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Seppo Orjasniemi

# **Optimal fiscal policy of a monetary union member**



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# Optimal Fiscal Policy of a Monetary Union Member

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## Abstract

In this essay we study the optimal noncoordinated fiscal policy in a monetary union, where a common and independent monetary authority commits to optimally set the union-wide nominal interest rate. The national governments in the monetary union implement independent fiscal policies by choosing the level of government expenditures. We show that under a non-coordinated optimal fiscal policy rule government spending should react counter cyclically to the local output gap and inflation, while the union-wide aggregate fluctuations are stabilized by the common monetary policy. We also show that the spillovers caused by asymmetric shocks depend on the relative size of the country subject to these shocks.

Keywords: monetary union, monetary policy, fiscal policy

JEL Classification: E52, E62, F41

## 1 Introduction

In this essay we show how national optimal discretionary fiscal policy can help to stabilize the economies of individual countries in a monetary union. In recent years a vast amount of research has been done on the optimal monetary and fiscal policy of a monetary union. However, there has been little analysis of the optimal fiscal policy of an individual country in a monetary union.

In the literature on optimal currency area initiated by Mundell (1961), it is well known that the members of a monetary union are vulnerable to asymmetric shocks. As shown in Galí and Monacelli (2005a), in a single

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small open economy local productivity shocks can be stabilized by using country specific optimal monetary policy. In a monetary union, common monetary policy is not able to eliminate the asymmetric shocks, and they must be stabilized with fiscal policy. Recent papers, e.g. Beetsma and Jensen (2005), Galí and Monacelli (2008) and Ferrero (2009), argue that coordinated fiscal policy is needed in the stabilization of inflation differentials inside a monetary union. In principle, this means that fiscal policy should be used in a countercyclical manner. While Galí and Monacelli (2005b) present a country-specific discretionary fiscal policy rule which maximizes the average welfare of the households in the monetary union, Gnocchi (2007) argues that coordinated discretionary fiscal policy is not an optimal tool for stabilization in a monetary union. The country-specific fiscal policy is studied for example by Kirsanova et al. (2007). By using simple and potentially implementable fiscal rules, they find that fiscal policy should react to national inflation and output gaps.

In this essay we derive the optimal fiscal policy rule for the independent fiscal authority of an individual monetary union country. The model builds on the recent works by Galí and Monacelli (2005a, 2008) who analyze the monetary unions formed by a continuum of countries. In our model the monetary union is formed by a number of countries whose fiscal policies remain independent. The dynamics of each economy are derived assuming that prices adjust slowly, monetary policy is conducted by a common central bank and national fiscal authorities maximize the utility of the local households using public spending. Monetary policy is assumed to keep union-wide output and inflation at their efficient levels.

We show that, under the optimal policy, government spending reacts counter cyclically to local output gap and inflation. When a member country of the monetary union faces a negative output gap, government spending exceeds its efficient level. Our simulations show that nonoptimal monetary policy strengthens the spillover effects caused by the country-specific productivity shocks. We also find that the home bias in households' consumption affects the dynamics of the output gap. Openness to international trade reduces the effects of local, country-specific shocks.

The rest of the paper is organized as follows. In section 2 we lay out the model. The equilibrium dynamics are derived in section 3. Section 4 analyzes the optimal discretionary fiscal policy. The numerical experiments are presented in section 5. Section 6 concludes.

## 2 Setup

### 2.1 Households of the monetary union

We construct a Dynamic General Equilibrium model with nominal rigidities and monopolistic competition. Our model is partly based on Galí and Monacelli (2005a, 2008). The monetary union ( $MU$ ) is formed by  $n \in [2, \infty)$  small open economies.<sup>1</sup> The monetary union economies are subject to idiosyncratic shocks on productivity and share the same preferences, technology and market structure.

Utility of the representative household in country  $i$  depends on consumption  $C^i$  and on labor hours  $L^i$ . To give a microfoundation for public spending  $G^i$ , it is also assumed to yield utility to households. In period  $t$ , a representative household maximizes the expected utility based on

$$E_0 \sum_{t=0}^{\infty} \beta^t \left\{ \log C_t^i + \kappa \log G_t^i - \frac{(L_t^i)^{1+\phi}}{1+\phi} \right\}, \quad (1)$$

where  $\phi > 0$ ,  $\kappa \in (0, 1)$ ,  $\beta \in (0, 1)$  is a discount factor and  $E_0$  denotes the mathematical expectation operator conditional on information available in period 0. The representative household consumes locally produced goods and goods imported from other  $MU$  countries. Private consumption in a  $MU$  country  $i$  is described by a composite index

$$C_t^i = \left( \frac{C_{i,t}^i}{1-\alpha} \right)^{1-\alpha} \prod_{j \in MU \setminus i} \left( \frac{C_{j,t}^i}{\alpha} \right)^{\frac{\alpha}{n-1}}, \quad i \in MU.$$

$C_{i,t}^i$  is an index of country  $i$ 's consumption of domestic goods and  $C_{j,t}^i$  an index of country  $i$ 's consumption of imported goods. The weight of domestic goods in the utility from private consumption of the households is  $(1-\alpha)$ .

In each economy, differentiated goods are produced by a continuum of monopolistically competitive firms. The consumption of goods produced in country  $i$  is given by

$$C_{i,t} = \left( \int_0^1 C_{i,t}(k)^{\frac{\epsilon-1}{\epsilon}} dk \right)^{\frac{\epsilon}{\epsilon-1}},$$

where  $\epsilon > 1$  denotes the elasticity of substitution between the differentiated goods produced in one country and  $k$  denotes the number of types of goods.

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<sup>1</sup>In contrast to Galí and Monacelli (2008), the monetary union does not consist of a continuum of countries.

