On the desirability of supply-side intervention in a monetary union*

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Abstract

This paper examines the desirability of supply-side intervention within a monetary union, given the constraints on monetary and fiscal policy, and compares it with an economic framework characterized by the independence of monetary policy. To this end, firstly, we develop a simple two-country model in order to analyse in strategic terms how the authorities can deal with monetary, real and supply shocks, and the extent to which supply-side intervention may be useful to deal with those shocks. Next, we study whether the formation of a monetary union could be benefitial when there is coordination over labour market intervention.

Key words: Monetary union, supply-side policies, policy coordination.

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1 Introduction

The costs of losing the exchange rate and monetary policy as instruments of macroeconomic stabilization, acquire a special importance when deciding the convenience of forming a monetary union. Most of the theoretical and empirical studies conclude that these costs will depend on the asymmetry of the shocks. So, for instance, Bayoumi and Eichengreen (1993) found that the costs imposed by asymmetric shocks in an European monetary union would be large, since these shocks require country-specific adjustment policies.

Another question broadly discussed is that, in the absence of fully flexible prices and wages, as well as labour mobility, as adjustment mechanisms, governments have to deal with shocks using mainly fiscal policy. But the disciplining effects of a monetary union may require some limitations on the use of fiscal policy. We can mention, as an example, the fiscal discipline imposed by the Pact for Stability and Growth in the European monetary union. Since fiscal policy in monetary unions may be inefficient, the case for fiscal policy coordination has been discussed; see, e.g. Díaz-Roldán (2000a).

On the other hand, given these limitations to the use of fiscal policy, it would be desirable to have other alternative policies available. Among them, the possibility of using supply-side policies has been discussed (Jimeno, 1992); however, the available literature has hardly studied supply-side policies. An exception is De Miguel and Sosvilla (2001), who develop a two-country model in order to analyse the effects of macroeconomic policies in a monetary union, with different degrees of wage rigidity, where supply policies are represented by changes in the employers' social security contributions, having a direct impact on real wages.

In this paper we examine the desirability of supply side intervention within a monetary union, given the constraints on monetary and fiscal policy, and compares it with an economic framework characterized by the independence of monetary policy. To this end, we first develop a simple two-country model in order to analyse in strategic terms how the authorities can deal, in the short-run, with monetary, real and supply shocks, and the extent to which supply side intervention may be useful to deal with those shocks. The authorities can act individually or cooperatively and, in the rest of the paper, we will identify authorities cooperation with policy coordination. Secondly, we modify the model so that the two countries form a monetary union. In particular, an independent central bank controls monetary policy within the monetary union, and supply policies are determined by the authorities at the national level. Next, we study whether the formation of a monetary union could be benefitial when there is coordination over labour market intervention. This approach should allow us to answer the main question of our study: to what extent supply-side coordination is required in a monetary union as compared to the previous situation in which monetary policy was conducted at the national level. In other words, we try to find the conditions that could support the coordination of supply-side intervention in a monetary union.

As an original contribution of this paper, we can mention, first of all, that we make use of a model specifically designed for a monetary union. This type of models are not frequent in the literature, and we have used a simplification of the model developed in Díaz-Roldán (2000b). An important result derived from our analysis is that the desirability of supply-side policies coordination is not only related to the characteristics of the shocks, but is also related to how their effects are transmitted among countries. Secondly, we analyse the role of supply policies, something also hardly discussed in the literature. Since supply-side policies are presumed to be useful to deal with labour market inefficiencies, our supply-side instrument could be thought as a way of institutional intervention in the labour market.

The paper is structured as follows. In section 2 a theoretical two-country model is developed, which will allow us to study the possibility of coordination of supply policies, and the welfare aspects of the optimal solution. In section 3 the two-country model is modify in order to describe a monetary union, which will allow us to study the effects of shocks on the union's member countries. Finally, in section 4 the main conclusions are shown together with the policy implications.

2 A two-country model

2.1 Setup of the model

We will consider a model of two symmetric economies, country 1 and country 2, with flexible exchange rates and perfect capital mobility between them. This last assumption implies that the countries' interest rates are equal to the world's interest rate denoted by r.

The set of equations for country 1 is as follows, and a similar setup holds for country 2:

$$y_1 = -\alpha r + \beta(e + p_2 - p_1) + \delta y_2 + f_1 \tag{1}$$

$$m_1 - p_1 = \theta y_1 - \psi r \tag{2}$$

$$p_{c1} = (1 - \mu)p_1 + \mu(p_2 + e) \tag{3}$$

$$w_1 - \varepsilon p_{c_1} = \phi prod_1 - \eta u_1 + z_1 - v_1 - t_1 \tag{4}$$

$$p_1 - w_1 = -\phi prod_1 - \varphi u_1 \tag{5}$$

$$y_1 = n_1 + prod_1 \tag{6}$$

$$u_1 = l_1 - n_1 \tag{7}$$

All the variables are defined as rates of change, except r and u that capture the instantaneous changes in the interest rate, and in the unemployment rate, respectively. All parameters, denoted by Greek letters, are nonnegative.

Equation (1) represents the goods market equilibrium condition. Output, y, depends on the world's interest rate r, the real exchange rate (defined from the nominal exchange rate, e , and the countries' relative prices $p_1$and p_2), the other country's output, and a positive real shock f.

Equation (2) shows the money market equilibrium condition, where m denotes the money supply, and money demand depends on demestic output, and the world interest rate.

Equations (3) to (7) represent the aggregate supply of the economy, built along the lines of Layard, Nickell and Jackman (1991). First, equation (3) defines the consumer price index p_c, as a weighted average of the domestic goods' and the imported goods' prices in terms of the domestic currency.

Equation (4) shows that nominal wages, w, are determined by the degree of indexation with respect to the consumer price index, depending on the parameter ε; labour productivity, $prod$; the unemployment rate, u; wage pressure factors, z; the error in expectations, captured by the variable v; and the use, as a policy instrument, of a supply-side variable t, which could be used as a direct way of policy intervention on the labour market. Notice that the parameter ε denotes the degree of wage rigidity, with $0 \leqq \varepsilon \leqq 1$; we will assume here the intermediate case so that $0 < \varepsilon < 1$.

In equation (5), prices are set by adding a margin to wages, which depends on productivity, $prod$, and the unemployment rate, u. We also assume that the parameter ϕ is the same than in the wage-setting equation (4). This assumption, which simplifies the analysis without altering the basic results, is commonly used in the literature, and is justified since in the long term productivity changes do not affect the unemployment rate (see e.g. Layard, Nickell and Jackman (1991)).

Finally, equation (6) defines changes in output as the sum of changes in employment, n , and productivity, $prod$. And equation (7) defines changes in the unemployment rate, u, in terms of active population, l , and employment, n.

