Fiscal Policy and Macroeconomic Stability in a Monetary Union*

Andrea Pescatori[†], *Massimiliano Pisani* [‡]

July 2006

Abstract

We analyze the effects of fiscal policy in a currency area. We develop a two-region model having sticky prices, a common monetary authority and regional fiscal policies. We break the ricardian equivalence and allow for keynesian effects of public expenditure introducing rule-of-thumb agents in each region. Main results are the following. First, consistently with the empirical evidence, after a public spending shock in one region private agents demand for imports increases and the terms of trade appreciates. Second, a countercyclical fiscal rule can restore the Taylor principle and the uniqueness of the equilibrium. Finally, a countercyclical fiscal rule contributes to reduce macroeconomic volatility.

Keywords: Currency area; Sticky prices; Terms of trade; Rule-of-thumb consumers; Fiscal multiplier; Government spending; Taylor rules

JEL classification: E32; E52; E62; F41.

---

*Preliminary. We owe thanks to Gianluca Benigno and Jordi Gali for useful comments. Earlier version previously circulated under the title 'Fiscal Spillovers in a Monetary Union'. All errors are ours. Usual disclaimers hold.

[†]Universitat Pompeu Fabra and Ente L. Einaudi. Email: andrea.pescatori@upf.edu.

[‡]Bank of Italy, Research Department. Email: massimiliano.pisani@bancaditalia.it.

1 Introduction

The fiscal rules that EMU country members are requested to respect have stimulated and renewed a long-standing debate about the spillovers of nationally-driven fiscal policies in a monetary union.[1]

International fiscal spillovers are particularly relevant in a highly integrated area. Changes in the level of public expenditure and taxation in one country are able to affect the economic performance of the partners. The related change in relative national welfare levels arise the question about the opportunity of some form of coordination or centralization of national fiscal policies.[2]

Recently, several contributions have empirically investigated the spillovers of fiscal policy. Giuliodori and Beetsma (2004) use a VAR to explore cross-border effects of fiscal policy. Main result is that a fiscal expansion in Germany, France and Italy - the three major countries in the euro area - leads to significant higher imports from other countries belonging to European union by stimulating domestic activity. On the contrary, any direct spillover caused by government purchases of foreign goods seems to be unimportant. In the same fashion, Fatàs and Mihov (2001a,b) estimate a VAR using OECD data. They find that a positive discretionary change in public expenditure leads to increase in output and, most importantly, private consumption and imports.[3]

In this paper we analyze the short-run effects of fiscal policy in a monetary union. Following Benigno (2003), we develop a two-country setup with centralized monetary policy and sticky prices. Consistently with the above reported evidence, we allow for positive effects of public expenditure on private consumption. Following Gali et al.(2003, 2004), we assume there are two types of agents in each region of the union: Ricardian agents that have access to financial markets and smooth consumption over time; rule-of-thumb agents that do not save and in each period consume all their available income.[4] Thanks to rule-of-thumb agents, in each region aggregate consump-

[1] Among the first contributes, see for istance Buiter, Corsetti and Roubini (1993), De grauwe (1998), Eichengreen and Wyplosz (1998) and Giavazzi and Pagano (1990).

[2] See among the others Canzoneri and Henderson (1991), Canzoneri et al. (2004), Lombardo and Sutherland (2003).

[3] Blanchard and Perotti (2002) estimate a VAR using U.S. data. They also find that private consumption and domestic activity increase after a positive fiscal shock. For other empirical studies on fiscal policy effects, see Canova and Pappa (2004), Perotti (1999), Mountford and Hulig (2004), Ramey and Shapiro (1998), Hemming et al. (2002).

[4] See also Wolff (1998) and Campbell and Mankiw (1989).

tion may increase after an exogenous positive shock in public expenditure, with the consequence of further stimulating not only the domestic economic activity but also the one of the other region belonging to the union. Public expenditure can be financed through public debt and/or lump sum taxation. The latter is set according to a systematic simple tax rule. Given that the rule-of-thumb agents break the ricardian equivalence, we can compare alternative tax rules in terms of their macroeconomic stabilization properties.

To maintain simplicity and tractability, we abstract from a number of topics. First, we only look at the short run effects of fiscal policy. We therefore concentrate on spillovers induced by changes in terms of trade, the amount of imports, the area-wide interest rate. We do not consider issues such as the long-run sustainability of public debt. Second, we do not specify the preferences over public goods and mainly look at the impact of spending changes on aggregate demand. Third, we (realistically) confine our analysis to public goods that are supplied domestically. Fourth, we do not perform a micro-founded welfare analysis.

We conduct several exercises. We initially analyze whether the Taylor principle - which says that in closed economy an active reaction of the monetary policy to inflation guarantees a unique equilibrium - holds in a currency union featuring non-Ricardian agents. Then we perform an impulse response analysis of the public spending spillovers. Finally, we compare alternative fiscal rules in terms of their capability of affecting the cyclical properties of inflation and output.

The main results are as follows.

First, according to the determinacy analysis, the Taylor principle does not hold when the share of rule-of-thumb agents and the degree of price stickiness are sufficiently high: aggregate private demand becomes more sensitive to current available income than to real interest rate.

Second, setting the parameters to values commonly used in the literature, we are able to replicate the increase of the private demands for imports following a domestic public spending shock. The spillovers on the other member of the area - generated by changes in relative prices, the common nominal interest rate and the amount of traded goods - are stronger the higher are the share of rule-of-thumb, the lower the home bias, the higher elasticity of substitution between domestic and imported goods, the bigger the relative size of the region in which the shock originates.

Third, more 'flexible' regional fiscal rules - i.e. ones that countercyclically react to domestic output - reduce the macroeconomic volatility.

Our paper contributes to the recent theoretical literature of fiscal policy in a monetary union. Corsetti and Pesenti (2001) analyze the spillovers induced by public spending through changes in the terms of trade. Duarte and Wolman (2002) analyze the impact of national public expenditure on inflation differentials across regions of a currency union. However, these authors do not consider Keynesian effects of public spending. Coenen and Straub (2005) revisit the effects of government spending shocks on private consumption within an estimated New-Keynesian DSGE model of the euro area featuring rule-of-thumb households. Their setup, differently from ours, is based on a closed economy; hence, they do not consider cross-regional spillovers. Finally, Canzoneri et al (2004) develop a framework close to ours, based on a two-region currency union and rule-of-thumb agents. They focus on effects of public expenditure on regional inflation differential. Differently from us, they do not perform a systematic analysis neither of the equilibrium determinacy nor of the stabilization properties of alternative fiscal rules.

The paper is structured as follows. Next section illustrates the setup. Section three describes the results. Section four illustrates the conclusions.

2 The setup

We develop a two-region model with sticky prices, a common central bank and two fiscal authorities. Each fiscal authority has sovereignty over only one region. The two regions are labelled H (Home) and F (Foreign)and may have different size. The whole area is populated by a continuum of households on the interval $[0, 1]$. The population on the segment $[0, n)$ belongs to region H $(0 < n < 1)$, while the population on the segment $[n, 1]$ belongs to F. There is no possibility of migration across regions. We assume that in each region a fraction of the households does not have access to financial markets and hence consumes all the available income. We call them rule of thumb agents. In region H the share of rule-of-thumb agents over its population is equal to λ (with $0 \leq \lambda < 1$), in region F to λ^* (again $0 \leq \lambda^* < 1$). Remaining households, to the contrary, have access to a complete set of internationally traded state contingent securities. We call them optimizing or Ricardian agents. In what follows, we indicate variables relative to the region F with a star (*).

2.1 Preferences

The preferences of the generic household belonging to region H can be expressed as (equivalently for the other region):

$$U_t = E_t \left\{ \sum_{s=t}^{\infty} \beta^{s-t} \left[\frac{C_s^{1-\sigma}}{1-\sigma} - \frac{N_s^{1+\varphi}}{1+\varphi} \right] \right\} \tag{1}$$

E_t denotes the expectation conditional on the information set at date t, while β is the intertemporal discount factor ($0 < \beta < 1$). Agents obtain utility from consumption C, while they receive disutility from supplying labor N. The utility function is separable in these two factors. The elasticity of intertemporal substitution is $1/\sigma$ ($\sigma > 0$), while $1/\varphi$ is the Frisch labor elasticity ($\varphi > 0$). The index C is defined as:

$$C_t \equiv \left[\gamma_H^{\frac{1}{\theta}} C_{H,t}{}^{\frac{\theta-1}{\theta}} + (1-\gamma_H)^{\frac{1}{\theta}} C_{F,t}{}^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}} \tag{2}$$

where C_H and C_F are indexes of consumption across the continuum of differentiated goods produced respectively in region H and F:

$$C_{H,t} \equiv \left[\left(\frac{1}{n} \right)^{\frac{1}{\varepsilon}} \int_0^n c(h)^{\frac{\varepsilon-1}{\varepsilon}} dh \right]^{\frac{\varepsilon}{\varepsilon-1}}, \quad C_{F,t} \equiv \left[\left(\frac{1}{1-n} \right)^{\frac{1}{\varepsilon}} \int_n^1 c_t(f)^{\frac{\varepsilon-1}{\varepsilon}} df \right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{3}$$

The elasticity of substitution between the bundles C_H and C_F is θ ($\theta > 0$), while the elasticity of substitution across goods produced within a country is ε ($\varepsilon > 1$).

Similarly for region F we have

$$C_t^* \equiv \left[(1-\gamma_F)^{\frac{1}{\theta}} C_{H,t}^*{}^{\frac{\theta-1}{\theta}} + \gamma_F^{\frac{1}{\theta}} C_{F,t}^*{}^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}} \tag{4}$$

The bundles C_H^* and C_F^* are similar to their counterparts in region H. The parameter γ_H and γ_F are the weights of the two bundles. They measure the degree of home bias. If $n = .5$ and $.5 < \gamma_H = \gamma_F < 1$ we have a mirror symmetric home bias across countries. If $\gamma_H > n$ and $\gamma_F > (1-n)$ there is home-bias.

We assume that in each region the composition of the investment basket is the same as that of the correspondent consumption bundle. Hence, in the region H the index of investment I is defined as:

$$I_t \equiv \left[\gamma_H^{\frac{1}{\theta}} I_{H,t}{}^{\frac{\theta-1}{\theta}} + (1-\gamma_H)^{\frac{1}{\theta}} I_{F,t}{}^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}} \tag{5}$$

where the indexes I_H and I_F are defined as:

$$I_{H,t} \equiv \left[\left(\frac{1}{n}\right)^{\frac{1}{\varepsilon}} \int_0^n I_t(h)^{\frac{\varepsilon-1}{\varepsilon}} dh\right]^{\frac{\varepsilon}{\varepsilon-1}}, \quad I_{F,t} \equiv \left[\left(\frac{1}{1-n}\right)^{\frac{1}{\varepsilon}} \int_n^1 I_t(f)^{\frac{\varepsilon-1}{\varepsilon}} df\right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{6}$$

In region F, the following investment index holds:

$$I_t^* \equiv \left[(1-\gamma_F)^{\frac{1}{\theta}} I_{H,t}^{*\frac{\theta-1}{\theta}} + \gamma_F^{\frac{1}{\theta}} I_{F,t}^{*\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}} \tag{7}$$

The bundles I_H and I_F are similar to their counterparts in region H.

We assume that in each region public expenditure is completely biased towards domestically produced goods and that the aggregator is similar to that of private agents; hence, we can define public expenditure bundle G in the region H and G^* in region F as:

$$G_t \equiv \left[\left(\frac{1}{n}\right)^{\frac{1}{\varepsilon}} \int_0^n g(h)^{\frac{\varepsilon-1}{\varepsilon}} dh\right]^{\frac{\varepsilon}{\varepsilon-1}}, \quad G_t^* \equiv \left[\left(\frac{1}{1-n}\right)^{\frac{1}{\varepsilon}} \int_n^1 g_t^*(f)^{\frac{\varepsilon-1}{\varepsilon}} df\right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{8}$$

We derive the price indexes from the above described bundles. The price index P is the minimum expenditure in region H required to purchase goods resulting in the index C, such that $C = 1$. It is equal to:

$$P_t = \left[\gamma_H P_{H,t}^{1-\theta} + (1-\gamma_H) P_{F,t}^{1-\theta}\right]^{\frac{1}{1-\theta}} \tag{9}$$

where P_H and P_F are equal to:[5]

$$P_{H,t} = \left[\left(\frac{1}{n}\right) \int_0^n p(h)^{1-\varepsilon} dh\right]^{\frac{1}{1-\varepsilon}}, \quad P_{F,t} = \left[\left(\frac{1}{1-n}\right) \int_n^1 p_t(f)^{1-\varepsilon} df\right]^{\frac{1}{1-\varepsilon}} \tag{10}$$

[5]The index P_H is the minimum expenditure in region H required to purchase goods resulting in the index C_H, such that $C_H = 1$. A similar definition applies to the index P_F, P_H^*, P_F^*.