The aggregate consumer price index in country  $i$  is given by

$$P_{c,t}^i = (P_{i,t})^{1-\alpha} \prod_{j \in MU \setminus i} (P_{j,t})^{\frac{\alpha}{n-1}}, \quad i, j \in MU.$$

The price index for goods produced in country  $i$  is given by

$$P_{i,t} = \left( \int_0^1 (P_{i,t}(k))^{1-\epsilon} dk \right)^{\frac{1}{1-\epsilon}}, \quad i, j \in MU.$$

The optimal allocation of expenditures of the representative household in country  $i$  is:

$$P_{i,t} C_{i,t}^i = (1 - \alpha) P_{c,t}^i C_t^i, \quad P_{i,t} C_{j,t}^i = \frac{\alpha}{n-1} P_{c,t}^i C_t^i, \quad (2)$$

where  $i, j \in MU$  and  $j \neq i$ . The demand for good  $k$  produced in country  $j$  by a household in country  $i$  is given by

$$C_{j,t}^i(k) = \left( \frac{P_{j,t}^j(k)}{P_{j,t}^j} \right)^{-\epsilon} C_{j,t}^i.$$

Using equations (2) we can write the consumption index of a household in country  $i$  as

$$P_{c,t}^i C_t^i = (1 - \alpha) P_{i,t} C_{i,t}^i + \frac{\alpha}{n-1} \sum_{j \in MU \setminus i} (P_{j,t} C_{j,t}^i),$$

where  $i, j \in \{MU\}, i \neq j$ . The union-wide indices are defined as geometric means, i.e.  $x_t^{MU} = \prod_{i \in MU} (x_t^i)^{1/n}$ .

In each period and in each country, households earn nominal labor income  $W$ . They also have access to a complete set of state contingent claims of securities traded internationally. The representative household in country  $i$  maximizes its utility (1) subject to the periodic budget constraint given by

$$P_{c,t}^i C_t^i + \frac{E_t\{B_{t+1}^i\}}{R_t} \leq B_t^i + W_t^i L_t^i - T_t^i.$$

$T_t^i$  denotes lump-sum taxes. The nominal payoff of the portfolio held at the end of period  $t$  is denoted by  $B_{t+1}^i$ .<sup>2</sup> The payoff is paid in period  $t+1$  and is

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<sup>2</sup>The portfolio includes also the shares of firms.

discounted by the gross nominal interest rate  $R_t$ . The optimality conditions of the utility maximization problem are given by:

$$(L_t^i)^\phi = \frac{W_t^i}{C_t^i P_{c,t}^i} \quad (3)$$

$$E_t \{C_{t+1}^i P_{c,t+1}^i\} = \beta R_t C_t^i P_{c,t}^i. \quad (4)$$

Equation (3) is the intratemporal optimality condition for labour hours. Equation (4) is a conventional Euler equation. These optimality conditions hold for each country. The Euler equation (4) of a household in country  $i$  can be written in logarithmic terms as

$$c_t^i = E_t \{c_{t+1}^i\} - (r_t - E_t \{\pi_{c,t+1}^i\} - \rho), \quad (5)$$

where  $\rho = -\log \beta$  and  $r_t$  is the logarithm of the gross nominal interest rate  $R_t$ .

## 2.2 Terms of trade and inflation

The bilateral terms of trade between countries  $i$  and  $j$  are defined as  $S_{j,t}^i = \frac{P_{j,t}}{P_{i,t}}$ , i.e. as the price of goods produced in country  $j$  in terms of price of goods produced in country  $i$ . The effective terms of trade of country  $i$  are defined as a geometric mean of bilateral terms of trade, i.e.

$$S_t^i = \prod_{j \in MU \setminus i} (S_{j,t}^i)^{\frac{1}{n-1}}.$$

Denoting the logarithms of variables by lower case letters, we may write the consumer price index in country  $i$  as

$$p_{c,t}^i = p_{i,t} + \alpha s_t^i.$$

Domestic producer price inflation in country  $i$  is defined as the rate of change in the price index of domestically produced goods,  $\pi_t^i = \Delta p_{i,t} = p_{i,t} - p_{i,t-1}$ . The consumer price inflation in country  $i$  can be written as

$$\pi_{c,t}^i = \pi_t^i + \alpha \Delta s_t^i. \quad (6)$$

Finally, the consumer price inflation in the monetary union is defined as the average of country-specific inflation levels, i.e.  $\pi_{c,t}^{MU} = \sum_{j \in MU} \frac{\pi_{c,t}^j}{n}$ .

### 2.3 International risk sharing

We assume complete markets for state-contingent securities across the economy. Under this assumption, an Euler equation analogous to equation (4) holds for the households in all countries. For country  $i$  we may write the equation (4) as

$$\beta \left( \frac{C_t^i}{C_{t+1}^i} \right) \left( \frac{P_{c,t}^i}{P_{c,t+1}^i} \right) = E_t \{ \Lambda_{t,t+1} \}. \quad (7)$$

After combining equations (4) and (7), we write the following condition between MU countries  $i$  and  $j$

$$C_t^i = \vartheta_j^i C_t^j \frac{P_{c,t}^j}{P_{c,t}^i} = \vartheta_j^i C_t^j (S_{j,t}^i)^{1 - \frac{n}{n-1}\alpha}, \forall t, \quad (8)$$

where  $i, j \in MU$  and  $\vartheta_j^i$  is a constant depending on the initial conditions. Using the union-wide aggregate consumption index,  $C_t^{MU} = \prod_{j \in MU} (C_t^j)^{\frac{1}{n}}$ , we can express the optimal risk-sharing condition as follows:

$$C_t^i = \vartheta_0 C_t^{MU} (S_t^i)^{\frac{n-1}{n}\alpha}, \quad \forall t. \quad (9)$$

As in Chari et al. (2002), we assume that  $\vartheta_0$  is unity. The above equation shows that the level of consumption in a  $MU$  country depends on the union-wide aggregate consumption and on country's effective terms of trade. When the number of countries in the  $MU$  increases, international spillovers of country-specific shocks become weaker and consumption level in each country becomes more dependent on the local producer price level.