The transmission of the shocks

From equations (1) to (7), and assuming equilibrium in the goods market, we can obtain the reduced forms for the two countries (see Appendix).

$$y_1 = \overline{M}_y m_1 \pm \overline{M}'_y m_2 + \overline{F}_y f_1 \pm \overline{F}'_y f_2 - \overline{S}_y s_1 - \overline{S}'_y s_2 + \overline{S}_y t_1 + \overline{S}'_y t_2 \qquad (8)$$

$$y_2 = \overline{M}_y m_2 \pm \overline{M}'_y m_1 + \overline{F}_y f_2 \pm \overline{F}'_y f_1 - \overline{S}_y s_2 - \overline{S}'_y s_1 + \overline{S}_y t_2 + \overline{S}'_y t_1 \qquad (9)$$

$$p_1 = \overline{M}_p m_1 \pm \overline{M}'_p m_2 + \overline{F}_p f_1 + \overline{F}'_p f_2 + \overline{S}_p s_1 + \overline{S}'_p s_2 - \overline{S}_p t_1 - \overline{S}'_p t_2 \qquad (10)$$

$$p_2 = \overline{M}_p m_2 \pm \overline{M}'_p m_1 + \overline{F}_p f_2 + \overline{F}'_p f_1 + \overline{S}_p s_2 + \overline{S}'_p s_1 - \overline{S}_p t_2 - \overline{S}'_p t_1 \qquad (11)$$

where$\overline{M}_y > \overline{M}'_y, \overline{F}_y > \overline{F}'_y, \overline{S}_y > \overline{S}'_y$, and also $\overline{M}_p > \overline{M}'_p$, $\overline{F}_p > \overline{F}'_p, \overline{S}_p > \overline{S}'_p$. Notice that in order to simplify, for each country i, all the exogenous supply shocks have been grouped into a contractionary disturbance s,

$$s_i = z_i - v_i - \tfrac{1}{\lambda} l_i - \tfrac{1}{\lambda} prod_i$$

for $i = 1, 2$, so that s embodies the negative effect on output of an increase in the degree of wage pressure, as well as the positive effects of increases in the expectations' errors, active population, and productivity, being $\lambda = \frac{1}{\eta+\varphi}$.

Equations (8) to (11) show the interdependence between the two countries, given by the interaction of the variables.

We find that a negative supply shock affecting one of the countries (s_1, $s_2 > 0$), leads to a fall in output and a rise in prices in both countries, and this effect is independent of the channel of transmission and the origin of the shock. Regarding the supply policy instruments of the countries (t_1, t_2), their effects have the same absolute value but the opposite sign as compared to supply shocks.

In turn, positive demand shocks (m_1,m_2, f_1, $f_2 > 0$) lead to positive effects on the output and prices of the country of origin of the shock. But when the shock is transmitted between the two countries, the sign of the coefficients depends on which channel of transmission prevails. In our model, the channels of transmission of the demand shocks are the aggregate demand, the interest rate, the nominal exchange rate, and the countries' relative prices.When aggregate demand prevails, the result is the "*locomotive effect*": the effects on the output and prices of the country of origin of the shock are transmitted to the other country with the same sign, so that we find an aggregate demand expansion coupled with an output expansion an a rise in prices in all the involved economies. But when changes in the interest rate and the real exchange rate prevail, the result is the "*beggar-thy-neighbour effect*": the effects on the output and prices of the country of origin of the shock are transmitted to the other country with the opposite sign.

We have just shown the way in which macroeconomic shocks and supply-side policies adopted by the countries' governments, are transmitted between the two countries. The purpose of the next subsection will be to show to what extent policy coordination may internalize the potential spillover effects.

2.2 Supply policies coordination

The theoretical arguments supporting policy coordination are based on the idea that cooperation internalizes the effects of economic interdependence. In this way, we need to take into account the strategic behaviour of the authorities, so we will use the Game Theory approach in order to study how the authorities can deal with shocks.

We assume that countries 1 and 2 are represented by their authorities, which face the problem of minimizing their loss functions:

$$L_1 = y_1^2 + \pi_1 p_1^2 \tag{12}$$

$$L_2 = y_2^2 + \pi_2 p_2^2 \tag{13}$$

where the target variables are the rates of change in both output (y_1, y_2), and prices (p_1, p_2). In order to minimize their loss functions, the authorities will use as a policy instrument a supply side variable (t_1, t_2), affecting the labour market. We assume $\pi_1 \neq \pi_2$, so we consider asymmetric preferences. On the other hand, the quadratic form of the loss function implies that any change, positive or negative, in the variables will represent a loss of utility. So, each country will minimize its loss function when all the objectives become equal to zero: $y_1 = y_2 = 0$ and $p_1 = p_2 = 0$.

Each country has to minimize its loss function by choosing the optimal rate of change of the supply side variable, subject to the restrictions imposed by the international economic framework. We will focus our analysis on the comparison between the competitive solution and the cooperative solution. We will show that, in any case, the solutions will depend on the characteristics of the shocks and on the way in which their effects are transmitted among countries.

a) Non-cooperative solution: The competitive solution

When each country solves the problem individually, ignoring interdependence and taking as given the other country's policy, the solution is the Nash-Cournot Equilibrium. The optimization problem of country 1 is as follows:

$$\begin{aligned} \min_{t_1} L_1 &= y_1^2 + \pi_1 p_1^2 \\ & \quad s.t.(8) \text{ and } (10) \end{aligned} \tag{14}$$

from which we obtain the reaction function (see Appendix):

$$t_{R,1} = -\overline{R}_1 t_2 - \overline{R}_2 m_1 \pm \overline{R}_3 m_2 - \overline{R}_4 f_1 \pm \overline{R}_5 f_2 + s_1 + \overline{R}_1 s_2 \tag{15}$$

where all the $\overline{R}$'s are positive coefficients.

The problem for country 2 is similar:

$$\min_{t_2} L_2 = y_2^2 + \pi_2 p_2^2 \tag{16}$$
$$s.t.(9) \text{ and } (11)$$

from which we obtain:

$$t_{R,2} = -\overline{R}_1 t_1 - \overline{R}_2 m_2 \pm \overline{R}_3 m_1 - \overline{R}_4 f_2 \pm \overline{R}_5 f_1 + s_2 + \overline{R}_1 s_1 \tag{17}$$

where all the $\overline{R}$'s are again positive coefficients.