The price indexes in region F are similarly defined. The consumer price index is equal to:

$$P_t^* = \left[(1-\gamma_F)\, P_{H,t}^{*1-\theta} + \gamma_F P_{F,t}^{*1-\theta}\right]^{\frac{1}{1-\theta}} \tag{11}$$

where P_H^* and P_F^* are defined as their counterparts in region H:

$$P_{H,t}^* = \left[\left(\frac{1}{n}\right)\int_0^n p^*(h)^{1-\varepsilon}dh\right]^{\frac{1}{1-\varepsilon}}, \quad P_{F,t}^* = \left[\left(\frac{1}{1-n}\right)\int_n^1 p_t^*(f)^{1-\varepsilon}df\right]^{\frac{1}{1-\varepsilon}} \tag{12}$$

We assume that firms set prices considering the whole area as a common market and that there are no transaction costs in transporting goods across regions. It follows that the law of one price holds:

$$p_t(h) = p_t^*(h), \quad p_t(f) = p_t^*(f) \tag{13}$$

Given the structure of consumption and investment bundles, the law of one price implies that:

$$P_{H,t} = P_{H,t}^*, \quad P_{F,t} = P_{F,t}^* \tag{14}$$

We define the terms of trade T of the region H as the ratio of the price of the bundle of goods imported from region F relative to the price of the bundle domestically produced:

$$T_t \equiv \frac{P_{F,t}}{P_{H,t}} \tag{15}$$

The real exchange rate of the region H is defined as the ratio of the consumer price index of region F relative to that of region H:[6]

$$RS_t \equiv \frac{P_t^*}{P_t} \tag{16}$$

2.2 Intratemporal Allocation

Given a decision on C, household in region H optimally allocates the expenditure on C_H and C_F by minimizing the total expenditure PC under the

[6]The real exchange rate is not constant because of the home bias assumption. For the purchasing power parity condition to hold, in fact, the assumptions of international law of one price, tradeability of goods and symmetric preferences should be satisfied. Home bias implies that preferences are not symmetric, but mirror symmetric.

constraint given by (2). The resulting demands are:

$$C_{H,t} = \gamma_H \left(\frac{P_{H,t}}{P_t}\right)^{-\theta} C_t, \quad C_{F,t} = (1-\gamma_H)\left(\frac{P_{F,t}}{P_t}\right)^{-\theta} C_t \tag{17}$$

Then, given the decisions on C_H and C_F, the household allocates the expenditure among the differentiated goods by minimizing expenditures $P_H C_H$ and $P_F C_F$ under the constraints given by (3). The demands of a generic good h and f are:

$$C_t(h) = \frac{1}{n}\left(\frac{p_t(h)}{P_{H,t}}\right)^{-\varepsilon} C_{H,t}, \quad C_t(f) = \frac{1}{1-n}\left(\frac{p_t(f)}{P_{F,t}}\right)^{-\varepsilon} C_{F,t} \tag{18}$$

Similar equations hold for the investment goods and for bundles of agents belonging to region F. Total demands of good h and f are:

$$\begin{aligned} y_t(h) &= \left(\frac{p_t(h)}{P_{H,t}}\right)^{-\varepsilon} \left(C_{H,t} + I_{H,t} + C^*_{H,t} + I^*_{H,} + G_t\right) \\ y_t(f) &= \left(\frac{p_t(f)}{P_{F,t}}\right)^{-\varepsilon} \left(C_{F,t} + I_{F,t} + C^*_{F,t} + I^*_{F,t} + G^*_t\right) \end{aligned} \tag{19}$$

Finally, we compute aggregate demand in both regions by using the appropriate Dixit-Stiglitz aggregators:

$$Y_{H,t} \equiv \left[\left(\frac{1}{n}\right)^{\frac{1}{\varepsilon}} \int_0^n y(h)^{\frac{\varepsilon-1}{\varepsilon}} dh\right]^{\frac{\varepsilon}{\varepsilon-1}}, \quad Y_{F,t} \equiv \left[\left(\frac{1}{1-n}\right)^{\frac{1}{\varepsilon}} \int_n^1 y_t(f)^{\frac{\varepsilon-1}{\varepsilon}} df\right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{20}$$

We apply equation (20) to (19) and obtain:

$$Y_{H,t} = \gamma_H \left(\frac{P_{H,t}}{P_t}\right)^{-\theta} (C_t + I_t) + (1-\gamma_F)\left(\frac{P_{H,t}}{P^*_t}\right)^{-\theta} (C^*_t + I^*_t) + G_t \tag{21}$$

$$Y_{F,t} = (1-\gamma_H)\left(\frac{P_{F,t}}{P_t}\right)^{-\theta} (C_t + I_t) + \gamma_F \left(\frac{P_{F,t}}{P^*_t}\right)^{-\theta} (C^*_t + I^*_t) + G^*_t \tag{22}$$

2.3 Ricardian Agents

We assume that the Ricardian agents, differently from the rule-of-thumb agents, have access to financial complete markets, at domestic and international level. Having the same preferences it is possible to show that exists

a representative ricardian agent in each country. We will use the superscript o to label his variables. In period-t each Ricardian agent in region-H chooses consumption C_t^o, capital K_{t+1}^o, investment I_t^o, a portfolio of nominal state-contingent securities A_{t+1}^o with a pricing kernel $\Lambda_{t,t+1}$ and a nominal one-period risk-less bond B_t^o issued by the national government[7]. This is in order to maximize the utility function (1) subject to (Ricardian agents in the Foreign region face a similar constraint):

$$\begin{aligned} & E_t\left\{\Lambda_{t,t+1}A_{t+1}^o\right\} - A_t^o + B_t^o/R_t - B_{t-1}^o \\ \leq\ & W_tN_t^o + R_t^kP_tK_{t-1}^o \\ & +D_t^o - P_tT_t^o - P_tC_t^o - P_tI_t^o \end{aligned} \tag{23}$$

where W_t is the nominal wage, $R_t^KP_tK_{t-1}^o$ are nominal revenues from renting physical capital holdings K_{t-1}^o to firms at the real rental cost R_t^K. D_t^o are nominal profits from owning shares of one or more domestic firms. T_t^o are lump-sum taxes (or transfer, if negative) paid by Ricardian agents. The capital is accumulated according to the following law:

$$K_t^o = (1-\delta)\,K_{t-1}^o + \phi\left(\frac{I_t^o}{K_{t-1}^o}\right)K_{t-1}^o \tag{24}$$

where the term $\phi\left(\frac{I_t^o}{K_{t-1}^o}\right)K_{t-1}^o$ represents the capital adjustment costs. We assume $\phi' > 0$ and $\phi'' \leq 0$, with $\phi'(\delta) = 1$, and $\phi(\delta) = \delta$.

Given the international financial markets structure, idiosyncratic risk is shared across households that have access to financial markets. At the margin consumption utilities, weighted by the real exchange rate, must be equated in every state of nature. Intuitively, a benevolent social planner would allocate consumption across Ricardian agents such that the marginal benefits from an extra unit of foreign consumption equal its marginal costs, given by the Home marginal utility of consumption times the real exchange rate $RER_t = \frac{P_t^\star}{P_t}$,

[7]At the time of the portfolio decision, A_{t+1}^o is a random variable, whose value will depend upon the state of the world in period $t+1$. However the household chooses the complete specification of this random variable, its value in every possible state. The absence of arbitrage opportunities (a necessary requirement for equilibrium) then requires that there exist a (unique) stochastic discount factor (or asset pricing kernel),$\Lambda_{t,t+1}$ with the property that the price in period t of any portfolio with random value A_{t+1} in the following period is given by $E_t\Lambda_{t,t+1}A_{t+1}^{o,*}$

i.e., the relative price of C_t^o in terms of $C_t^{o\star}$.[8] Hence we have the following international risk-sharing condition that holds between Ricardian households:

$$\frac{(C_t^o)^{-\sigma}}{P_t} = \xi_0 \frac{(C_t^{o,\star})^{-\sigma}}{P^\star} \tag{25}$$

The constant ξ_0 represents the initial wealth distribution. Given that we are not interested in levels but only in deviation from the non-stochastic steady state the value of constant ξ_0 does not play any role for our results.

Government bonds, B_t^o, are redundant assets so, by no arbitrage condition, their price must satisfy

$$1/R_t = E_t \Lambda_{t,t+1} \tag{26}$$

where

$$\Lambda_{t,t+1} = \beta \frac{\left(C_{t+1}^o\right)^{-\sigma} P_t}{\left(C_t^o\right)^{-\sigma} P_{t+1}}$$

The first order conditions for investment and capital are respectively given by the following two equations:

$$Q_t = \frac{1}{\phi'\left(\frac{I_t^o}{K_{t-1}^o}\right)} \tag{27}$$

$$\begin{aligned} P_t Q_t &= E_t \left\{ \beta \left(\frac{C_{t+k}^o}{C_t^o} \right)^{-\sigma} R_{t+1}^K \right\} \\ &\quad + E_t \left\{ \beta \left(\frac{C_{t+k}^o}{C_t^o} \right)^{-\sigma} Q_{t+1} \left[1 - \delta + \phi_{t+1} - \left(\frac{I_{t+1}^o}{K_{t+1}^o} \right) \phi'_{t+1} \right] \right\} \end{aligned} \tag{28}$$

Equation (27) defines the (real) shadow value of capital in place (the Tobin's Q). Given the assumptions on ϕ, the elasticity of the investment-capital ratio with respect to Q is $\eta \equiv -\frac{1}{\phi''(\delta)\delta}$. Equation (28) states that the value

[8] If we define the probability of being in the state of the world $s' \in S'$ conditional to the present state s as $\pi^{prob}(s'/s)$ the following equation $Q^{kernel}(s'/s) = \beta \frac{u'(C(s'))}{u_c(C(s))} \pi^{prob}(s'/s)$ must hold $\forall s' \in S'$ for all union-wide ricardian agents - i.e. for all union-wide agents that have access to financial markets

of capital in place must be equated across time periods. At the optimum, the shadow price of capital must equal the next period's sum of capital's marginal product, shadow value and the capital stock contribution to lower installation costs.

We do not report the intratemporal efficiency condition linking the consumer's marginal rate of substitution and real wage. We follow Gali et al. (2006) and assume that the wage is set by a union, hours are determined by firms' labor demand. We refer the reader to Section (2.5) below and Appendix (A-1) for a detailed description of the labor market.

2.4 Rule-of-Thumb Agents

Home rule-of-thumb households do not borrow or save, because of lack of access to financial markets. Hence, they cannot smooth their consumption path. Given that they have same preferences and face the same budget constraint, there exists a representative rule-of-thumb agent in each region. The budget constraint of the rule-of-thumb agent in region H is:[9]

$$P_t C_t^r = W_t N_t^r - P_t T_t^r \tag{29}$$

As in the case of optimizing households, hours N_t^r are determined by firms' labor demand and are not chosen optimally by each household given the wage W_t.[10] Taxes T_t^r (or transfer, if negative) are paid (received) in lump-sum fashion.

Rule-of-thumb agents are the key feature of the model: they break the Ricardian equivalence (that holds only for Ricardian agents) and hence allow for positive effects of public spending on private demand.

2.5 Aggregation

Aggregate consumption is given by a weighted average of the consumption variables for each type of household. So, it is equal to:

$$C_t \equiv n\lambda C_t^r + n\left(1-\lambda\right) C_t^o \tag{30}$$

[9] A similar equation holds for rule-of-thumb agents in the region F.

[10] As emphasized by Gali et al. (2004), under a perfectly competitive labor market, hours and consumption of rule-thub agents would move in opposite directions in response to movements in real wages. This is not plausible. Under the alternative framework illustrated below, the three variables are positively correlated.

while aggregate labor is:

$$N_t \equiv n\lambda N_t^r + n\left(1-\lambda\right) N_t^o \tag{31}$$

Similarly, aggregate investment and capital are respectively:

$$I_t \equiv n\left(1-\lambda\right) I_t^o \tag{32}$$

$$K_t \equiv n\left(1-\lambda\right) K_t^o \tag{33}$$

We assume that wages are determined according to the following schedule:

$$\frac{W_t}{P_t} = L(C_t, N_t) \tag{34}$$

where the function L is increasing in both arguments, capturing both convex marginal disutility of labor and wealth effects. This function can be interpreted as a generalized wage schedule consistent with a variety of models of wage determination. Given the wage, each firm decides how much labor to hire, and allocates its labor demand uniformly across households, independently of their type. Accordingly:

$$N_t^r = N_t^o \tag{35}$$

for every t; as a consequence, we get:

$$N_t \equiv n\lambda N_t^r + n\left(1-\lambda\right) N_t^o = nN_t^r = nN_t^o \tag{36}$$

We assume that the resulting wage markup is sufficiently high (and fluctuations sufficiently small) that the following inequalities are satisfied at all times:

$$L(C_t, N_t) \quad > \quad \left(C_t^o\right)^\sigma N_t^\varphi \tag{37}$$

$$L(C_t, N_t) \quad > \quad \left(C_t^r\right)^\sigma N_t^\varphi \tag{38}$$

Both conditions, and their analogues in the region F, guarantee that in each country both types of households will meet firms' labor demand at the prevailing wage (see the Appendix for more details).

2.6 The Firms

Region H and F have a continuum of monopolistic firms of mass n and $(1-n)$, respectively. Firms solves two problems: a static cost minimization and an intertemporal profit maximization problem. Here, we consider only the problem solved by firms belonging to region H Firms in region F solve a similar problem.

2.6.1 The cost minimization problem

In each period, the generic firm h hires capital and labor from agents belonging to its region and combine them according to a common Cobb-Douglas technology:

$$y(h) = Z_t K_t(h)^{\alpha} N_t(h)^{1-\alpha} \tag{39}$$

The result of the cost minimization problem is the marginal cost equation:

$$\frac{MC_t(h)}{P_t} = \frac{\left(R_t^k\right)^{\alpha} (W_t/P_t)^{1-\alpha}}{Z_t \alpha^{\alpha}(1-\alpha)^{1-\alpha}} \tag{40}$$

where MC_t is the nominal marginal cost which is common across firms of the same region. The following two first order conditions, with respect to labor and capital respectively, hold:

$$\frac{W_t N_t(h)}{P_t} = (1-\alpha)\frac{MC_t y(h)}{P_t} \tag{41}$$

$$R_t^k K_t(h) = \alpha \frac{MC_t y(h)}{P_t} \tag{42}$$

2.6.2 The price setting problem

Firms set prices in a staggered fashion, as in Calvo (1983): each firm resets its price with probability $1-\vartheta$ each period, independently of the time elapsed since last adjustment. As a consequence, each period a fraction $1-\vartheta$ of producers reset their price, while a fraction ϑ keep their prices unchanged.

