximate covariance matrix, based on the inverse Hessian matrix evaluated at the mode. Second, we explore the posterior distribution by generating draws using the Metropolis–Hastings algorithm. We take as the proposal distribution the multivariate normal density centered at the previous draw with a covariance matrix proportional to the inverse Hessian at the posterior mode. For further explanations, see Schorfheide (2000) and Smets and Wouters (2003).

(2007) and higher than those reported by Christoffel et al. (2008) and Forni et al. (2009), equal to 5. The estimate of the adjustment cost on the net foreign asset position is around 0.02, higher than the estimate provided by Adolfson et al. (2007) and equal to around 0.15.

On the nominal side, we find that in the euro area the prices of domestic and imported goods adjust once every five quarters. Export prices adjust once every four quarters. The value we get for price stickiness of domestic goods is lower than corresponding estimates found in the related literature (prices are adjusted once every 8-10 quarters). However, they are comparable to findings reported by Forni et al. (2009) and Galí et al. (2001). For imports price stickiness, our estimate is relatively high. In particular, Adolfson et al. (2007) finds that import prices adjust on average once every 2–3 quarters. We find that euro area wage are less sticky than prices, as they adjust once every 4 quarters (a similar result is obtained by Adolfson et al. 2007). As to the indexation parameters, the estimation results suggest that the persistence in price and wage inflation is not extremely high, confirming that the estimated Phillips curves are essentially forward-looking, a result similar to that obtained by Christoffel et al. (2008) and Galí et al. (2001)

For fiscal policy rules, we find that all fiscal processes appear to be rather persistent, pointing to a high persistence of fiscal policy innovations. The labor tax process has the highest persistence (the posterior mean is 0.98), while public consumption and consumption taxes are the least persistent ones (the respective posterior means are equal to 0.92). The magnitude of reactions to debt level is rather similar across all fiscal items. They are lower than the corresponding prior mean values. Moreover, there is no clear difference between expenditures on the one hand and tax rates on the others in terms of reaction to public debt. Similar considerations hold for responses to output.

For the monetary policy rule, estimated policy coefficients feature a relatively low degree of interest-rate smoothing. For the weight on inflation and inflation change, results are in line with Forni et al. (2009).[30] For the response to output and change in output, they are relatively small. Finally, we do find that the persistence of shocks is generally not extremely high.[31]

Figure 1 reports the actual time series of the transformed variables and the corresponding fit. The latter is rather satisfactory and in line with other similar contributions such as Adolfson et al. (2007).

[30]The estimated inflation response is above unity, ensuring determinacy of the model solution.
[31]The only exception is the transitory technology shock, that is equal to 0.99.

4.4 The role of fiscal and open economy parameters

In Table 4 we provide information on the sensitivity of our estimation results with respect to several changes in the benchmark specification. We formally compare the alternative specification by computing the corresponding marginal likelihood values. Specifically,we show the posterior mode estimates of the parameters and the marginal likelihood in correspondence of i) benchmark model (for ease of comparison); ii) low elasticity of substitution between domestic and imported good (0.8 instead of 3.0); iii) low share of non-Ricardian households (0.15 instead of 0.35), iv) no reaction of fiscal items to changes in output. The main results are three. First, the benchmark model shows the best fit. Second, we do not observe a large deterioration in the likelihood in correspondence of low values of non-Ricardian households and no-reaction of fiscal items to changes in output, signalling that these parameters are not extremely relevant for the overall (unconditional) fit of the model (they can be however relevant for the transmission of fiscal shocks, as shown later). To the opposite, we observe a large deterioration in the likelihood in the case of low elasticity.[32] The result can be however strongly conditioned by the lack of data on import and export prices. For this reason, and given also the high degree of uncertainty that surrounds the value of the elasticity of substitution in the literature, we do sensitivity analysis on this parameter when assessing the value of fiscal multipliers and the impact of open economy variables. Third, the estimates generally do not greatly change across the different specifications. The only exception is constituted by import price stickiness, that is relatively low when the elasticity of substitution is calibrated to 0.8 so as to try to fit the volatile export and import.

5 Fiscal policy in open economy

In this section we report the implications of alternative fiscal shocks in our estimated open economy model. We initially consider the two public expenditure shocks and, thereafter, the tax shocks. Finally, we report the related multipliers.

[32]Adolfson et al. (2007) find a similar result. A large value of the elasticity is needed to simultaneously fit the stable consumption and the volatile exports and imports.

5.1 Public expenditure shocks

We discuss the implications of our estimates for the effects of government spending shocks on the economy, in particular on output, the trade balance and the public deficit. In Figure 2 we report impulse responses to a shock to public consumption while in Figure 3 we show responses to a shock to public transfers. In each chart, the solid line corresponds to the mean value based on 2000 draws from the posterior distribution, while the dotted lines correspond to the 5th and 95th percentile.[33] We set the magnitude of the shocks in order to have an initial increase in considered expenditure equal to one percent of steady state (pre-stimulus) output. We express impulse responses as percent deviation from corresponding steady state values. The exceptions are the interest rate and the inflation rate, expressed as annualized percentage points, and the primary fiscal deficit, the trade balance, the public consumption, public transfers and the total tax revenues that are expressed as a ratio to domestic output (percentage point-deviations from the steady state).[34]

The positive shock to public consumption (Figure 2) induces an increase in output equal to 0.9 percent on impact. This corresponds also to the peak level. Subsequently the output gradually returns to the baseline. The primary public deficit (as a ratio to output) increases by about 0.6 percentage points on impact. Thereafter it gradually decreases, as taxes and public spending (for consumption and transfers) smoothly and persistently adjust to make the public debt stable, consistently with the estimates of the fiscal rules. The trade balance-to-output ratio deteriorates, up to around 0.1 percentage points in the third quarter (the peak level). Subsequently, it returns to the baseline level and, from the tenth quarter, becomes slightly positive. So the increase in public consumption generates the "twin-deficits". However, the deterioration of the trade balance is smaller and less persistent than that of the public balance. The trade deficit is mainly driven by the drop in (gross) exports. The mechanism is based on the expenditure-switching effect. The public consumption is fully biased towards Home goods. As such, the increase in public demand drives up production costs, that positively affect not only the domestic price of the Home good, but also its Foreign price. Foreign households' demand shifts away from Home goods. For the same reason, Home imports increase. The impact on the trade balance of the decrease in exports and the increase in imports is only partially compensated by the improvement

[33] In general, the mean response turns out to be very similar to the median and the mode of the responses.

[34] Output and its components are evaluated in real terms (at steady state prices). For the real exchange rate and the terms of trade, we report the corresponding pre-consumption tax indeces.

in the Home terms trade associated with the higher relative price of the Home good (the latter is also the source of the Home real exchange rate appreciation, by 0.16 percent at the peak level in the third quarter).

Private sector's aggregate consumption decreases following the decrease in Ricardian households' consumption. The latter is driven by the negative wealth effect of debt-financed spending (Ricardian households foresee higher future taxes) and the increase in the real interest rate (not reported), as the monetary authority gradually rises the policy rate to counterbalance the higher inflation and output. Non-Ricardian households' consumption increases, as the real labor income augments (firms increase demand of labor to meet the higher aggregate demand).[35] However, the increase is not large enough to counterbalance the drop of Ricardian households' consumption. Investment decreases as well, as Ricardian households' use savings to finance the higher public deficit.

In Figure 3 we report the effects of a positive shock to transfers to households. On impact, output increases by 0.2 percent (the peak level) and thereafter it gradually returns to the baseline. The government budget deficit increases by about 0.9 percentage points of output on impact. Subsequently, it slowly decreases. The trade balance-to-output ratio response is negative and equal to around -0.06 percent on impact. As in the case of public consumption shock, we obtain the "twin-deficits". Quantitatively, the trade deficit is relatively low. Differently from the case of the public consumption based stimulus, it's now the increase in imports that mainly drives the trade balance deterioration. The transmission mechanism of the shock is mainly based on its large and persistent effect on aggregate consumption, as it translates one to one into an increase in disposable income of non-Ricardian households. Higher Home private consumption and its relatively low home bias (compared to public consumption) are the sources of the relatively large increase in imports. Their negative impact on the trade balance is partially compensated by a (relatively muted) improvement in Home terms of trade. Given the lower increase in the price of the Home good, exports decrease less than in the case of a positive shock to public consumption. Consumption and capital accumulation by Ricardian households decrease, because of the negative wealth effect of debt-financed spending.

[35] Pappa (2009) shows that in the new Keynesian model, differently from the standard real business cycle model, the real wage increases after a public spending shock as it's not only labor supply to increase but also labor demand.

5.2 Shocks to tax rates

We now look at the effects of tax rates innovations. In Figures 4-6 we show the impulse responses of a shock to the tax rate on, respectively, labor income, capital income and consumption. We calibrate all shocks in order to achieve on impact a decrease in corresponding tax revenues equal to 1 percent of steady state (pre-stimulus) output.

We report the effects of a reduction in labor income tax rate in Figure 4. On impact, output increases by 0.5 percent, it reaches a peak (0.8 percent) after two years from the beginning of the stimulus and then return to the baseline in a rather slow way. Public deficit in the first period increases by 0.8 percentage points of output, subsequently decreases as expenditures and taxes adjust (they gradually decrease and increase, respectively) Also in this case, we obtain a deterioration in the trade balance, albeit very small. The trade deficit is equal to 0.03 percentage points of output in the first quarter, subsequently it moves towards the baseline. Differently from the case of higher public spending, now both exports and imports increase. The former increase in a gradual manner, while the latter immediately. The terms of trade persistently deteriorate, contributing to limit the improvement in the trade balance, while the real exchange rate persistently depreciates. The movements in real exports and imports as well as international relative prices suggest that the tax reduction does largely impact not only on aggregate demand but also on the aggregate supply. The low labor income tax rate is an incentive for households to increase labor supply, as current leisure becomes more expensive than current consumption and future leisure. Higher labor supply induces Ricardian households to increase consumption (which is a complement to labour) and investment in physical capital (firms have an incentive to increase capital so as to make the higher labor more productive). Also non-Ricardian households increase consumption, given the higher available income (lower taxes and higher number of hours worked more than compensate for the reduction in the pre-tax real wage). Overall, the tax reduction favours a demand-driven increase in import, which is compensated in the medium run by a supply-driven increase in export and a deterioration of the international relative prices.

In Figure 5 we report the effects of a decrease in capital income tax rate. Output increases only gradually and by a relatively small amount (less than 0.1 percent at the peak after three years). On impact the public deficit-to-output ratio increases by 1 percent point and then decreases. The trade balance-to-output ratio decreases only gradually and marginally. The deficit is equal to -0.03 (peak level) percentage points of output after one year from the shock. The deterioration is however persistent (the trade balance returns to the baseline after five years from the shock). Imports gradually and persistently increase. Exports do not significantly change initially, while they increase in medium run. Real exchange rate and terms of trade do not greatly change. The latter slightly improve (deteriorate) in the short (medium) run. The increase in gross imports mimics the gradual increase in investment. The latter, by favouring the expansion of aggregate supply, induces also the medium run increase in exports. Consumption, instead, is not in this case the main driver of imports. Ricardian intertemporal choices favor investment rather than consumption, as lower capital income taxes imply that the former is cheaper than the latter.[36] Consumption of non-Ricardian households hardly increases, because their disposable income is relatively stable (labor does not increase, given that firms have an incentive to substitute capital for labor).

In Figure 6 we show the effects of a decrease in the consumption tax rate. The Home output increases by 0.6 percent (peak) in the second quarter and then gradually returns to the baseline. The public deficit-to-output ratio deteriorates by 0.5 percent on impact. For the trade balance, it improves on impact by 0.1 percent. Subsequently, it deteriorates, up to -0.1 percent of output after one year from the shock. The initial trade surplus is related to the terms of trade improvement, driven by the real exchange rate depreciation and the assumption of local currency pricing (that implies incomplete nominal exchange rate pass-through in the price of import). The source of the exchange rate depreciation is the response of the monetary authority, that reduces the policy rate in correspondence of the lower after-tax inflation. As for the reduction in the labor tax rate, the low consumption tax gradually stimulates Ricardian and non-Ricardian consumption and, hence, gross imports.[37] The latter contribute to the trade deficit in the medium run, jointly with the decrease in exports and the less favorable terms of trade movements. Exports gradually decrease in the medium run, as their price increases following the real exchange rate depreciation and the increase in the (marginal) production costs.

Overall, we do find that an increase in public spending or a reduction in taxes favor a deterioration of both public sector and external balances. The deterioration of the trade balance is driven by the increase in gross imports and the decrease in gross exports, partially compensated

[36] See Baxter and King (1993) and Leeper and Yang (2008).

[37] Ricardian households increase consumption as they anticipate future higher consumption tax rates. Moreover, they reduce investment in physical capital, as the lower tax rate makes consumption cheaper than investment. Non-Ricardian households immediately increase their consumption as well, because their current available income increases, thanks to the low consumption tax and higher labor demand by firms (that have to increase output to meet the higher aggregate demand).

by the improvement in the terms of trade. Only in the case of the labor income tax shock the trade deficit is associated with exports increase, that, however, is not sufficiently large to compensate for the increase in imports and the deterioration of the terms of trade.

5.3 Fiscal multipliers

To summarize the quantitative effects of our five fiscal shocks, in particular the output multiplier and the trade leakages, we report in Table 5 the fiscal multipliers for the main variables (average effects in the first 1, 4, 8, 24 and 100 quarters). We report the primay fiscal deficit, the trade balance and the trade leakages as a ratio to output (deviations from steady state in percentage points), while the other varables as percent deviations from steady state. We compute the trade leakages (variable NX) as the net exports-to-output ratio evaluated at the steady state relative prices (in other terms, as the net trade contribution to output). For the real exchange rate, we report the pre-consumption tax index (RER τ^c) and the after-consumption tax index (RER). For the terms of trade (TOT), we show the pre-consumption tax index.