The absolute value of each coefficient indicates the size of the response to shocks. For a supply shock originated in the own country, the coefficient equals one, so that the use of the supply side variable totally offset the (adverse) effects of the shock. But when a country has to deal with a shock from the other country, the supply side variable changes in a proportion lower than one (since $\left|\overline{R}_i\right| < 1$ for $i = 1, ..., 5.$). So, these shocks are not totally offset, which may indicate that supply-side policies are not the best policies to cope with that kind of shocks.

Both reaction functions have negative slopes. Given that $0 < \overline{R}_1 < 1$, the country 1's reaction function has a slope greater than one in absolute value: $\left.\frac{dt_2}{dt_1}\right|_{t_1=\overline{R}(t_2)} = -\frac{1}{\overline{R}_1}$, with $\left|-\frac{1}{\overline{R}_1}\right| > 1$. On the contrary, for country 2, we find that $\left.\frac{dt_2}{dt_1}\right|_{t_2=\overline{R}(t_1)} = -\overline{R}_1$, with $\left|-\overline{R}_1\right| < 1$.This means that any movement along the country 1's reaction function requires a lower change of the supply-side variable in country 1 than in country 2. In other words, solving their problems individually, and ignoring interdependence, a country's minimization of the changes in its supply-side variable requires a greater variation of the other country's variable.

The Nash-Cournot equilibrium is given by the point where the reaction functions intersect (see Apendix):

$$t_{N,1} = -\overline{N}_{1,1} m_1 \pm \overline{N}_{1,2} m_2 - \overline{N}_{1,3} f_1 \pm \overline{N}_{1,4} f_2 + s_1 \tag{18}$$

$$t_{N,2} = -\overline{N}_{2,1} f_1 \pm \overline{N}_{2,2} f_2 - \overline{N}_{2,3} f_1 \pm \overline{N}_{2,4} f_2 + s_2 \tag{19}$$

where $\overline{N}_{1,i}; \overline{N}_{2,i} > 0, i = 1, ..., 4.$

We can see that in the competitive solution each country only offsets the supply shock originated in the own country, but not the rest of the shocks. As it is shown in Appendix, the coefficients of the Nash solution are lower, in absolute value, than the coefficients of the reaction function. That is, when solving the problem individually each country acts in a "myopic" way and, since interdependence is ignored, the effects of supply-side policies are transmitted abroad.

b) Cooperative solution: The social planner problem

If the countries' authorities coordinate their policies, they will minimize the weighted sum of their loss functions. Given the assumption of symmetry, and making the weights of each country equal to $\frac{1}{2}$ for simplicity, the social planner problem would be:

$$\begin{aligned} \min_{t_1,t_2} \mathfrak{L} &= \left[\frac{1}{2}(y_1^2 + \pi_1 p_1^2) + \frac{1}{2}(y_2^2 + \pi_2 p_2^2)\right] \\ & s.t.(8) \text{ to } (11) \end{aligned} \tag{20}$$

From the first-order conditions we obtain (see Appendix):

$$t_{C,1} = \pm\overline{C}_{1,1}m_1 \pm \overline{C}_{1,2}m_2 \pm \overline{C}_{1,3}f_1 \pm \overline{C}_{1,4}f_2 + \overline{C}_{1,5}s_1 + \overline{C}_{1,6}s_2 \tag{21}$$

$$t_{C,2} = \pm\overline{C}_{2,1}m_1 \pm \overline{C}_{2,2}m_2 \pm \overline{C}_{2,3}f_1 \pm \overline{C}_{2,4}f_2 + \overline{C}_{2,5}s_1 + \overline{C}_{2,6}s_2 \tag{22}$$

where $\overline{C}_{1,i}, \overline{C}_{2,i} > 0, i = 1, ..., 6.$

2.3 Welfare aspects of the optimal solution

From a theoretical point of view, the cooperative solution is Pareto improving since it internalizes the spillover effects arising from economic interdependence. These externalities, $\frac{\partial L_1}{\partial t_2}$ and $\frac{\partial L_2}{\partial t_1}$, show how the loss function of a country changes in response to changes in the other country's instrument.

On the one hand, the first-order conditions from which we have obtained the Nash Equilibrium are $\frac{dL_1}{dt_1} = 0$ and $\frac{dL_2}{dt_2} = 0$. But for these points $\frac{\partial L_1}{\partial t_2} \neq 0$ and $\frac{\partial L_2}{\partial t_1} \neq 0$.

In turn, the first-order conditions of the social planner problem are:

$$\frac{\partial \mathfrak{L}}{\partial t_1} = \frac{1}{2}\left(\frac{\partial L_1}{\partial t_1} + \frac{\partial L_2}{\partial t_1}\right) = 0 \tag{23}$$

$$\frac{\partial \mathfrak{L}}{\partial t_2} = \frac{1}{2}\left(\frac{\partial L_1}{\partial t_2} + \frac{\partial L_2}{\partial t_2}\right) = 0 \tag{24}$$

From these conditions it is clear that $\frac{\partial L_1}{\partial t_1} = -\frac{\partial L_2}{\partial t_1}$ and $\frac{\partial L_2}{\partial t_2} = -\frac{\partial L_1}{\partial t_2}$, which shows how the cooperative solution internalizes externalities. But the desirability of the cooperative solution will depend on the nature of the externality. If the externality has the same sign than the shock, the externality reinforce the effects of the shock. Subsequently, the cooperative solution requires a greater change of the policy instrument than the competitive solution. On the contrary, when the externality shows a different sign than the shock, the cooperative solution is the solution that requires the lowest change of the instrument (see Appendix for details).

In order to avoid the spillover effects of their policies, the countries' authorities will try to minimize the use of the supply side variable, so that they identify stabilization with avoiding changes in the policy instrument. In particular, we have modelled a loss function in which any change in the variables implies a loss of utility. Since the target variables are linear in the policy instruments, the solution that requires a lower change in the supply-side variable would be the optimal solution. So, in a first step, authorities will minimize their loss functions, and, in a second step, they will choose the solution (competitive or cooperative) with the lower absolute value:

$$t_i = \min\left\{\left|t_{N,i}\right|, \left|t_{C,i}\right|\right\} \;\; \forall i = 1, 2$$

It is difficult to know the size of some of the coefficients of the solutions, since they depend on the coefficients of the reduced form -equations (8) to (11). For that reason, in order to compare the Nash solution with the cooperative solution we will make use of graphical analysis. We will take into account both the slope of the reaction functions, and the sign of the solutions.

Graphical analysis

From the reduced form -equations (8) to (11)- we can see that the target variables (y_1, y_2) and (p_1, p_2) are linear in the policy instruments (t_1, t_2). So, we can plot both the reaction functions and the indifference curves in the same t_1- t_2 plane; for simplicity, we will not show the indifference curves. If any disturbance takes place, the reaction functions would shift to the left or to the right according to the particular type of shock.