A firm resetting its price in period t will maximize:

$$\max_{p_t^{new}(h)} E_t \sum_{k=0}^{\infty} \vartheta^k \left\{ \Lambda_{t,t+k} \left(p_t^{new}(h) - MC_{t+k} \right) y_{t+k}(h) \right\} \tag{43}$$

subject to the sequence of demand constraints:

$$y_{t+k}(h) = \left(\frac{p_t^{new}(h)}{P_{H,t+k}}\right)^{-\varepsilon} \left(C_{H,t+k} + I_{H,t+k} + C^*_{H,t+k} + I^*_{H,t+k} + G_{t+k}\right) \quad (44)$$

where $p_t^{new}(h)$ represents the price chosen by firms resetting prices at time t. The first order condition for the above problem is:

$$E_t \sum_{k=0}^{\infty} \vartheta^k \left\{ \Lambda_{t,t+k} \left(p_t^{new}(h) - \frac{\varepsilon}{\varepsilon - 1} MC_{t+k} \right) y_{t+k}(h) \right\} \quad (45)$$

At the optimum, firms equate expected discounted marginal revenues to expected discounted marginal costs. Profits are rebated lump-sum to domestic Ricardian households.

Finally, the equation describing the dynamics for the price level of the composite good produced in region H is:

$$P_{H,t} = \left[\vartheta P_{H,t-1}^{1-\varepsilon} + (1-\vartheta)\, p_t^{new}(h)^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}} \quad (46)$$

2.7 Fiscal policy

The Home government budget constraint is (in what follows similar relations hold true for the foreign country):

$$\frac{B_{G,t}}{R_t} - B_{G,t-1} = P_{H,t} G_t + P_t T_{X,t} \quad (47)$$

B_G is the negative of a riskless one-period nominal bond domestically sold (government debt). T_X are total lump-sum taxes (in consumption units) paid by the households. We assume that Ricardian and rule-of-thumb agents are equally taxed ($T^r = T^o$); hence the following equation holds for the total amount of collected taxes:

$$T_{X,t} = (1-\lambda)\, n T_t^o + n\lambda T_t^o = n T_t^o = n T_t^r \quad (48)$$

We assume that taxes are set accordingly to the following tax rule:

$$\log T_{X,t} = \phi_b (B_{G,t-1}/P_t) + \phi_g \log(P_{H,t} G_t / P_t) + \phi_{yx} \log(Y_{H,t}) + \text{const} \quad (49)$$

Taxes react to public debt, public expenditure and (possibly) also to output volumes when $\phi_{yx} \neq 0$. To guarantee stability of the government budget

constraint we assume $\phi_b > 0$. The higher the parameter the faster the government debt returns to its steady state value. The parameter ϕ_g, instead, determines how the government consumption is initially financed - at the extremes with only taxes $\phi_g = 1$ or with deficit spending $\phi = 0$. The constant term is determined accordingly with steady state values. In most of the sections we will assume that the governments have to finance a stream of public consumption G which evolves exogenously according to the following first order autoregressive process:

$$g_t = \rho_g g_{t-1} + \varepsilon_{g,t} \tag{50}$$

where $0 < \rho < 1$ and $\varepsilon_{g,t}$ represents an i.i.d shock with constant variance $\sigma^2_{\varepsilon_g}$. We define g_t as $\left(\frac{G_t - \bar{G}}{\bar{Y}}\right)$ where $\bar{G}$ and $\bar{Y}$ are the steady-state level respectively of public expenditure and output.

However we will also analyze a fiscal rule composed by the previous tax rule plus a public spending rule (government consumption now is endogenous):

$$g_t = \rho_g g_{t-1} - \phi_{yg} \log(Y_{H,t}/\bar{Y}) + \varepsilon_{g,t} \tag{51}$$

When $\phi_{yg} = 0$ we back to the previous case.

2.8 Monetary Policy

We assume that the central bank of the union set nominal interest R_t every period according to the following interest rule:

$$\log R_t = \phi_\pi \log \pi_t^U + \phi_y \log Y_t^U + \text{const} \tag{52}$$

The rule reacts to the union-wide inflation rate $\pi_t^U \equiv \left(P_t^U / P_{t-1}^U\right)$ and to union-wide output Y_t^U. The constant term is determined accordingly with steady state values. We define P_t^U as:

$$P_t^U = P_t^n P_t^{*1-n}$$

while Y_t^U is defined as:

$$Y_t^U = Y_{H,t}^n Y_{F,t}^{1-n}$$

2.9 The market clearing conditions

The following market clearing conditions hold in the region H:

- labor market
$$\int_0^n N_t(h)\,dh = nN_t \tag{53}$$
- capital market
$$\int_0^n K_t(h)\,dh = n(1-\lambda)K_{t-1} \tag{54}$$
- public sector's bond
$$B_{G,t} = n(1-\lambda)B_t^o \tag{55}$$

Similar market clearing conditions hold in the region F.

- The following resource constraints holds, respectively for the Home and Foreign good:

$$Y_{H,t} = \gamma_H \left(\frac{P_{H,t}}{P_t}\right)^{-\theta}(C_t + I_t) + (1-\gamma_F)\left(\frac{P_{H,t}}{P_t^*}\right)^{-\theta}(C_t^* + I_t^*) + G_t \tag{56}$$

$$Y_{F,t} = (1-\gamma_H)\left(\frac{P_{F,t}}{P_t}\right)^{-\theta}(C_t + I_t) + \gamma_F\left(\frac{P_{F,t}}{P_t^*}\right)^{-\theta}(C_t^* + I_t^*) + G_t^* \tag{57}$$

2.10 The shocks

The model features three sources of uncertainty (in every region).

As we described in the fiscal policy section government spending is or has an exogenous stochastic component.

$$g_t = \rho_g g_{t-1} + \phi_{yg}\log(Y_{H,t}/\bar{Y}) + \varepsilon_{g,t}$$

when $\phi_{yg} = 0$ government spending is a standard exogenous AR(1) process. If $\phi_{yg} \neq 0$ then it becomes a spending rule with a an exogenous disturbance $\varepsilon_{g,t}$. In both cases we set the autoregressive parameter $\rho_g = 0.87$ in line with most of the empirical evidence on government spending processes.

Total factor productivity, Z_t, is assumed to be a stationary AR(1) process:

$$\log Z_t = \rho_z \log Z_{t-1} + \varepsilon_{z,t}$$

where $0 < \rho_z < 1$ and $\varepsilon_{z,t}$ represents an i.i.d shock with constant variance $\sigma^2_{\varepsilon_z}$.

Finally we introduce a markup shock to the firms' price equation.

$$\log u_t = \rho_u \log u_{t-1} + \varepsilon_{u,t}$$

where $0 < \rho_u < 1$ and $\varepsilon_{u,t}$ represents an i.i.d shock with constant variance $\sigma^2_{\varepsilon_u}$.

In all the following analyzes we will assume a diagonal variance-covariance matrix between the 6 shocks (3 in each country) that characterize the monetary union.

2.11 Equilibrium

The equilibrium of the model follows by combining the aggregate demand block with the aggregate supply. It is a sequence of allocations and prices such that - given initial conditions K_{-1}, B_{-1}, B^G_{-1}, $P_{H,t-1}$ and their foreign counterparts - the following conditions hold in the region H (correspondent conditions hold in the region F):

- the representative Ricardian agent satisfies consumption intratemporal conditions (17) and (18) and their investment analogues, the risk-sharing condition (25), the capital accumulation law (24), the labor market equation (34), the labor market's participation constraint (37), the intertemporal conditions (26)-(28)
- the representative rule-of-thumb agent satisfies consumption intratemporal conditions (17), (18), the budget constraint (29), the labor market equation (34) and the labor market's participation constraint (38)
- the public sector budget constraint (47) and the tax rule (58)
- the monetary policy policy rule (52)
- the clearing conditions (53)
- the law of motion of exogenous shock (50)

The model equilibrium is not solvable in a closed form solution. We log-linearize it around a non-stochastic steady state equilibrium. We report both the steady state and the log-linearized equations in the appendix.

2.12 Calibration of the Model

We calibrate the model at quarterly frequency as in Gali et al. (2006). The baseline calibration is reported in Table (1).
We assume the two regions having equal size ($n = 0.5$) and the share of rule-of-thumb agents in each region, λ and λ^*, are set equal to 0.5. This is still within the range of estimated values in the literature of the weight of the rule-of- thumb behavior (see Gali (2006) and Mankiw(2000)).
We set the capital share, α, in both countries to .35, the depreciation rate of capital, δ, to 0.025 and identical total factor productivity in the two countries. This implies a steady-state investment-to-GDP ratio of about 22% in both countries. Following King and Watson (1996) the elasticity of investment with respect to Tobin's q, η, is set to 1. The elasticity of substitution across brands produced in the same country, ε, is set equal to 6, which means a steady state mark-up of 20 percent. The probability that firms do not adjusting prices, ϑ, is the same across regions and equal to 0.75 (this value corresponds to an average duration of one year).

The elasticity of substitution between goods produced in region H and F, θ, is set equal to 1.5. In the baseline model, for better interpretability of the results we assume no-home-bias - i.e. we set the home-bias parameters, γ_H and γ_F, equal to 0.5 - which means imports are about 40% of the GDP. However we will also use a (more realistic) value for those parameters such as .75 that would imply an import-over-GDP ratio roughly equal to 22%, in line with national accounting values for European countries.
The elasticity of marginal utility with respect to consumption, σ, is set equal to 1. The elasticity of wages with respect to hours, φ, is set equal to 0.2. This is not in line with micro studies but it is still a widely used value in the business cycle literature (see Cooley- Prescott (1995)).

In the baseline calibration we set the weight on inflation in the monetary reaction function,ϕ_π , equal to 1.5; the weight on output, ϕ_Y, equal to 0. In the tax rule, the weight on public expenditure, ϕ_G, is equal to 0.12, the one on public debt, ϕ_b, is equal to 0.3 while ϕ_x, the weight on domestic output is zero (i.e. government consumption is exogenous). The autoregressive coefficient in the law of motion of public spending, ρ_g, is equal to 0.87. Those values

correspond to the ones estimated in Gali et. al. (2006). Regarding the other two processes we set the technology shock autoregressive parameter $\rho_z = .90$ and the innovation standard deviation $\sigma_z = 0.057$ while, for the markup shock we have $\rho_u = .30$ and $\sigma_u = 0.010$

As shown in the appendix the share of rot consumers λ and λ^* does not affect aggregate variables and prices: the same result obtained in a closed economy holds (see Gali et. al 2006).
Under the baseline calibration the terms of trade and the RER are equal to one. In Table 1 we show prominent steady state and parameters values.
The government spending over GDP ratio is set equal to .20 in both regions.

Variable	Value		Parameter	Value
Aggregate Consumption cap.	1.287		λ, λ^* (RoT Share)	0
Real GDP cap.	2.173		n (Country-H Size)	.5
Investment	0.266		θ (CES home-foreign)	1.5
Capital output ratio	8.309		γ_h, γ_f (home-bias)	.75
Investment-GDP ratio	0.207		ϵ_h, ϵ_f (CES goods)	6
Imports	0.217		σ (Rel Risk Aver.)	2
Imports-GDP ratio	0.200		φ (Inv. Frisch Lab.El.)	0.2
Aggregate Labor	0.347		α_h, α_f (Capital Share)	.35
Real Wage	1.694			
Govt. Spending-GDP ratio	.200			

Table 1: Steady State Values (left) relative to the Baseline Calibration (right). "cap." stands for "per capita". Given perfect symmetry values are for both the home and foreign country.

In Table (2) we show how long run increase in government spending has a negative spillover to the neighbor country. In particular a 10% increase in the region-H public spending has a positive effect on the terms of trade which appreciates. Higher government consumption crowds private consumption out and investment in. The overall impact on imports in negative. Hence, spillovers on the region-F are negative: foreign output decreases and so does consumption and investment. In the next paragraphs we will focus on the short-run effects of transitory changes in government spending which could revert the previous result.

Home	Value		Foreign	Value
Terms of Trade	0.996			
Real Exchange Rate	0.998			
Aggr. Cons. cap.	-1.58		Aggr. Cons. cap.	-0.13
Real GDP cap.	1.86		Real GDP cap.	-0.13
Investment	1.86		Investment	-0.13
Capital output ratio	0.11		Capital output ratio	-0.11
Investment-GDP ratio	0.23		Investment GDP ratio	-0.22
Imports	-0.52		Imports	-0.29
Imports-GDP ratio	-2.34		Imports GDP ratio	-0.17
Aggregate Labor	1.69		Aggregate Labor	0.04
Real Wage	0.17		Real Wage	-0.17
Govt. Spending-GDP ratio	0.10		Govt. Spending GDP ratio	0

Table 2: Steady state percentage difference relative to baseline calibration (Table 1) for a long run 10% increase in the home country government spending-GDP ratio. Home (left) and foreign (right) country. 'cap.' stands for 'per capita'.

3 The results

In this section we initially analyze under which conditions the model has a unique equilibrium. Then, we investigate the domestic and international effects of a public expenditure shock through an impulse response analysis. Finally, we consider how and if different fiscal rules can help in reducing macroeconomic volatility.

3.1 Indeterminacy, rule-of thumb agents and the Taylor principle in a monetary union

As emphasized by Woodford (2001), a monetary rule that reacts to inflation adjusting the nominal interest rate more than one-to-one is a sufficient condition for the existence of a unique equilibrium (Taylor principle). This result holds in a closed economy with full access to financial markets and no capital accumulation. Dupor (2005) finds that a similar result also holds when capital accumulation is added, Gali et al. (2005) when the share of rule-of-thumb agents is sufficiently low.

Here we study the existence of a unique equilibrium in a currency union model with partial access to financial instruments.

In Figure 1 (panel A) we explore the existence of a unique equilibrium as a function of the degree of price stickiness (indexed by parameter ϑ) and the weight of rule-of-thumb households (indexed by parameter λ) - keeping values symmetric in both countries. The arrows represent the movement of the indeterminacy region, (the dark one), when the value of the coefficient of relative risk adversion σ increases from its baseline value, equal to one, to two. Remaining parameters are set to their baseline values.