Output multipliers are always smaller than one, even on impact. Overall, the shock to public consumption has the bigger effects on output, followed by the labor income tax shock and consumption tax shock. The other shocks (to public transfers and to capital income tax) have multipliers between zero and 0.25. Values are generally lower than those reported by Forni et al. (2009) for the closed economy case, consistently with the presence, in our case, of trade leakages.[38] The trade leakages are negative. We get the largest (negative) values in correspondence of shocks to public consumption and consumption tax (around -0.1) . In the first case, (Home and Foreign) households have the largest incentive to substitute cheaper Foreign goods for Home goods. In the second case, there is a large increase in households' consumption, that drives up imports.

Overall, trade leakages are mainly associated with the increase in imports and, in the case of public spending shocks, to the decrease of exports. The multipliers for imports mimic the multipliers for consumption and investment, depending on the considered fiscal shock. The highest (import) multiplier is obtained in correspondence of shocks to labor income tax, consumption tax and transfers, as these shocks stimulate households' consumption, which is the largest component of aggregate demand. The effect, in all cases, works through the increase in households' current real income and, for Ricardian households, the lower price of current consumption and/or labor.

[38] The only exception is the multiplier associated with the shock to labor income tax, which is larger than in Forni et al. (2009) becuse we estimate a more persistent labor income tax shock.

In the case of labor income tax shock, moreover, the import multiplier is to some extent enhanced also by firms, that rise investment to make employment more productive. We obtain lower values for import multipliers in correspondence of capital income tax shock, as private investment react in a very gradual and muted manner, and public consumption shock, as public consumption is fully biased towards domestic goods and crowds out Ricardian households' consumption and investment (the effect on consumption is expansionary but small and short-lived in the case of innovations to public expenditure).[39]

For exports, multipliers are generally negative. The increase in Home aggregate demand makes Home goods more expensive than Foreign goods. This is true in particular for the case of the public consumption shock. To the opposite, in the case of the labor income tax shock, the higher labor supply induces a relatively large increase in Home aggregate supply, which is partially absorbed through higher exports (whose multipliers are, hence, positive).

Finally, the multipliers for the real exchange rate are positive and sizeable in the case of the labor income and consumption tax shocks. They are negative in the case of shocks associated with the increase in public spending. For the terms of trade, the multipliers are overall negative (only in correspondence of the labor income tax shock they are positive).

6 The role of monetary policy and fiscal financing

In the previous section we have shown how output, the public sector balance and the trade balance respond to alternative discretionary fiscal shocks. Results are based on the parameter estimates obtained using data before the recent financial crisis and the related policy responses. In particular, recent contributions on fiscal policy effectiveness and the debate on fiscal consolidation strategies have stressed the relevance of the monetary policy stance and the way the discretionary fiscal measures are financed.

For fiscal policy effectiveness, the crucial issues are two. First, the monetary policy authority can maintain the policy rate at the baseline level instead of rising it in the aftermath of a stimulus, reducing through the implied lower real interest rate the crowding-out of households' aggregate demand. Second, the fiscal financing of the stimulus can affect its effectiveness, as households' current decisions do depend on the expected future path of the fiscal items and interest rate.

For fiscal consolidation (without any initial fiscal stimulus), the issue is that the implemen-

[39]Perotti (2005) for West Germany gets a similar result using a VAR methodology.

tation of the fiscal-exit strategy can have a negative impact that is amplified by the zero lower bound, as the negative impact on inflation can induce an increase in the (ex-ante) real interest rate if the monetary policy is constrained by the zero bound and cannot sufficiently reduce the nominal policy rate.

In the following sections we explore these issues and their implications for the impact of fiscal shocks on trade variables, by appropriately modifying the estimated model.

6.1 Accommodative monetary policy

How does the monetary policy affect the size of fiscal multipliers and the transmission mechanism of fiscal stimulus measures in open economy? To answer to this question we consider the case of accommodative monetary policy.[40] Specifically, we assume that the monetary authority does not rise the policy rate to stabilize the economy in correspondence of an expansionary public consumption shock, but maintains it constant at the baseline (steady state) level for four periods and, alternatively, for nine periods from the beginning of the shock. Thereafter, the monetary authority resumes to follow the standard (estimated) Taylor rule. We assume that the monetary authority announces the path of the policy rate. As such, households and firms are not surprised (the only exception is the impact period) and incorporate this information in their (optimal) decisions.[41] In Figure 7 we report the case of the monetary policy being accommodative for four periods. For comparison purposes, we report the responses when monetary policy follows the standard Taylor rule (dashed line) and when it is accommodative (continuous line). Output increases relatively more in the case of accommodative monetary policy, up to 1 percent on impact. Subsequently, it smoothly declines. The public sector balance and the trade balance deteriorate, confirming the emerging of twin deficit in the case of higher public consumption. Only in the first period the trade balance slightly improves. The real exchange rate strongly depreciates on impact, consistently with real interest rates lower today than in the future. The terms of trade improve, consistently with the exchange rate depreciation and the local currency pricing assumption. This favors the trade surplus. Subsequently, as imports increase following the increase in households' demand, the trade balance moves towards deficit. Quantitatively, the trade deficit is only marginally larger than in the case of Taylor rule-based monetary policy in the

[40] Corsetti and Mueller (2008) stress the relevance of monetary policy for the effectiveness of fiscal policy.

[41] For the implementation of policy simulations with alternative instrument-rate paths anticipated by the private sector in DSGE models see Laséen and Svensson (2009). Such simulations correspond to situations where the monetary authority transparently announces that it plans to implement a particular instrument-rate path and where this announcement is believed by the private sector.

first four quarters. The extra-increase in aggregate demand is due to two factors. First, Ricardian households reduce consumption and investment to a lower extent, as the persistent reduction in the *ex-ante* real interest rate (the expected inflation rate widely increases while the nominal interest rate is constant) partially counterbalances the negative wealth effect associated with anticipated higher future taxes. Second, non-Ricardian households increase their consumption relatively more, as the labor income increases because of the higher labor demand by firms (that have to satisfy the higher increase in aggregate demand).[42]

In Figure 9 we report the case of the monetary policy being accommodative for nine periods. The initial expansion in output is so large (around two percent) that induces a decline in the public deficit-to-output ratio. The trade balance-to-output ratio initially improves, by 0.5 percentage points. As in the previous case, the surplus is driven by the large initial real exchange rate depreciation, that induces the increase in real exports and a large improvement in the Home terms of trade. After one year from the beginning of the stimulus the trade balance moves towards deficit, as the the effects of the depreciation vanish and the imports gradually increase So in the first year we observe twin surpluses instead of twin deficits. The latter do reappear in the medium run.

We report in Tables 6-7 the related multipliers. The accommodative stance of monetary policy implies, when compared to the standard stance, higher fiscal multipliers consistently with impulse responses. In particular, the output multiplier is above one on impact. For trade leakages, they are relatively large when monetary policy is accommodative, as the imports multiplier widely increases because of the higher private absorption. Overall, results suggest the relevance of the monetary policy stance for the impact of the fiscal policy on the trade balance through the magnified response of domestic absorption and internationa relative prices.

6.2 Spending-reversal

Recent contributions by Corsetti et al. (2008) emphasize that the impact of fiscal stimulus depends not only on short-term tax and spending policies, but also on expectations about future offsetting measures. In particular, the authors show, using a sticky price model calibrated to

[42]It is interesting to note that the accommodative monetary policy implies a positive consumption multiplier together with exchange rate depreciation, a stylized fact found by Monacelli and Perotti (forthcoming) and Ravn et al. (2007) for some OECD countries not belonging to the euro area (US, UK, Canada and Australia). Even if we do not find evidence in favor of that stylized fact for the euro area (as our estimates imply a large reaction of monetary policy to inflation), we do find that our estimated model is consistent with that fact once we assume a sufficiently accommodative monetary policy (a point also stressed by Corsetti and Muller 2008). This result remarks the relevance of the appropriate monetary and fiscal policy mix for the effects of fiscal policy.

the US, that the short-run multipliers associated with government consumption are enhanced when public consumption is expected to be persistently and systematically reduced in the future to stabilize public debt.[43] In this section we build on Corsetti et al. (2008) contribution and evaluate the impact of the spending reversal for the case of an open economy such as the euro area. We assume an initial increase in public consumption equal to one percent of pre-stimulus output and that the response to the public debt in the public consumption rule is large enough to guarantee that the public consumption goes below the baseline after around nine quarters from the shock.

We report results in Figure 10. Output increases slightly more in the case of spending reversal (on impact, by 0.94 percent instead of 0.87 as in the benchmark). Subsequently, the output smoothly declines. The public deficit increases slightly less now than in the case of the estimated fiscal rules. The trade balance deteriorates as well. Also in this case we observe the twin deficits in the short run. Quantitatively, the trade deficit is only marginally larger than under the estimated fiscal rules. The increase in imports is larger under spending reversal because of the positive effect of relatively higher aggregate demand. The spending reversal implies that households consumption increases to a larger extent, as the crowding out of Ricardian households' consumption and investment in physical capital is relatively low. The real exchange rate depreciates under spending reversal, as the real interest rate are low.[44] Consistently, the terms of trade improve slightly more, partially counterbalancing the increase in gross imports.

In the medium run the trade balance shows a faster improvement in the case of spending reversal, consistently with the faster improvement in the primary public sector balance. It is driven by the relatively large increase of exports, so as to absorb the excess of available resources.

In Tables 8 we report the implied multipliers. Output multipliers are relatively large when the spending reversal is activated, at all horizons. Trade leakages are relatively large in the short run, as the imports multiplier increases much more than the export multipliers does. In the medium run, instead, the contribution of trade to output becomes positive, as the multiplier for gross real exports benefits from the large real exchange rate depreciation.

[43] Chung and Leeper (2009) provide VAR evidence based on US data in favor of spending reversal. Similarly, Galì and Perotti (2003) document a responsiveness of government spending to public debt for OECD countries.

[44] Both the reduction in crowding out and the depreciation reflect the slack in demand for Home goods in the medium run. As explained by Corsetti et al. (2008), the spending reversals create expectations of a future fall in short-term real interest rates. With sticky prices it's the real output, instead of the policy rate, to significantly adjust on impact. As such, today's long-term rate (equal to the sum of today's and future expect short rates) decrease, limiting the crowding-out in households' aggregate demand. T

6.3 The zero lower bound

The monetary policy stance can affect not only the effectiveness of fiscal stimulus, as considered in the previous section, but also the impact of a fiscal restriction. This is true in particular if the monetary policy authority is constrained by the zero lower bound on the nominal policy rate. If the latter variable has touched the zero floor (and hence it cannot be further reduced), a reduction in public spending or an increase in tax can have negative effects on households' aggregate demand, as the reduction in inflation causes an increase in real interest rate. The issue is particularly relevant from a not only from a theoretical point of view but also from a policy perspective. Interest rates are relatively low in nominal terms worldwide, while many countries do not have fiscal space to implement a stimulus and are called to adopt restrictive measures to reduce public debt. In this section we assess the impact of the zero lower bound on fiscal contractions. We assume that the steady state nominal interest rate is equal to 0.25 percent on annualized terms (instead of 5.30 percent as in the benchmark calibration). We then comparing two scenarios. In the first scenario, we assume a decrease in public consumption such that the policy rate violates the zero bound for nine periods (the implied value of the shock is equal to -1.5 percent of pre-stimulus output). In the second scenario, we impose the zero bound for nine periods. For simplicity, we assume that the fiscal items other then the public consumption are exogenous and that public consumption, after the shock, reacts only to public debt (and not to output). We report results in Figure 10. As it can be seen, there is a somehow larger decrease in output when the zero lower bound is binding, as the short-term real interest rates are relatively high currently and in near future and, hence, crowd out private absorption. The trade balance on impact improves to a lower extent when the zero lower bound is binding. Imports, given the larger reduction in aggregate demand, decrease relatively more. However the terms of trade largely deteriorate (the real exchange rate appreciates relatively more, because of the high real interest rate). Subsequently, as the terms of trade move towards the baseline level, the trade balance gradually improves, in line with values obtained when the monetary policy is unconstrained. Overall, we have a positive correlation between trade and public balances (both improve) in the two scenarios. Moreover, the quantitative implications for output and trade balance are not greatly different across the two scenarios.

7 Sensitivity analysis

In this section we initially show how the (benchmark) value of fiscal multipliers and the transmission mechanism of fiscal shocks do change when we modify the values of some key parameters such as the home bias, the share of non-Ricardian households and elasticity of substitution between domestic and imported goods. As in the benchmark simulations, we consider expansionary fiscal shocks equal to one percent of pre-stimulus output.

7.1 Home bias

We set the home bias in the households' consumption and investment baskets so that they are consistent with a steady-state value of import and export-to-output ratios equal to 0.25 (instead of 0.17 as in the benchmark calibration). This is the value that is obtained when the intra-euro area exports and imports are taken into account. We report the multipliers in Table 9. Results are not extremely different from those obtained under the benchmark simulations (Table 5).

Focusing on the effects of an increase in public consumption spending, the relatively low home bias in households' preferences implies a slight reduction in the output multiplier, as the trade leakages (measured by the trade contribution to output) slightly increase. Consistently, the trade balance and the government deficit (as a ratio to output) deteriorate slightly more. Gross export and imports respectively decrease and increase to a lower extent, as the low home bias implies a relatively low real exchange rate appreciation (as such, the related switching effect is more muted).[45] The real exchange rate appreciates to a lower extent, as the weight of the domestic good (whose relatively price increases) in the consumption and investment basket is relatively low. The lower appreciation of the real exchange rate induces a larger improvement in the terms of trade in the short run, driven by the increase in the exports' price. A similar logic applies to the other fiscal shocks. As for the case of the public consumption shocks, the differences with respect to the benchmark calibration are small.[46]

[45]The low response of exports and imports is not in contrast with the higher trade leakages, as the economy is now more open.

[46]Interestingly, Henry et al. (2004) find effect on output of a 1% of GDP increase in purchases of goods and services depends on the degree of openness and size of the considered country when comparing the fiscal outcomes of different large scale traditional macroeconomic models. Specifically, in the first year ranges between 1.18 for the Deutsche Bundesbank model (hence, for a relatively large economy such as Germany) to 0.87 for the model of the National Bank of Belgium (as such, a small and very open economy like Belgium).