Figure 1 shows the reaction functions after an expansionary shock in both countries. In these cases, the authorities find optimal a contractionary policy to offset the effects of the shock, so the reaction functions shift to the left and the *bliss points* for countries 1 and 2 are at points $B_1 = (0, t_2 < 0)$ and $B_2 = (t_1 < 0, 0)$ respectively.

The Nash solution is at point N, where the reaction functions intersect. There are infinite cooperative solutions, but we can focus on the case in which both countries react in the same way, $t_1 = t_2$. In a symmetric model, with the same bargaining weights for each country, it is reasonable to assume that the gains and losses from cooperation would be divided equally. In that case, the solution -which is the most symmetric possible- is given by point C in Figure 1. But, in any case, cooperative solutions require a greater change in the supply side variable than the Nash solution, so that cooperation would be undesirable.

[Figure 1]

If we depict the case of a contractionary shock leading to a recession in both countries, the reaction functions would shift to the right (see Figure 2). The Nash solution is at point N in Figure 2, where the reaction functions intersect, and the symmetric cooperative case, point C, requires a greater change in the supply side variable than in the Nash solution. Hence, cooperation would be again undesirable.

[Figure 2]

On the other hand, we can see from the reaction functions -equations (15) and (17)- that, when a supply shock has its origin in only one of the countries (i.e., either $s_1 \neq 0$ or $s_2 \neq 0$, but not simultaneously), the shift of the reaction function is greater for the country where the shock occurs. As an example, in Figure 3 we depict the case of a contractionary supply shock in country 1 ($s_1 > 0$). Now, *bliss points* are $B_1 = (0, t_2 > 0)$ and $B_2 = (t_1 > 0, 0)$, whereas the competitive solution is given by point N where the reaction functions intersect. This point coincides with B_2. The cooperative solution is along the line linking B_1 and B_2, and coincides with a segment of country 1's reaction function. In this particular case, cooperation would be desirable for country 1 but undesirable for country 2, which has not suffered the shock. The reason is that along the line linking B_1 and B_2, changes in country 1's supply-side instrument are lower compared with the case in which country 1 acts individually.

[Figure 3]

We have just shown that supply-side policy coordination would result undesirable for the countries, when they cope with shocks that are transmited with the same sign to both countries. However, for supply shocks, cooperation could be desirable, but only for the country where the shock occurs. It can be proved that the cases studied above are those in which the aggregate demand prevails as the way of transmission of the shocks, and the shocks are transmited with the same sign between the countries. This channel of transmission leads to the "locomotive effect": for positive shocks externalities are also positive, and for negative shocks externalities are negative. For that reason cooperation would be undesirable, since it internalizes externalities that reinforce the effect of the shock and requires a greater change in the supply-side variable. So, in order to avoid some of the adverse effects, it would be preferable not to coordinate. This result holds also in the case depicted in Figure 3, where cooperation results desirable only for one country.

In contrast, different results for the desirability of coordination can appear when expansionary (contractionary) demand shocks in a country of the union translate into a contraction (expansion) to the other country. This possibility appears when the interest rate and the real exchange rate prevail as channels of transmission of the shocks, leading to the "beggar-thy-neighbour effect", so that externalities have the opposite sign than the shock. Accordingly, cooperation would be desirable since it offsets the effects of the shock and requires a lower change in the supply-side variable. Figures 4 and 5 show the alternative possibilities in which cooperation proves to be desirable. In both cases, when the output of a country expands, the output of the other falls and cooperation results desirable since cooperative solutions require a lower change in the supply-side variable (see point C which represents the cooperative symmetric case) as compared to the Nash solution (point N).

[Figure 4]

[Figure 5]

Summarising the results obtained so far, we can derive the conditions under which coordination of supply policies could be desirable. These conditions are presented in Table 2.1, and we can conclude that the results are determined not only by the origin of the shock (country 1 or country 2), but also by its nature (monetary, real or supply-side), and the channel of transmission. In the case of supply shocks, cooperation always results undesirable for the two countries as a whole, but when dealing with demand shocks, the channel of transmission proves to be determinant.

TABLE 2.1

DESIRABILITY OF SUPPLY POLICY COORDINATION IN A TWO-COUNTRY MODEL

SHOCK	COOPERATION
Monetary (m_1, m_2)	• "Locomotive effect": **undesirable** • "Beggar-thy-neigbour effect": **desirable**
Real (f_1, f_2)	• "Locomotive effect": **undesirable** • "Beggar-thy-neigbour effect": **desirable**
Supply (s_1, s_2)	**Undesirable**

3 The model for a monetary union

3.1 Setup of the model

In this section the two symmetric economies of section 2, country 1 and country 2, form a monetary union. The economic framework of the union's member countries is given again by equations (1) to (7) of the previous section for country 1, and the corresponding symmetric equations for country 2. But for describing a monetary union, these two sets of equations are modified in the following way: first, the nominal exchange rate is made equal to zero; and, second, both countries replace each individual money market equilibrium condition (equation (2) for country 1, and the symmetric one for country 2) by a common equilibrium condition, which can be written as follows:

$$m - \frac{1}{2}p_1 - \frac{1}{2}p_2 = \frac{\theta}{2}y_1 + \frac{\theta}{2}y_2 - \psi r \tag{25}$$

In equation (25), m denotes the union's money supply, so the demand for money depends on the output of the countries, and the union's interest rate.

Notice that, since all the variables are in rates of change, the variables of the monetary union are equal to the weighted sum of the member countries' variables, and we can assume that their relative weights reflect the bargaining power of each country inside the union. That is, for any variable x of the monetary union:

$$x = \frac{Y_1}{Y}x_1 + \frac{Y_2}{Y}x_2$$

where x, x_1, x_2 are the rates of change of each variable for the union, country 1, and country 2 respectively; Y, Y_1, Y_2 are their levels of output, and $Y_1 + Y_2 = Y$. For convenience, we have assumed $\frac{Y_1}{Y} = \frac{Y_2}{Y} = \frac{1}{2}$.

The transmission of the shocks

As can be seen in Appendix, we can obtain the reduced forms for the two countries.

$$y_1 = M_y m + F_y f_1 \pm F'_y f_2 - S_y s_1 - S'_y s_2 + S_y t_1 + S'_y t_2 \tag{26}$$

$$y_2 = M_y m + F_y f_2 \pm F'_y f_1 - S_y s_2 - S'_y s_1 + S_y t_2 + S'_y t_1 \tag{27}$$

$$p_1 = M_p m + F_p f_1 \pm F'_p f_2 + S_p s_1 + S'_p s_2 - S_p t_1 - S'_p t_2 \tag{28}$$

$$p_2 = M_p m + F_p f_2 \pm F'_p f_1 + S_p s_2 + S'_p s_1 - S_p t_2 - S'_p t_1 \tag{29}$$

where $F_y > F'_y, S_y > S'_y$,and also $F_p > F'_p, S_p > S'_p$. Again, to simplify, for each country i, all the exogenous supply shocks have been grouped in a contractionary disturbance s_i, for $i = 1, 2$, defined as in the two-country model.