The main result is that the combination of a high degree of price stickiness with a large share of rule-of-thumb agents generates indeterminacy. The intuition of this results can be illustrated with the following example. Let's consider a transitory but persistent increase in the region H's production due to a non fundamental shock. Sluggish price adjustment induces a decline in the markups which allows real wages to go up - even if labor productivity declines given the higher employment. Higher real wages generate a boom in rule-of-thumb consumption. Hence when the share of those agents is high enough their increase in consumption more then offset the decrease in ricardian consumption and investment (the latter is generated by a monetary rule that reacts with a coefficient bigger than one on inflation). On the other hand, exports to the foreign country are very sensitive to changes in the relative prices. Under the baseline calibration the increase in region H output generates a positive spillover on the neighbor country stimulating its output, employment and so foreign rule-of-thumb consumption. When the terms of trade does not appreciate enough foreign imports (home exports) barely decreases at impact and then increases. A higher share of foreign rule-of-thumb agents further mitigates this effect. This means that aggregate demand for output produced in region H increases, making possible to sustain the persistent boom in output the was originally anticipated by agents. This result is similar to that found by Gali et al. (2005) for a closed economy.

The Figure also shows that a higher σ, to which corresponds a lower intertemporal elasticity of substitution $1/\sigma$, increases the indeterminacy area shifting the frontier towards the origin. When $1/\sigma$ is low, the ricardian consumption is less sensitive to real interest rate. In terms of the previous example, it decreases less when real interest rate increases; hence, now a lower share of rule-of-thumb agents is able to offset the drop of ricardian demand.

Figure (1) panel B shows results for several configurations of λ (with $\lambda = \lambda^*$) and the parameter measuring the reaction of monetary authority to inflation, ϕ_π. As expected, equilibrium determinacy necessitates a rela-

tively low share of rule-of-thumb households and a relatively high ϕ_π. When λ is relatively high, the inverted Taylor principle holds: to have a unique equilibrium, monetary policy should increase nominal interest rate less than one-for-one when inflation increases. The size of indeterminacy shrinks as ϕ_x, the parameter measuring the reaction of fiscal authority to domestic output, increases.[11] This result is also quantitatively interesting because a positive small reaction of taxes to output (it is $\phi_x = 0.1$ in the figure) entails a big reduction in the indeterminacy (dark) area.

Panel A in Figure (2) reports the equilibrium properties for all configurations of λ and λ^*. Remaining parameters are set to their baseline values. As anticipated in the previous example, a combination of high large shares of rule-of-thumb in both regions generates indeterminacy. The size of the indeterminacy region shrink gradually as the size of φ, the inverse of the Frisch labor elasticity, increases (while keeping other parameters constant). If the country-size is not 0.50 the two axes should be weighted by the respective sizes (n and $1-n$).

Once λ is weighted by n, the country-size does not affect the results as far as there is no home bias - which means in this case that $\gamma_H = n$ and $\gamma_F = 1-n$.

When the two regions are perfectly symmetric we could always construct a sunspot where the two regional outputs are perfectly positively correlated and treat the currency union as a closed economy.

Instead the slightest deviation from this symmetry would make impossible to assume the two outputs perfectly correlated.[12]

In this case and differently from the closed economy, higher values of σ could reintroduce determinacy (see panel B in Figure 2). Then a standard monetary policy rule can still guarantee the determinacy of the equilibrium. Using the previous example, given a lower intertemporal elasticity of substitution the increase in region H output generates a sudden drop in the terms of trade which causes foreign marginal costs and real wages to drop. In presence of a high share of rule-of-thumb agents in region F a strong drop in the real wages implies a dramatic fall in their imports (region H exports). This is able to revert the region H increase in consumption making aggregate demand for output H to decrease. This is not only related to the intertem-

[11] This is also true when monetary policy itself reacts to union output.

[12] Notice that in Figure2 Panel B the two shares of rule-of-thumb consumers are not exactly the same. For the plot we set $\lambda^* = \lambda + 10^{-4}$.

poral elasticity of substitution but whenever the system absorbs exogenous shocks through changes in relative prices rather then quantities - i.e. more specifically when σ, φ are high and θ is low.[13]

3.2 Impulse response analysis

Purpose of this section is to analyze the spillovers of an exogenous increase in Home public expenditure having stimulating effects on private consumption and activity. The crucial parameters are three: λ, the share of rule-of-thumb agents; γ_H, the parameter regulating the degree of home bias in consumption and investment; θ, the elasticity of substitution between Home and Foreign goods in the consumption and investment bundles. In what follows, the three parameters are changed each in turns, while the remaining are set equal to their respective baseline values, as illustrated in the previous section. Finally, we will also analyze how fiscal rules can dampen government spending effects.

Baseline vs No Rule-of-Thumb Agents

We compare the impulse responses of the benchmark model ($\lambda = 0.5$) to those obtained assuming that there are no rule-of-thumb agents ($\lambda = 0$) - see figure 3 from panel A to panel C.

After a positive public expenditure shock in the region H, in presence of rule-of-thumb agents the domestic private aggregate consumption C increases: the consumption of the rule-of-thumb agents increases, given the positive income effect associated to the increase in real wages; this increase more than compensate the decrease of Ricardian agent's consumption.[14] The labor increase associated to the higher consumption allows for a strong increase in the domestic output (the public expenditure multiplier is greater than one). Consumer price inflation increases, as well as the price inflation of the domestically produced good. The domestic investment, given our monetary rule, is crowded out but not enough to compensate the consumption boom. In the case of no rule-of-thumb-agents, private consumption drops, output increases but less than the public expenditure does (hence the public expenditure multiplier is smaller than one), inflation raises but to a lower extent than in the previous case so that investment is also crowded out to a less extent.

Finally under our fiscal rule the higher public consumption is financed mainly

[13] This cannot be analyze in a closed economy-one sector model.

[14] The increase of real wages is determined by the assumptions of flexible wages and sticky prices.

with public debt: the public debt initially increases, taxes increases only slowly to repay the debt. As we will see later the way of financing crucially determines the magnitude of the crowding in effect for aggregate consumption.

The sources of spillovers are three: the terms of trade, the amount of imports, the nominal interest rate set by the central bank of the union.

The terms of trade appreciate: government is completely biased towards domestic goods. A positive shock to government spending is a direct demand shock for goods produced domestically that generates an increase in their prices.[15] On impact, the terms of trade appreciation is stronger in presence of rule-of-thumb agents, given the higher increase in aggregate demand. The appreciation induces a positive substitution effect towards the good produced in region F. This effect, coupled with the positive income effect of higher wages in region H, stimulates imports of region H, inducing higher production, labor effort and also higher production-prices in region F. When there are only ricardian agents, the amount of imports decreases, contributing to lower output and labor effort in region F.

The central bank rises the nominal interest rate, given the higher union-wide inflation. The higher interest rate implies a decrease in the consumption and investment of region F. Aggregate consumption in region F decreases: the higher consumption of rule-of-thumb agents, favoured by the increase of labor effort, is not sufficient for compensating the lower consumption of ricardian agents. In absence of rule-of-thumb agents, the nominal interest rate increases by less, given the lower increase of inflation at the union level.

The bottom line is that, under the baseline calibration, the introduction of rule-of-thumb agents revert the sign of the response of domestic imports and foreign output volume from negative to positive.

Sensitivity to the Home Bias

In Figure 4 we now compare the impulse responses of the benchmark model (no home bias, i.e. $\gamma_H = 0.5$) to those of the model having mirror home bias ($\gamma_H = \gamma_F = 0.75$): in each region agents have a stronger preference for the domestically produced good.

In presence of home bias, the reaction of the terms of trade is stronger; this induces a positive income effect on domestic agents; in particular, the real wage increase is stronger, inducing an increase of the rule-of-thumb

[15] Given the assumption of no home bias, the real exchange rate stays constant at its steady state level.

agents' consumption; aggregate consumption in region H increases by more, implying higher output and inflation rate.

Spillovers are as follows. Imports are higher in presence of home bias, given that the increase of the consumption and substitution effect are higher.

The terms of trade and real exchange rate appreciate by a greater extent. This induces a negative income effect on agents belonging to region F: notwithstanding higher imports from region H, the amount of output and labor effort decrease in region F: the domestic real wage decrease is stronger, depressing aggregate consumption and demand.

The home bias does not affect the size of the interest rate increase, given that the central bank faces the same rise of union-wide inflation rate. The higher interest rate reduces the consumption and investment of ricardian agents in region F.

Hence, home bias does not affect union-wide variables; however, it increases diverges across the two regions. In particular, following a public spending shock in region H, private consumption, labor effort and output volume in region F decrease, while they increase in region H.

Sensitivity to the Elasticity of Demand

In Figure 5 we increase the elasticity of substitution between goods produced in the two regions, θ, from the baseline value equal to 1.5 to a value equal to 5.

For a given increase in the relative price of the good produced in the region H, private agents are more willing to substitute for the good produced in region F in correspondence of a higher θ. Hence, the positive income effect on agents belonging to region H is lower; private consumption and output increase to a lower amount.

The lower income effect in region H implies that the increase in imports is lower; the terms of trade appreciates to a lower extent.

The interest rate increases, given that inflation rate increases at the union level. All the union-wide variables are not affected by the change in the elasticity of substitution. Labor effort and output increase in region F: agents substitute the good produced in the region H with the good they produce; the relative income effect positively affects the consumption of rule-of-thumb agents; its increase more than compensate the decrease of ricardian agents' demand and stimulate economic activity in the region F.

Overall, higher elasticity of substitution implies a convergence of the output and inflation variations across the two regions. In particular, in the region F private consumption and labor effort increase, as well as in region

H.

Sensitivity to the Country Size

In Figure 6 we compare our benchmark, characterized by the two regions having equal size ($n = 0.5$) to the case where the region H is relatively big ($n = 0.95$).

Qualitatively, variables in the region H are not affected by the change in the size. At union level, the interest rate, inflation rate and output increase, in particular, the union-wide inflation rate and output closely mimic their correspondent variables in the region H, given the big size of the latter. Spillovers to the region F are particularly strong: the big size of region H implies not only an increase in the amount of the good produced in region F, but also, differently from the previously considered cases, in the relative price (a depreciation of the region H's terms of trade and of the real exchange rate). The related positive income effect stimulates the consumption of rule-of-thumb agents in the region F, which induces an increase in aggregate consumption. The big region government spending multiplier for the small region output is greater than one.

Sensitivity to Fiscal rules

In Figure 7 we now modify the benchmark fiscal rule ($\phi_b = 0.3$, $\phi_g = 0.12$) by allowing a stronger reaction to public expenditure ($\phi_g = 1$). Hence, the new rule does not permit deficit spending, given that public expenditure variation are entirely financed by taxation. The direct implication of the new rule is that the multiplier of the public expenditure becomes lower than one. The higher burden of taxes make the consumption of rule-of-thumb decrease. Given the decrease in private demand, imports from region H decrease. The interest rate increase is lower, given the lower increase of inflation. In the region F - given the lack of a spillover stimulating the economic activity - output, investment and consumption decrease.

3.3 Policy Frontier

Shocks that generate a negative correlation between output and inflation force the central bank to face a trade-off between the variability of output and that of inflation at the union level. We investigate whether fiscal rules contribute to alleviate this trade-off. We compare the stabilization property of alternative fiscal rules, assumed to be symmetric across countries: a 'rigid' tax rule, calibrated using the baseline values, that mainly focuses on stabilizing the level of domestic public debt; a 'flexible' tax rule, that limits

the movements of domestic output; a 'flexible' public spending rule, that, given the rigid tax rule, limits the movements of domestic output. To compare alternative tax rules based on lump-sum taxation is not trivial in our case, given that we break the ricardian equivalence through the rule-of-thumb agents.

If the government itself is the main source of uncertainty in the economy then a rule which allows to exploit the limited financial markets participation of some agents would only generate higher macro-volatility. In this case financing government consumption with taxes, $\phi_g = 1$, kills the 'Keynesian' effect and improve macro-stability (see Figure 7). Hence, in order to evaluate how fiscal policy could help to reduce macroeconomic volatility we shut off the shock associated to government expenditure $\sigma_{\varepsilon^g} = 0$ and we focus on how different simple fiscal rules could make the system better absorb a technology and a markup shock.

In the 'flexible' tax rule we keep $\phi_b = .30$ and $\phi_g = .12$ at their baseline values while the parameter measuring the reaction of taxation to output is set equal to $\phi_{yx} = 1$ (symmetrically in region F):

$$\log T_{X,t} = .30(B_{G,t-1}/P_t) + .12\log(P_{H,t}G_t/P_t) + \log(Y_{H,t}) + \text{const} \tag{58}$$

In the 'flexible' public spending rule we keep $\rho_g = .87$ at its baseline value while the parameter measuring the reaction of government expenditure to output is set equal to $\phi_{yg} = 1$ (symmetrically in region F):

$$g_t = .87g_{t-1} - \log(Y_{H,t}/\bar{Y}) \tag{59}$$

We compute the inflation-output volatility frontiers for alternative parameterizations of the interest rate rule.[16] Specifically, we minimize the weighted unconditional variances of output and inflation at different relative preferences of the monetary authority for inflation versus output variance. We consider only values of the parameters that generate a unique equilibrium.

We assume a symmetric markup and technology shock, following the process reported in section (2.10) (for their calibration see section 2.12).

Panel A in Figure 8 shows the union-wide inflation-output frontier in correspondence of each tax rule. Government spending is held constant at its steady state value for both regions. The flexible tax rule contributes to

[16] See Levin et al. (1999).

reduce the trade-off between stabilizing the inflation and the output: for most of plotted space, given the variance of one variable the variance of the other decreases. However, when the monetary policy is mainly focused on stabilizing one of the two variables, the differences between the two fiscal rules decreases. In particular, when the central bank mainly minimizes the variance of the inflation, the curves intersect and the flexible rule has a lower capability of stabilizing economy than the rigid rule.

