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# Fiscal policy and inflation in a monetary union

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# Fiscal Policy and Inflation in a Monetary Union*

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**Abstract**

This paper studies optimal fiscal policies in a small open economy within a monetary union. The government has access to nominal non-state contingent debt and distortionary labour taxes to finance exogenous spending. Price levels differ across countries due to consumption home bias; thus fiscal policy influences inflation and the terms of trade. Prices are flexible. We show that, unlike in a country with an independent monetary policy, some variability in labour taxes is optimal. This is true even when the terms-of-trade externality is shut down. While fiscal policy aims at smoothing production distortions, with nominal public debt there is an incentive to use taxes to inflate in bad times when debt levels are high, reminiscent of Chari et al's (1991) optimal monetary policy result.

Key words: optimal fiscal policy, inflation, monetary union, small open economy, non-state-contingent debt.

JEL codes: E62, E31, F41

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# 1 Introduction

This paper studies optimal fiscal policies in a small open economy within a monetary union. In particular, we consider the choice of labour income taxes and new debt issuance when monetary policy is exogenous, i.e. when the weight of the member country in the monetary policy making process is small. Such a country nevertheless retains a powerful instrument to influence its domestic prices: fiscal policy. We show in this paper that an incentive to change taxes, and hence domestic prices, arises from the fact that governments hold nominal non-state-contingent assets.

The fiscal authority faces conflicting objectives. On the one hand, the cost of raising taxes is their distortionary effect on production. This is a classic result going back to Lucas and Stokey (1983). On the other hand, taxes can be used to raise domestic inflation and hence lower the real value of public debt in bad times, a result reminiscent of Chari et al's (1991) use of monetary policy to change inflation.

The monetary union is composed of two countries with independent fiscal authorities. We consider the case of a small open economy by taking the limit as the country size goes to zero. Monetary policy, conducted at the union level, is assumed to be exogenous. Due to home bias, consumption baskets differ across countries and so do price levels. The fiscal authority taxes labour income and issues nominal non-state-contingent debt to finance exogenous public spending; this provides an incentive to generate inflation to lower the public debt burden. The small country cannot choose monetary policy independently; however, it can use fiscal policy to vary domestic inflation. We consider optimal policy under commitment as in Ramsey (1927). We characterise the welfare-maximising fiscal policy in this environment: the implied responses to government spending changes and productivity shocks, as well as the optimal volatility of taxes.

As opposed to Benigno and De Paoli (2010), we assume that monetary policy is exogenous. In their model, the tax rate varies optimally to take advantage of the terms of trade externality whenever home and foreign goods are complements or substitutes in consumption. In the special case where the goods are independent in the agents' utility, taxes should be smooth. Here, we focus on this special case to show that optimal tax variability rises if monetary policy is exogenous and public debt is nominal and non-state-contingent. Our result applies to a small open economy with a fixed exchange rate as well as to a monetary union country. From the vantage point of a small open economy the two are identical. In either case, monetary policy is unavailable and the tax rate is the only lever that the country has to influence domestic inflation.

Galí and Monacelli (2008) and Ferrero (2009) solve for the optimal coordinated fiscal and monetary policies in a monetary union. In contrast, we derive the optimal fiscal policy without coordination under the assumption that monetary policy is exogenous. Given the independence of the European Central Bank and the lack of a European fiscal institution, we regard this setup as consistent with current policymaking arrangements in Europe.

Other research on fiscal policy in a monetary union concentrates on (optimal) simple rules and typically assumes sticky prices. For instance, Duarte and Wolman (2008) analyse the effects of fiscal policy on inflation and competitiveness for a given tax rule in a sticky-price economy. Kirsanova et al (2007) consider optimal fiscal rules in the presence of price rigidities and other frictions such as rule-of-thumb consumers.

More recently, Farhi and Werning (2014) study optimal transfers between members of a currency union and compute how the welfare gain depends on the size and persistence of shocks and the degree of openness. They focus on cooperative fiscal policy. Dmitriev and Hoddenbagh (2015) show how, in a cooperative setup, cross-country transfers should be designed for optimal risk sharing in a currency union. Under incomplete financial markets and if the trade elasticity is high, fiscal transfers can help to insure against country-specific shocks. In contrast to these two contributions on optimal fiscal unions, we consider non-cooperative fiscal policy from the perspective of a single currency union member.

The remainder of the paper is structured as follows. In Section 2, we outline the model, starting from a two-country model and then zooming in on the small open economy case. Section 3 discusses optimal fiscal policies in the small open economy. We contrast the monetary union model with nominal government debt with the efficient benchmark of a standalone country that has full control over its monetary policy, which as shown in Benigno and De Paoli (2010) is equivalent to the small open economy case with access to state-contingent debt. We also consider the effect of varying model parameters capturing openness, the steady state debt ratio and the government spending share. Then Section 4 investigates the effect on the results of varying country size. Finally, Section 5 concludes.

# 2 Model

The economy is composed of two countries (denoted $H$ and $F$) that share the same currency but have separate fiscal authorities. Monetary policy is conducted at the union level and is assumed to be exogenous. Agents have a bias towards domestically produced goods, which implies that the home and foreign consumption bundles and their prices differ. Financial markets between home and foreign agents are complete. We start from a two-country model where the countries differ in size. Then we discuss the small open economy case by letting the size of the home country go to zero. The model structure is similar to Benigno and De Paoli (2010); however, we assume that the countries belong to a monetary union and the home government issues only nominal non-state-contingent bonds. We present the model equations for the home country and relegate the foreign equilibrium conditions, which are analogous, to the appendix.

## 2.1 Households

Preferences of home agents are summarised by:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left( \ln c_t - \frac{1}{1+\eta} {l_t}^{1+\eta} \right), \tag{1}$$

where $0 < \beta < 1$ is the subjective discount factor, $c_t$ is the composite good (including both domestic and foreign goods), $l_t$ is labour, and $\eta$ is the inverse Frisch elasticity of labour supply to the real wage.

The composite good $c_t$ is defined as a Cobb-Douglas aggregate,

$$c = \frac{c_H^{\nu} c_F^{1-\nu}}{\nu^{\nu} (1-\nu)^{1-\nu}}, \tag{2}$$

where $\nu$ is the weight that determines the agents' bias towards domestic goods. As in Benigno and De Paoli (2010), $\nu$ is a function of the relative size of the domestic economy with respect to the rest of the world $n$ and of the degree of openness $\lambda$,

$$1 - \nu = (1 - n)\lambda. \tag{3}$$

The more open the country (the greater is $\lambda$), the lower is the degree of home bias. The larger the country (the greater is $n$), the higher is the degree of home bias.