We find that for a negative supply shock affecting one of the countries of the union (s_1, $s_2 > 0$), the same result than in the two-country model holds: an output fall and a rise in prices.

In turn, positive demand shocks (m, f_1, $f_2 > 0$) also lead to positive effects on the output and prices of the country of origin of the shock. But for the particular case of real shocks (f_1, $f_2 > 0$) when they are transmitted between the countries of the union, the sign of the coefficients depends on which channel of transmission prevails: the aggregate demand or the interest rate, and the monetary union's relative prices. In other words: a real shock may lead to both the "*locomotive effect*" or the "*beggar-thy-neighbour effect*". This alternative does not hold for monetary shocks, in contrast with the two-country model, and the reason is that a monetary union does not allow for country-specific monetary shocks. In consequence, a monetary shock will always be a symmetric shock within a monetary union.

After analysing the way in which macroeconomic shocks are transmitted between the countries of the monetary union, we will show in the next subsection to what extent policy coordination may internalize the potential spillover effects.

3.2 Supply policies coordination in a monetary union

We assume that countries 1 and 2 are represented by their authorities, which face the problem of minimizing their loss functions:

$$L_1 = y_1^2 + \sigma_1 g_1^2 + \pi_1 p_1^2 \tag{30}$$

$$L_2 = y_2^2 + \sigma_2 g_2^2 + \pi_2 p_2^2 \tag{31}$$

where the target variables are the rates of change in output (y_1, y_2), in the budget deficit (g_1, g_2), and also in prices (p_1, p_2). In this context, the objective of prices captures the cost of the authorities' intervention in terms of inflation. In addition, the fact that the disciplining effects of a monetary union imply some restrictions on fiscal policy, allows us to include the budget deficit as an objective of the authorities. An example of this situation is the European monetary union, where each member country has to fulfil the budget deficit requirements of the Pact for Stability and Growth. In order to minimize their loss functions, the authorities will use as a policy instrument a supply side variable (t_1, t_2). We also assume $\sigma_1 \neq \sigma_2$ and $\pi_1 \neq \pi_2$, so we consider asymmetric preferences. On the other hand, as explained in section 2, the quadratic form of the loss function implies that any change, positive or negative, in the variables will represent a loss of utility. So, each country will minimize its loss function when all the objectives become equal to zero: $y_1 = y_2 = 0$, $g_1 = g_2 = 0$, and $p_1 = p_2 = 0$.

Next, we will show the effects of the authorities' decisions when coping with shocks.

a) Non-cooperative solution: The competitive solution

The optimization problem of country 1 is as follows:

$$\begin{aligned} \min_{t_1} L_1 &= y_1^2 + \sigma_1 g_1^2 + \pi_1 p_1^2 \\ & \quad s.t.(26) \text{ and } (28) \end{aligned} \tag{32}$$

and the reaction function of country 1 (see Appendix):

$$t_{R,1} = -R_1 t_2 - R_2 f_1 \pm R_3 f_2 - R_4 m + s_1 + R_1 s_2 \tag{33}$$

where all the R's are positive.

The problem for country 2 is similar:

$$\begin{aligned} \min_{t_2} L_2 &= y_2^2 + \sigma_2 g_2^2 + \pi_2 p_2^2 \\ & \quad s.t.(27) \text{ and } (29) \end{aligned} \tag{34}$$

from which we obtain:

$$t_{R,2} = -R_1 t_1 - R_2 f_2 \pm R_3 f_1 - R_4 m + s_2 + R_1 s_1 \tag{35}$$

where all the R's are again positive.

The Nash-Cournot equilibrium is given by the point where the reaction functions intersect:

$$t_{N,1} = -N_{1,1} f_1 \pm N_{1,2} f_2 - N_{1,3} m + s_1 \tag{36}$$

$$t_{N,2} = \pm N_{2,1} f_1 - N_{2,2} f_2 - N_{2,3} m + s_2 \tag{37}$$

where $N_{1,i}; N_{2,i} > 0, i = 1, 2, 3.$

b) Cooperative solution: The social planner problem

With the weights of each country equal to $\frac{1}{2}$, the social planner problem would be:

$$\begin{aligned}\min_{t_1,t_2} \mathfrak{L} &= \left[\frac{1}{2}(y_1^2 + \sigma_1 g_1^2 + \pi_1 p_1^2) + \frac{1}{2}(y_2^2 + \sigma_2 g_2^2 + \pi_2 p_2^2)\right] \\ & s.t.(26) \text{ to } (29) \end{aligned} \tag{38}$$

From the first-order conditions we obtain (see Appendix):

$$t_{C,1} = \pm C_{1,1} f_1 \pm C_{1,2} f_2 - C_{1,3} m + C_{1,4} s_1 + C_{1,5} s_2 \tag{39}$$

$$t_{C,2} = \pm C_{2,1} f_1 \pm C_{2,2} f_2 - C_{2,3} m + C_{2,4} s_1 + C_{2,5} s_2 \tag{40}$$

where $C_{1,i}; C_{2,i} > 0, i = 1, ..., 5.$

When shocks are transmitted leading to the "locomotive effect" the authorities use contractionary supply-side policies when dealing with expansionary shocks, and expansionary supply-side policies when dealing with contractionary shocks. Moreover, both in the competitive solution and in the cooperative solution, the sign (expansionary or contractionary) of the policy is the same than in the optimal response given by the reaction function.

But in the "beggar-thy-neighbour" case, the supply-side policies used to deal whit real shocks from the monetary union have an ambiguous sign. From this result we can conclude that the cooperative solution will not always coincide with the optimal response given by the reaction function, since in those cases the instability of the cooperative solution would increase. The reason is that the cooperative solution would not be on the reaction function and, in addition, would not coincide with the optimal individual policy response of each country.

3.3 Welfare aspects of the optimal solution

From the reduced form -equations (26) to (29)- we can see that the target variables (y_1, y_2) and (p_1, p_2) are linear in the policy instruments (t_1, t_2). So, we can plot both the reaction functions and the indifference curves in the t_1–t_2 plane, in the same way that in the two-country model (subsection 2.2).