7.2 The share of non-Ricardian households

In Table 10 we report the effects of setting the fraction of non-Ricardian households equal to 0.05. Keynesian effects are now essentially absent from the model. In comparison to the benchmark simulations, output increases to a lower extent in the case of an expansionary shock to public consumption, public transfers and labor tax income. In other cases, the difference is less strong. The lower output multipliers are due to the lower reaction of households' consumption. The public balance deterioration does not greatly changes across the two calibrations. The trade balance generally deteriorates to a lower extent than in the benchmark simulations. The main reason is that gross imports increase to a lower extent, as they mimic the path of households' consumption. The trade balance is also positively affected by gross exports, that decrease relatively less because of the lower pressure from aggregate demand (in the case of labor income tax shock exports increase relatively more). For the same reason, the the terms of trade improve to a lower extent, partially counterbalancing the positive effect of the real net exports on the trade balance. Overall, results suggest the relevance of share of non-Ricardian households and the related Keynesian effects for the impact of fiscal shocks not only on output, but also on trade related variables.

7.3 The elasticity of substitution between domestic and imported goods

In Table 11 we report the effects of setting the elasticity of substitution between domestic and imported tradeables to 0.8 (in the benchmark calibration it is equal to 3.0). The relative price fluctuations are now enhanced. As such, their role in driving the trade balance is somehow magnified. Overall, however, results are not different from those under the benchmark simulations. In the case of public consumption shock, the output multiplier is slightly higher than under the benchmark calibration, as households find more difficult to substitute the more expensive Home good for the imported good. The deterioration in the public deficit and trade balance is overall similar across the two cases. The deterioration in the trade balance is more frontloaded in the case of low elasticity, because it is driven by the initial terms of trade deterioration. The latter is due to the huge appreciation of the real exchange rate. Similarly, the large medium-run improvement in the terms of trade drives the faster trade improvement by more than compensating for the decrease in real exports and the increase in real imports.

A similar transmission mechanism holds for the shock to transfers. Differences with respect to results obtained under the benchmark calibration are less striking than in the case of higher public consumption. The latter implies, because of the full home bias, a larger change in relative prices and hence a stronger propagation mechanism.

In the case of the labor income tax shock, the initial reduction in the price of the Home good, due to the supply-side effects of the shocks, is magnified. Output increases slightly less than in the benchmark case, as for households is relatively difficult to shift demand between domestic and imported goods. The real exchange rate widely depreciates, inducing an improvement in the terms of trade and, hence, a short-run improvement in the trade balance (instead of a deterioration as in the benchmark calibration). In the medium run the trade balance shows a deficit (it is equal to zero in the benchmark calibration), as the deterioration in the terms of trade more than compensates for the increase in the real exports and the decrease of imports. The latter two variables, however, give a persistent positive contribution to output (larger than in the benchmark calibration). Finally, for the capital income tax and the consumption tax shocks the results are in line with those obtained under the benchmark calibration.

8 Conclusions

In this paper, we have estimated the effects of public spending and tax rate shocks on the euro area trade balance and international relative prices, based on an open economy new-Keynesian DSGE model estimated using euro area data. Results suggest that the expansionary fiscal shocks induce twin deficits. The deterioration in the trade balance is however limited, as movements in real net export are partially counterbalanced by offsetting movements in the real exchange rate and terms of trade. The transmission mechanism of the shocks is rather different. In the case of public spending-based stimulus, the deterioration of the trade balance is frontloaded and driven by the decrease in gross export and the real exchange rate appreciation. In the case of tax-based stimulus, the deterioration is gradual and driven by the smooth increase in domestic absorption and the exchange rate depreciation. The monetary policy stance and the fiscal financing do affect the impact of the fiscal measures on the trade balance only to some extent, while they impact on the response of gross imports and international relative prices.

References

[1] Abel, A. 1990. Asset Prices under Habit Formation and Catching Up with the Joneses. American Economic Review, 80(2), pp. 38–42.

[2] Adolfson, M., Laséen, S., Lindé, J., Villani, M., 2007. Bayesian estimation of an open economy DSGE model with incomplete pass-through. Journal of International Economics 72, 2007, 481-511.

[3] Baxter, M., King, R.G., 1993. Fiscal policy in general equilibrium. American Economic Review 83 (3), 315 334.

[4] Baxter, M., 1995. International trade and business cycles," in: Handbook of International Economics 3, (G. Grossman and K. Rogoff, eds.), December.

[5] Beetsma R. , Giuliodori, M., Klaassen, F., 2008. The Effects of Public Spending Shocks on Trade Balances and Budget Deficits in the European Union, Journal of the European Economic Association, Vol. 6, no. 2-3, pp. 414-423.

[6] Benigno, P., 2009a. Are Valuation Effects Desirable from a Global Perspective? Journal of Development Economics, Volume 89, Issue 2, Pages 170-180.

[7] Benigno, P., 2009b. "Price Stability with Imperfect Financial Integration," Journal of Money, Credit and Banking, Volume 41 Issue s1, Pages 121 – 149.

[8] Calvo, G., 1983. Staggered prices in a utility maximizing framework. Journal of Monetary Economics 12, 383–398.

[9] Campbell, J.Y., Mankiw, G., 1989. Consumption, income and interest rate: reinterpreting the time series evidence. In: Blanchard, O.J., Fisher, S. (Eds.), NBER Macroeconomics Annual 1989. MIT Press.

[10] Canova, F., Pappa E., 2004. Does it cost to be virtuous? the macroeconomic effects of fiscal constraints. In R. Clarida, J. Frenkel, and F. Giavazzi, editors, NBER International Macroeconomic Annual. MIT Press.

[11] Canova, F., Pappa E., 2007. Price differentials in monetary unions: The role of fiscal shocks. Economic Journal, 117:713–737, March.

[12] Coenen, G., Straub, R., 2005. Does Government Spending Crowd in Private Consumption? Theory and Empirical Evidence for the Euro Area, International Finance, 8(3), 435-470.

[13] Christiano, L.J., Eichenbaum, M., Evans, C., 2005. Nominal rigidities and the dynamic effects of a shock to monetary policy. Journal of Political Economy 113 (1), 1–45.

[14] Christoffel, K., Coenen, G., Warne A., 2008. The New Area-Wide Model of the Euro Area: A Micro-Founded Open-Economy Model for Forecasting and Policy Analysis, ECB Working Paper No. 944, October.

[15] Chung, H., Leeper, E. M., 2009. What has financed government debt?, mimeo

[16] Corsetti, G., Muller, G. 2006. Twin deficits: Squaring theory, evidence and common sense. Economic Policy, 48, 598–638.

[17] Corsetti, G., Muller, G. 2008. The effectiveness of fiscal policy depends on the financing and monetary policy mix. http://www.voxeu.org/index.php?q=node/2554.

[18] Corsetti, G., Meier, A. and Muller, G. 2008. Fiscal Stimulus with spending reversals. CEPR Discussion Paper 302 (May).

[19] Devereux, M.B., Engel, C., 2002. Exchange rate pass-through, exchange rate volatility and exchange rate disconnect. Journal of Monetary Economics 49 (4), 913–940.

[20] Devereux, M., Smith G. and Yetman, J., 2009. Consumption and Real Exchange Rates in Professional Forecasts. Queen's Economics Department Working Paper 1195.

[21] de Walque, G., Wouters, R., Smets, F., 2005. An Open Economy DSGE Model Linking the Euro Area and the US Economy. Manuscript. National Bank of Belgium.

[22] Duarte, M., Stockman, A.C., 2005. Rational speculation and exchange rates. Journal of Monetary Economics 52, 3–29.

[23] Erceg, C., Guerrieri L., Christopher G., 2005. Expansionary Fiscal Shocks and the Trade Deficit, International Finance, vol. 8 (December), pp. 363-397

[24] Erceg, C., Henderson, D., Levin, A., 2000. Optimal monetary policy with staggered wage and price contracts. Journal of Monetary Economics 46 (2), 281–313.

[25] Fagan, G., Henry, J., Mestre, R., 2005. An area-wide model for the Euro area. Economic Modelling 22 (1), 39–59.

[26] Forni, L., Monteforte, L., Sessa, L. 2009. The general equilibrium effects of fiscal policy: estimates for the Euro area. Journal of Public Economics 93, 559–585.

[27] Galì, J., D. Lopez-Salido and J. Vallès, 2007, Understanding the Effects of Government Spending on Consumption, Journal of European Economic Association 5, 227-270.

[28] Galí, J., Perotti, R., 2003. Fiscal policy and monetary integration in Europe. Economic Policy, 37: 534–572.

[29] Galí, J., Gertler, M., Lopez-Salido, D., 2001. European inflation dynamics. European Economic Review 45 (7), 1237–1270.

[30] Gomes, S., Jacquinot P., Pisani, M., 2010, The EAGLE. A model for policy analysis of macroeconomic interdependence in the euro area. ECB Working paper 1195, May

[31] Henry, J., Hernandez de Cos, P., Momigliano, S., 2004. The short term impact of government budgets on prices: evidence from macroeconomic models. ECBWorking Paper No. 396.

[32] Kollmann, R., 2009. Limited Asset Market Participation and the Consumption-Real Exchange Rate Anomaly. CEPR Discussion Paper 7542.

[33] Kollmann, R., 2010. Government Purchases and the Real Exchange Rate, Open Economies Review, Vol. 21, pp.49-64

[34] Lane, P., Perotti, R., 2003. The importance of composition of fiscal policy: evidence from different exchange rate regimes, Journal of Public Economics 87, 2253–2279

[35] Laséen, S., Svensson L., 2009. Anticipated Alternative Instrument-Rate Paths in Policy Simulations, NBER Working Paper No. 14902 April.

[36] Leeper, E.M., Yang, S.-C.S., 2008. Dynamic scoring: Alternative financing schemes. Journal of Public Economics 92 (1 2), 159–182.

[37] Leeper E. M., Plante, M., Traum N., 2010. Dynamics of fiscal financing in the United States Journal of Econometrics 156, 304–321.

[38] Mendoza E. G., Tesar L., 1998. The International Ramifications of Tax Reforms: Supply-Side Economics in a Global Economy, The American Economic Review, 88(1), 226-245.

[39] Monacelli, T., Perotti, R. (forthcoming). Fiscal Policy, the Real Exchange Rate, and Traded Goods. The Economic Journal.

[40] Pappa E., 2009. The effects of fiscal shocks on employment and the real wage. International Economic Review, Vol. 50, Issue 1, pp. 217-244, February.

[41] Perotti, R., 2005. Estimating the effects of fiscal policy in OECD countries. CEPR Discussion Paper No. 4842.

[42] Ravn M., Schmitt-Grohe S., Uribe M., (2007). Pricing to Habits and the Law of One Price, American Economic Review vol. 97(2), pp. 232-38 (P&P).

[43] Rotemberg, J.J., 1982. Monopolistic price adjustment and aggregate output. Review of Economic Studies 49, 517–531.

[44] Schmitt-Grohé, S., Uribe, M., 2001. Stabilization policy and the cost of dollarization. Journal of Money, Credit and Banking 33 (2), 482–509.

[45] Schorfheide, F., 2000. Loss function-based evaluation of DSGE models. Journal of Applied Econometrics 15 (6), 645–670.

[46] Smets, F., Wouters, R., 2002. Openness, imperfect exchange rate pass-through and monetary policy. Journal of Monetary Economics 49 (5), 913–940.

[47] Smets, F., Wouters, R., 2003. An estimated dynamic stochastic general equilibrium model of the Euro area. Journal of the European Economic Association 1 (5), 1123–1175.

[48] Smets, F., Wouters, R., 2005. Comparing shocks and frictions in US and Euro area Business cycles: a Bayesian DSGE approach. Journal of Applied Econometrics 20 (2), 161–183.

[49] Turnovsky, S. J., 1985. Domestic and Foreign Disturbances in an Optimizing Model of Exchange-Rate Determination. Journal of International Money and Finance 4 (1), 151-71.