Given a decision on the composite consumption good $c$, the home households allocate optimally the expenditure on domestic and foreign goods, by minimising the natural definition of the total expenditure $Pc = P_H c_H + P_F c_F$, subject to (2). This leads to the following demand functions,

$$c_H = \nu \left(\frac{P_H}{P}\right)^{-1} c, \quad c_F = (1 - \nu) \left(\frac{P_F}{P}\right)^{-1} c, \tag{4}$$

where $P_H$ and $P_F$ are, respectively, the prices of home- and foreign-produced goods faced by consumers in country $H$. Replacing $c_H$ and $c_F$ in (2), we obtain the following price index for the composite consumption good in country $H$,

$$P = P_H^{\nu} P_F^{1-\nu}. \tag{5}$$

The home households choose consumption, labour and bonds to maximise utility (1) subject to the budget constraint given by

$$P_t c_t + E_t\{Q_{t,t+1} D_{t,t+1}\} + B_t + P_t T_t \leq (1 - \tau_t) W_t l_t + R_{t-1} B_{t-1} + D_t, \tag{6}$$

where $B_t$ are holdings of home government bonds, which cost one home currency unit today and pay $R_t$ currency units tomorrow, $R_t$ being the nominal interest rate, set exogenously by the union monetary authority. Further, $D_{t,t+1}$ are holdings of state-contingent bonds, traded with the foreign households, which cost $Q_{t,t+1}$ units of the home currency today and pay one unit of home currency in a particular state tomorrow, $W_t l_t$ is nominal labour income, which is taxed at rate $\tau_t$, and $T_t$ are lump-sum taxes expressed in consumption units. We rule out Ponzi games by assuming $\lim_{T \to \infty} Q_{0,T} \left[B_T + E_t\{Q_{T,T+1} D_{T,T+1}\}\right] \geq 0$.

The first order conditions of the households' problem with respect to labour, government bonds and state-contingent bonds, are:

$$(1-\tau_t)\, w_t = c_t l_t^{\eta}, \tag{7}$$

$$1 = \beta R_t E_t \left( \frac{c_t/c_{t+1}}{\pi_{t+1}} \right), \tag{8}$$

$$Q_{t,t+1} = \beta \frac{c_t/c_{t+1}}{\pi_{t+1}}, \tag{9}$$

where $w_t = W_t/P_t$ is the real wage and $\pi_t = P_t/P_{t-1}$ is gross inflation. Combining the households' first order conditions for government bonds and state-contingent bonds, (8) and (9), we obtain $E_t\{Q_{t,t+1}\} = \frac{1}{R_t}$.

## 2.2 Firms

Production is linear in labour, which in turn is immobile across countries, such that

$$y_{H,t} = A_t l_t. \tag{10}$$

Firms choose labour to maximise profits $y_{H,t} p_{H,t} - (1-\varkappa) w_t l_t$, where $\varkappa$ is a constant employment subsidy financed with lump sum taxes. Using the production function (10), the firms' demand for labour is such that after-tax wages are equal to the marginal product of labour, adjusted for the relative price of home-produced goods,

$$(1-\varkappa) w_t = A_t p_{H,t}. \tag{11}$$

Alternatively, combining the production function (10) with labour demand (11), we can state that the wage bill, including the employment subsidy, equals revenues,

$$(1-\varkappa) w_t l_t = y_{H,t} p_{H,t}. \tag{12}$$

For simplicity, we reduce the model by eliminating the real wage $w_t$ and labour $l_t$. Combining the households' labour supply (7) with the firms' labour demand (11) and the production function (10) yields

$$\frac{1-\tau_t}{1-\varkappa} A_t p_{H,t} = c_t (\frac{y_{H,t}}{A_t})^{\eta}, \tag{13}$$

which describes the optimality condition for production.

## 2.3 Prices

We define the real exchange rate in the monetary union as $S_t = P_t^*/P_t$, where $P_t^*$ is the price index for the composite consumption good in country $F$. Since demand elasticities are equal across regions, the firms set the same price in $H$ and in $F$ in producer currency, i.e. the law of one price holds. In a monetary union, the producer currency and the local currency are the same, such that $P_{H,t} = P_{H,t}^*$ or

$$p_{H,t}^* = \frac{p_{H,t}}{S_t}, \tag{14}$$

where we have defined the relative prices $p_{H,t} = P_t^H/P_t$ and $p_{H,t}^* = P_t^{H*}/P_t^*$.

Combining the home households' first order condition for state-contingent bonds with its foreign equivalent yields the following risk-sharing condition, $\frac{c_t P_t}{c_{t+1} P_{t+1}} = \frac{c_t^* P_t^*}{c_{t+1}^* P_{t+1}^*}$, whereby the growth of the marginal utility of nominal consumption will be equalised across countries. Defining $\kappa = \frac{c_0^* P_0^*}{c_0 P_0}$ as in Chari et al (2002), the risk sharing condition can be written as

$$S_t = \kappa \frac{c_t}{c_t^*}. \tag{15}$$

Starting from an initial steady state in which consumption and price levels are equal across countries, i.e. $\kappa = 1$, this implies that the consumption ratio at any point in time is equal to the real exchange rate.

## 2.4 Government

The fiscal authority has to finance an exogenous stream of public expenditure $g_t$, using labour income taxes $\tau_t$ and issuing nominal government bonds $B_t^g$. Lump sum taxes $T_t$ are available only at the steady state and cannot be varied over the business cycle. The domestic government budget constraint, in terms of the home composite consumption good, is as follows,

$$g_t + \frac{R_{t-1} b^g_{t-1}}{\pi_t} = (\tau_t - \varkappa) w_t l_t + b^g_t + T_t, \tag{16}$$

where $b^g_t = B^g_t / P_t$ are government bonds in real terms. We assume that the government's preferences towards consumption goods are the same as those of the households. Hence, given total government spending $g_t$, public consumption of each individual good is given by identical expressions to those obtained for private consumption in (4).

Following Leith and Wren-Lewis (2013), we set a constant employment subsidy, financed by lump-sum taxes, that makes the steady state efficient. This implies that lump sum taxes are pinned down by the relation $T_t = \varkappa w_t l_t$. Inserting this relation into the government budget constraint (16) to replace lump sum taxes and eliminating the wage bill using (12), we have

$$g_t + \frac{R_{t-1} b^g_{t-1}}{\pi_t} = \frac{\tau_t}{1-\varkappa} y_{H,t} p_{H,t} + b^g_t. \tag{17}$$