If the authorities find optimal a contractionary (expansionary) policy to offset the effects of the shock, the reaction functions shift to the left (right). When the aggregate demand is the channel of transmission of the shocks, supply-side policy coordination in a monetary union would result undesirable for the union member countries, when they cope with demand shocks in general (see Figures 1 and 2). However, for supply shocks within the monetary union, cooperation could be desirable, but only for the country where the shock occurs (see Figure 3). It can be proved that (see Appendix), in the "locomotive effect" case, for positive shocks externalities are also positive, and for negative shocks externalities are negative. For that reason cooperation would be undesirable, since it internalizes externalities that reinforce the effect of the shock and requires a greater change in the institutional variable. So, in order to avoid some of the adverse effects, it would be preferable not to coordinate.

On the other hand, different results about the desirability of coordination would appear when expansionary (contractionary) real shocks in a country of the union translate into a contraction (expansion) to the other country. Figure 4 and Figure 5 show that when the output of a country expands, the output of the other falls and cooperation results desirable since cooperative solutions require a lower change in the supply-side variable (see point C which represents the cooperative symmetric case) as compared to the Nash solution (point N).

Summarising the results obtained, we can derive the conditions under which coordination of supply policies may be desirable. These conditions are presented in Table 3.1, and show that for monetary and supply shocks, cooperation always results undesirable, but when dealing with real shocks, the channel of transmission proves to be determinant.

In particular, we find that cooperation may be desirable for shocks leading to different (asymmetric) effects between the two countries. In a monetary union, this happens only for real shocks transmitted through the "beggar-thy-neighbour effect", whereas monetary and supply-side shocks always lead to identical (symmetric) effects.

TABLE 3.1

DESIRABILITY OF SUPPLY POLICY COORDINATION IN A MONETARY UNION

SHOCK	COOPERATION
Monetary (m)	**Undesirable**
Real (f_1, f_2)	• "Locomotive effect": **undesirable** • "Beggar-thy-neigbour effect": **desirable**
Supply (s_1, s_2)	**Undesirable**

4 Conclusions

In this paper we have tried to analyse the desirability of supply-side intervention within a monetary union when dealing with shocks, provided that the countries suffer some restrictions in the use of fiscal policy. In order to offset the effects of the shocks the authorities use as a policy instrument a supply-side variable which could be interpreted as a way of institutional intervention on the labour market.

First, we developed a simple two-country model, that was later modified in order to describe a monetary union. After analysing the solutions for the two alternatives, we could conclude that coordinated labour market intervention would be desirable when the effects of the shocks are different in the involved economies, and so requiring a different policy response; in other words, when shocks are asymmetric. According to our results, this occurs when the "beggar-thy-neighbour effect" is the channel of transmission of demand shocks, both monetary and real, in the two-country model; and only of real shocks in the monetary union.

Summarising, a monetary union would require less use of coordinated supply-side intervention than a two-country model, since it would be desirable only for real shocks transmitted through the "beggar-thy-neighbour effect". The reason is that a monetary union does not allow for country-specific monetary shocks and, accordingly, these are always transmitted in the same way across the union's member countries; i.e., they are always symmetric. On the contrary, when monetary policy is conducted at the national level, we find that country-specific monetary shocks can lead to ambiguous effects across the two economies, depending on the transmission mechanism.

In other words, a monetary union would make monetary shocks always symmetric. Therefore, a monetary union would reduce the room for the cooperative setting of supply-side intervention, given that cooperation would be desirable only when dealing with asymmetric shocks.

As can be seen from the results, the country-specific origin of the shocks to deal with is not the only relevant characteristic when deciding whether coordination over intervention is desirable or not. The nature (demand or supply) and the channel of transmission of the shocks will be also determinant. For this reason, it would be crucial to know which would be the channel of transmission and the kind of disturbances actually prevailing in a particular monetary union. In relation to this, recall that Viñals and Jimeno (1998) proposed supply policies as a way to deal with real shocks in a monetary union. Linking this to our conclusions, if real shocks from the monetary union would prevail, and their effects would be transmitted according to the "beggar-thy-neighbour" effect, the desirability of the cooperative setting of supply side intervention in a monetary union would be greater.

5 Appendix

5.1 Two-country model

5.1.1 The reduced form

We obtain the aggregate demand of country 1 from equations (1) and (2):

$$y_1^d = \frac{\alpha}{D}(m_1 - p_1) + \frac{\beta\psi}{D}(e + p_2 - p_1) + \frac{\delta\psi}{D}y_2 + \frac{\psi}{D}f_1 \qquad \text{(A.1.1)}$$

where $D = \psi + \alpha\theta$

and, similarly, for country 2:

$$y_2^d = \frac{\alpha}{D}(m_2 - p_2) - \frac{\beta\psi}{D}(e + p_2 - p_1) + \frac{\delta\psi}{D}y_1 + \frac{\psi}{D}f_2 \qquad \text{(A.1.2)}$$

From equations (3) to (7), and replacing, we obtain the aggregate supply of country 1:

$$y_1^s = -\lambda(\varepsilon - 1)p_1 - \lambda\varepsilon\mu(e + p_2 - p_1) - \lambda s_1 + \lambda t_1 \qquad \text{(A.1.3)}$$

where $\lambda = \frac{1}{\eta+\varphi}$ and $s_1 = z_1 - v_1 - \frac{1}{\lambda}l_1 - \frac{1}{\lambda}prod_1$

and similarly for country 2:

$$y_2^s = -\lambda(\varepsilon - 1)p_2 + \lambda\varepsilon\mu(e + p_2 - p_1) - \lambda s_2 + \lambda t_2 \qquad \text{(A.1.4)}$$

From equation (2) in the main text, we obtain the equilibrium output in the money market, and replace it into the goods market equilibrium condition (equation (1)). Doing the same in the equations for country 2, and substracting, we obtain the real exchange rate between country 1 and country 2:

$$(e + p_2 - p_1) = \frac{(m_1-p_1)-(m_2-p_2)-\delta\theta(y_1-y_2)-\theta(f_1-f_2)}{2\beta\theta} \qquad \text{(A.1.5)}$$

Replacing (A.1.1) and the world interest rate, r, from equation (2) into equation (1) we obtain:

$$y_1 = a_1 m_1 - a_1 p_1 - a_2 m_1 + a_2 p_2 + a_3 y_2 + a_4 f_1 + a_4 f_2 \qquad \text{(A.1.6)}$$

and:

$$y_2 = a_1 m_2 - a_1 p_2 - a_2 m_2 + a_2 p_2 + a_3 y_1 + a_4 f_1 + a_4 f_2 \qquad \text{(A.1.7)}$$