Panel B in Figure 8 shows what happens to the variances of output and inflation of region H. The diagram is similar to that of the union, given that we assume a symmetric structure of the shocks. For the same reason, the frontier computed using variables of region F is similar. To save on space, we do not report it.

Finally, we analyze the stabilization property of a public expenditure rule. It is known that this kind of rule stabilizes the economy of the currency union also in absence of rule-of thumb agents.[17] The parameters of the tax rule are set to their baseline values - i.e. $\phi_b = .30$ $\phi_g = .12$ and $\phi_{yx} = 0$. Panel A in Figure 9 reports the results obtained for the union-wide inflation and output. The spending rules, offsetting the variation in the private spending, stabilizes the economy of the union. The frontier of the monetary authority shifts towards the origin. As in the case of alternative tax rules, the two frontiers will eventually intersect when the central bank mainly stabilizes inflation. As shown in Panel B, this property holds also at regional level (to save on space, we report only the results obtained in the case of the region H, those relative to region F are similar).

4 Conclusions

In this paper we have analyzed the effects of fiscal policy in a currency area using a DSGE model with sticky prices. We have allowed for the positive effects of public expenditure on private consumption and a nontrivial role of lump-sum taxes by introducing rule-of-thumb agents. We have assumed that fiscal policy is managed at regional level in a systematic way having the stabilization of domestic variables as exclusive target. We have done the

[17] See Beetsma and Jensen (2005). We have computed the shift of the frontier in correspondence of the public expenditure rule and no rule-of-thumb agents. Results are not qualitatively different from those reported in the text. To save on space, we do not report them.

opposite assumption for the common monetary policy which reacts to the union-wide variables only.

Given this framework, we have explored which characteristics the monetary and fiscal rules should have to guarantee a unique stable equilibrium. We have analyzed the domestic and cross-regional effects of a given regional public expenditure shock. Finally, we have analyzed the capability of decentralized (at regional level) simple tax and expenditure rules to stabilize the union-wide variables.

The main results are two: we have been able to reproduce, consistently with empirical evidence on countries belonging to the European Union, the increase in private demand for imported goods that follows a domestic public spending shock; second, the presence of rule-of-thumb agents, that allows to reproduce the quoted stylized fact, does not dramatically affect the capability of regional fiscal policy to contribute to the stability and equilibrium determinacy of the union-wide economy, at least compared to the case of closed economy model.

There are various directions in which the main point of this paper can be further developed. First, we have assumed that fiscal policy is exclusively conducted at regional level; this assumption can be relaxed by assuming that there are some fiscal transfers across regions or that there is a central fiscal authority (at union level). Second, we have assumed that, differently from rule-of-thumb agents, the Ricardian agents can share idiosyncratic risk; we can relax this assumption and assume that also Ricardian agents face some financial frictions; an alternative assumption, with implications for the dynamics of the model, is that Ricardian agents have access only to a riskless bond traded domestically and across regions. Finally, we can add distortive taxation, that directly affect relative prices, and analyze how the union-wide implications of fiscal policy change.

Appendix

A-1 Labor Market Structure

We assume that in each country labor markets are not perfectly competitive. Following GLV 2006 we assume an aggregate labor supply of the following form:

$$\mu_w \left(\frac{C_t^i}{n_i}\right)^{\sigma} \left(\frac{N_t^i}{n_i}\right)^{\varphi} = w_t^i \tag{A-1}$$

The coefficient μ_w represents a wage markup. The previous equation can be rationalize introducing a union. In each region, say region H, firms have a demand for different types of labor:

$$N_t(j) = \frac{1}{n}\Big(\frac{w_t(j)}{w_t}\Big)^{-\epsilon_n} N_t$$

Different types of labors are randomly distributed across households (disregardful of household type). It follows that in aggregate we will have $N_t^r = N_t^o = N_t/n$

The union sets wages in order to maximize the objective function (with a slight abuse of notation n_j denotes both the mass of households of labor type-j and its set):

$$\int_{j\in n_j} c_t(j)^{-\sigma} w_t(j) N_t(j) - \frac{N_t^{1+\varphi}(j)}{1+\varphi} dj$$

subject to a labor demand schedule

$$N_t(j) = \frac{1}{n}\Big(\frac{w_t(j)}{w_t}\Big)^{-\epsilon_n} N_t$$

first order conditions for this problem gives (we define $\mu_w \equiv \epsilon_n/(\epsilon_n - 1)$):

$$w_t = \mu_n \Big(\frac{C_t}{n}\Big)^{\sigma} \Big(\frac{N_t}{n}\Big)^{\varphi} \int_{j\in n_j} \Big(\frac{1}{n_j}\Big)^{\sigma} \Big(\frac{C_t(j)}{C_t}\Big)^{-\sigma} dj$$

The same holds symmetrically true for the other country.
We assume that the union is not able to observe the marginal utility of each single households but only aggregate consumption. We take $n_z = n$ and using a marginal utility of average consumption in the objective function cancels the integral in the above condition delivering the same result as postulated in the beginning[18].

A-2 Non-Stochastic Steady State

The steady state has a closed form solution for $ToT = 1$. This is not the case when countries are not symmetric - e.g. different government spending

[18] We calibrate the model such that the participation constraint for each households is almost always satisfied.

ratios. In this case there is no closed form solution but the main relations among variables keep the same functional form.
The ToT is our unknown to be found.

$$\left(\frac{P_H}{P}\right)^{\theta-1} = \gamma_h + (1-\gamma_h)TOT^{1-\theta} \tag{A-2}$$

$$\left(\frac{P_F}{P^*}\right)^{\theta-1} = \gamma_f + (1-\gamma_f)TOT^{\theta-1} \tag{A-3}$$

$$RER = \frac{P^*}{P_F}\frac{P_H}{P}TOT \tag{A-4}$$

From the FOC on capital we find return on capital which is the same in both countries is $r^k = 1/\beta - 1 + \delta$.
The steady state markup is μ and μ^* in the home and foreign country, respectively. It implies:

$$mc = \frac{1}{\mu}\frac{P_H}{P}$$

$$mc^* = \frac{1}{\mu^*}\frac{P_F}{P^*}$$

using marginal costs we can find the great ratios for both countries (we assume zero steady state price dispersion).

$$\frac{K}{Y} = \alpha mc/r^k$$

$$\frac{Y}{N} = Z^{\frac{1}{1-\alpha}}\left(\frac{K}{Y}\right)^{\frac{\alpha}{1-\alpha}}$$

Using the output-labor ratio we can find the real wage

$$w = \frac{Y}{N}(1-\alpha)mc \tag{A-5}$$

symmetrically for the other country.

We will impose the trade balance equal to zero. This means the value of imports must be equal to the value of export or, in other words, that the value of the output produced in one country (the GDP) must be equal to the country total aggregate demand

$$P(C+I) + P_H G = P_H Y_H$$

which means (we assume $G/Y_H = g$)

$$\frac{C}{Y_H} = \frac{P_H}{P} - \delta\frac{K}{Y_H} - \frac{P_H}{P}g$$

from the labor supply equation we can finally determine the outputs' levels (we introduce μ_w the wage markup).

$$\mu_w\Big(\frac{C}{Y_H}\Big)^{\sigma}\Big(\frac{N}{Y_H}\Big)^{\varphi}{Y_H}^{\sigma+\varphi} = n^{\sigma+\varphi}w$$

symmetrically for the other country.

We are know able, using the great ratios and the output levels, to calculate also the consumption and investment levels.

We close the system imposing that the trade balance must be actually equal to zero.

$$TB = (1-\gamma_f)\frac{P_H}{P}\Big(\frac{P_H}{P^*}\Big)^{-\theta}(C^* + I^*) - (1-\gamma_h)\Big(\frac{P_F}{P}\Big)^{-\theta}\frac{P_F}{P}(C+I) = 0$$

It is interesting to note that, as for a closed economy, aggregate steady state variables are not affected by the RoT share λ. This result is in fact not really surprising given that the main restriction imposed to the RoT is to smooth consumption *intertemporally*. On the other hand, as we have shown, technology and market distortions determine the great ratios of the economy and so also the aggregate labor income making the number of capital holders affect only the wealth distribution of the economy but not the production side.

From the previous equations we can find the RoT consumption from their budget constraint (given that $N^o = N^r = N/n$, $T_x = nT^r$ and we assume $T_x/Y_H = G/Y_H = g$)

$$\frac{nC^r}{Y} = (1-\alpha)mc - g \tag{A-6}$$

or in terms of aggregate RoT consumption

$$\frac{\lambda nC^r}{Y} = \lambda[(1-\alpha)mc - g] \tag{A-7}$$

This means that the aggregate steady state RoT consumption depends linearly on their share. Optimizers consumption is determined residually.

References

[1] Beetsma, Roel M. V., and Henrik Jensen [2004] "Monetary and Fiscal Policy Interactions in a Micro-founded Model of a Monetary Union", mimeo.

[2] Benigno, Pierpaolo, [2003] "Optimal Monetary Policy in a Currency Area" *Journal of International Economics*, forthcoming.

[3] Blanchard, Olivier, and Roberto Perotti [2002], "An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output" *Quarterly Journal of Economics*, 117, 4, 1329-1368.

[4] Buiter, Willem, Giancarlo Corsetti and Nouriel Roubini [1993], "Excessive Deficits: Sense and Non-Sense in the Treaty of Maastricht", *Economic Policy*, 16.

[5] Calvo. Guillermo A, [1983] "Staggered Prices in a Utility-Maximizing Framework", *Journal of Monetary Economics* 12, 383-398.

[6] Campbell, John. Y., and N. Gregory. Mankiw [1989] "Consumption, Income and Interest Rates: Reinterpreting Time Series Evidence", in Olivier J. Blanchard and Stanley Fisher (eds.) National Bureau of Economic Research Macroeconomic Annual 1989, MIT Press.

[7] Canzoneri, M., Cumby, R. and B. Diba (2005), "How Do Monetary and Fiscal Policy Interact in the European Monetary Union?", National Bureau of Economic Research Working Paper #11055.

[8] Canova, Fabio, and Evi Pappa [2004] "Does it Cost to be Virtuous? The Macroeconomic Effects of Fiscal Constraints", mimeo

[9] Canzoneri, Matthew B., and Dale W. Henderson [1991] *Monetary Policy in Interdependent Economies,* Cambridge, MA: MIT Press.

[10] Canzoneri, Matthew B., Robert E. Cumby and Behzad T. Diba [2004] "The need for International Policy Coordination: What's Old, What's New, What's yet to Come?", National Bureau of Economic Research Working Paper, No. 8765..

[11] Canzoneri, Matthew B., Robert E. Cumby and Behzad T. Diba [2004] "How Do Monetary and Fiscal Policy Interact in the European Monetary Union?", mimeo.

[12] Caselli, Paola [2001] "Fiscal Consolidations under Fixed Exchange Rates" *European Economic Review*, vol. 45, no.3, pp. 425-450.

[13] Chari, Varadarajan.V., and Patrick Kehoe [1999] "Optimal Fiscal and Monetary Policy", National Bureau of Economic Research Working Paper no. 6891.

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

[15] Corsetti, Giancarlo, and Paolo Pesenti [1999] "Can the Ins Hurt the Outs? A Welfare Analysis of International Fiscal Links", in Andrew Hughes Hallet, Michael M. Hutchinson and Svend E. Hogaard Jensen *Fiscal Aspects of European Monetary Integration*, Cambridge University Press.

[16] Corsetti, Giancarlo and Paolo Pesenti (2001) "Welfare and Macroeconomic Interdependence", *Quarterly Journal of Economics*, 116, 421-445.

[17] De grauwe, Paul [1998] "The Risk of Deflation in the Future EMU: Lessons of the 1990s" Center for Economic Policy Research Discussion Paper no. 1384, March.

[18] Duarte, Margarida, and Alexander L. Wolman [2002] "Regional Inflation in a Currency Union: Fiscal Policy vs. Fundamentals", European Central Bank Working Paper, September.

[19] Dupor, Bill (2002): "Interest Rate Policy and Investment with Adjustment Costs", manuscript.

[20] Eggertsson, Gauti, and Michael Woodford [2004] "Optimal Monetary and Fiscal Policy in a Liquidity Trap", mimeo.

[21] Eichengreen, Barry, and Charles Wyplosz [1998] "The Stability Pact: More than a Minor Nuisance", *Economic Policy*, 26.

[22] Fatàs, Antonio and Ilian Mihov [2001a] "Fiscal Policy and Business Cycles: An Empirical Investigation", *Moneda y Credito* 212.

[23] Fatàs, Antonio, and Ilian Mihov [2001b] "The Effects of Fiscal Policy on Consumption and Employment: Theory and Evidence", Center for Economic Policy Research Discussion Paper, no. 2760.

[24] Gali, Jordi, J. David Lòpez-Salido, and Javier Vallés [2003] "Rule-of-Thumb Consumers and the Design of Interest Rate Rules", Bank of Spain Working Paper, no.0320.

[25] Gali, Jordi, J. David Lòpez-Salido, and Javier Vallés [2004] "Understanding the Effects of Government Spending on Consumption", European Central Bank Working Paper, no.339, April.

[26] Giavazzi, Francesco. and Marco Pagano [1990] "Can Severe Fiscal Contractions be Expansionary? Tales of Two Small European Countries" in Olivier J. Blanchard and Stanley Fisher (eds.) National Bureau f Economic Research Macroeconomics Annual 1990, MIT Press.

[27] Giuliodori Massimo and Roel Beetsma [2004] "What Are the Spillovers from Fiscal Shocks in Europe? An Empirical Analysis", European Central Bank Working Paper 325, March.

[28] Hemming, Richard, Michael Kell and Selma Mahfouz [2002] "The effectiveness of Fiscal Policy in Stimulating Economic Activity- A Review of the Literature", International Monetary Found Working Paper no. 02/208.