## 2.5 Market Clearing

There is a mass $n$ of households in country $H$ and a mass $(1-n)$ of households in country $F$. The market clearing condition for the good produced in $H$ is obtained by combining private and public demands at home and abroad, weighted by the respective country size,

$$\begin{aligned} y_{H,t} &= (c_{H,t} + g_{H,t}) + \frac{1-n}{n}\left(c^*_{H,t} + g^*_{H,t}\right) \\ &= \nu p^{-1}_{H,t}\left(c_t + g_t\right) + \frac{1-n}{n}\nu^*\left(p^*_{H,t}\right)^{-1}\left(c^*_t + g^*_t\right), \end{aligned}$$

where we have substituted $c_{H,t}$ and $c^*_{H,t}$ using (4) and $g_{H,t}$ and $g^*_{H,t}$ using the analogous demand functions from the government sector. Setting $p^*_{H,t} = \frac{p_{H,t}}{S_t}$ from the pricing condition (14), and replacing the home bias parameters $\nu$ and $\nu^*$, this becomes:

$$p_{H,t} y_{H,t} = [1 - (1-n)\lambda]\left(c_t + g_t\right) + (1-n)\,\lambda^* S_t \left(c^*_t + g^*_t\right). \tag{18}$$

Asset market clearing requires

$$n D_t + (1-n) D^*_t = 0, \quad B^g_t = B_t. \tag{19}$$

Combining the households' and government budget constraints yields the aggregate resource constraint,

$$n\left(c_t+g_t\right)+(1-n)\,S_t\left(c_t^*+g_t^*\right)=nw_tl_t+(1-n)\,S_tw_t^*l_t^*. \tag{20}$$

## 2.6 Monetary Policy

Monetary policy is described by the following interest rate rule,

$$\frac{R_t}{R}=\left(\frac{\pi_t^U}{\pi^U}\right)^{\alpha}, \tag{21}$$

where $\pi_t^U=\pi_t^n\left(\pi_t^*\right)^{1-n}$ is union-wide inflation and $\alpha>1$. As shown by Ferrero (2009), strict inflation targeting is optimal in a currency union where monetary and fiscal policies are coordinated.

## 2.7 Small Open Economy

The small open economy case is derived by letting the home country size $n$ go to zero, such that $1-\nu=\lambda$ and $\nu^*=0$. The price levels in countries $H$ and $F$, equation (5) and its foreign counterpart, reduce to

$$p_{H,t}^{1-\lambda}p_{F,t}^{\lambda}=1, \qquad p_{F,t}^*=1. \tag{22}$$

The price level in country $H$ depends on prices of domestically produced goods and the price of imports, where the weights depend only on the country's openness $\lambda$. Combining the price levels (22) with the law of one price for foreign goods (42), we find

$$p_{H,t}^{1-\lambda}S_t^{\lambda}=1. \tag{23}$$

Usually, a country's terms of trade is defined as the price of exports divided by the price of imports (both expressed in domestic currency). Here, we follow the convention in the open economy literature of defining the terms of trade as the price of domestic goods $p_{H,t}$ over the price of imports $p_{F,t}$, both expressed in terms of the home consumption basket, i.e.

$$ToT_t = \frac{p_{H,t}}{S_t p^*_{F,t}} = \frac{p_{H,t}}{S_t}.$$

In the demand functions for home and foreign goods, setting $1 - \nu = \lambda$ and $\nu^* = 0$ and substituting out the foreign prices $p^*_{H,t}$ and $p^*_{F,t}$ using (14) and $p^*_{F,t} = p_{F,t}/S_t$, respectively, gives

$$p_{H,t} y_{H,t} = (1 - \lambda)(c_t + g_t) + \lambda S_t (c^*_t + g^*_t), \tag{24}$$

$$y^*_{F,t} = c^*_t + g^*_t. \tag{25}$$

Government spending and log productivity $a_t = \ln A_t$ follow autoregressive processes,

$$g_t = \left(1 - \rho_g\right) g + \rho_g g_{t-1} + \varepsilon_{g,t}, \tag{26}$$

$$a_t = (1 - \rho_a)\, a + \rho_a a_{t-1} + \varepsilon_{a,t}. \tag{27}$$

We abstract from foreign shocks, which in the small open economy model implies that foreign variables are constant. Moreover, the nominal interest rate, determined through the foreign Euler equation, is constant at $R = \frac{1}{\beta}$. The resulting system of equilibrium conditions is summarised in Table 1.

[ insert Table 1 here ]

The steady state is defined as an equilibrium in which the exogenous variables $A_t$ and $g_t$ are constant. In particular, we set $A = 1$ and $\frac{g}{y_H} = \Gamma$. We consider a symmetric zero-inflation steady state where $S = \pi = 1$. Symmetry between the countries is characterised by $c = c^*$, $g = g^*$, $y_H = y^*_F$ and initial holdings of state-contingent assets are zero, $d_0 = D_0/P_0 = 0$.[1] Under these considerations, the production choice (13), the government budget constraint (17) and the market clearing condition (24) at the steady state can be used to derive a recursive system of three equations in $c$, $y_H$, $\tau$, given calibrated values for $\beta$, $\eta$, $\varkappa$, $\Gamma$ and

[1] See the online appendix for details.

$\bar{b} = Rb^g/y_H$,

$$\tau = \frac{\Gamma + (1-\beta)\,\bar{b}}{1 + \Gamma + (1-\beta)\,\bar{b}}, \tag{28}$$

$$y_H = \left(\frac{1}{1-\Gamma}\right)^{\frac{1}{1+\eta}}, \tag{29}$$

$$c = y_H^{-\eta}. \tag{30}$$

Given that the labour tax is the only steady state distortion in this model, it is clear that an employment subsidy equal to the tax rate on labour income, $\varkappa = \tau$, makes the steady state efficient.

# 3 Optimal Fiscal Policy in the Small Open Economy

In the following, we derive optimal fiscal policies in the small open economy under two scenarios. First, we consider the monetary union case as outlined above. This implies that the real depreciation rate is a constraint for the policy maker, tying the domestic inflation rate inversely to the change in the real exchange rate. Second, we contrast this with the case of a standalone country that is not part of a monetary union. The nominal exchange rate is flexible and monetary policy can be set freely to pin down the real depreciation rate, $S_t/S_{t-1}$. In both cases we characterise optimal allocations as in Ramsey (1927), which are welfare-maximising allocations derived subject to the constraints given by the equilibrium conditions. We then calibrate the model and analyse the dynamics arising in response to government spending and productivity shocks. This is done by linearising the first order conditions of the Ramsey planner around the deterministic steady state. Finally, we study the optimal tax variability in the two models for different parameter constellations.

## 3.1 Monetary Union Case: Exogenous Monetary Policy

The small open economy model of the previous section is reduced further for the policy problem. In particular, we substitute out the prices $\pi_t$, $S_t$ and $p_{H,t}$, as well as the policy instrument $\tau_t$. We eliminate the tax rate $\tau_t$ by combining the optimal production choice (13) with the government budget constraint. We also eliminate the domestic inflation rate in the government budget constraint using the real exchange rate identity under constant foreign inflation, $\pi_t = S_{t-1}/S_t$. Then, we use the risk sharing condition to replace $S_t$ in the government budget constraint and in the market clearing condition with $c_t/c^*$. Finally, we eliminate the real price of home goods $p_{H,t}$ using the price index, i.e. $p_{H,t} = (\frac{c_t}{c^*})^{\lambda/(\lambda-1)}$.