### 2.4 Public sector

Fiscal policy is conducted independently in each country. As shown in equation (1), public spending yields utility to local households. Government of a country  $i$  buys locally produced goods only. Government expenditures are described by a CES bundle

$$G_t^i = \left( \int_0^1 G_i(k)^{\frac{\epsilon-1}{\epsilon}} dk \right)^{\frac{\epsilon}{\epsilon-1}},$$

where  $\epsilon$  is the price elasticity of demand faced by each monopolistic producer. With cost minimization, the demand for locally produced good  $k$  by the government is given by

$$G_t^i(k) = \left( \frac{P_{i,t}^i(k)}{P_{i,t}^i} \right)^{-\epsilon} G_t^i. \quad (10)$$



As in Galí and Monacelli (2005a), we assume that government pays an employment subsidy,  $\tau L_t^i$ , to the local firms.<sup>3</sup> Public spending and the employment subsidy are financed by lump sum taxes  $T_t^i$ . The nominal government budget constraint can be written in the form

$$T_t^i = \tau L_t^i + P_{i,t}^i G_t^i.$$

## 2.5 Firms

In each country there is a continuum of firms indexed on an interval  $[0, 1]$ . The firms are owned by local households. The demand for good  $k$  produced in country  $i$  by households of country  $j$  is given by

$$C_{i,t}^j(k) = \left( \frac{P_{i,t}^i(k)}{P_{i,t}^i} \right)^{-\epsilon} C_{i,t}^j,$$

and the demand by the local government is given in equation (10).

Each firm in country  $i$  produces a differentiated good with a linear technology

$$Y_t^i(k) = A_t^i L_t^i(k), \quad i, k \in [0, 1],$$

where the country-specific productivity level  $A_t^i$  follows an AR(1) process  $\ln(A_t^i) = \theta \ln(A_{t-1}^i) + e_t^i$  with  $\theta \in [0, 1]$ . The amount of goods produced by firm  $k$  in country  $i$  is given by

$$Y_t^i(k) = \left( \frac{P_t^i(k)}{P_{i,t}^i} \right)^{-\epsilon} Y_t^i,$$

where  $Y_t^i$  is the aggregate output of country  $i$  given by

$$Y_t^i = \left( \int_0^1 (Y_t^i(k))^{\frac{\epsilon-1}{\epsilon}} dk \right)^{\frac{\epsilon}{\epsilon-1}}.$$

Because the production technology is linear and the productivity level is common to all producers within a country, the real marginal cost, in terms of locally produced goods, in country  $i$  is given by

$$MC_t^i = \frac{(1 - \tau)W_t^i}{P_{i,t}^i A_t^i}, \tag{11}$$

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<sup>3</sup>The employment subsidy is paid to monopolistic producers to guarantee the efficient price level. See e.g. Galí and Monacelli (2008) for discussion.

where  $\tau$  is an employment subsidy. Labor is supplied by local households. With linear technology, the aggregate labor demand in country  $i$  is given simply by

$$L_t^i = \int_0^1 L_t^i(k) dk = \frac{Y_t^i Z_t^i}{A_t^i}, \quad (12)$$

where  $Z_t^i = \int_0^1 \frac{Y_t^i(k)}{Y_t^i} dk$ . In logarithmic terms, the first-order approximation of the aggregate labor demand in country  $i$  is thus given by  $l_t^i = y_t^i - a_t^i$ .

Price setting follows the rule by Calvo (1983). In each period in every country, a fraction  $0 < 1 - \xi < 1$  of firms are randomly and independently chosen and permitted to set their prices, while the prices of other firms remain unchanged. The optimal price set in period  $t$  is denoted by  $\check{P}_t^i$ . The consumer price index of goods produced in country  $i$  in period  $t$  is given by

$$P_t^i = \left( \xi (P_{t-1}^i)^{1-\epsilon} + (1-\xi)(\check{P}_t^i)^{1-\epsilon} \right)^{\frac{1}{1-\epsilon}}. \quad (13)$$

When permitted, a firm sets its price to maximize the present value of profits over the period when the chosen price is in effect. The optimal price for the monopolistic producer in period  $t$  is given by

$$\check{P}_t^i(k) = \frac{\epsilon}{\epsilon - 1} \frac{E_t \left\{ \sum_{j=0}^{\infty} (\beta\xi)^j Y_{t+j}^i(k) P_{t+j}^i m c_{t+j}^i(k) \right\}}{E_t \left\{ \sum_{j=0}^{\infty} (\beta\xi)^j Y_{t+j}^i(k) \right\}}. \quad (14)$$

Using log-linear approximations of equations (13) and (14), we can solve for domestic producer price inflation:

$$\pi_t^i = \beta E_t \{ \pi_{t+1}^i \} + \frac{(1-\xi)(1-\beta\xi)}{\xi} \widehat{m c}_t^i, \quad (15)$$

where variables denoted with hat are the percentage deviations from the steady state value, i.e.  $\hat{x}_t = x_t - x$ .

## 3 Equilibrium dynamics

### 3.1 The flexible price allocation

In equilibrium, the national labor markets, and the international and national goods markets clear. The market clearing condition for goods originating

from country  $i$  is

$$\begin{aligned}
Y_t^i &= C_{i,t}^i + \sum_{j \in MU \setminus i} (C_{i,t}^j) + G_t^i \\
&= (1 - \alpha) \left( \frac{P_{c,t}^i}{P_{i,t}} \right) C_t^i + \frac{\alpha}{n-1} \sum_{j \in MU \setminus i} \left( \frac{P_{c,t}^j}{P_{i,t}} \right) C_t^j + G_t^i \\
&= C_t^i (S_t^i)^\alpha + G_t^i, \quad i, j \in MU,
\end{aligned} \tag{16}$$

where the second equation is derived by using equations (2) and (8). The market clearing condition for the whole economy is

$$Y_t^{MU} = C_t^{MU} + G_t^{MU}.$$

The optimal allocation from the viewpoint of the individual monetary union country is a solution to a social planner's problem of maximizing the utility of the representative household, taking the rest of the world consumption as given. The social planner's problem is to maximize

$$V_t^i = \log C_t^i + \kappa \log G_t^i - \frac{(L_t^i)^{1+\phi}}{1+\phi} \tag{17}$$

subject to market clearing constraints (16), technological constraints (12) and risk sharing conditions (9). Using equations (16) and (9), the consumption level in a  $MU$  country  $i$  can be written as:

$$C_t^i = (Y_t^i - G_t^i)^{(1-\alpha)} \prod_{j \in MU \setminus i} \left[ (Y_t^j - G_t^j)^{\frac{\alpha}{n-1}} \right]. \tag{18}$$