[29] King, Robert, and Mark Watson [1996] "Money, Prices, Interest Rates and the Business Cycle", *Review of Economics and Statistics*, 78, 35-53.

[30] Lombardo, Giovanni, and Alan Sutherland [2003] "Monetary and Fiscal Interactions in Open Economies", European Central Bank Working Paper, November.

[31] Mankiw N. Gregory [2000] "The Savers-Spenders Theory of Fiscal Policy" *American Economic Review*, 90, 2, 120-125.

[32] Mountford, Andrew and Harald Hulig [2004] "What are the Effects of Fiscal Policy Shocks?" Discussion Paper 31, Tilburg University, Center for Economic Research.

[33] Obstfeld, Maurice, and Kenneth Rogoff [2004] The Unsustainable US Current Account Position Revisited, mimeo.

[34] Perotti, Roberto [1999] "Fiscal Policy in Good Times and Bad" *Quarterly Journal of Economics*, 114, 4, 1399-1436.

[35] Persson, Torsten, and Guido Tabellini [1995] "Double-Edged Incentives: Institutions and Policy Coordination", in G. Grossman and K. Rogoff (eds.) *Handbook of International Economics*, Vol. III, Amsterdam: Elsevier.

[36] Ramey Valerie, and Matthew Shapiro [1998] "Costly Reallocation and the Effect of Government Spending" Carnegie-Rochester Conference Series on Public Policy, 48, 145-194.

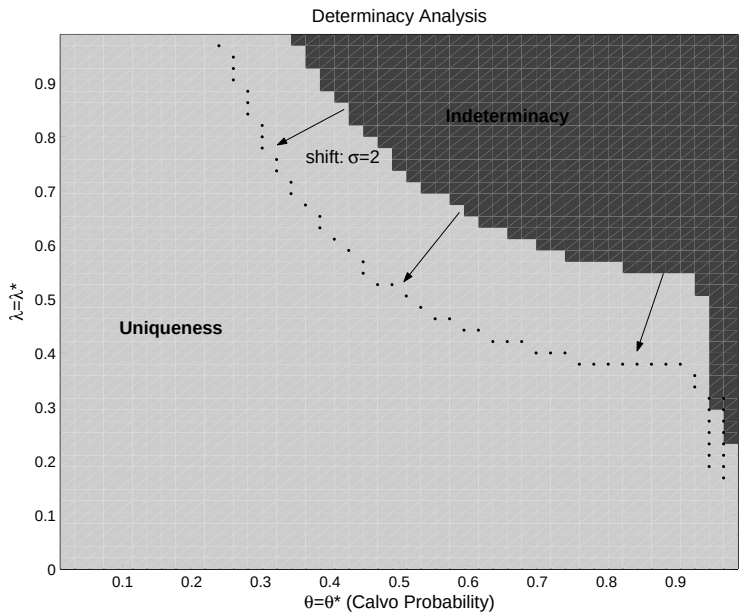
[37] — [1999] "Interest Rate Rules in an Estimated Sticky Price Model" in J.B. Taylor (ed.) Monetary Policy Rules, University of Chicago Press and National Bureau of Economic Research.

[38] Schmitt-Grohé, Stefanie, and Martin Uribe [2004] "Optimal Fiscal and Monetary Policy under Sticky Prices" *Journal of Economic Theory*, forthcoming.

[39] Woodford, Michael [2001] "The Taylor Rule and Optimal Monetary Policy", *American Economic Review* vol. 91, no. 2, 232-237.

[40] Wolff, Edward [1998] "Recent Trends in the Size Distribution of Household Wealth" *Journal of Economic Perspectives* 12, 131-150.

Panel A



Panel B

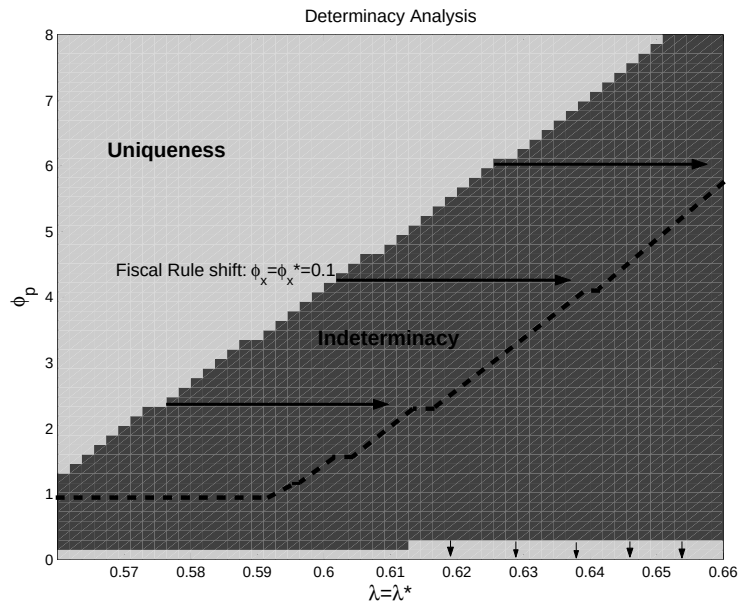
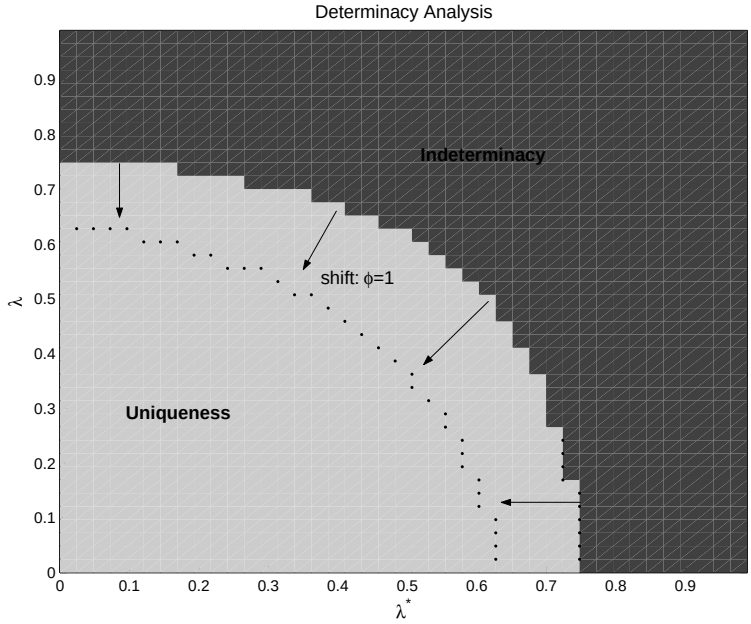


Figure 1: All other parameters at their baseline values. Dotted lines show the shift in the indeterminacy region frontier.

Panel A



Panel B

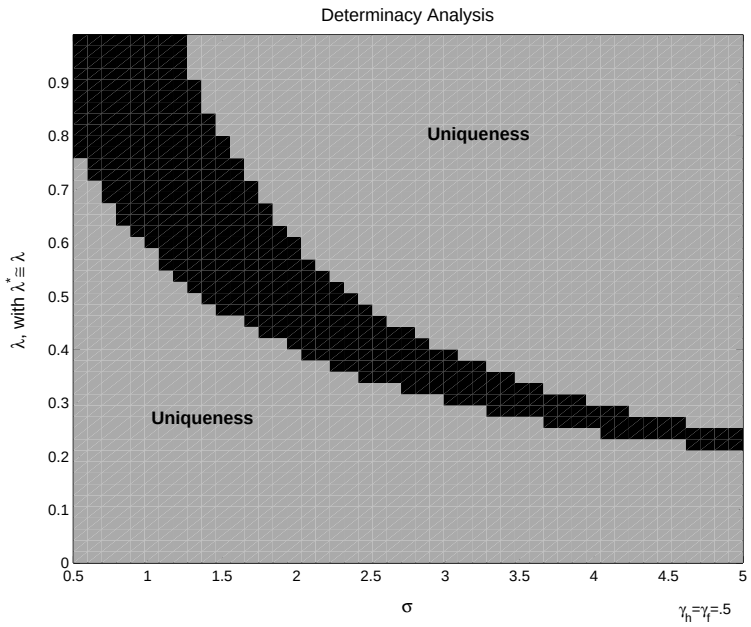
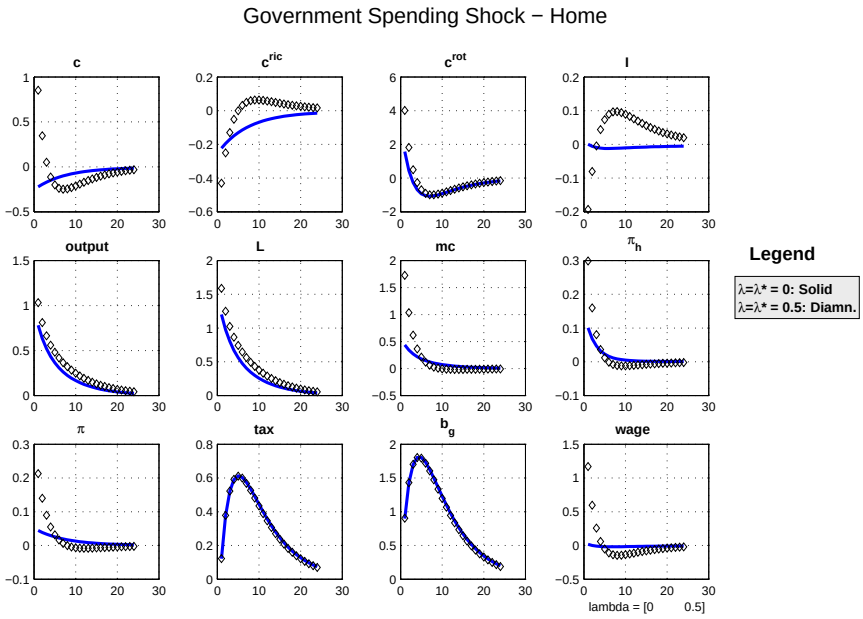


Figure 2: All other parameters at their baseline values. Dotted lines, when plotted, show the shift in the indeterminacy region frontier.

Panel A



Panel B

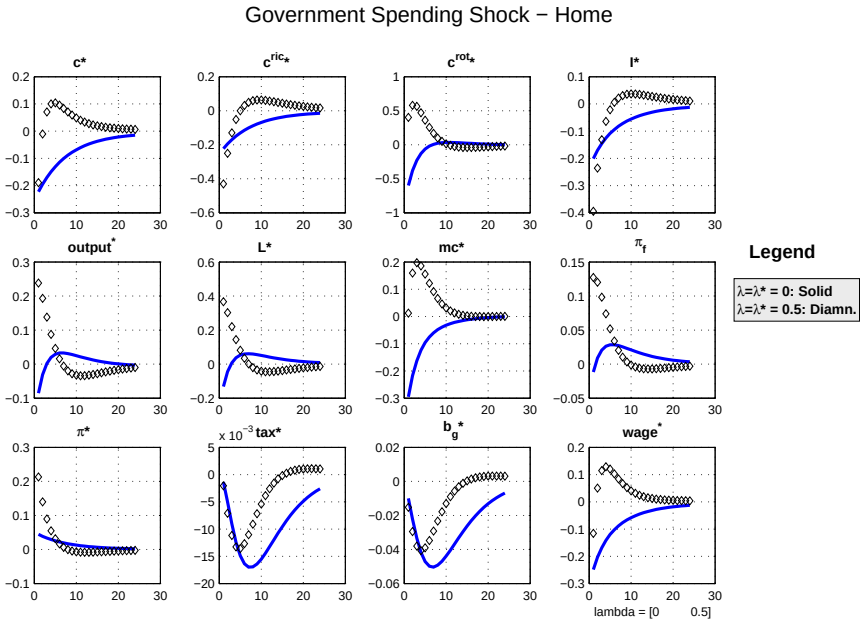


Figure 3: Impulse response function to a 1% increase in the region-H government spending. All other parameters at their baseline values. Horizontal axis: time (quarters). Vertical axis: deviation from steady state.

Panel C

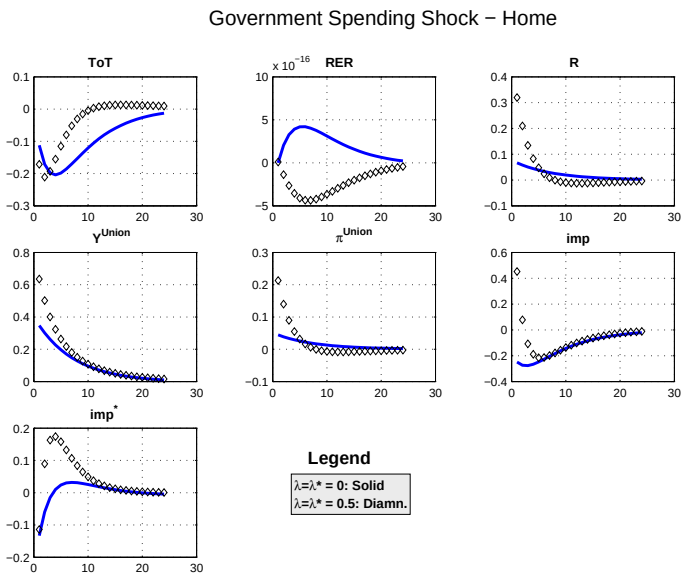
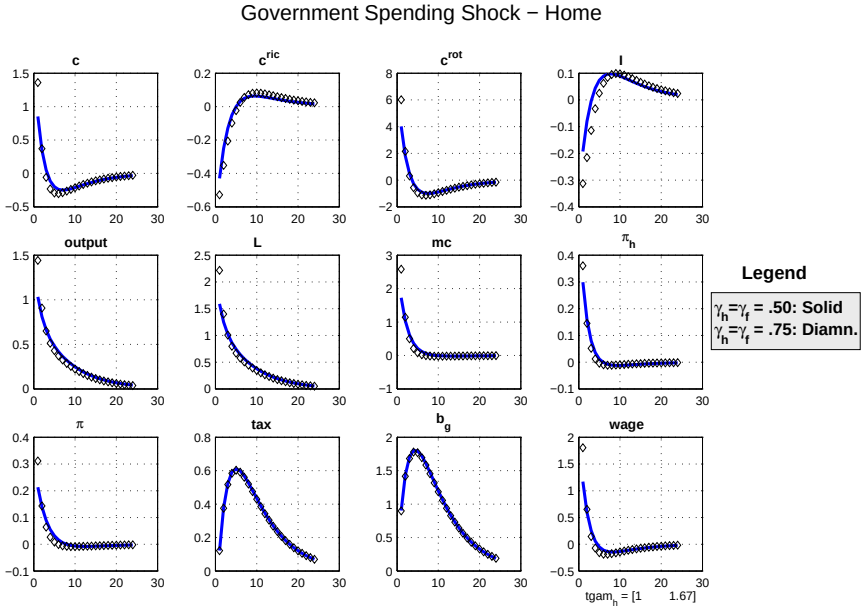


Figure 3: Impulse response function to a 1% increase in the region-H government spending. All other parameters at their baseline values. Horizontal axis: time (quarters). Vertical axis: deviation from steady state.