Table 1: Calibrated parameters

Parameter	Description	Value
β	Discount factor	0.9982
α	Capital share in production	0.31
η	Substitution elasticity btw tradables	3.0
σ^L	Labor supply elasticity	2.0
δ	Depreciation rate of capital	0.025
$\theta_i (i = H, F, H^*, F^*)$	Substitution elasticity btw brands	6.0
θ^L	Substitution elasticity btw labor varieties	4.3
$1 - a_{HI}$	Imported investment share	0.30
$1 - a_H$	Imported consumption share	0.20
λ^{NR}	Share of rule-of-thumb agents	0.35
τ^w	Labor income tax rate	0.47
τ^k	Capital and dividend income tax rate	0.19
τ^c	Private consumption tax rate	0.16

Table 2: Steady state relationships

Parameter	Description	Value
$\bar{\pi}$	Inflation rate	2.30
gr	Growth rate	2.18
R	Nominal interest rate	5.30
$PC/(P_Y Y)$	Consumption-to-output ratio	0.60
$P_I I/(P_Y Y)$	Investment-to-output ratio	0.20
$P_F Y_F (SP_H^* Y_H^*)/(P_Y Y)$	Imports (Exports)-to-output ratio	0.17
$B^*/(P_Y Y)$	Net foreign asset-to-output ratio	0.00
$\tilde{B}/(P_Y Y)$	Public debt-to-output ratio	2.40
$bb/(P_Y Y)$	Public deficit-to-output ratio	0.027
$P_H G/(P_Y Y)$	Public consumption-to-output ratio	0.20
$TR/(P_Y Y)$	Lump sum transfers-to-output ratio	0.19
$\tau^l WL/(P_Y Y)$	Revenues on labor income tax-to-output ratio	0.24
$\tau^k R^K K/(P_Y Y)$	Rev. on capital income tax-to-output ratio	0.04
$\tau^c PC/(P_Y Y)$	Rev. on consumption tax-to-output ratio	0.09

Table 3: Prior and posterior distributions

		Prior distribution			Posterior distribution			
Parameter		Type	Mean	S.D.	Mode	Mean	5 %	95 %
Habit in formation	b	Beta	0.650	0.100	0.645	0.640	0.603	0.680
Calvo employment	ξ_E	Beta	0.675	0.100	0.862	0.857	0.841	0.874
Invest. adj. cost	γ_I	Inv.Gamma	7.694	1.500	8.504	10.327	6.913	13.334
NFA adj. cost	$\tilde{\phi}_a$	Inv.Gamma	0.010	0.050	0.022	0.022	0.017	0.026
Rotemberg domestic prices	κ_H	Inv.Gamma	60.000	30.000	113.573	99.863	72.993	132.839
Rotemberg import prices	κ_F	Inv.Gamma	60.000	30.000	97.520	112.080	81.298	145.931
Rotemberg wages	κ_W	Inv.Gamma	40.000	20.000	38.374	35.504	25.127	49.224
Rotemberg export prices	κ_F^*	Inv.Gamma	60.000	30.000	58.619	71.409	53.453	90.292
Indexation domestic good prices	α_H	Beta	0.500	0.150	0.231	0.246	0.184	0.311
Indexation import prices	α_F	Beta	0.500	0.150	0.120	0.155	0.100	0.278
Indexation wages	α_W	Beta	0.500	0.150	0.137	0.149	0.083	0.215
Indexation export prices	α_F^*	Beta	0.500	0.150	0.111	0.068	0.036	0.119
Interest rate smoothing	ρ_R	Beta	0.800	0.100	0.771	0.782	0.736	0.821
Inflation response	ρ_π	Normal	1.700	0.100	1.801	1.820	1.701	1.944
Difference inflation response	$\rho_{\Delta\pi}$	Normal	0.300	0.100	0.339	0.320	0.242	0.401
Output response	ρ_y	Normal	0.125	0.050	-0.021	-0.023	-0.038	-0.007
Difference output response	$\rho_{\Delta y}$	Normal	0.063	0.050	0.030	0.041	0.011	0.072
Public cons.	ρ_g	Beta	0.800	0.100	0.915	0.920	0.891	0.940
Public transfer	ρ_{tr}	Beta	0.800	0.100	0.972	0.971	0.956	0.982
Labor tax	ρ_{τ^c}	Beta	0.800	0.100	0.973	0.983	0.974	0.992
Capital tax	ρ_{τ^k}	Beta	0.800	0.100	0.954	0.961	0.936	0.979
Consumption tax	ρ_{τ^c}	Beta	0.800	0.100	0.943	0.921	0.902	0.942
Public cons.	$\eta_{g\tilde{b}}$	Inv.Gamma	0.040	0.100	0.006	0.004	0.002	0.008
Public transf.	$\eta_{tr\tilde{b}}$	Inv.Gamma	0.040	0.100	0.007	0.008	0.005	0.010
Labor income tax	$\eta_{\tau^l\tilde{b}}$	Inv.Gamma	0.040	0.100	0.001	0.000	0.000	0.000
Capital income tax	$\eta_{\tau^k\tilde{b}}$	Inv.Gamma	0.040	0.100	0.009	0.009	0.006	0.014
Cons. tax	$\eta_{\tau^c\tilde{b}}$	Inv.Gamma	0.040	0.100	0.007	0.011	0.008	0.014
Public cons.	η_{gy}	Inv.Gamma	0.040	0.100	0.010	0.005	0.003	0.006
Public transf.	η_{try}	Inv.Gamma	0.040	0.100	0.008	0.007	0.006	0.009
Labor income tax	$\eta_{\tau^l y}$	Inv.Gamma	0.040	0.100	0.001	0.002	0.002	0.003
Capital income tax	$\eta_{\tau^k y}$	Inv.Gamma	0.040	0.100	0.001	0.002	0.001	0.004
Cons. tax	$\eta_{\tau^c y}$	Inv.Gamma	0.040	0.100	0.002	0.001	0.000	0.001

Table 3 (continued): Prior and poster distributions

Parameter		Prior distribution			Posterior distribution			
		Type	Mean	S.D.	Mode	Mean	5 %	95 %
Unit root technology	ρ_μ	Beta	0.800	0.100	0.729	0.788	0.710	0.836
Transitory technology	ρ_ϵ	Beta	0.800	0.100	0.992	0.992	0.989	0.995
Invest. spec. tech.	ρ_Υ	Beta	0.800	0.100	0.707	0.597	0.516	0.726
Consumption preference	ρ_{ξ^c}	Beta	0.800	0.100	0.936	0.935	0.903	0.960
Risk premium	$\rho_{\tilde{\phi}}$	Beta	0.800	0.100	0.956	0.955	0.938	0.970
Domestic price markup	ρ_{θ_H}	Beta	0.800	0.100	0.923	0.922	0.886	0.949
Import price markup	ρ_{θ_F}	Beta	0.800	0.100	0.912	0.872	0.840	0.902
Wage markup	ρ_{θ_L}	Beta	0.800	0.100	0.800	0.791	0.704	0.858
Export markup shock	$\rho_{\theta_H^*}$	Beta	0.800	0.100	0.922	0.899	0.873	0.923
Inflation target	$\rho_{\overline{\pi}}$	Beta	0.800	0.100	0.891	0.949	0.911	0.981
Foreign inflation target	$\rho_{\overline{\pi}^*}$	Beta	0.800	0.100	0.800	0.887	0.829	0.918
Public cons.	σ_g	Inv.Gamma	0.001	0.010	0.005	0.005	0.004	0.005
Public transfer	σ_{tr}	Inv.Gamma	0.001	0.010	0.005	0.005	0.004	0.006
Labor tax	σ_{τ^l}	Inv.Gamma	0.001	0.010	0.006	0.006	0.005	0.006
Capital tax	σ_{τ^k}	Inv.Gamma	0.001	0.010	0.009	0.009	0.008	0.010
Consumption tax	σ_{τ^c}	Inv.Gamma	0.001	0.010	0.007	0.007	0.006	0.008
Monetary policy	σ_R	Inv.Gamma	0.001	0.010	0.001	0.001	0.000	0.001
Inflation target	$\sigma_{\overline{\pi}}$	Inv.Gamma	0.001	0.010	0.003	0.002	0.001	0.002
Unit root technology	σ_μ	Inv.Gamma	0.001	0.010	0.004	0.003	0.003	0.004
Transitory technology	σ_ϵ	Inv.Gamma	0.001	0.010	0.013	0.013	0.011	0.016
Invest. spec. tech.	σ_Υ	Inv.Gamma	0.001	0.010	0.057	0.085	0.059	0.119
Consumption preference	σ_{ξ^c}	Inv.Gamma	0.001	0.010	0.026	0.025	0.021	0.029
Risk premium	$\sigma_{\tilde{\phi}}$	Inv.Gamma	0.001	0.010	0.005	0.005	0.005	0.006
Domestic price markup	σ_{θ_H}	Inv.Gamma	0.001	0.010	0.105	0.103	0.080	0.133
Import price markup	σ_{θ_F}	Inv.Gamma	0.001	0.010	0.200	0.246	0.197	0.309
Wage markup	σ_{θ_L}	Inv.Gamma	0.001	0.010	0.221	0.215	0.163	0.285
Export markup shock	$\sigma_{\theta_H^*}$	Inv.Gamma	0.001	0.010	0.207	0.230	0.193	0.263
Foreign inflation target	$\sigma_{\overline{\pi}^*}$	Inv.Gamma	0.001	0.010	0.001	0.001	0.000	0.002

Table 4: Sensitivity analysis, posterior mode estimates

		Benchmark	$\eta = 0.8$	$\lambda^{NR} = 0.15$	$\eta_y = 0.0$
Habit in formation	b	0.645	0.599	0.724	0.639
Calvo employment	ξ_E	0.862	0.843	0.860	0.863
Invest. adj. cost	γ_I	8.504	7.152	8.432	8.310
NFA adj. cost	$\tilde{\phi}_a$	0.022	0.007	0.023	0.022
Rotemberg domestic prices	κ_H	113.573	33.160	116.213	112.119
Rotemberg import prices	κ_F	97.520	41.902	99.772	102.078
Rotemberg wages	κ_W	38.374	29.078	38.664	37.903
Rotemberg export prices	κ_F^*	58.619	13.974	58.022	59.388
Indexation domestic good prices	α_H	0.231	0.183	0.229	0.231
Indexation import prices	α_F	0.120	0.122	0.120	0.119
Indexation wages	α_W	0.137	0.159	0.136	0.139
Indexation export prices	α_F^*	0.111	0.161	0.111	0.110
Interest rate smoothing	ρ_R	0.771	0.774	0.777	0.776
Inflation response	ρ_π	1.801	1.828	1.789	1.792
Difference inflation response	$\rho_{\Delta\pi}$	0.339	0.313	0.330	0.331
Output response	ρ_y	-0.021	-0.042	-0.021	-0.025
Difference output response	$\rho_{\Delta y}$	0.030	0.038	0.031	0.031
Public cons.	ρ_g	0.915	0.915	0.916	0.927
Public transfer	ρ_{tr}	0.972	0.974	0.972	0.973
Labor tax	ρ_{τ^l}	0.973	0.979	0.973	0.974
Capital tax	ρ_{τ^k}	0.954	0.964	0.954	0.962
Consumption tax	ρ_{τ^c}	0.943	0.942	0.943	0.948
Public cons.	$\eta_{g\tilde{b}}$	0.006	0.007	0.006	0.005
Public transf.	$\eta_{tr\tilde{b}}$	0.007	0.010	0.007	0.006
Labor income tax	$\eta_{\tau^l\tilde{b}}$	0.001	0.001	0.001	0.001
Capital income tax	$\eta_{\tau^k\tilde{b}}$	0.009	0.011	0.009	0.008
Cons. tax	$\eta_{\tau^c\tilde{b}}$	0.007	0.011	0.008	0.008
Public cons.	η_{gy}	0.010	0.008	0.009	0.000
Public transf.	η_{try}	0.008	0.008	0.008	0.000
Labor income tax	$\eta_{\tau^l y}$	0.001	0.001	0.001	0.000
Capital income tax	$\eta_{\tau^k y}$	0.001	0.001	0.001	0.000
Cons. tax	$\eta_{\tau^c y}$	0.002	0.001	0.001	0.000

Table 4 (continued): Sensitivity analysis, posterior mode estimates

		Benchmark	$\eta = 0.8$	$\lambda^{NR} = 0.15$	$\eta_y = 0.0$
Unit root technology	ρ_μ	0.729	0.688	0.726	0.727
Transitory technology	ρ_ϵ	0.992	0.996	0.991	0.992
Invest. spec. tech.	ρ_Υ	0.707	0.628	0.710	0.697
Consumption preference	ρ_{ξ^c}	0.936	0.958	0.935	0.938
Risk premium	$\rho_{\tilde{\phi}}$	0.956	0.996	0.955	0.956
Domestic price markup	ρ_{θ_H}	0.923	0.913	0.921	0.925
Import price markup	ρ_{θ_F}	0.912	0.878	0.899	0.902
Wage markup	ρ_{θ_L}	0.800	0.796	0.793	0.794
Export markup shock	$\rho_{\theta^*_H}$	0.922	0.734	0.922	0.922
Inflation target	$\rho_{\overline{\pi}}$	0.891	0.865	0.891	0.888
Foreign price markup	ρ_{θ_F}	0.798	0.800	0.799	0.804
Foreign Inflation target	$\rho_{\overline{\pi}}$	0.800	0.800	0.799	0.798
Public cons.	σ_g	0.005	0.005	0.005	0.005
Public transfer	σ_{tr}	0.005	0.005	0.005	0.005
Labor tax	σ_{τ^l}	0.006	0.006	0.006	0.006
Capital tax	σ_{τ^k}	0.009	0.009	0.009	0.009
Consumption tax	σ_{τ^c}	0.007	0.006	0.007	0.007
Monetary policy	σ_R	0.001	0.001	0.001	0.001
Inflation target	$\sigma_{\overline{\pi}}$	0.003	0.003	0.003	0.002
Unit root technology	σ_μ	0.004	0.004	0.004	0.004
Transitory technology	σ_ϵ	0.013	0.011	0.013	0.014
Invest. spec. tech.	σ_Υ	0.057	0.057	0.056	0.056
Consumption preference	σ_{ξ^c}	0.026	0.023	0.027	0.025
Risk premium	$\sigma_{\tilde{\phi}}$	0.005	0.002	0.005	0.005
Domestic price markup	σ_{θ_H}	0.105	0.094	0.106	0.106
Import price markup	σ_{θ_F}	0.200	0.323	0.209	0.207
Wage markup	σ_{θ_L}	0.221	0.188	0.221	0.224
Export markup shock	$\sigma_{\theta^*_H}$	0.207	0.278	0.206	0.207
Foreign Inflation target	$\sigma_{\overline{\pi}*}$	0.001	0.001	0.001	0.001
Log marginal likelihood		-5318.65	-6350.85	-5323.75	-5329.16