By plugging equation (18) to equation (17) we can write the first-order conditions of the planner's problem as

$$\begin{aligned}
\frac{dV_t}{dG_t^i} = 0 &\iff G_t^i = \frac{\kappa}{1 - \alpha + \kappa} A_t^i L_t^i, \quad \forall i \in \{MU\}, \\
\frac{dV_t}{dL_t^i} = 0 &\iff (L_t^i)^\phi = (1 - \alpha) \frac{A_t^i}{Y_t^i - G_t^i}, \quad \forall i \in \{MU\}.
\end{aligned}$$

The solution to the social planner's problem is given by pair

$$(L_t^i, G_t^i) = \left( (1 - \alpha + \kappa)^{\frac{1}{1+\phi}}, \frac{\kappa}{1 - \alpha + \kappa} Y_t^i \right),$$

i.e. the employment level is fixed and government consumption is a constant share of output. The flexible price level of output depends on the utility parameters  $\kappa$  and  $\phi$  and on the parameter for consumption allocation  $\alpha$ .

As shown in Galí and Monacelli (2005a), the planner's solution above can be interpreted as an equilibrium with flexible prices. Denoting the variables in the regime of flexible prices with bar, we may write the marginal costs in a *MU* country  $i$  as

$$\overline{MC}_t^i = 1 - \frac{1}{\epsilon} = (1 - \tau) \left( \overline{L}_t^i \right)^{(1+\phi)} \left( 1 - \frac{\overline{G}_t^i}{\overline{Y}_t^i} \right).$$

To guarantee that the flexible price allocation yields the optimal outcome, the governments must set  $(1 - \tau)(1 - \alpha) = \frac{\epsilon - 1}{\epsilon}$ , and government spending in each *MU* country must follow the rule

$$\overline{G}_t^i = \frac{\kappa}{1 - \alpha + \kappa} Y_t^i = \kappa (1 - \alpha + \kappa)^{\frac{-\phi}{1+\phi}} A_t^i. \quad (19)$$

Using equations (16) and (19) with the assumption of full risk sharing, we are able to write the flexible price bilateral terms of trade between the *MU* countries  $i$  and  $j$  as a function of country-specific productivity levels

$$\overline{S}_{j,t}^i = \frac{A_t^i}{A_t^j}$$

and the difference between inflation rates as

$$\overline{\pi}_t^i - \overline{\pi}_t^j = - \left( \Delta a_t^i - \Delta a_t^j \right). \quad (20)$$

Together with equation (9), the above equations show that, when prices are flexible, the country-specific consumption level depends on the country-specific productivity and the aggregate productivity of the *MU*.

In logarithmic terms, the output and government spending associated with the flexible price equilibrium are  $\overline{y}_t^i = \log \mu^i + a_t^i$  and  $\overline{g}_t^i = \log \nu^i + a_t^i$ , where  $\mu^i = (1 - \alpha + \kappa)^{\frac{1}{1+\phi}}$  and  $\nu^i = \kappa \mu^{-\phi}$ . Below, the flexible price levels are referred to as the natural levels. Note that the logarithmic steady-state values of output and government spending are  $\overline{y}^i = \log \mu$  and  $\overline{g}^i = \log \nu$ , respectively.

### 3.2 Dynamics with rigid price setting

By denoting the share of public spending in the steady-state aggregate output in each country by  $\gamma$ , we may approximate equation (16) around the steady state as

$$\hat{y}_t^i = (1 - \gamma) [\hat{c}_t^i + \alpha s_t^i] + \gamma \hat{g}_t^i. \quad (21)$$

Now, using equations (5), (6) and (21), the dynamic IS equation for a  $MU$  country  $i$  can be written as

$$\hat{y}_t^i = E_t \{ \hat{y}_{t+1}^i \} - (1 - \gamma) (r_t - E_t \{ \pi_{t+1}^i \} - \rho) - \gamma E_t \{ \Delta \hat{g}_{t+1}^i \}. \quad (22)$$

With equation (21), the log-linearized version of equation (11) for the real marginal costs of producers in  $MU$  country  $i$  can be written as

$$\widehat{mc}_t^i = \left( \frac{1}{1 - \gamma} + \phi \right) \hat{y}_t^i - \frac{\gamma}{1 - \gamma} \hat{g}_t^i - (1 + \phi) a_t^i. \quad (23)$$

Substituting equation (23) to the domestic inflation equation, (15), we can write the New Keynesian Phillips Curve (NKPC) in country  $i$  as

$$\pi_t^i = \beta E_t \{ \pi_{t+1}^i \} + \lambda (1 + \phi) (\hat{y}_t^i - a_t^i) - \frac{\lambda \gamma}{1 - \gamma} (\hat{g}_t^i - \hat{y}_t^i), \quad (24)$$

where  $\lambda = \frac{(1 - \xi)(1 - \beta\xi)}{\xi}$ .

The output and government spending gaps in country  $i$  are defined as logarithmic deviation of output and government spending from their natural levels, i.e.  $\tilde{y}_t^i = y_t^i - \bar{y}_t^i$  and  $\tilde{g}_t^i = g_t^i - \bar{g}_t^i$ , respectively. The fiscal gap in country  $i$  is defined as the difference between the government spending gap and the output gap, i.e.  $\tilde{f}_t^i = \tilde{g}_t^i - \tilde{y}_t^i$ .