Under these considerations, the Ramsey problem becomes

$$\max_{\{c_t, y_{H,t}, b_t^g\}_{t=0}^{\infty}} E_0 \sum_{t=0}^{\infty} \beta^t \left[ \ln c_t - \frac{1}{1+\eta} (\frac{y_{H,t}}{A_t})^{1+\eta} \right]$$

subject to the government budget constraint and the market clearing condition,

$$g_t + \frac{b_{t-1}^g c_t}{\beta c_{t-1}} = \frac{1}{1-\varkappa} (\frac{c_t}{c^*})^{\frac{\lambda}{\lambda-1}} y_{H,t} - c_t (\frac{y_{H,t}}{A_t})^{1+\eta} + b_t^g, \tag{31}$$

$$(\frac{c_t}{c^*})^{\frac{\lambda}{\lambda-1}} y_{H,t} = (1-\lambda)(c_t + g_t) + \lambda c_t \frac{y_F^*}{c^*}, \tag{32}$$

for all $t$, and $b_{-1}^g$, $c_{-1}$ given. Denote by $\mu_{1t}$ and $\mu_{2t}$ the Lagrange multipliers on the constraints (31) and (32), respectively. The Lagrangian problem is

$$\begin{aligned} \max_{\{c_t, y_{H,t}, b_t^g\}_{t=0}^{\infty}} \min_{\{\mu_{at}, \mu_{bt}\}_{t=0}^{\infty}} \mathcal{L} \;=\; & E_0 \sum_{t=0}^{\infty} \beta^t \Bigg\{ \ln c_t - \frac{1}{1+\eta} (\frac{y_{H,t}}{A_t})^{1+\eta} \\ & + \mu_{at} \left[ g_t + \frac{b_{t-1}^g c_t}{\beta c_{t-1}} - \frac{1}{1-\varkappa} (\frac{c_t}{c^*})^{\frac{\lambda}{\lambda-1}} y_{H,t} + c_t (\frac{y_{H,t}}{A_t})^{1+\eta} - b_t^g \right] \\ & + \mu_{bt} \left[ (\frac{c_t}{c^*})^{\frac{\lambda}{\lambda-1}} y_{H,t} - (1-\lambda)(c_t + g_t) - \lambda c_t \frac{y_F^*}{c^*} \right] \Bigg\}. \end{aligned}$$

After some algebra, we obtain the following first order conditions of the Ramsey problem,

$$1 - \mu_{at} g_t + (1-\lambda) \mu_{bt} g_t = \left( \frac{\mu_{at}}{1-\varkappa} - \mu_{bt} \right) \frac{1}{\lambda - 1} (\frac{c_t}{c^*})^{\frac{\lambda}{\lambda-1}} y_{H,t}, \tag{33}$$

$$[\mu_{at}(1+\eta) c_t - 1] (\frac{y_{H,t}}{A_t})^{1+\eta} = \left( \frac{\mu_{at}}{1-\varkappa} - \mu_{bt} \right) (\frac{c_t}{c^*})^{\frac{\lambda}{\lambda-1}} y_{H,t}, \tag{34}$$

$$\mu_{at} c_t = E_t \left\{ \mu_{at+1} c_{t+1} \right\}. \tag{35}$$

## 3.2 Standalone Country Case: Endogenous Monetary Policy

If the small open economy is not part of a monetary union, the real depreciation rate is no longer pinned down by real allocations and therefore is not a constraint for the Ramsey planner. Instead, by controlling monetary policy, the policy maker can choose the inflation rate to "complete the markets" and make the government debt state-contingent. This is because inflation is costless: there is no price rigidity either in the form of price stickiness, price adjustment costs, or a fixed nominal exchange rate.

Benigno and De Paoli (2010) show that the small open economy model with nominal debt and costless inflation is equivalent to a model in which the government is able to trade state-contingent assets. Debt dynamics play no role and we can abstract from inflation and monetary policy. The equations summarising the allocation are given in Table 2.

[ insert Table 2 here ]

In the following, we parameterise the model and show the optimal impulse responses to productivity shocks and to government spending shocks. We compare the optimal dynamics of a monetary union country to those in a standalone country.

## 3.3 Parameterisation

Having found the first order conditions of the Ramsey problem, we linearise them around the deterministic steady state and consider persistent shocks to government spending and productivity. In choosing the parameter values, we largely follow Benigno and De Paoli (2010). The parameterisation is given in Table 3.

[ insert Table 3 here ]

The discount factor $\beta$ has the value 0.99, which is conventional for a quarterly frequency as it implies a steady state interest rate of $4\,(1/\beta - 1) = 0.04$ or 4% per annum. The constant of relative risk aversion $\sigma$ is set to 1 corresponding to logarithmic consumption utility. The elasticity of marginal (dis-)utility of labour $\eta$ is set to 0.47. The elasticity of substitution between home- and foreign-produced composite goods is set to unity, differently from Benigno and De Paoli (2010). We thus assume that $H$ and $F$ goods bundles are independent in the agents' utility. The degree of openness $\lambda$ is calibrated at 0.24, such that the import share in GDP is 24%. The government is assumed to consume one fifth of domestic output in steady state, i.e. $\Gamma = 0.2$, which corresponds roughly to the average government spending share in the US. The standard deviation and persistence of the productivity shocks are consistent with Gali and Monacelli (2005), while the shock process for government spending is calibrated as in Lubik and Schorfheide (2005).

The Ramsey steady state under this parameterisation is as follows. Inflation and relative prices are all equal to unity, $\pi = p_H = S = ToT = 1$. Production is $y_H = 1.16$, while four fifths of production goes to private consumption, such that $c = 0.93$. To finance a government debt ratio roughly equal to 60% of GDP, $\bar{b} = 0.6$, the optimal steady state labour tax rate is around 0.17. By itself, this labour taxes would distort production; therefore, employment should be subsidised at a rate of 17 percent.

### 3.4 Optimal Dynamics

Recall that the incentives of the fiscal authorities in our small monetary union country are twofold. First, it wants to smooth tax distortions over time, which suggests that tax variability should be low. Second, taxes can be used to generate inflation. When government debt is high in nominal terms, inflation reduces its real value and is therefore desirable.

As emphasised in Benigno and De Paoli (2010), there may be a third incentive due to the so-called terms of trade externality. Whenever home and foreign goods are substitutes or complements in utility, there is an incentive to manipulate the terms of trade using fiscal policy, such that home consumption can be raised without a corresponding increase in production. We eliminate this channel by studying the knife-edge case where home and foreign goods are independent in utility, which requires that the trade elasticity, i.e. the elasticity of substitution between the home and foreign composite good, is unity.