Table 5: Fiscal multipliers

	Qrts	PD	TB	Y	NX	C	I	X	M	RER	RER τ^c	TOT
$+\Delta g$	1	0.55	-0.07	0.87	-0.07	0.07	-0.17	-0.29	0.15	-0.12	-0.12	-0.03
	4	0.56	-0.08	0.57	-0.11	-0.11	-0.38	-0.51	0.12	-0.15	-0.15	-0.14
	8	0.49	-0.04	0.15	-0.08	-0.32	-0.75	-0.55	-0.06	-0.11	-0.10	-0.23
	24	0.06	0.02	-0.10	0.01	-0.20	-0.54	-0.15	-0.21	-0.08	-0.03	-0.06
	100	-0.09	0.00	-0.01	0.00	-0.04	0.07	0.00	0.00	-0.01	0.00	0.00
$+\Delta tr$	1	0.87	-0.06	0.24	-0.07	0.58	-0.10	-0.05	0.35	0.01	0.01	-0.04
	4	0.85	-0.05	0.16	-0.06	0.49	-0.24	-0.08	0.27	0.00	0.00	-0.05
	8	0.77	-0.02	0.05	-0.03	0.35	-0.51	-0.08	0.10	-0.01	0.00	-0.05
	24	0.35	0.01	-0.11	0.00	0.14	-0.67	-0.08	-0.10	-0.09	-0.02	-0.03
	100	-0.26	0.00	-0.07	0.00	-0.10	0.11	-0.01	-0.01	-0.07	0.00	0.00
$-\Delta\tau^l$	1	0.80	-0.04	0.44	-0.05	0.80	0.14	0.16	0.45	0.16	0.16	-0.08
	4	0.73	-0.02	0.58	-0.02	0.91	0.31	0.35	0.45	0.17	0.18	0.02
	8	0.58	0.00	0.77	0.03	1.04	0.63	0.61	0.44	0.18	0.19	0.17
	24	0.25	0.00	0.67	0.03	0.88	0.70	0.57	0.38	0.11	0.16	0.18
	100	-0.18	0.00	0.22	0.01	0.28	0.31	0.20	0.14	0.01	0.05	0.07
$-\Delta\tau^k$	1	0.99	-0.01	0.01	-0.01	-0.01	0.13	-0.01	0.04	0.01	0.01	-0.01
	4	0.93	-0.02	0.02	-0.02	-0.02	0.26	-0.02	0.09	-0.01	0.00	-0.01
	8	0.76	-0.03	0.04	-0.03	-0.05	0.44	-0.02	0.15	-0.02	0.00	-0.01
	24	0.22	0.01	0.02	0.01	-0.01	0.23	0.09	0.02	-0.04	0.03	0.02
	100	-0.18	0.00	0.01	0.00	-0.02	0.14	0.02	0.02	-0.02	0.01	0.01
$-\Delta\tau^c$	1	0.46	0.09	0.49	-0.08	0.98	0.06	0.10	0.60	2.34	1.10	-1.06
	4	0.37	-0.02	0.48	-0.12	1.07	-0.04	-0.01	0.71	1.68	0.58	-0.60
	8	0.36	-0.09	0.17	-0.10	0.67	-0.46	-0.19	0.42	0.77	-0.02	-0.10
	24	0.11	0.02	-0.08	0.03	0.05	-0.57	-0.02	-0.18	0.16	-0.03	0.03
	100	-0.06	0.00	-0.02	0.00	-0.04	0.04	0.00	0.00	-0.01	0.00	0.00

Note:PD=public sector deficit;TB=trade balance; Y=output;NX=trade contribution to output;C=consumption; I=investment;X=exports; M=imports;RER=real exchange rate; RER τ^c=pre-consumption tax real exchange rate;TOT= pre-consumption tax terms of trade. PD and TB are p.p. of nominal output. Other variables are % deviation from steady state. Output and its components are in real terms. NX is the trade contribution to output. It corresponds to the difference between real exports and real imports divided by the real output (evaluated at steady state prices)

Table 6: Public consumption multipliers and accommodative monetary policy (four quarters)

Qrts	PD	TB	Y	NX	C	I	X	M	RER	RER τ^c	TOT
1	0.45	0.03	1.04	-0.08	0.31	0.00	-0.18	0.30	0.57	0.57	-0.67
4	0.44	-0.04	0.78	-0.14	0.19	-0.10	-0.42	0.39	0.32	0.32	-0.57
8	0.44	-0.08	0.25	-0.14	-0.17	-0.47	-0.60	0.21	-0.03	-0.03	-0.34
24	0.09	0.02	-0.06	0.02	-0.18	-0.52	-0.11	-0.21	-0.05	-0.02	-0.05
100	-0.08	0.00	-0.01	0.00	-0.04	0.06	0.00	0.00	-0.01	0.00	0.00

Table 7: Public consumption multipliers and accommodative monetary policy (nine quarters)

Qrts	PD	TB	Y	NX	C	I	X	M	RER	RER τ^c	TOT
1	-0.13	-0.13	0.46	1.80	-0.07	1.27	0.81	0.44	0.86	3.38	3.38
4	-0.29	-0.29	0.18	1.83	-0.20	1.56	1.31	0.26	1.47	2.40	2.39
8	-0.04	-0.04	-0.20	0.99	-0.39	0.90	1.25	-0.58	1.74	0.69	0.67
24	0.24	0.24	0.04	0.09	0.04	-0.02	-0.56	0.03	-0.21	0.08	0.03
100	-0.02	-0.02	0.00	-0.01	0.00	-0.02	0.02	0.00	0.00	-0.01	0.00

Table 8: Public consumption multipliers and spending reversal

Qrts	PD	TB	Y	NX	C	I	X	M	RER	RER τ^c	TOT
1	0.50	-0.07	0.94	-0.09	0.19	-0.05	-0.29	0.26	0.00	0.00	-0.15
4	0.45	-0.10	0.66	-0.14	0.09	-0.10	-0.50	0.36	-0.04	-0.04	-0.25
8	0.17	-0.06	0.17	-0.10	-0.02	-0.01	-0.34	0.28	0.06	0.07	-0.29
24	-0.13	0.02	-0.03	0.05	0.03	0.22	0.21	-0.09	-0.03	-0.03	0.17
100	0.01	0.00	0.01	0.00	-0.01	-0.02	-0.02	0.00	-0.01	-0.01	-0.01

Note:PD=public sector deficit;TB=trade balance; Y=output;NX=trade contribution to output;C=consumption; I=investment;X=exports; M=imports;RER=real exchange rate; RER τ^c=pre-consumption tax real exchange rate;TOT=pre-consumption tax terms of trade. PD and TB are p.p. of nominal output. Other variables are % deviation from steady state. Output and its components are in real terms. NX is the trade contribution to output. It corresponds to the difference between real exports and real imports divided by the real output (evaluated at steady state prices)

Table 9: Fiscal multipliers and low home bias

	Qrts	PD	TB	Y	NX	C	I	X	M	RER	RER τ^c	TOT
$+\Delta g$	1	0.56	-0.08	0.84	-0.10	0.07	-0.16	-0.26	0.12	-0.07	-0.07	-0.06
	4	0.56	-0.09	0.55	-0.13	-0.10	-0.35	-0.46	0.07	-0.09	-0.09	-0.15
	8	0.49	-0.05	0.15	-0.10	-0.30	-0.71	-0.51	-0.11	-0.07	-0.07	-0.22
	24	0.06	0.02	-0.09	0.01	-0.19	-0.52	-0.17	-0.19	-0.08	-0.03	-0.06
	100	-0.09	0.00	-0.01	0.00	-0.04	0.07	0.00	0.00	-0.01	0.00	0.00
$+\Delta tr$	1	0.88	-0.08	0.20	-0.09	0.56	-0.10	-0.03	0.35	0.04	0.04	-0.06
	4	0.86	-0.06	0.14	-0.08	0.48	-0.24	-0.04	0.26	0.03	0.03	-0.05
	8	0.77	-0.02	0.04	-0.03	0.35	-0.51	-0.04	0.08	0.01	0.02	-0.04
	24	0.34	0.01	-0.11	0.00	0.13	-0.66	-0.08	-0.09	-0.09	-0.02	-0.03
	100	-0.26	0.00	-0.07	0.00	-0.10	0.11	-0.02	-0.01	-0.07	0.00	-0.01
$-\Delta\tau^l$	1	0.82	-0.06	0.40	-0.07	0.77	0.12	0.17	0.46	0.16	0.16	-0.07
	4	0.74	-0.03	0.55	-0.02	0.88	0.28	0.38	0.45	0.16	0.17	0.04
	8	0.59	0.00	0.76	0.05	1.00	0.57	0.65	0.45	0.16	0.17	0.19
	24	0.25	0.00	0.65	0.05	0.84	0.63	0.59	0.39	0.09	0.14	0.19
	100	-0.18	0.00	0.21	0.02	0.26	0.29	0.20	0.14	0.00	0.05	0.07
$-\Delta\tau^k$	1	0.99	-0.01	0.01	-0.01	-0.01	0.13	0.00	0.04	0.01	0.01	-0.01
	4	0.93	-0.02	0.02	-0.02	-0.02	0.26	-0.01	0.07	0.00	0.00	-0.01
	8	0.77	-0.03	0.04	-0.03	-0.04	0.44	0.00	0.12	-0.01	0.00	0.00
	24	0.22	0.01	0.02	0.01	-0.02	0.22	0.08	0.02	-0.04	0.03	0.01
	100	-0.18	0.00	0.01	0.00	-0.02	0.14	0.02	0.02	-0.02	0.01	0.01
$-\Delta\tau^c$	1	0.46	0.15	0.44	-0.12	0.96	0.07	0.13	0.61	2.34	1.12	-1.05
	4	0.38	-0.01	0.44	-0.16	1.06	-0.03	0.06	0.69	1.69	0.60	-0.59
	8	0.36	-0.10	0.15	-0.12	0.67	-0.44	-0.11	0.39	0.79	0.01	-0.08
	24	0.11	0.03	-0.08	0.03	0.05	-0.57	-0.03	-0.16	0.16	-0.04	0.02
	100	-0.06	0.00	-0.02	0.00	-0.04	0.05	0.00	0.00	-0.01	0.00	0.00

Note:PD=public sector deficit;TB=trade balance; Y=output;NX=trade contribution to output;C=consumption; I=investment;X=exports; M=imports;RER=real exchange rate; RER τ^c=pre-consumption tax real exchange rate;TOT=pre-consumption tax terms of trade. PD and TB are p.p. of nominal output. Other variables are % deviation from steady state. Output and its components are in real terms. NX is the trade contribution to output. It corresponds to the difference between real exports and real imports divided by the real output (evaluated at steady state prices)

Table 10: Fiscal multipliers and low share of non-Ricardian households

	Qrts	PD	TB	Y	NX	C	I	X	M	RER	RER τ^c	TOT
$+\Delta g$	1	0.60	-0.04	0.78	-0.05	-0.15	-0.14	-0.27	0.01	-0.13	-0.13	-0.01
	4	0.60	-0.06	0.51	-0.08	-0.29	-0.32	-0.47	0.01	-0.15	-0.15	-0.12
	8	0.51	-0.04	0.14	-0.07	-0.42	-0.62	-0.52	-0.10	-0.11	-0.10	-0.21
	24	0.05	0.02	-0.07	0.01	-0.19	-0.43	-0.13	-0.18	-0.07	-0.03	-0.05
	100	-0.08	0.00	-0.01	0.00	-0.02	0.03	0.00	0.00	-0.01	0.00	0.00
$+\Delta tr$	1	0.98	-0.01	0.03	-0.01	0.09	-0.05	-0.02	0.05	-0.01	-0.01	0.00
	4	0.94	-0.01	0.02	-0.01	0.10	-0.10	-0.04	0.05	-0.01	-0.01	-0.01
	8	0.81	-0.01	-0.01	-0.01	0.10	-0.23	-0.05	0.02	-0.02	-0.01	-0.02
	24	0.34	0.00	-0.09	0.00	0.05	-0.33	-0.05	-0.05	-0.09	-0.01	-0.02
	100	-0.25	0.00	-0.04	0.00	-0.03	0.05	0.00	0.00	-0.06	0.00	0.00
$-\Delta\tau^l$	1	0.90	0.01	0.25	0.00	0.37	0.18	0.18	0.19	0.14	0.14	-0.04
	4	0.80	0.01	0.45	0.02	0.59	0.40	0.38	0.26	0.16	0.16	0.06
	8	0.62	0.01	0.71	0.04	0.84	0.84	0.62	0.39	0.16	0.18	0.19
	24	0.25	0.00	0.67	0.03	0.79	0.97	0.59	0.41	0.11	0.16	0.19
	100	-0.17	0.00	0.24	0.01	0.33	0.26	0.21	0.15	0.01	0.06	0.07
$-\Delta\tau^k$	1	1.00	0.00	0.01	-0.01	-0.03	0.15	0.00	0.03	0.01	0.01	-0.01
	4	0.93	-0.01	0.02	-0.01	-0.06	0.32	0.01	0.08	0.00	0.00	0.00
	8	0.77	-0.02	0.05	-0.02	-0.09	0.57	0.02	0.14	-0.01	0.01	0.01
	24	0.20	0.01	0.07	0.01	0.00	0.40	0.13	0.06	-0.03	0.04	0.03
	100	-0.17	0.00	0.01	0.00	0.02	0.06	0.02	0.02	-0.02	0.01	0.01
$-\Delta\tau^c$	1	0.51	0.12	0.39	-0.06	0.75	0.08	0.11	0.46	2.33	1.09	-1.04
	4	0.41	0.00	0.42	-0.10	0.93	0.00	0.01	0.62	1.67	0.57	-0.58
	8	0.36	-0.08	0.16	-0.10	0.61	-0.38	-0.18	0.40	0.77	-0.03	-0.09
	24	0.10	0.02	-0.07	0.03	0.05	-0.50	-0.01	-0.16	0.16	-0.03	0.03
	100	-0.06	0.00	-0.01	0.00	-0.02	0.02	0.00	0.00	-0.01	0.00	0.00

Note:PD=public sector deficit;TB=trade balance; Y=output;NX=trade contribution to output;C=consumption; I=investment;X=exports; M=imports;RER=real exchange rate; RER τ^c=pre-consumption tax real exchange rate;TOT=pre-consumption tax terms of trade. PD and TB are p.p. of nominal output. Other variables are % deviation from steady state. Output and its components are in real terms. NX is the trade contribution to output. It corresponds to the difference between real exports and real imports divided by the real output (evaluated at steady state prices)