Panel A



Panel B

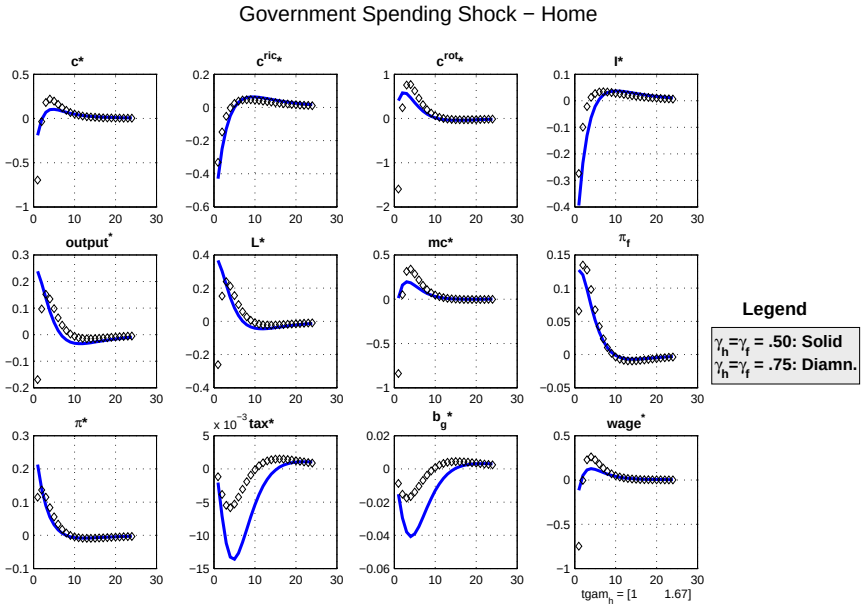


Figure 4: Impulse response function to a 1% increase in the region-H government spending. All other parameters at their baseline values. Horizontal axis: time (quarters). Vertical axis: deviation from steady state.

Panel C

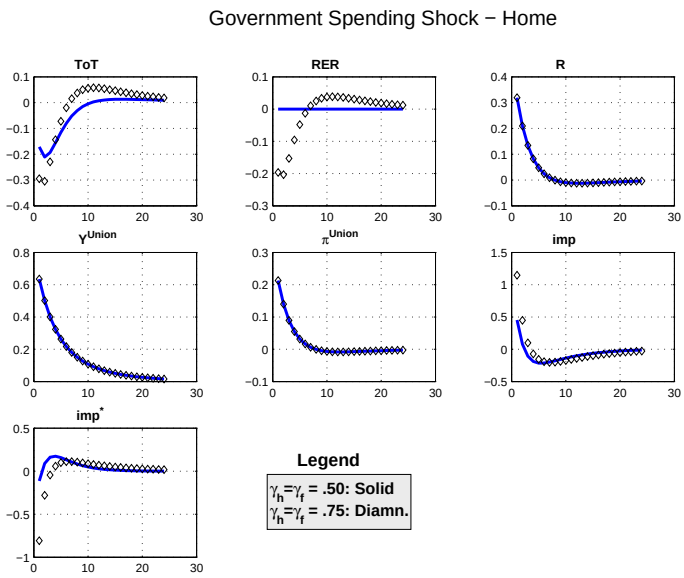
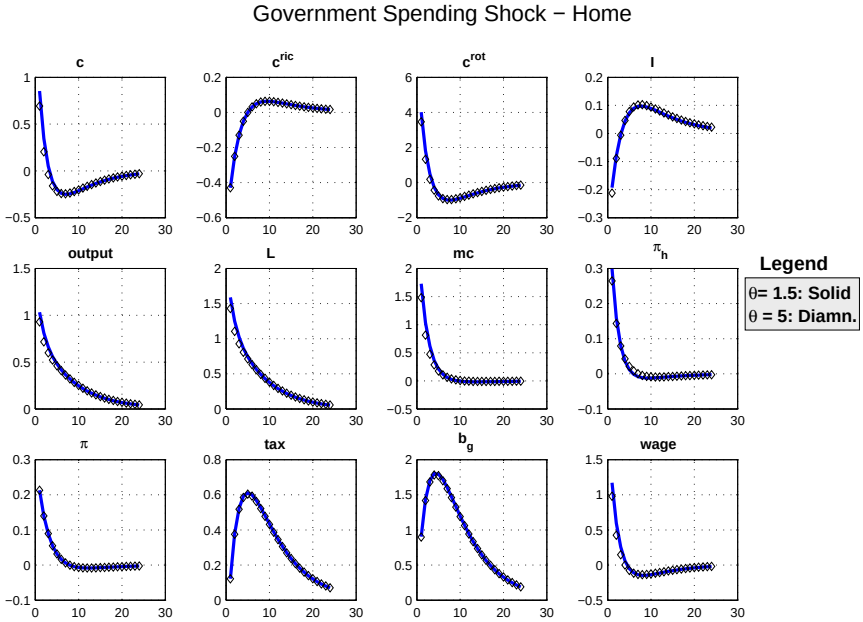


Figure 4: Impulse response function to a 1% increase in the region-H government spending. All other parameters at their baseline values. Horizontal axis: time (quarters). Vertical axis: deviation from steady state.

Panel A



Panel B

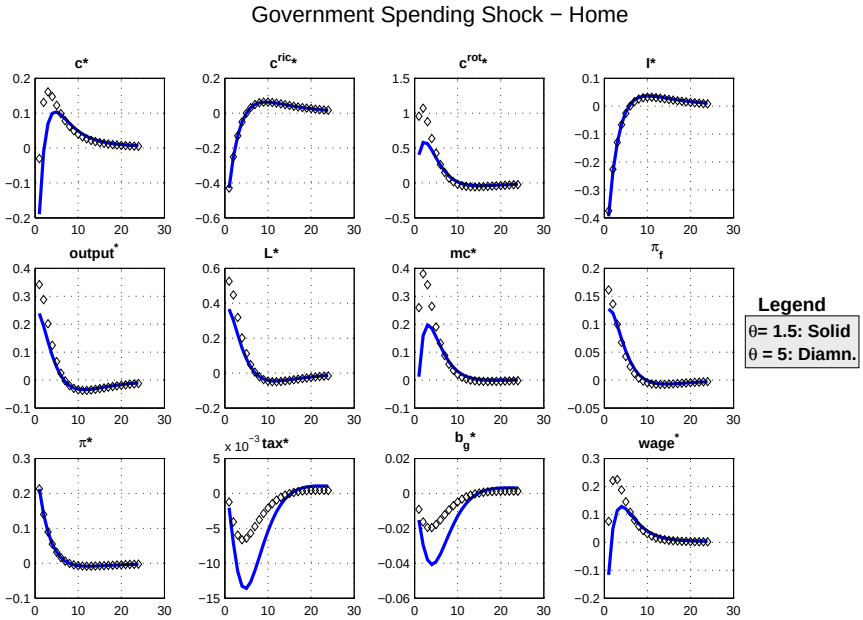


Figure 5: Impulse response function to a 1% increase in the region-H government spending. All other parameters at their baseline values. Horizontal axis: time (quarters). Vertical axis: deviation from steady state.

Panel C

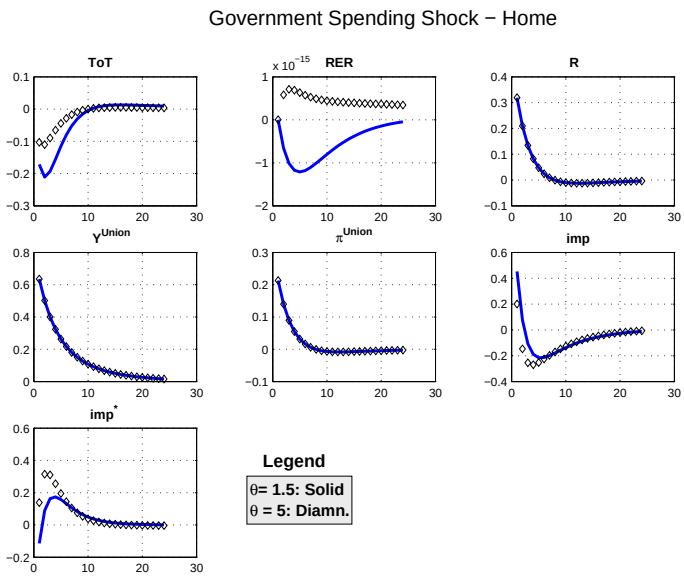
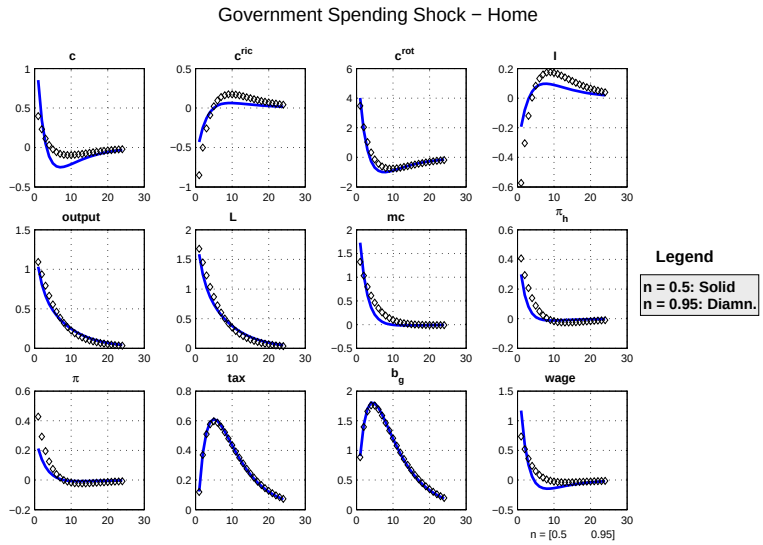


Figure 5: Impulse response function to a 1% increase in the region-H government spending. All other parameters at their baseline values. Horizontal axis: time (quarters). Vertical axis: deviation from steady state.

Panel A



Panel B

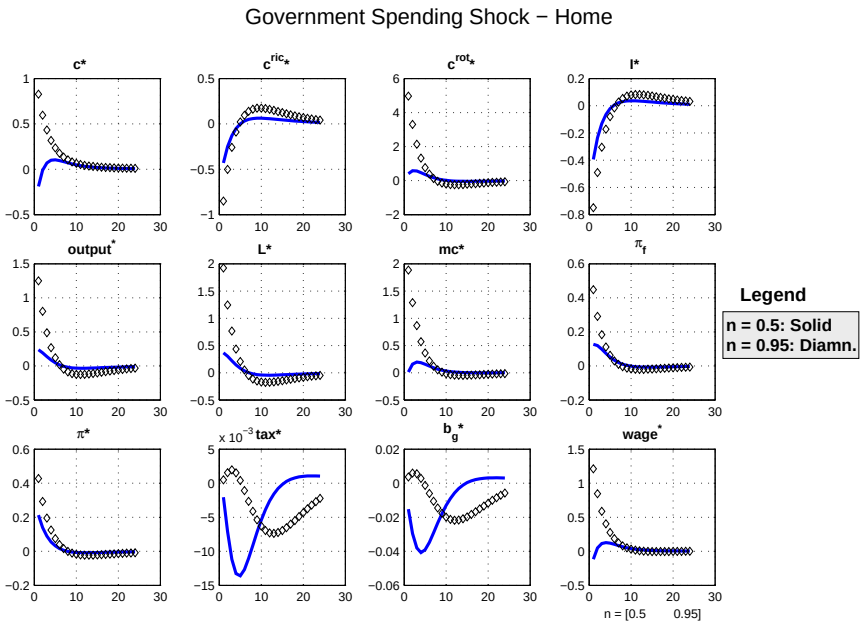


Figure 6: Impulse response function to a 1% increase in the region-H government spending. All other parameters at their baseline values. Horizontal axis: time (quarters). Vertical axis: deviation from steady state.