Figures 1 and 2 exhibit impulse response functions to a government spending shock and a productivity shock, respectively. We analyse "bad" shocks, that is, an increase in government spending and a reduction of productivity. The dynamic responses under the optimal plan have the same sign in both models, but there is a difference in magnitude, which we explain further below. Notice that the assumption of log consumption utility, coupled with complete risk sharing across countries, implies that the dynamics of consumption and the real exchange rate $S_t$ are identical.

[ insert Figure 1 here ]

Consider a persistent increase in *government spending* in a small monetary union country with only nominal non-state-contingent public debt. We observe a rise in domestic production to satisfy the increased demand, while private consumption is crowded out. The increase in government outlays is financed partly through higher taxes and partly through an increase in government debt. Due to home bias in government consumption, the terms of trade improve, i.e. the relative price of domestically produced goods increases. The real exchange rate (or the relative price of consumption) appreciates; home consumption becomes more expensive relative to foreign consumption.

Turning to the responses in the model with state-contingent debt (i.e. the standalone economy with endogenous monetary policy), we note that consumption, the real exchange rate and the terms of trade respond less strongly to the shock, while home output responds more strongly to the shock. The existence of complete markets allows the government to finance the rise in spending with state-contingent bonds, without the need to raise taxes.

[ insert Figure 2 here ]

Figure 2 displays the optimal dynamics following a negative *productivity* shock. Inflation rises on impact, while production in the home country falls. Consumption falls, too, and the real exchange rate appreciates accordingly. Domestically produced goods become dearer (the terms of trade improve). The fall in production is greater than the rise in the terms of trade, such that home revenues decline. In the monetary union model, government debt $b_t^g$ drops initially, while government spending has not changed. Thus, to maintain government revenues given a lower tax base, the optimal tax rate rises.

In the model with state-contingent public debt, the impulse responses of the real variables are very similar to the monetary union model with nominal non-state-contingent debt, which suggests that - with the help of the tax instrument and domestic inflation - the optimal Ramsey policy can almost complete the markets in response to productivity shocks.

### 3.5 Optimal Tax and Inflation Variability

The impulse response analysis of the previous section suggested that some variability in labour taxes is optimal in a small country that is part of a monetary union. In the following, we present the results of a simple simulation exercise.[2] Table 5 presents the optimal standard deviation of the tax rate (in absolute terms and relative to the standard deviation of output), in the benchmark model of a monetary union country with nominal debt.

How does the optimal variability depend on parameter values? To answer this question, we analyse variations in the degree of openness $\lambda$, the steady state share of government spending $\Gamma$, and the steady state debt ratio $\bar{b}$.

[ insert Table 5 here ]

In a monetary union country whose government holds only nominal debt, taxes exhibit considerable volatility, both in absolute and in relative terms. For all parameter perturbations considered, the taxes are more variable than output. This is a result of the nominal rigidity that the monetary union membership imposes. With an independent monetary policy, there would be no need to influence domestic inflation via tax policies, because this could be done directly by adjusting the money supply. Then, taxes could be held constant as in Chari et al (1991); it would be optimal to smooth taxes completely, so as to minimise the associated production distortion. Consider first the benchmark parameterization. The optimal variance of the tax rate is around 10, while the variance of inflation is lower at 7 in absolute terms. The tax rate is one and a half times as volatile as output; inflation is slightly more volatile than output.

Optimal tax and inflation volatility are decreasing in the degree of openness and therefore

[2] Notice that in our model simulations we consider only domestic shocks to productivity and to government spending. Therefore, the absolute volatilites reported here should not be compared with Benigno and de Paoli (2010), who also include shocks to foreign consumption.

increasing in the consumption home bias parameter, $\nu$.[3] As the degree of openness increases, the government loses freedom to affect inflation, so it prefers to keep taxes as smooth as possible (with $\lambda = 1$ inflation is completely determined abroad, so optimal inflation volatility actually approaches 0). On the contrary, for small $\lambda$, the government raises taxes in bad times to induce inflation and hence reduce the burden of nominal debt.

When we increase the steady state share of government spending $\Gamma$, the standard deviation of taxes falls both in absolute terms and relative to output. This can be attributed to the rise in the steady state tax rate that is needed to finance the additional government spending. Given a higher tax rate, any change in taxes induces more inflation volatility, so there is less need to change taxes so much.

The variability of taxes is not very sensitive to the steady state debt ratio $\bar{b}$. As the required steady state tax rate rises, the optimal tax volatility falls slightly. Inflation volatility hardly changes in response to perturbations in the steady state debt ratio and stays roughly the same as the variability of output. This is also true for negative values of $\bar{b}$, i.e. when the government holds nominal assets. In such circumstances, the government would like to have deflation, but it still needs to increase taxes to finance the negative shock (since this is the only instrument available) and this induces inflation. This finding suggests a role for choosing a different composition of the public debt/assets portfolio, which is however beyond the scope of the present paper.[4]

# 4 The Role of Country Size

We now explore the role of country size for optimal fiscal policy in the monetary union country with nominal non-state-contingent debt. To this end, we analyse the two-country model with a given monetary policy rule reacting to union-wide inflation as in (21), and increase the relative size of the home country from our benchmark parameterization $n = 0$, the small open economy case, to $n = 1$, the closed economy case. We also allow for different

[3] Recall from (3) that the degree of home bias is inversely related to openness.

[4] We conjecture that it would be optimal for the government to issue nominal debt and hold inflation-linked assets, similar to Angeletos (2002) and Buera and Nicolini (2004), who derive the optimal maturity structure in a closed economy. When the government issues long-term debt and holds short-term assets, negative shocks induce a higher interest rate and hence decrease the market value of long-term debt.

monetary policy rules by changing the parameter $\alpha$. As before, we report the volatility of the labour tax $\tau_t$ and of inflation $\pi_t$ in the Ramsey allocation, both in absolute value and relative to output volatility. The results are shown at the bottom of Table 5.

As explained above, the optimal steady state tax rate is not affected by country size and remains at 17%. Optimal tax volatility increases from 1.5 times that of output in the small open economy to around 1.7 times that of output in the closed economy. At the same time, relative inflation volatility in the Ramsey economy falls from above 1 in the small open economy ($n = 0$) to around one fourth in the closed economy ($n = 1$). This result makes intuitive sense: In the open economy, the absence of the exchange rate as an adjustment mechanism implies, as argued above, that tax changes can affect domestic inflation and thus the value of government debt through international relative prices. The nominal rigidity implied by the currency union leads to optimal tax volatility being higher than in a standalone country, which can engineer surprise inflation through an independent monetary policy. This beneficial effect of the currency union becomes weaker as the home country size $n$ increases, and disappears completely in the closed economy. When $n$ goes to zero, monetary policy from the union perspective does not take into account the small open economy problem but when $n$ is different from zero, then monetary policy at the union level adjusts the interest rate in response to union-wide inflation, $\pi_t^U$. The result is a fall in optimal inflation volatility as the country size increases. As inflation cannot be used as easily in a larger country, government spending shocks generate larger responses in the tax rate, and thus tax volatility is larger for larger values of $n$.