Table 11: Fiscal multipliers and low elasticity

	Qrts	PD	TB	Y	NX	C	I	X	M	RER	RER τ^c	TOT
$+\Delta g$	1	0.54	-0.09	0.92	-0.05	0.10	-0.14	-0.19	0.12	-0.63	-0.63	0.25
	4	0.53	-0.06	0.65	-0.07	-0.07	-0.31	-0.37	0.08	-0.67	-0.66	-0.11
	8	0.46	0.01	0.21	-0.09	-0.26	-0.59	-0.54	0.00	-0.60	-0.59	-0.58
	24	0.04	0.01	-0.06	-0.05	-0.12	-0.27	-0.28	0.04	-0.31	-0.27	-0.36
	100	-0.07	0.00	0.00	0.00	-0.02	0.06	0.01	0.00	0.00	0.01	0.01
$+\Delta tr$	1	0.87	-0.07	0.24	-0.07	0.59	-0.10	-0.04	0.35	-0.09	-0.09	0.02
	4	0.85	-0.05	0.17	-0.06	0.51	-0.22	-0.07	0.28	-0.11	-0.10	-0.05
	8	0.77	-0.02	0.05	-0.04	0.37	-0.47	-0.11	0.14	-0.11	-0.10	-0.14
	24	0.34	0.01	-0.10	-0.02	0.16	-0.58	-0.13	-0.02	-0.20	-0.13	-0.16
	100	-0.26	0.00	-0.06	0.00	-0.08	0.12	-0.01	0.01	-0.08	-0.01	-0.02
$-\Delta\tau^l$	1	0.80	0.05	0.42	-0.03	0.75	0.09	0.20	0.38	0.89	0.89	-0.47
	4	0.75	0.02	0.54	0.02	0.83	0.19	0.43	0.30	0.91	0.91	0.00
	8	0.62	-0.02	0.72	0.11	0.91	0.34	0.79	0.13	0.95	0.96	0.77
	24	0.30	-0.01	0.59	0.17	0.70	0.15	0.86	-0.16	0.81	0.87	1.05
	100	-0.20	0.00	0.13	0.06	0.12	0.14	0.27	-0.08	0.20	0.27	0.34
$-\Delta\tau^k$	1	0.99	0.00	0.01	-0.01	-0.01	0.12	0.00	0.04	0.03	0.03	-0.02
	4	0.93	-0.01	0.03	-0.01	-0.03	0.25	0.01	0.07	0.01	0.02	0.00
	8	0.76	-0.02	0.04	-0.01	-0.06	0.42	0.02	0.11	0.01	0.02	0.02
	24	0.22	0.00	0.01	0.02	-0.03	0.19	0.10	-0.02	0.04	0.11	0.11
	100	-0.19	0.00	0.00	0.01	-0.03	0.12	0.03	0.00	0.00	0.03	0.04
$-\Delta\tau^c$	1	0.47	0.06	0.46	-0.11	0.97	0.07	0.00	0.64	2.24	1.00	-1.00
	4	0.38	-0.03	0.47	-0.13	1.07	-0.03	-0.05	0.71	1.57	0.47	-0.59
	8	0.34	-0.06	0.20	-0.09	0.68	-0.44	-0.14	0.37	0.66	-0.13	-0.18
	24	0.10	0.02	-0.07	0.01	0.07	-0.51	-0.05	-0.11	0.12	-0.08	-0.03
	100	-0.06	0.00	-0.01	0.00	-0.03	0.04	0.00	0.00	-0.01	0.00	0.00

Note:PD=public sector deficit;TB=trade balance; Y=output;NX=trade contribution to output;C=consumption; I=investment;X=exports; M=imports;RER=real exchange rate; RER τ^c=pre-consumption tax real exchange rate;TOT=pre-consumption tax terms of trade. PD and TB are p.p. of nominal output. Other variables are % deviation from steady state. Output and its components are in real terms. NX is the trade contribution to output. It corresponds to the difference between real exports and real imports divided by the real output (evaluated at steady state prices)

Figure 1: Data (thick) and one-sided predicted values from the model (thin).

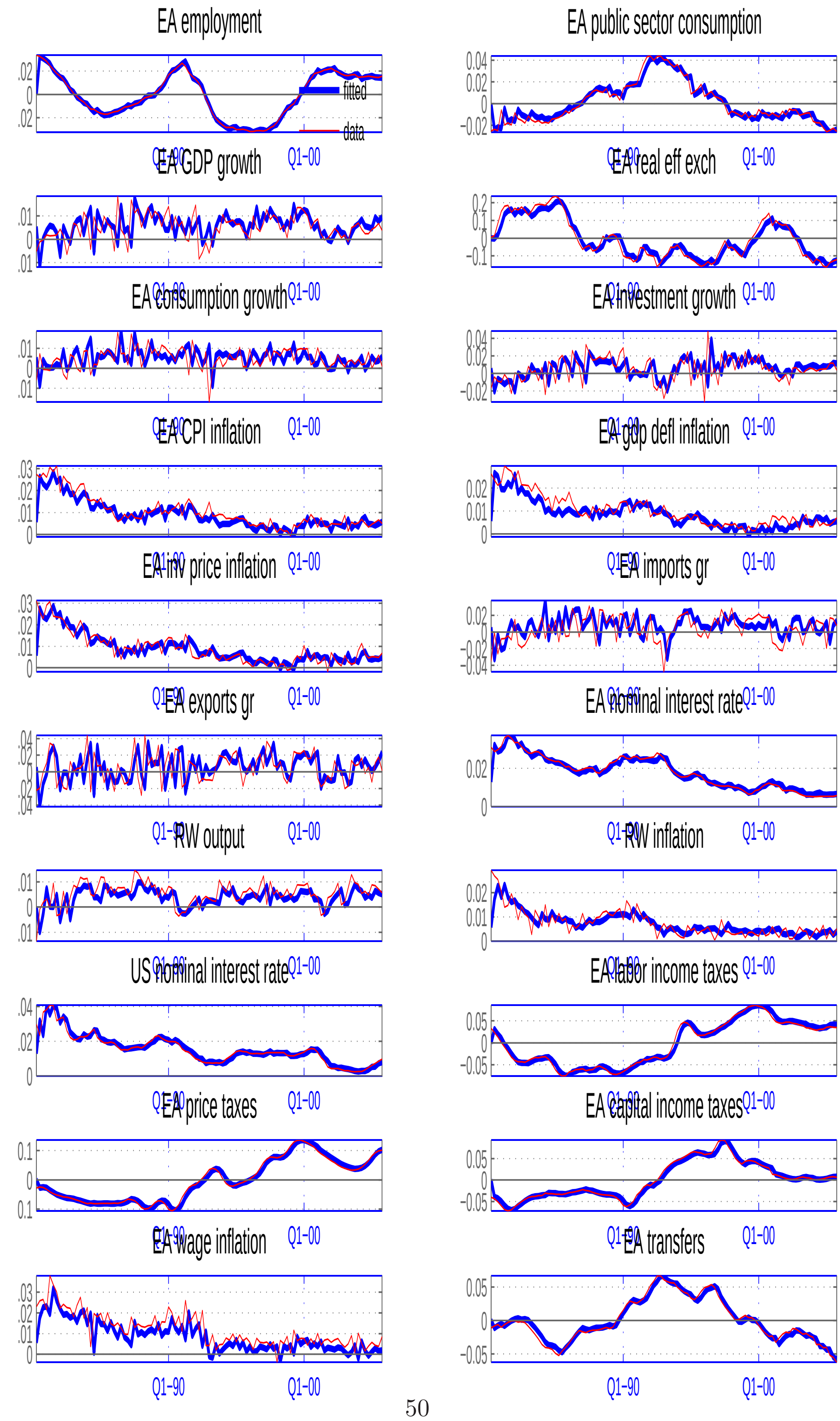
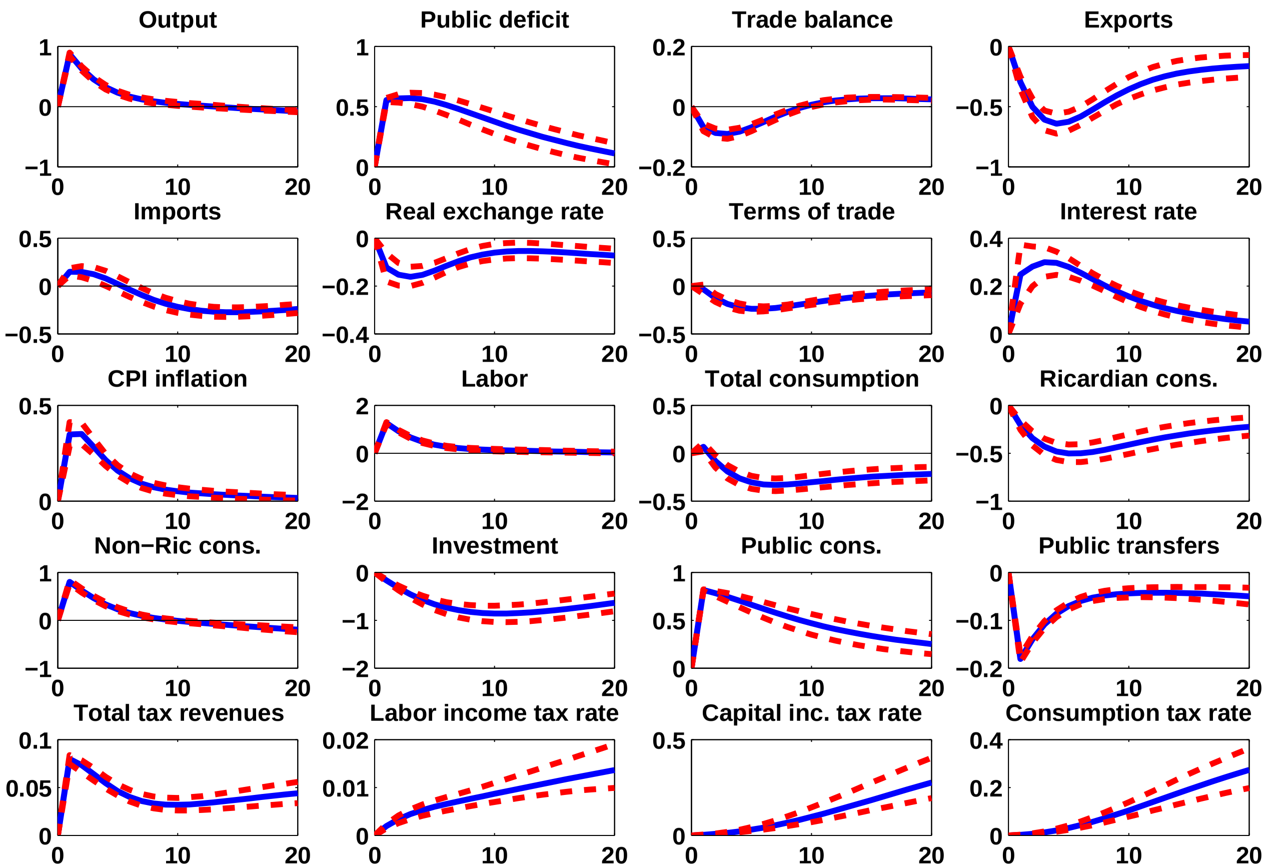
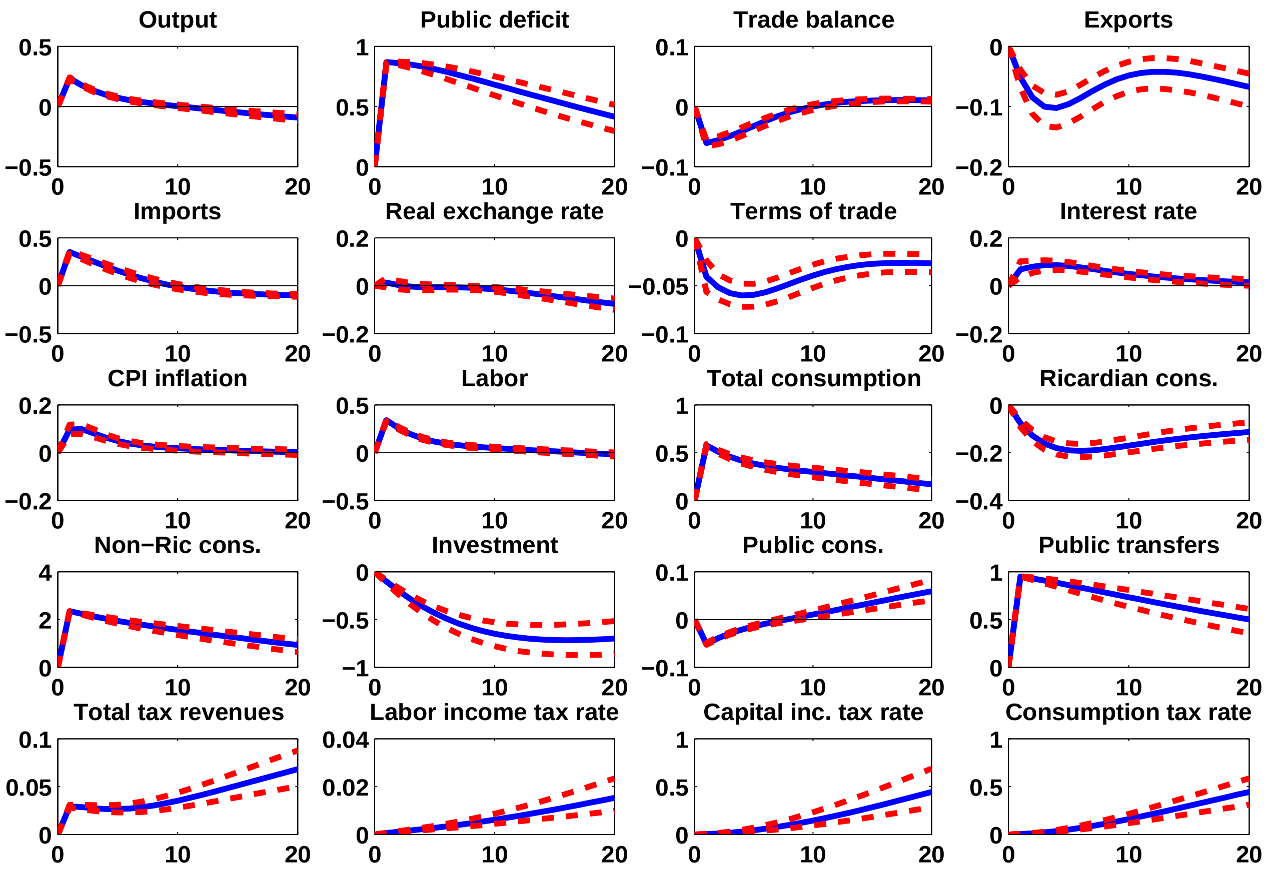