Then, replacing (A.1.5) into the aggregate demand and aggregate supply -equations (A.1.3) and (A.1.4) - we obtain the following expressions:

$$p_1 = a_5 m_1 + a_5 p_2 - a_5 m_2 + a_6 y_1 - a_7 y_2 - a_8 f_1 + a_8 f_2 + a_9 s_1 - a_9 t_1 \qquad \text{(A.1.8)}$$

$$p_2 = a_5 m_2 + a_5 p_1 - a_5 m_1 + a_6 y_2 - a_7 y_1 - a_8 f_2 + a_8 f_1 + a_9 s_2 - a_9 t_2 \qquad \text{(A.1.9)}$$

where:

$$a_1 = \frac{2\theta\alpha+\psi}{\theta(2\psi+2\alpha\theta-\delta\psi)}, \qquad a_2 = \frac{\psi}{\theta(2\psi+2\alpha\theta-\delta\psi)}, \qquad a_3 = \frac{\delta\psi}{2\psi+2\alpha\theta-\delta\psi},$$

$$a_4 = \frac{\psi}{2\psi+2\alpha\theta-\delta\psi}, \qquad a_5 = \frac{\lambda\varepsilon\mu}{\lambda\varepsilon\mu+\lambda 2\beta\theta(1-\lambda\varepsilon\mu)}, \quad a_6 = \frac{(2\beta+\lambda\varepsilon\mu\delta)\theta}{\lambda\varepsilon\mu+\lambda 2\beta\theta(1-\lambda\varepsilon\mu)},$$

$$a_7 = \frac{\delta\theta\lambda\varepsilon\mu}{\lambda\varepsilon\mu+\lambda 2\beta\theta(1-\lambda\varepsilon\mu)}, \quad a_8 = \frac{\theta\lambda\varepsilon\mu}{\lambda\varepsilon\mu+\lambda 2\beta\theta(1-\lambda\varepsilon\mu)}, \quad a_9 = \frac{2\beta\theta\lambda}{\lambda\varepsilon\mu+\lambda 2\beta\theta(1-\lambda\varepsilon\mu)}$$

with $a_1 > a_2, a_2 > a_4$, $a_4 > a_3$, $a_6 > a_5$, and $a_8 > a_7$ and the denominators are all positive.

To obtain the equilibrium values for output and prices, we need to solve the system given by equations (A.1.6) to (A.1.9):

$$\begin{pmatrix} 1 & -a_3 & a_1 & -a_2 \\ -a_3 & 1 & -a_2 & a_1 \\ -a_7 & a_8 & 1 & -a_6 \\ a_8 & -a_7 & -a_6 & 1 \end{pmatrix} \begin{pmatrix} y_1 \\ y_2 \\ p_1 \\ p_2 \end{pmatrix} = \begin{pmatrix} a_1 m_1 - a_2 m_2 + a_4 f_1 + a_4 f_2 \\ -a_2 m_1 + a_1 m_2 + a_4 f_1 + a_4 f_2 \\ a_5 m_1 - a_5 m_2 - a_8 f_1 + a_8 f_2 + a_9 s_1 - a_9 t_1 \\ -a_6 m_1 + a_6 m_2 + a_9 f_1 - a_9 f_2 + a_9 s_2 - a_9 t_2 \end{pmatrix}$$

Equations (8) to (11) in the main text are the solution, where the coefficients are:

$$\overline{M}_y = [a_5(a_1 + a_2)(-1 + a_3 + a_5 - a_6(a_1 - a_2)) + a_1(a_1 a_7 - a_3 a_5 + a_2 a_6) -$$

$$a_2(a_3 + a_2(a_6 + a_7)) + a_1(1 - a_5^2 + a_6(a_1 - a_2 a_5) + a_7(a_2 - a_1 a_5))] \diagup \Delta$$

$$\overline{M'}_y = [a_5(a_1+a_2)(1-a_3-a_5-a_7(a_1-a_2)) - a_2(a_1a_7-a_3a_5+a_2a_6)+$$

$$a_1(a_3+a_2a_6+a_1a_7)) - a_2(1-a_5^2+a_6(a_1-a_2a_5)+a_7(a_2-a_1a_5))] \diagup \Delta$$

$$\overline{F}_y = [a_4(1-a_5^2(1+a_3)+a_3+(a_1+a_2)(a_6+a_7)(1-a_5))+$$

$$a_8((a_1+a_2)(1-a_5^2(1+a_3)-a_3+(a_1-a_2)(a_6+a_7)))] \diagup \Delta$$

$$\overline{F'}_y = [a_4(1-a_5^2(1+a_3)+a_3+(a_1+a_2)(a_6+a_7)(1-a_5))-$$

$$a_8((a_1+a_2)(1-a_5^2(1+a_3)-a_3+(a_1-a_2)(a_6+a_7)))] \diagup \Delta$$

$$\overline{S}_y = [a_9(-a_1(1+a_3a_5)-a_6(a_1^2-a_2^2)+a_2(a_3+a_5))] \diagup \Delta$$

$$\overline{S'}_y = [a_9(a_2(1+a_3a_5)-a_7(a_1^2-a_2^2)-a_1(a_3+a_5))] \diagup \Delta$$

$$\overline{M}_p = [a_5((1-a_3^2)(1-a_5)+a_6((1+a_5)(a_1-a_2a_3)+2a_5(a_1a_3-a_2)+$$

$$a_6(a_1^2-a_2^2)+a_7((1+a_5)(a_2-a_1a_3)+2a_5(a_2a_3-a_1)-a_7(a_1^2-a_2^2)))] \diagup \Delta$$

$$\overline{M'_p} = [(1-a_5)(a_6(a_1a_3-a_2)+a_7(a_2a_3-a_1)-a_5(1-a_3^2))] \diagup \Delta$$

$$\overline{F}_p = [a_4(a_6+a_7)((1+a_3)(1+a_5)+(a_1+a_2)(a_6+a_7))-$$

$$a_8(1-a_3)((1+a_3)(1-a_5)+(a_1-a_2)(a_6-a_7)] \diagup \Delta$$

$$\overline{F'}_p = [a_4(a_6+a_7)((1+a_3)(1+a_5)+(a_1+a_2)(a_6+a_7))+$$

$$a_8(1-a_3)((1+a_3)(1-a_5)+(a_1-a_2)(a_6-a_7)] \diagup \Delta$$

$$\overline{S}_p = [(1-a_3^2)+a_6(a_1-a_2a_3)+a_7(a_2-a_1a_3)] \diagup \Delta$$

$$\overline{S'}_p = [a_5(1-a_3^2)+a_6(a_2-a_1a_3)+a_7(a_1-a_2a_3)] \diagup \Delta$$

$$\Delta = [1-a_5^2(1-a_3^2)-a_3^2+a_1a_6(2+a_1a_6+2a_3a_5)+a_2a_7(2+a_2a_7+2a_3a_5)$$

$$-a_2a_6(2a_5+a_2a_6+2a_3)-a_1a_7(2a_5+a_1a_7+2a_3)] > 0$$

5.1.2 The coefficients of the reaction functions

The coefficients are equal, in absolute value, in both the "locomotive effect" and the "beggar-thy-neighbour effect" cases.