However, this crucially depends on the monetary policy rule, when $n > 0$. When the rule is not so sensitive to inflation (small $\alpha$), monetary policy induces a lot more inflation volatility, without a major impact on tax variability, which allows for more consumption smoothing and a higher welfare. This suggests that the optimal monetary policy would induce more inflation volatility, following Chari et al. (1991).

# 5 Conclusion

In this paper, we analyse optimal fiscal policy in a small open economy that is part of a monetary union. Government spending must be financed with distortionary taxes on labour income and nominal non-state-contingent debt. Lump sum taxes or state-contingent government bonds are unavailable. When setting tax rates, the government must trade off two effects. First, taxes distort the production-consumption decision of the households, leading to a misallocation of resources. Second, taxes affect domestic prices and thus inflation, because home bias makes consumption baskets differ across countries. Inflation is helpful to reduce the real value of public debt when a bad shock hits, i.e. when government spending is high or when productivity is low.

We show that tax variability is substantially higher in an economy that is part of a monetary union than in a standalone country that has control over its monetary policy. In the former case, more tax volatility is optimal to induce inflation in bad times. In the latter case, there is an alternative instrument to generate inflation (monetary policy), so the tax smoothing incentive is the dominant objective of fiscal policy.

The results of this paper suggest that exploring the optimal public debt composition between nominal and real non-state-contingent instruments deserves attention in future research. As noticed, this will also depend on the coordination between the monetary policy set at the union level and the fiscal policies conducted at each individual country.

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# Appendix: Equilibrium Conditions in Country F

In country $F$, the representative agent maximises

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[ \ln c_t^* - \frac{1}{1+\eta} (l_t^*)^{1+\eta} \right], \tag{36}$$

where the consumption bundle $c^*$ is defined as Cobb-Douglas aggregate,

$$c^* = \frac{(c_H^*)^{\nu^*} (c_F^*)^{1-\nu^*}}{(\nu^*)^{\nu^*} (1-\nu^*)^{1-\nu^*}}, \tag{37}$$

with $\nu^* = n\lambda$. We have the following demands in country $F$ for the home- and foreign-produced goods,

$$c_H^* = \nu^* \left( \frac{P_H^*}{P^*} \right)^{-1} c^*, \quad c_F^* = (1-\nu^*) \left( \frac{P_F^*}{P^*} \right)^{-1} c^*. \tag{38}$$

Using the demand functions (38), we replace $c_H^*$ and $c_F^*$ in the natural definition of the composite expenditure $P^* c^* = P_H^* c_H^* + P_F^* c_F^*$ to get the associated foreign price index

$$P^* = (P_H^*)^{\nu^*} (P_F^*)^{1-\nu^*}. \tag{39}$$

The foreign production function and labour demand are, respectively,

$$y_{F,t}^* = A_t^* l_t^*, \tag{40}$$

$$(1 - \varkappa^*) w_t^* = A_t^* p_{F,t}^*. \tag{41}$$

In a monetary union, the producer currency and the local currency are the same, such that the currency price of foreign goods is the same in the two countries, $P_{F,t}^* = P_{F,t}$, which can be written as

$$p_{F,t} = S_t p_{F,t}^*, \tag{42}$$

where we have defined the relative prices $p_{F,t} = P_t^F / P_t$ and $p_{F,t}^* = P_t^{F*} / P_t^*$.

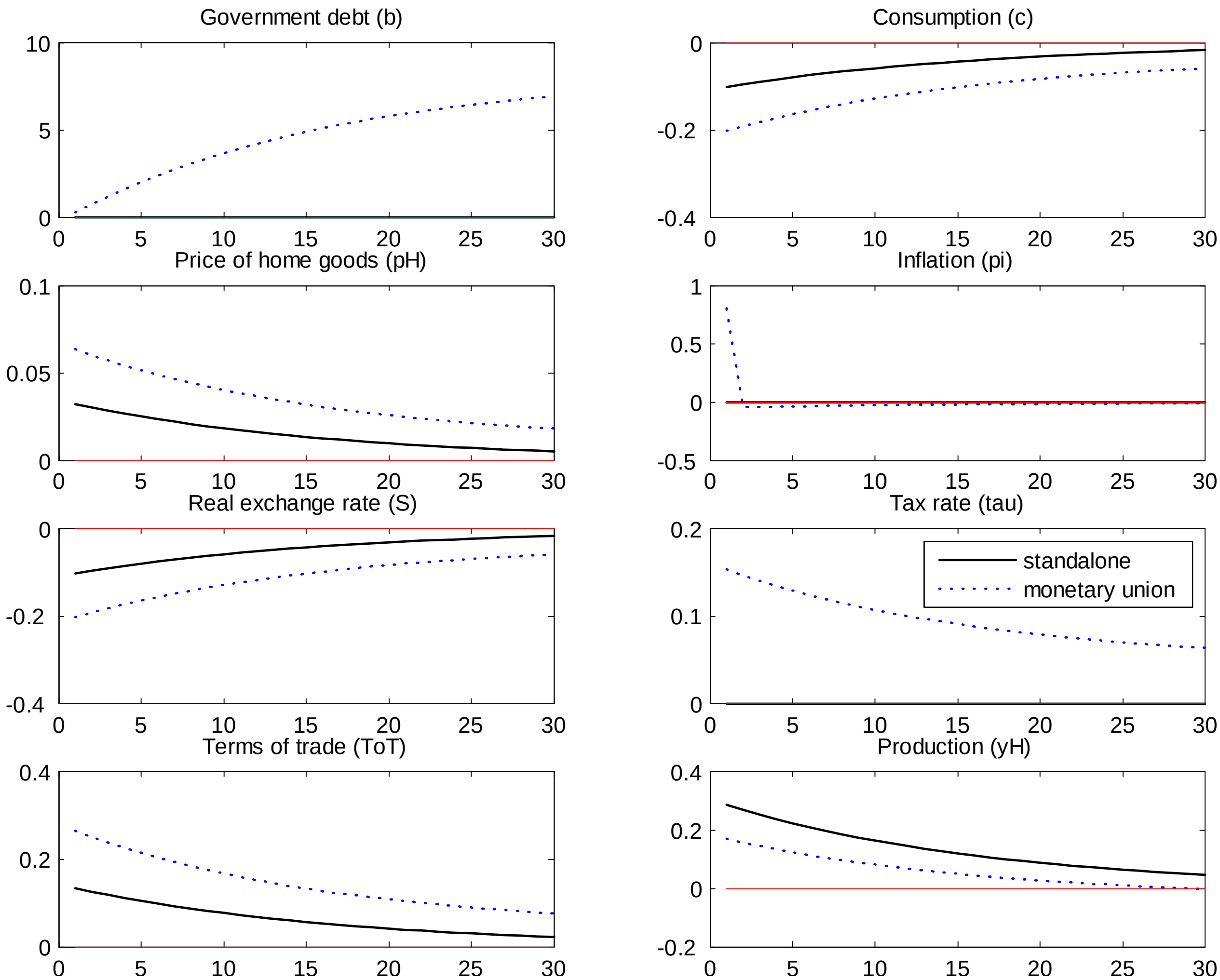
Demand functions for the differentiated foreign-produced goods, at home and abroad, are