We are now able to write the New Keynesian Phillips Curve, equation (24), of the  $MU$  country  $i$  in terms of output and fiscal gaps as

$$\pi_t^i = \beta E_t \{ \pi_{t+1}^i \} + \lambda (1 + \phi) \tilde{y}_t^i - \Gamma \lambda \tilde{f}_t^i, \quad (25)$$

where  $\Gamma = \frac{\kappa}{1 - \alpha}$ . The monetary union NKPC can now be written as

$$\pi_t^{MU} = \beta E_t \{ \pi_{t+1}^{MU} \} + \lambda (1 + \phi) \tilde{y}_t^{MU} - \Gamma \lambda \tilde{f}_t^{MU}, \quad (26)$$

where the union-wide logarithmic variables are aggregated by  $x_t^{MU} = \sum_{i \in MU} x_t^i / n$ . By using equation (22), we can write the expectational IS curve of a  $MU$  country  $i$  as

$$\tilde{y}_t^i = E_t \{ \tilde{y}_{t+1}^i - \Gamma \tilde{f}_{t+1}^i \} - (r_t - E_t \{ \pi_{t+1}^i \} - \bar{r}_t^i) + \Gamma \tilde{f}_t^i, \quad (27)$$

where  $\bar{r}_t^i$  is the natural rate of interest in a  $MU$  country  $i$  given by

$$\bar{r}_t^i = \rho + E_t \{ \Delta a_{t+1}^i \}.$$

The expectational IS curve of the monetary union is given by

$$\tilde{y}_t^{MU} = E_t \{ \tilde{y}_{t+1}^{MU} - \Gamma \tilde{f}_{t+1}^{MU} \} - (r_t - E_t \{ \pi_{t+1}^{MU} \} - \bar{r}_t^{MU}) + \Gamma \tilde{f}_t^{MU}, \quad (28)$$

where  $\bar{r}_t^{MU} = \rho + E_t \{ \sum_{i \in MU} \Delta a_{t+1}^i \} / n$ . Using equations (21) and (20) we may solve for the change in the output gap differences between a  $MU$  country  $i$  and the monetary union as

$$\Delta \tilde{y}_t^i - \Delta \tilde{y}_t^{MU} = \Gamma \left( \Delta \tilde{f}_t^i - \Delta \tilde{f}_t^{MU} \right) - (\pi_t^i - \pi_t^{MU} + \Delta a_t^i - \Delta a_t^{MU}). \quad (29)$$

The equations (22) and (24) define the paths of country-specific producer price inflation and output as functions of gross nominal interest rate and country-specific government spending. Equation (29) ties these dynamics to the union-wide output and fiscal gaps and to the differences in productivity. Given these linkages, the optimal noncoordinated fiscal policy has to balance between the effective provision of public goods and stabilization of local output gap and inflation.

### 3.3 Optimal noncoordinated fiscal policy

When the fiscal authority of country  $i$  is unable to credibly commit to its future policy, it cannot affect expectations of future values of fiscal gaps. As in Dixit and Lambertini (2003), the strategic interaction is modeled as a Stackelberg game where the central bank is assumed to be the leader and the fiscal policy authority in each monetary union member country a follower. The fiscal authorities take the union-wide variables, i.e. the nominal interest rate, the union-wide output gap and inflation, as given in each period. The nominal interest rate is set by the central bank, which follows a monetary policy rule. The decision problem of the fiscal authority thus becomes a single period problem of maximizing the one period utility of the representative household subject to the New Keynesian Phillips curve (25) and the expectational IS curve (27). The second-order Taylor approximation of the utility of households in country  $i$  is derived in appendix A.1. The problem of the fiscal authority of country  $i$  can be written as

$$\begin{aligned} \max \quad & \frac{1}{2} \left( \frac{\epsilon}{\lambda} (\pi_t^i)^2 + \frac{\kappa}{1-\alpha} (\tilde{f}_t^i)^2 + (1+\phi) (\tilde{y}_t^i)^2 \right) \quad s.t. \\ & \tilde{y}_t^i = E_t \left\{ \tilde{y}_{t+1}^i + \frac{\kappa}{1-\alpha} \tilde{f}_{t+1}^i + \pi_{t+1}^i \right\} - (r_t - \bar{r}_t^i) + \frac{\kappa}{1-\alpha} \tilde{f}_t^i \end{aligned} \quad (30)$$

$$\pi_t^i = \beta E_t \{ \pi_{t+1}^i \} + \lambda (1+\phi) \tilde{y}_t^i - \frac{\kappa}{1-\alpha} \lambda \tilde{f}_t^i, \quad (31)$$

where the values for expected variables,  $E_t \{ \pi_{t+1}^i, \tilde{y}_{t+1}^i, \tilde{f}_{t+1}^i \}$ , are taken as given. The first-order conditions for the above problem are

$$\frac{\epsilon}{\lambda} \pi_t^i + \Phi_t^i = 0$$

$$(1 + \phi) \tilde{y}_t^i + \Psi_t^i - \lambda (1 + \phi) \Phi_t^i = 0$$

$$\tilde{f}_t^i - \Psi_t^i + \lambda \Phi_t^i = 0,$$

where  $\Psi_t^i$  is associated with constraint (30) and  $\Phi_t^i$  with constraint (31). Using the first-order conditions, we can now write the optimal fiscal gap in country  $i$  under discretion as

$$\tilde{f}_t^i = -(1 + \phi) \tilde{y}_t^i - \epsilon \phi \pi_t^i. \quad (32)$$

The optimal government spending gap rule is  $\tilde{g}_t^i = -\phi (\tilde{y}_t^i + \epsilon \pi_t^i)$ , where  $\phi > 0$  and  $\epsilon > 1$ . Under this rule, government spending decreases when the output is above its efficient level or when either inflation or producer prices increase. Rule (32) is similar to the fiscal policy rule derived in Galí and Monacelli (2005b) where fiscal policy is used to maximize the union-wide welfare of the households.