Figure 2: Responses after a public consumption shock



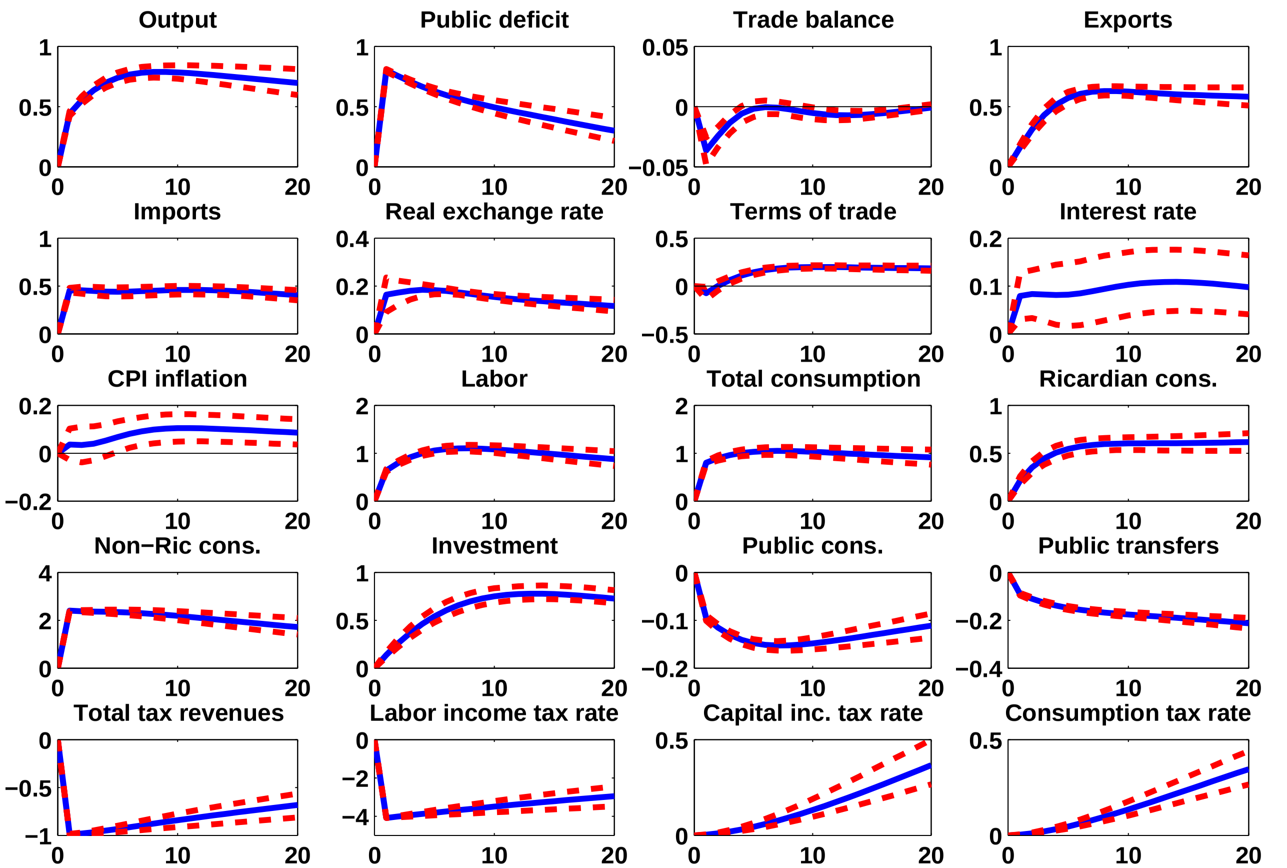
Horizontal axis: quarters. Vertical axis: percentage deviations from the baseline, except for inflation and interest rates (annualized percentage-point deviations), trade balance, public sector primary balance, public consumption, public transfers and total tax revenues (ratio to output, percentage-point deviations). Output and aggregate demand components are reported in real terms. (Posterior mean and 90% uncertainty intervals)

Figure 3: Responses after a public transfer shock



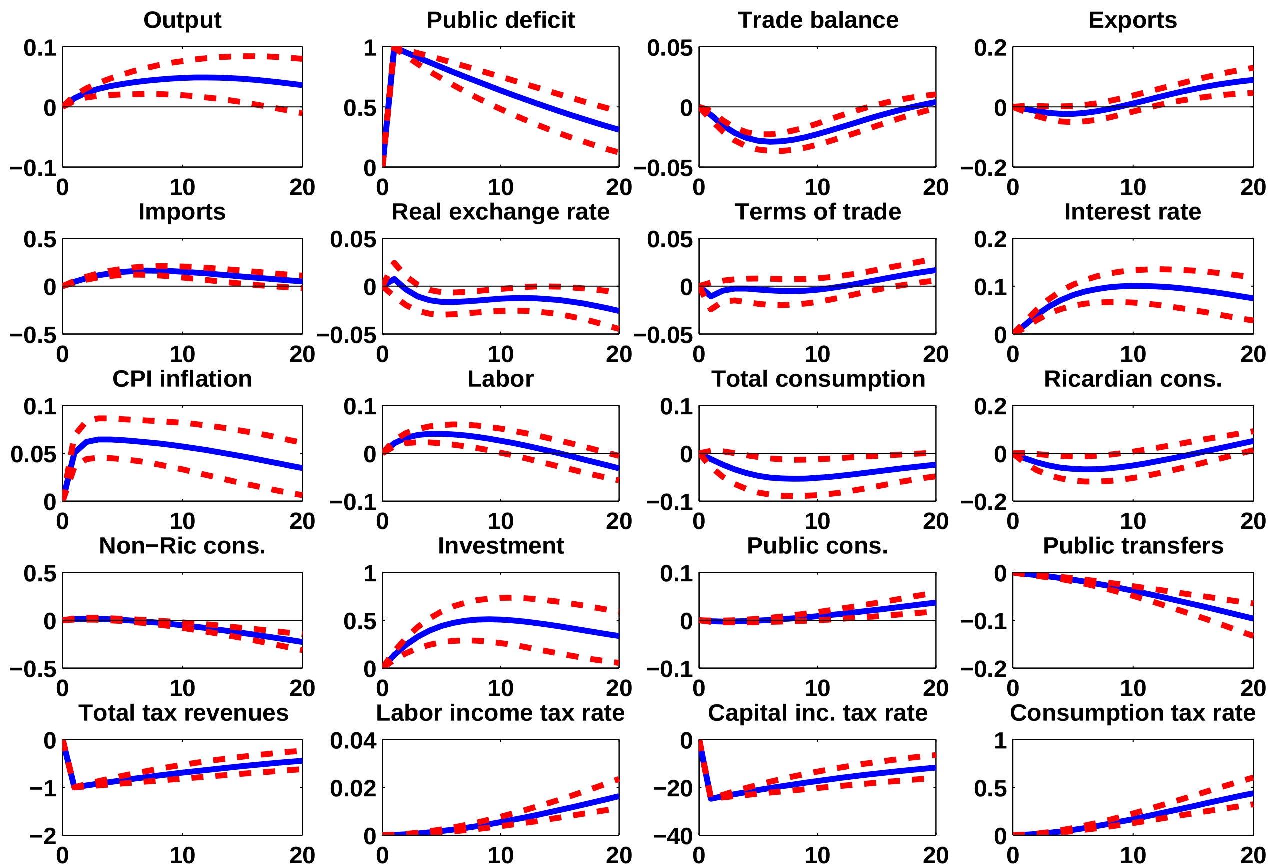
Horizontal axis: quarters. Vertical axis: percentage deviations from the baseline, except for inflation and interest rates (annualized percentage-point deviations), trade balance, public sector primary balance, public consumption, public transfers and total tax revenues (ratio to output, percentage-point deviations). Output and aggregate demand components are reported in real terms. (Posterior mean and 90% uncertainty intervals)

Figure 4: Responses after a labor income tax shock



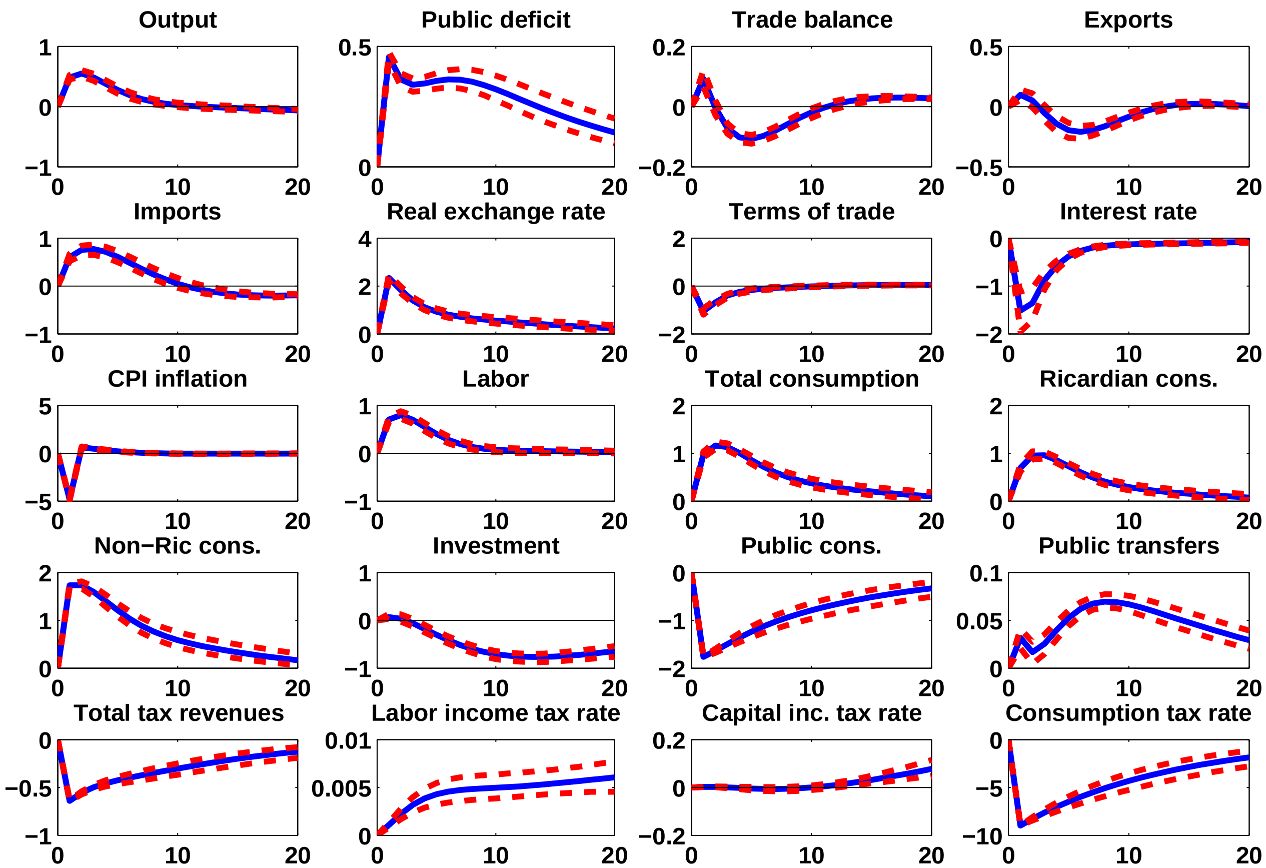
Horizontal axis: quarters. Vertical axis: percentage deviations from the baseline, except for inflation and interest rates (annualized percentage-point deviations), trade balance, public sector primary balance, public consumption, public transfers and total tax revenues (ratio to output, percentage-point deviations). Output and aggregate demand components are reported in real terms. (Posterior mean and 90% uncertainty intervals)

Figure 5: Responses after a capital income tax shock



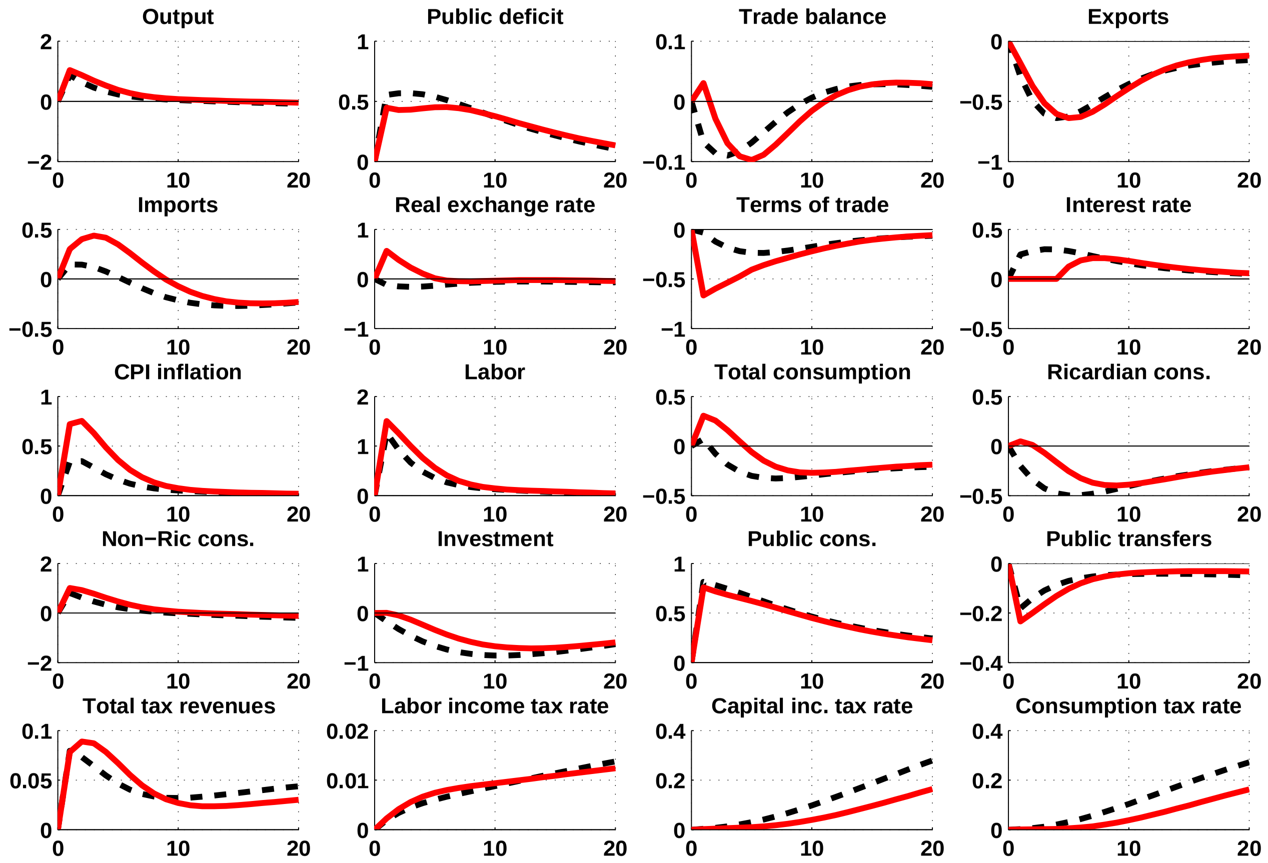
Horizontal axis: quarters. Vertical axis: percentage deviations from the baseline, except for inflation and interest rates (annualized percentage-point deviations), trade balance, public sector primary balance, public consumption, public transfers and total tax revenues (ratio to output, percentage-point deviations). Output and aggregate demand components are reported in real terms. (Posterior mean and 90% uncertainty intervals)