$$\begin{aligned} y^*_{F,t} &= \frac{n}{1-n}\left(c_{F,t}+g_{F,t}\right)+\left(c^*_{F,t}+g^*_{F,t}\right) \\ &= \frac{n}{1-n}(1-\nu)p^{-1}_{F,t}\left(c_t+g_t\right)+\left(1-\nu^*\right)\left(p^*_{F,t}\right)^{-1}\left(c^*_t+g^*_t\right), \end{aligned}$$

where we have substituted the demand functions (38) and the corresponding demands from the foreign government. Setting $p_{F,t} = S_t p^*_{F,t}$ from the pricing condition (42), this becomes:

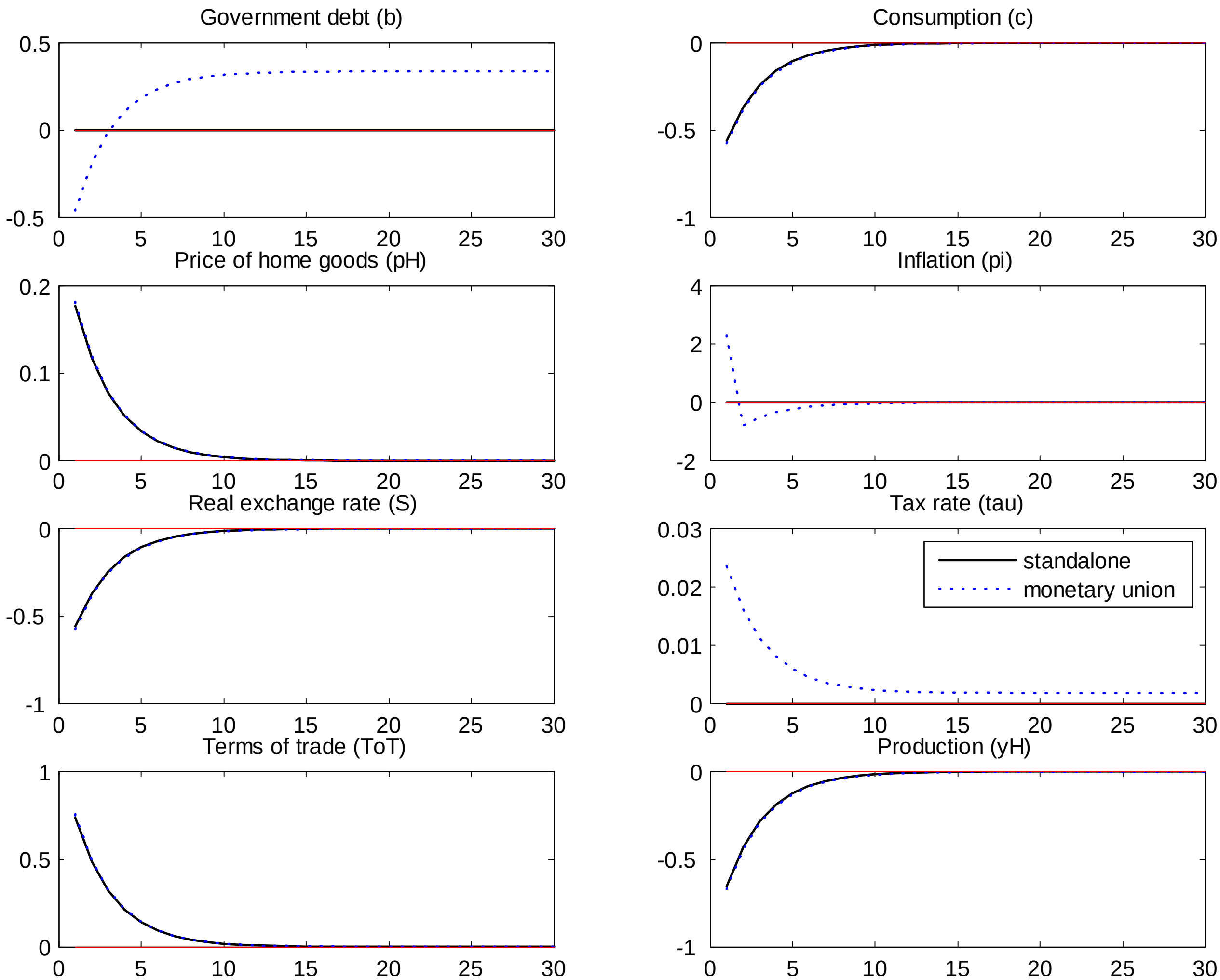
$$p^*_{F,t} y^*_{F,t} = n\lambda \frac{1}{S_t}\left(c_t+g_t\right)+\left(1-n\lambda^*\right)\left(c^*_t+g^*_t\right). \tag{43}$$

Figure 1: **Optimal Responses to a Government Spending Shock**




The figure shows the dynamic responses (multiplied by 100) to a positive one-standard deviation shock to *government spending* under the optimal policy in the small open economy. The dashed line corresponds to a monetary union country with nominal non-state-contingent government debt. The continuous line corresponds to a standalone country with state-contingent government debt.

Figure 2: **Optimal Responses to a Productivity Shock**




The figure shows the dynamic responses (multiplied by 100) to a negative one-standard deviation *productivity* shock under the optimal policy in the small open economy. The dashed line corresponds to a monetary union country with nominal non-state-contingent government debt. The continuous line corresponds to a standalone country with state-contingent government debt.