Panel C

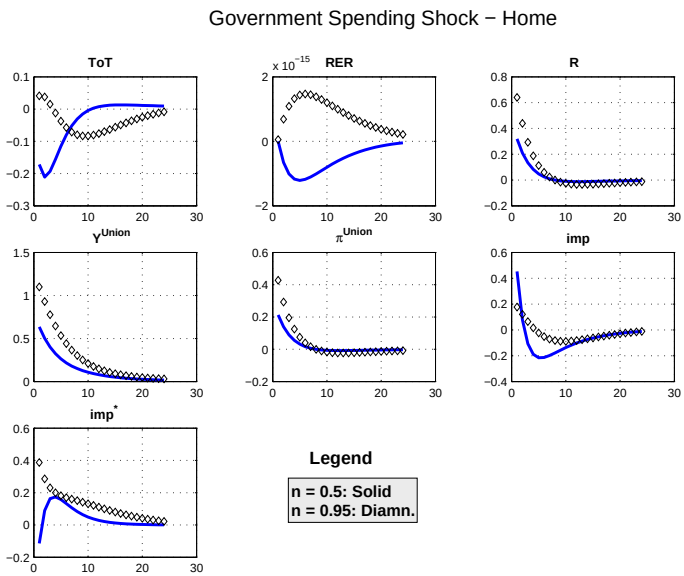
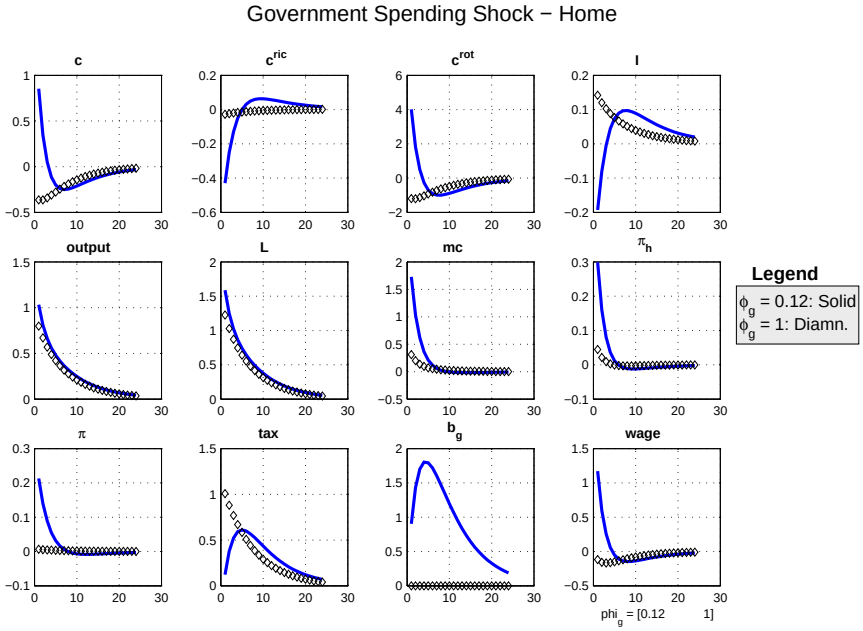


Figure 6: Impulse response function to a 1% increase in the region-H government spending. All other parameters at their baseline values. Horizontal axis: time (quarters). Vertical axis: deviation from steady state.

Panel A



Panel B

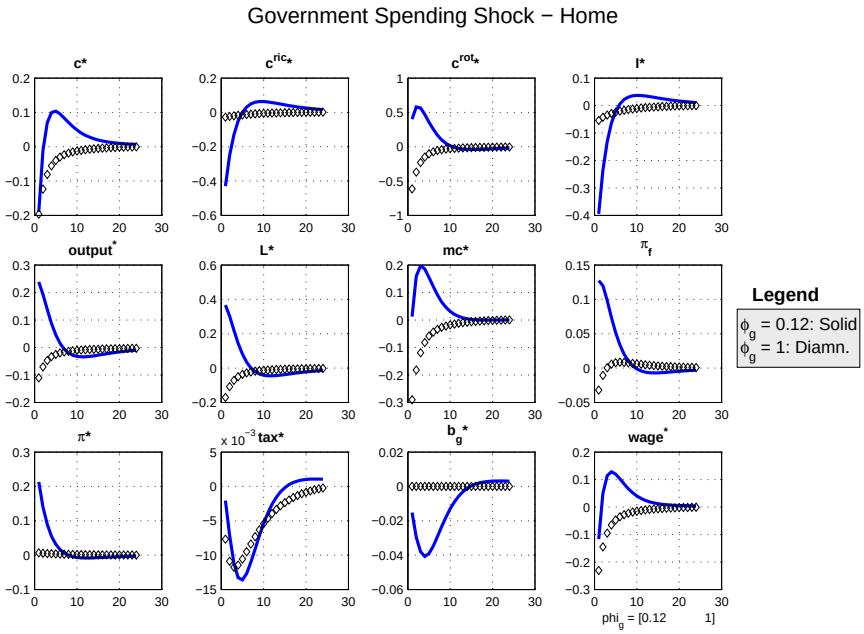


Figure 7: Impulse response function to a 1% increase in the region-H government spending. All other parameters at their baseline values. Horizontal axis: time (quarters). Vertical axis: deviation from steady state.

Panel C

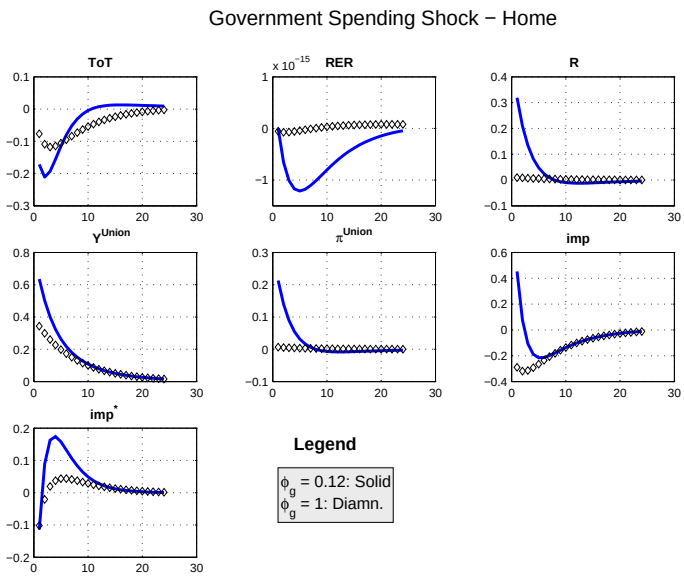
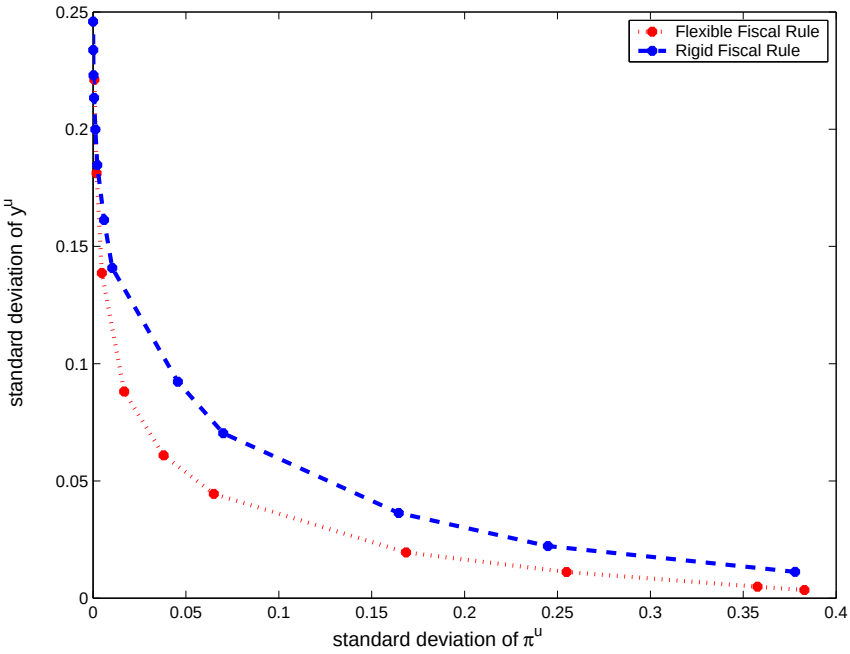


Figure 7: Impulse response function to a 1% increase in the region-H government spending. All other parameters at their baseline values. Horizontal axis: time (quarters). Vertical axis: deviation from steady state.

Panel A



Panel B

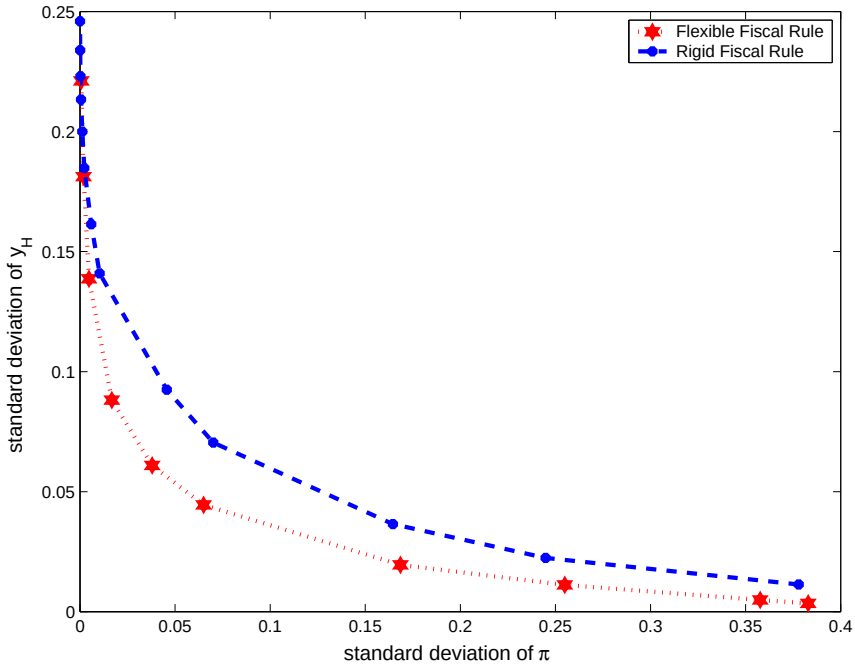
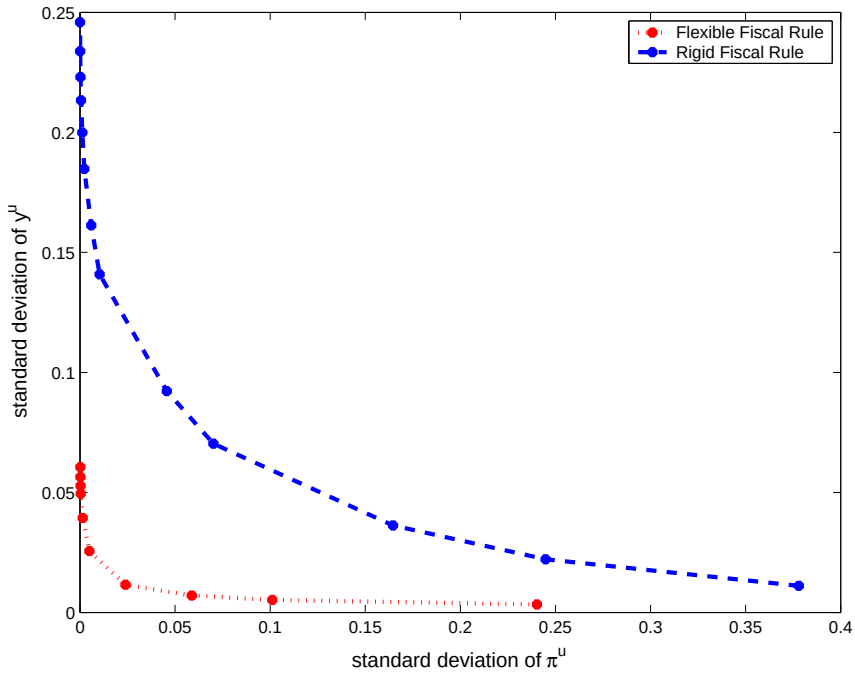


Figure 8: Monetary policy frontier. Panel A Union-wide output and inflation volatility. Panel B Region-F output and inflation volatility. Two different fiscal rule. Baseline calibration.

Panel A



Panel B

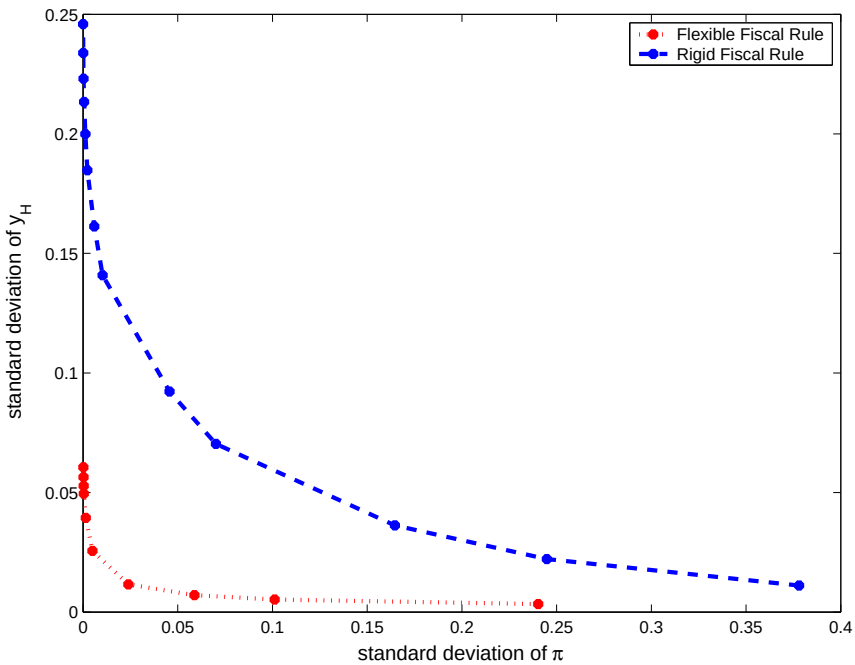


Figure 9: Monetary policy frontier. Panel A and B Union-wide output and inflation volatility. Panel A no rule-of-thumb consumers, Panle B $\lambda = \lambda^{\star} = 0.1$. Two different fiscal rule. The rest of the parameters at the baseline calibration.