By plugging the optimality condition (32) to equations (25) and (29) we can write the New Keynesian Phillips curve as

$$\pi_t^i = \frac{(1 - \alpha) \beta}{1 - \alpha - \kappa \lambda \epsilon \phi} E_t^i \{ \pi_{t+1}^i \} + \frac{\lambda (1 + \phi) (1 - \alpha - \kappa)}{1 - \alpha - \kappa \lambda \epsilon \phi} \tilde{y}_t^i \quad (33)$$

and the change in the output gap differences as

$$\begin{aligned} \Delta (\tilde{y}_t^i - \tilde{y}_t^{MU}) &= \frac{\kappa \epsilon \phi - (1 - \alpha)}{1 - \alpha + \kappa (1 + \phi)} (\pi_t^i - \pi_t^{MU}) - \frac{\kappa \epsilon \phi}{1 - \alpha + \kappa (1 + \phi)} (\pi_{t-1}^i - \pi_{t-1}^{MU}) \\ &\quad - \frac{1 - \alpha}{1 - \alpha + \kappa (1 + \phi)} (\Delta a_t^i - \Delta a_t^{MU}). \end{aligned} \quad (34)$$

By adding the aggregated rule for optimal fiscal gap (32) to the union-wide IS-curve (28) we have

$$\begin{aligned} \tilde{y}_t^{MU} &= E_t \{ \tilde{y}_{t+1}^{MU} \} + \frac{1 - \alpha + \kappa \epsilon \phi}{1 - \alpha + \kappa (1 + \phi)} E_t \{ \pi_{t+1}^{MU} \} \\ &\quad - \frac{\kappa \epsilon \phi}{1 - \alpha + \kappa (1 + \phi)} \pi_t^{MU} - \frac{1 - \alpha}{1 - \alpha + \kappa (1 + \phi)} (r_t - \bar{r}_t^{MU}). \end{aligned}$$

Similarly, the union-wide New Keynesian Phillips curve becomes the form

$$\pi_t^{MU} = \frac{(1 - \alpha) \beta}{1 - \alpha - \kappa \lambda \epsilon \phi} \pi_{t+1}^{MU} + \frac{\lambda (1 + \phi) (1 - \alpha - \kappa)}{1 - \alpha - \kappa \lambda \epsilon \phi} \tilde{y}_t^{MU}.$$

The fluctuations in union-wide output gap and producer price inflation can be stabilized by setting the nominal interest rate equal to the natural rate of interest in the monetary union. In what follows, this policy is referred to as the optimal monetary policy.

## 4 Numerical experiments

In this section, we present four numerical experiments regarding the proposed optimal fiscal policy rule. First, we compare the implications of a unit innovation in the productivity of a *MU* country  $i$  under the optimal fiscal policy rule and under a fiscal policy that keeps the fiscal gap constant at its steady-state value, while monetary policy is assumed to be optimal. In the second experiment, we analyze the macroeconomic implications of the optimal fiscal policy under two different monetary policy regimes for the monetary union. In the first policy regime, the nominal interest rate follows the union-wide natural rate of interest. In this regime the union-wide output and government spending remain at their efficient levels. In the other regime, the central bank follows a stylized Taylor rule.<sup>4</sup> This rule states that the interest rate responds to the union-wide output gap and union-wide inflation, i.e.

$$r_t = \rho + 1.5\pi_t^{MU} + .5\tilde{y}_t^{MU}.$$

In the third and fourth experiment, we study the effects of home bias in consumption and the relative size of the *MU* countries on the dynamics of the monetary union.

### 4.1 Parameterization

The EMU countries' openness to trade, defined as the share of imports plus exports relative to the GDP, has averaged 75 percent. For the model to correspond also to the average 23 percent government spending share relative to GDP in the EMU countries, we set the values of utility parameters  $\alpha$  and  $\kappa$  to 0.487 and 0.153, respectively. The time frequency of the model is one quarter. For the annual interest rate of four percent, the discount factor  $\beta$  has a parameter value 0.99, which is standard in quarterly business cycle models. As in Galí and Monacelli (2005a), the steady-state markup is set at 20 percent, i.e. the value of elasticity of substitution between locally produced goods ( $\epsilon$ ) is 6. We also assume that the elasticity of labor supply is  $\frac{1}{3}$ , i.e.  $\phi$  is 3. For the AR(1) process on labor productivity we use the estimates by Galí and Monacelli (2005a) and set  $\theta$  to .66. Finally, for the baseline simulations we set the number of countries in the monetary union to six.

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<sup>4</sup>See Taylor (1993).



## 4.2 The effects of a country-specific productivity shock

The underlying dynamics are similar in all the following simulations. A one percent rise in the productivity in a *MU* country  $i$  increases the natural level of output by an identical fraction, while in other *MU* countries, e.g. country  $j$ , the natural level of output stays unaltered. Under the optimal monetary policy, the nominal interest rate of common currency falls. As the marginal costs decrease, the producers in country  $i$  are able to lower their prices. Under the optimal monetary policy, the union-wide inflation rate is zero and the decrease in producer prices in country  $i$  is balanced by an equal rise of producer prices in other *MU* countries. As the output level does not reach its flexible price level in country  $i$  while in other *MU* countries the output gap is positive.

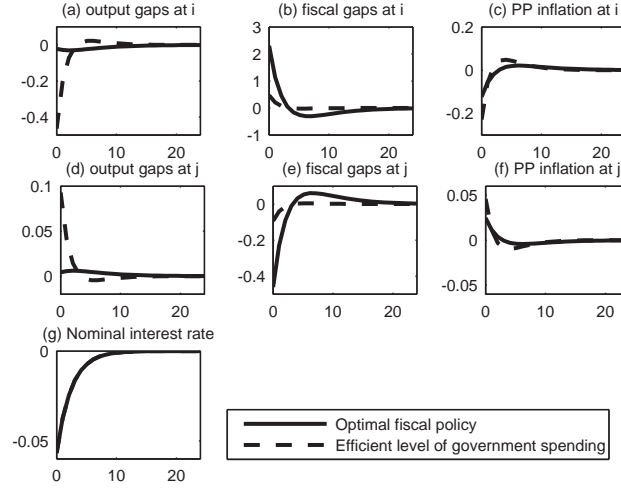


Figure 1: Impulse responses to a productivity shock in country  $i$  under different fiscal policy rules.