Table 1. Small Open Economy in a Monetary Union with Nominal Debt

| | |
|---|---|
| $\frac{S_t}{S_{t-1}} = \frac{1}{\pi_t}$ | Real exchange rate identity |
| $g_t + \frac{b^g_{t-1}}{\beta\pi_t} = \frac{\tau_t}{1-\varkappa} y_{H,t} p_{H,t} + b^g_t$ | Government budget constraint |
| $1 = p_{H,t}^{1-\lambda} S_t^{\lambda}$ | Price index |
| $c_t = c^* S_t$ | Risk sharing |
| $\frac{1-\tau_t}{1-\varkappa} A_t p_{H,t} = c_t (\frac{y_{H,t}}{A_t})^{\eta}$ | Production |
| $p_{H,t} y_{H,t} = (1-\lambda)(c_t + g_t) + \lambda S_t y_F^*$ | Market clearing |

Table 2. Small Open Economy with State-Contingent Debt

| | |
|---|---|
| $1 = p_{H,t}^{1-\lambda} S_t^{\lambda}$ | Price index |
| $c_t = c^* S_t$ | Risk sharing |
| $\frac{1-\tau_t}{1-\varkappa} A_t p_{H,t} = c_t (\frac{y_{H,t}}{A_t})^{\eta}$ | Production |
| $p_{H,t} y_{H,t} = (1-\lambda)(c_t + g_t) + \lambda S_t y_F^*$ | Market clearing |

Table 3. Two-country Monetary Union with Nominal Debt

| | |
|---|---|
| $1 = \beta R_t E_t \left\{ \frac{c_t}{c_{t+1}} \frac{1}{\pi_{t+1}} \right\}$ | Bond Euler equation |
| $\frac{S_t}{S_{t-1}} = \frac{\pi_t^*}{\pi_t}$ | Real exchange rate identity |
| $\frac{1-\tau_t}{1-\varkappa} A_t p_{H,t} = c_t (\frac{y_{H,t}}{A_t})^{\eta}$ | Production H |
| $\frac{1-\tau_t^*}{1-\varkappa^*} A_t^* p_{F,t}^* = c_t^* (\frac{y_{F,t}^*}{A_t^*})^{\eta}$ | Production F |
| $1 = p_{H,t}^{\nu} (S_t p_{F,t}^*)^{1-\nu}$ | Price index H |
| $1 = (p_{H,t}/S_t)^{\nu^*} p_{F,t}^{*(1-\nu^*)}$ | Price index F |
| $c_t = c^* S_t$ | Risk sharing |
| $p_{H,t} y_{H,t} = \nu(c_t + g_t) + (1-\nu) S_t (c_t^* + g_t^*)$ | Market clearing good H |
| $p_{H,t} y_{H,t} = (1-\lambda)(c_t + g_t) + \lambda S_t y_F^*$ | Market clearing good F |
| $\frac{R_t}{R} = \left(\frac{\pi_t^U}{\pi^U}\right)^{\alpha}$ | Monetary policy |
| $\pi_t^U = \pi_t^n (\pi_t^*)^{1-n}$ | Union-wide inflation |
| $g_t + \frac{b^g_{t-1}}{\beta\pi_t} = \frac{\tau_t}{1-\varkappa} y_{H,t} p_{H,t} + b^g_t$ | Government budget constraint |

Table 4. Benchmark Parameterization

| Parameter | Value | Name |
|---|---|---|
| Structural Parameters | | |
| $\beta$ | 0.99 | discount factor |
| $\eta$ | 0.47 | inverse Frisch elasticity of labour supply to the real wage |
| $\lambda$ | 0.24 | degree of openness |
| $\Gamma$ | 0.2 | steady state government spending share |
| $\bar{b}$ | $\frac{1}{\beta}(0.6)$ | steady state government debt ratio |
| Shock processes | | |
| $std(a_t)$ | 0.0071 | standard deviation of productivity shock |
| $std(g_t)$ | 0.0062 | standard deviation of government spending shock |
| $\rho_a$ | 0.66 | persistence of productivity shock |
| $\rho_g$ | 0.94 | persistence of government spending shock |

Table 5. Volatilities under the Ramsey Policy

| | | Tax Rate | | | Inflation | |
|---|---|---|---|---|---|---|
| | | $\tau$ (%) | $var(\widehat{\tau}_t)$ | $\frac{var(\widehat{\tau}_t)}{var(\widehat{y}_{H,t})}$ | $var(\pi_t)$ | $\frac{var(\pi_t)}{var(\widehat{y}_{H,t})}$ |
| Openness | $\lambda = 0$ | 17 | 17.16 | 1.70 | 12.06 | 1.19 |
| | $\boldsymbol{\lambda = 0.24}$ | **17** | **9.95** | **1.51** | **7.04** | **1.07** |
| | $\lambda = 0.4$ | 17 | 6.52 | 1.41 | 4.39 | 0.95 |
| | $\lambda = 0.6$ | 17 | 3.48 | 1.26 | 1.94 | 0.70 |
| | $\lambda = 0.8$ | 17 | 1.80 | 1.01 | 0.48 | 0.27 |
| | $\lambda = 0.999$ | 17 | 1.74 | 0.85 | 0.00 | 0.00 |
| Govt spending | $\Gamma = 0$ | 0.6 | 23.14 | 1.95 | 6.41 | 0.54 |
| | $\boldsymbol{\Gamma = 0.2}$ | **17** | **9.95** | **1.51** | **7.04** | **1.07** |
| | $\Gamma = 0.3$ | 23 | 6.29 | 1.33 | 7.38 | 1.57 |
| | $\Gamma = 0.4$ | 29 | 3.88 | 1.17 | 7.69 | 2.32 |
| Debt ratio | $\overline{b} = \frac{1}{\beta}(-1)$ | 16 | 10.56 | 1.56 | 7.06 | 1.04 |
| | $\overline{b}=\frac{1}{\beta}(\mathbf{0.6})$ | **17** | **9.95** | **1.51** | **7.04** | **1.07** |
| | $\overline{b} = \frac{1}{\beta}(1)$ | 17 | 9.80 | 1.50 | 7.04 | 1.07 |
| | $\overline{b} = \frac{1}{\beta}(1.25)$ | 18 | 9.71 | 1.49 | 7.04 | 1.08 |
| Country size | $\mathbf{n = 0}; \alpha = 1.02$ | **17** | **9.95** | **1.51** | **7.04** | **1.07** |
| | $\mathbf{n = 0}; \alpha = 1.5$ | **17** | **9.95** | **1.51** | **7.04** | **1.07** |
| | $\mathbf{n = 0}; \alpha = 2$ | **17** | **9.95** | **1.51** | **7.04** | **1.07** |
| | $n = 0.5; \alpha = 1.02$ | 17 | 13.59 | 1.61 | 8.54 | 1.01 |
| | $n = 0.5; \alpha = 1.5$ | 17 | 13.58 | 1.60 | 3.27 | 0.39 |
| | $n = 0.5; \alpha = 2$ | 17 | 13.54 | 1.60 | 2.51 | 0.30 |
| | $n = 1; \alpha = 1.02$ | 17 | 17.61 | 1.70 | 16.92 | 1.64 |
| | $n = 1; \alpha = 1.5$ | 17 | 17.52 | 1.70 | 2.70 | 0.26 |
| | $n = 1; \alpha = 2$ | 17 | 17.43 | 1.70 | 1.05 | 0.10 |