Figure 6: Responses after a consumption tax shock



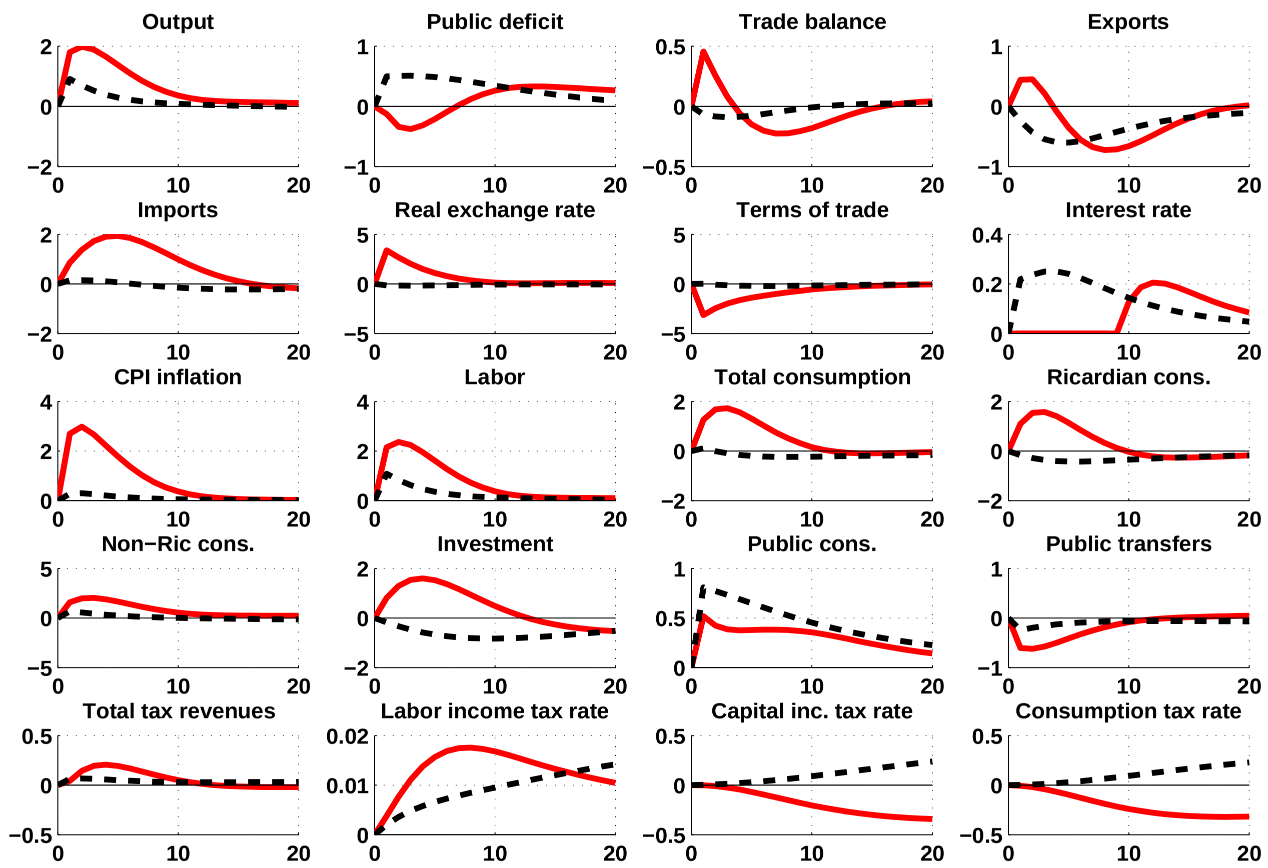
Horizontal axis: quarters. Vertical axis: percentage deviations from the baseline, except for inflation and interest rates (annualized percentage-point deviations), trade balance, public sector primary balance, public consumption, public transfers and total tax revenues (ratio to output, percentage-point deviations). Output and aggregate demand components are reported in real terms. (Posterior mean and 90% uncertainty intervals)

Figure 7: Responses after a public consumption shock and accommodative monetary policy (four quarters)



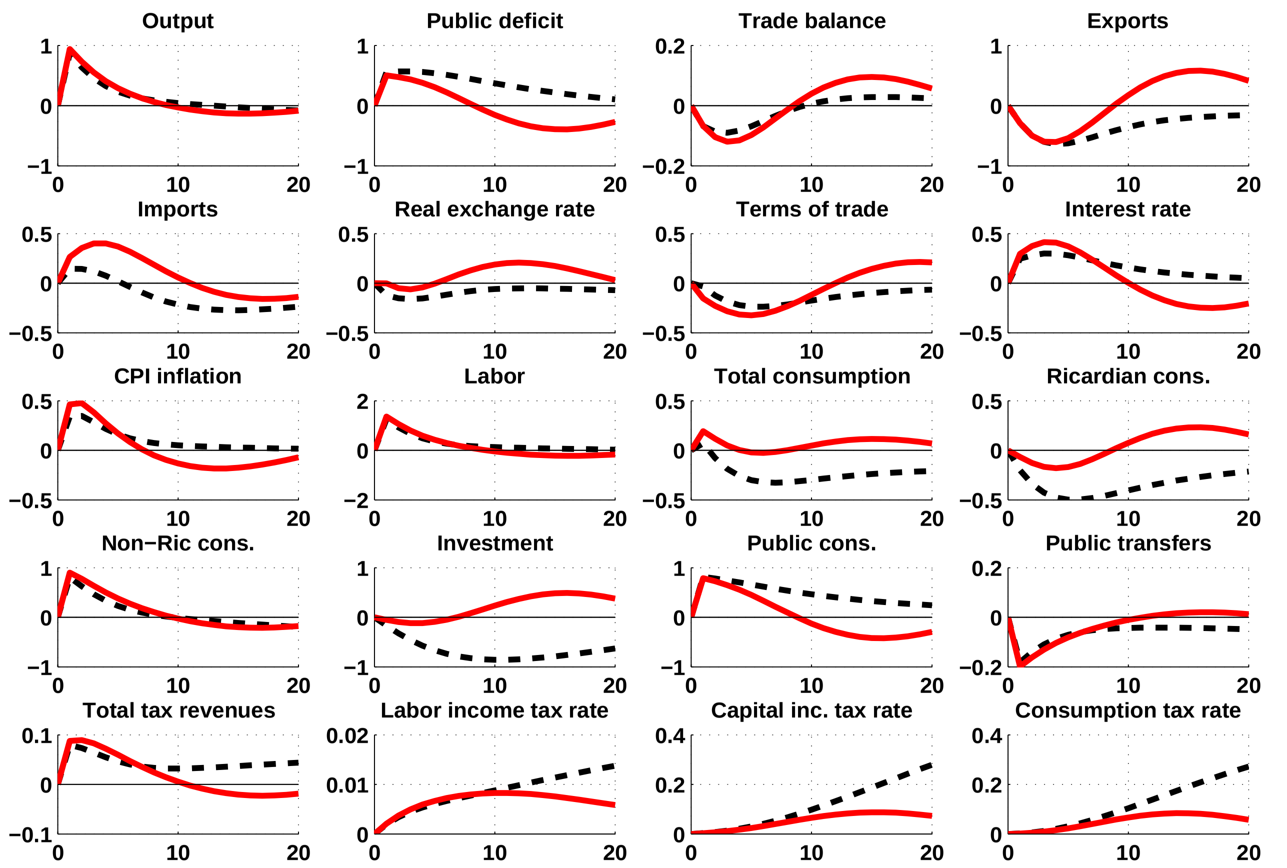
Horizontal axis: quarters. Vertical axis: percentage deviations from the baseline, except for inflation and interest rates (annualized percentage-point deviations), trade balance, public sector primary balance, public consumption, public transfers and total tax revenues (ratio to output, percentage-point deviations). Output and aggregate demand components are reported in real terms. (Dashed line: benchmark; Continuous line: accommodative monetary policy)

Figure 8: Responses after a public consumption shock and accommodative monetary policy (nine quarters)



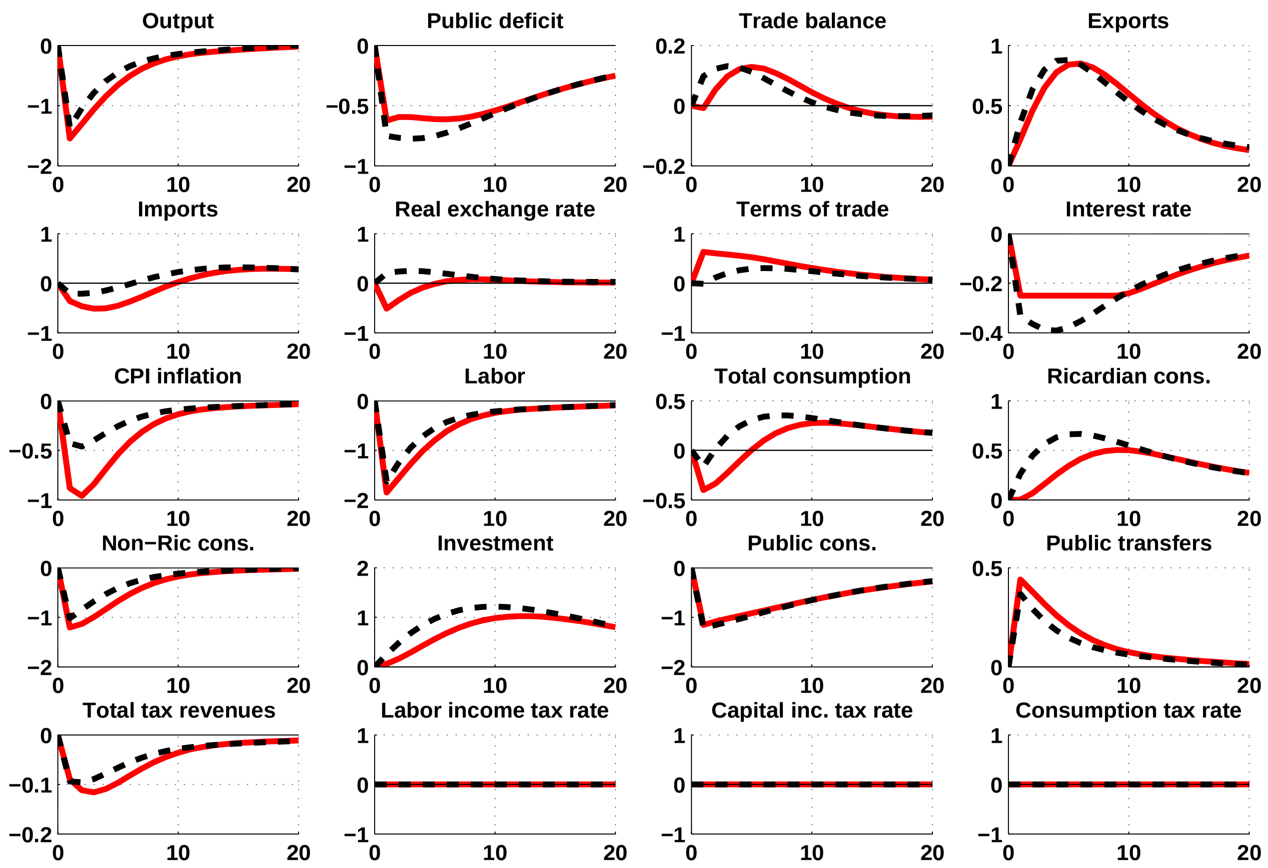
Horizontal axis: quarters. Vertical axis: percentage deviations from the baseline, except for inflation and interest rates (annualized percentage-point deviations), trade balance, public sector primary balance, public consumption, public transfers and total tax revenues (ratio to output, percentage-point deviations). Output and aggregate demand components are reported in real terms. (Dashed line: benchmark; Continuous line: accommodative monetary policy)

Figure 9: Responses after a public consumption shock and spending reversal



Horizontal axis: quarters. Vertical axis: percentage deviations from the baseline, except for inflation and interest rates (annualized percentage-point deviations), trade balance, public sector primary balance, public consumption, public transfers and total tax revenues (ratio to output, percentage-point deviations). Output and aggregate demand components are reported in real terms. (Dashed line: benchmark; Continuous line: spending reversal)

Figure 10: Responses after a public consumption shock and zero lower bound



Horizontal axis: quarters. Vertical axis: percentage deviations from the baseline, except for inflation and interest rates (annualized percentage-point deviations), trade balance, public sector primary balance, public consumption, public transfers and total tax revenues (ratio to output, percentage-point deviations). Output and aggregate demand components are reported in real terms. (Dashed line: benchmark; Continuous line: zero lower bound)