Figure 1 displays the impulse responses of the nominal interest rate, country-specific output and fiscal gaps, and producer price inflation rates to a productivity shock in one monetary union member country, under the optimal discretionary fiscal policy, and a policy that keeps government spending at its efficient level in every period, i.e.  $g_t^i = 0$ . In these simulations monetary policy is assumed to be optimal, i.e. the union-wide fiscal and output gaps and union-wide inflation are always zero. The figure shows that the efficient level of public spending is not enough to close the output gap, whereas under the optimal policy the output gap is almost closed.

Figure 2 displays the impulse responses to a productivity shock in one monetary union member country, associated with the optimal discretionary

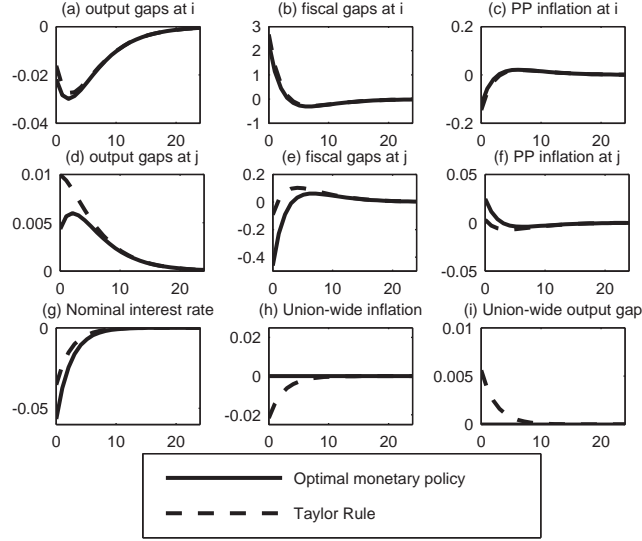


Figure 2: Impulse responses to a productivity shock in country  $i$  under different monetary policy rules.

fiscal policy, under the two monetary policy regimes. When monetary policy follows the simple Taylor-type rule, the union-wide fiscal and output gaps differ from their steady-state levels. Under the Taylor-type rule the spillover effects of the productivity shock to the output gaps of the other member countries are stronger than under the optimal monetary policy.

Figure 3 displays the impulse responses to a productivity shock in one monetary union member country associated with the optimal discretionary fiscal policy and optimal monetary policy. In these simulations we vary the parameter value for the home bias in the households' consumption baskets; as the value of  $\alpha$  increases, the share of local goods in the consumption basket decreases. The simulations show that when countries are more open to international trade, the country-specific productivity shocks cause smaller responses to the output gaps.

Figure 4 displays the impulse responses to a productivity shock in one monetary union member country associated with the optimal discretionary fiscal policy and optimal monetary policy. In these simulations we vary the number of countries in the monetary union, i.e. the relative size of the member countries compared to the size of the  $MU$ . In a bigger monetary union nominal interest rate reacts less to the country-specific shocks, increasing economic fluctuations in an individual country subject to the productivity shock. This means that the responses to the local productivity shock in a small monetary union member country are stronger than in a bigger country.

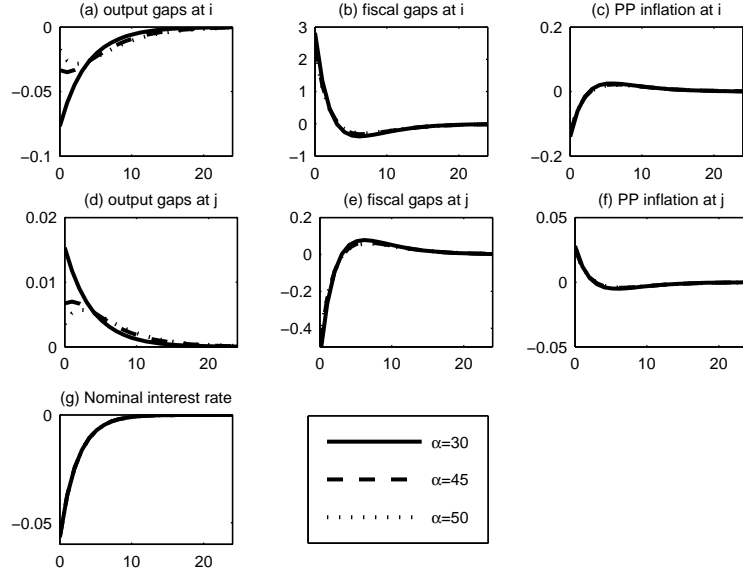


Figure 3: Impulse responses to a productivity shock in country  $i$  associated with different values of parameter  $\alpha$ .

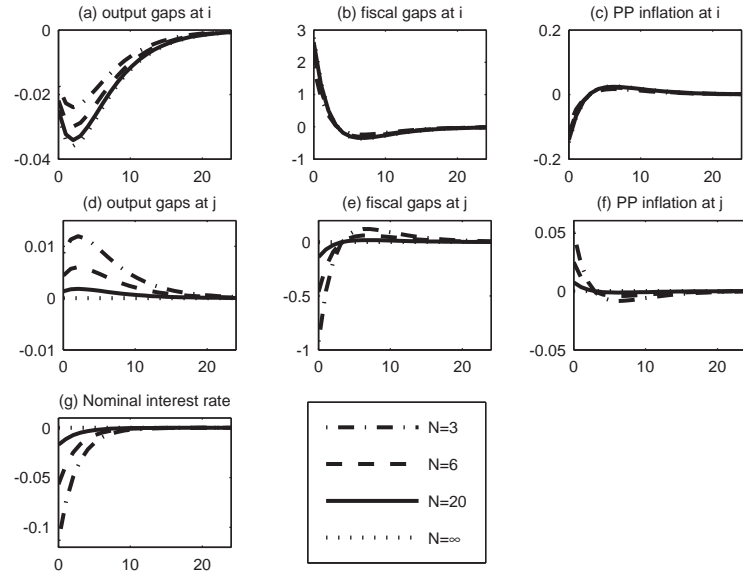


Figure 4: Impulse responses to a productivity shock in country  $i$  under different relative sizes of  $MU$  member countries.

When the number of countries in the  $MU$  approaches infinity the spillover effects of the country-specific shocks disappear.

The numerical experiments presented above show that an increase in productivity in one monetary union member also increases the demand for goods produced in other monetary union member countries, and this creates a positive output gap. Previous studies, e.g. Galí and Monacelli (2008) and Gnocchi (2007), show that these output gaps are not closed with optimal coordinated fiscal policy. This result holds also with the country-specific optimal fiscal policy.

## 5 Conclusions

This essay has explored the optimal noncoordinated discretionary fiscal policy in a model for a monetary union with price rigidities. We have presented a benchmark for policy analysis where the fiscal authority maximizes the welfare of local households and the monetary authority follows an optimal monetary policy that maximizes the average utility of the households in the monetary union. The results show that, under optimal noncoordinated discretionary fiscal policy, government spending should exceed its efficient level when the economy faces deflation or a negative output gap. We have also shown that suboptimal monetary policy increases the spillover effects of country-specific shocks. Numerical simulations of the model also show that the home bias in households' consumption increases economic fluctuations inside the monetary union.

In this work, fiscal policy has only been analyzed on the basis of lump sum taxes, i.e. in a Ricardian economy. It might also be interesting to analyze the optimal country-specific fiscal policy associated with distortionary taxation which would add non-Ricardian effects of fiscal policy to the framework. By relaxing the assumption of symmetry among the countries, the framework presented in this paper can also be used to analyze a monetary union with countries of different sizes.

## A Welfare loss functions

### A.1 The second order approximation of household utility in country $i$

Using equation (18) in the text, the utility of a representative household in a  $MU$  country  $i$  can be written as

$$V_t^i = E_0 \sum_{t=0}^{\infty} \beta^t \left\{ (1 - \alpha) \log (Y_t^i - G_t^i) + \frac{\alpha}{n - 1} \left[ \sum_{j \in MU \setminus i} \log (Y_t^j - G_t^j) \right] + \kappa g_t^i - \frac{(L_t^i)^{1+\phi}}{1 + \phi} \right\}.$$

Following Galí and Monacelli (2008), we can write the second-order Taylor approximation of the term  $\log (Y_t^i - G_t^i)$  in terms of output and government spending gaps as

$$\log (Y_t^i - G_t^i) = (1 + \Gamma) \tilde{y}_t^i - \Gamma \tilde{g}_t^i - \frac{\Gamma(1 + \Gamma)}{2} (\tilde{g}_t^i - \tilde{y}_t^i)^2 + \text{t.i.p} + o(\|a\|^3),$$

where t.i.p denotes the terms that are independent of policy and  $o(\|a\|^3)$  represents the terms that are of order higher than second, in the bound  $\|a\|$  on the amplitude of a productivity shock. Under the noncoordinated fiscal policy we have  $\Gamma = \frac{\kappa}{1 - \alpha}$  and  $\bar{L}^i = (1 - \alpha + \kappa)^{\frac{1}{1+\phi}}$ .

Following Galí and Monacelli (2005a), we can write the second-order Taylor approximation of the term for disutility from labor output about its flexible price level as

$$\begin{aligned} \frac{(L_t^i)^{1+\phi}}{1 + \phi} &= \frac{(\bar{L}_t^i)^{1+\phi}}{1 + \phi} + (\bar{L}_t^i)^{1+\phi} \left[ \tilde{y}_t^i + z_t^i + \frac{1}{2} (1 + \phi) (\tilde{y}_t^i)^2 \right] + o(\|a\|^3) \\ &= [1 - \alpha + \kappa] \left[ \tilde{y}_t^i + z_t^i + \frac{1}{2} (1 + \phi) (\tilde{y}_t^i)^2 \right] + \text{t.i.p} + o(\|a\|^3), \end{aligned}$$

where  $z_t^i = \log \int_0^1 \frac{Y_t^i(k)}{Y_t^i} dk = \int_0^1 \left( \frac{P_t^i(k)}{P_{i,t}} \right)^{-\epsilon} dk$ .

Considering the fluctuations outside the country  $i$  as independent to country  $i$ 's policy, we can write the second-order Taylor approximation of the

representative households utility function as

$$V_t^i = -[1 - \alpha + \kappa] \sum_{t=0}^{\infty} \beta^t \left[ z_t^i + \frac{1}{2} \frac{\kappa}{1 - \alpha} \left( \tilde{f}_t^i \right)^2 + \frac{1}{2} (1 + \phi) \left( \tilde{y}_t^i \right)^2 \right] \\ + \text{t.i.p} + o(\|a\|^3)$$

**Lemma 1.**  $z_t^i = \frac{\epsilon}{2} \text{var}_k \{p_t^i(k)\} + o(\|a\|^3)$ .

*Proof.* Galí and Monacelli (2005a).

**Lemma 2.**  $\sum_{t=0}^{\infty} \beta^t \text{var}_k \{p_t^i(k)\} = \frac{1}{\lambda} \sum_{t=0}^{\infty} \beta^t (\pi_t^i)^2$ , where  $\lambda = \frac{(1-\xi)(1-\beta\xi)}{\xi}$ .

*Proof.* Woodford (2003).

Now we can write the second-order Taylor approximation of utility of the representative household in the *MU* country *i* as

$$V_t^i = -\frac{1 - \alpha + \kappa}{2} \sum_{t=0}^{\infty} \beta^t \left[ \frac{\epsilon}{\lambda} (\pi_t^i)^2 + \frac{\kappa}{1 - \alpha} \left( \tilde{f}_t^i \right)^2 + (1 + \phi) \left( \tilde{y}_t^i \right)^2 \right] \\ + \text{t.i.p} + o(\|a\|^3).$$

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