We have, for the reaction function of country 1:

$$\overline{R}_1 = \frac{\overline{S}_y\overline{S}'_y+\overline{S}_p\overline{S}'_p\pi_1}{\overline{S}^2_y+\overline{S}^2_p\pi_1} \qquad \overline{R}_2 = \frac{S_Y\overline{M}_Y+S_p\overline{M}_p\pi_1}{\overline{S}^2_y+\overline{S}^2_p\pi_1} \qquad \overline{R}_3 = \frac{S_y\overline{M}'_y+S_p\overline{M}'_p\pi_1}{\overline{S}^2_y+\overline{S}^2_p\pi_1}$$

$$\overline{R}_4 = \frac{\overline{S}_y\overline{F}_y+\overline{S}_p\overline{F}_p\pi_1}{\overline{S}^2_y+\overline{S}^2_p\pi_1} \qquad \overline{R}_5 = \frac{\overline{S}_y\overline{F}'_y+\overline{S}_p\overline{F}'_p\pi_1}{\overline{S}^2_y+\overline{S}^2_p\pi_1}$$

5.1.3 The Nash-Cournot solution

For country 1:

$$\overline{N}_{1,1} = \frac{\pm\overline{S}'_y\left(\overline{S}_y\overline{M}'_y+\overline{S}_p\overline{M}'_p\pi_1\right)-\overline{S}_y\left(\overline{S}_y\overline{M}_y+\overline{S}_p\overline{M}_p\pi_1\right)}{\left(\overline{S}^2_y+\overline{S}^2_p\pi_1\right)^2-\left(\overline{S}'^2_y+\overline{S}'^2_p\pi_1\right)^2}$$

$$\overline{N}_{1,2} = \frac{\overline{S}'_y\left(\overline{S}_y\overline{M}_y+\overline{S}_p\overline{M}_p\pi_1\right)\pm\overline{S}_y\left(\overline{S}_y\overline{M}'_y+\overline{S}_p\overline{M}'_p\pi_1\right)}{\left(\overline{S}^2_y+\overline{S}^2_p\pi_1\right)^2-\left(\overline{S}'^2_y+\overline{S}'^2_p\pi_1\right)^2}$$

$$\overline{N}_{1,1} = \frac{\pm\overline{S}'_y\left(\overline{S}_y\overline{F}'_y+\overline{S}_p\overline{F}'_p\pi_1\right)-\overline{S}_y\left(\overline{S}_y\overline{F}_y+\overline{S}_p\overline{F}_p\pi_1\right)}{\left(\overline{S}^2_y+\overline{S}^2_p\pi_1\right)^2-\left(\overline{S}'^2_y+\overline{S}'^2_p\pi_1\right)^2}$$

$$\overline{N}_{1,2} = \frac{\overline{S}'_y\left(\overline{S}_y\overline{F}_y+\overline{S}_p\overline{F}_p\pi_1\right)\pm\overline{S}_y\left(\overline{S}_y\overline{F}'_y+\overline{S}_p\overline{F}'_p\pi_1\right)}{\left(\overline{S}^2_y+\overline{S}^2_p\pi_1\right)^2-\left(\overline{S}'^2_y+\overline{S}'^2_p\pi_1\right)^2}$$

5.1.4 The cooperative solution

For country 1:

$$\overline{C}_{1,1} = \frac{\left(\overline{S}_y\overline{M}_y+\overline{S}'_y\overline{M}'_y+\overline{S}_p\overline{M}_p\pm\overline{S}'_p\overline{M}'_p\right)-\left(\overline{S}_y\overline{M}'_y+\overline{S}'_y\overline{M}_y+\overline{S}_p\overline{M}'_p+\overline{S}'_p\overline{M}_p\right)A}{A-1}$$

$$\overline{C}_{1,2} = \frac{\pm\left(\overline{S}_y\overline{M}'_y + \overline{S}'_y\overline{M}_y + \overline{S}_p\overline{M}'_p + \overline{S}'_p\overline{M}_p\right) - \left(\overline{S}_y\overline{M}_y + \overline{S}'_y\overline{M}'_y + \overline{S}_p\overline{M}_p + \overline{S}'_p\overline{M}'_p\right)A}{A-1}$$

$$\overline{C}_{1,1} = \frac{\left(\overline{S}_y\overline{F}_y + \overline{S}'_yF'_y + \overline{S}_p\overline{F}_p \pm \overline{S}'_p\overline{F}'_p\right) - \left(\overline{S}_y\overline{F}'_y + \overline{S}'_y\overline{F}_y + \overline{S}_p\overline{F}'_p + \overline{S}'_p\overline{F}_p\right)A}{A-1}$$

$$\overline{C}_{1,2} = \frac{\pm\left(\overline{S}_y\overline{F}'_y + \overline{S}'_yF_y + \overline{S}_p\overline{F}'_p + \overline{S}'_p\overline{F}_p\right) - \left(\overline{S}_y\overline{F}_y + \overline{S}'_y\overline{F}'_y + \overline{S}_p\overline{F}_p + \overline{S}'_p\overline{F}'_p\right)A}{A-1}$$

$$\overline{C}_{1,4} = \frac{\overline{S}_y^2 + \overline{S}_y'^2 + \overline{S}_p^2 + \overline{S}_p'^2 + 4\overline{S}_y^2\overline{S}_y'^2\overline{S}_p^2\overline{S}_p'^2\pi_1^2\pi_2^2}{A-1}$$

$$\overline{C}_{1,5} = \frac{\left[\left(\overline{S}_y^2 + \overline{S}_y'^2 + \overline{S}_p^2 + \overline{S}_p'^2\right) + 1\right]A}{A-1}$$

being $A = 2\overline{S}_y\overline{S}'_y\overline{S}_p\overline{S}'_p\pi_1\pi_2$

5.1.5 Externalities

THE LOCOMOTIVE EFFECT

$$\frac{\partial L_1}{\partial t_2} = 2\overline{S}'_y\left(\overline{M}_ym_1 + \overline{M}'_ym_2 + \overline{F}_yf_1 + \overline{F}'_yf_2 - \overline{S}_ys_1 - \overline{S}'_ys_2 + \overline{S}_yt_1 + \overline{S}'_yt_2\right)$$

$$-2\pi_1\overline{S}'_p\left(\overline{M}_pm_1 + \overline{M}'_pm_2 + \overline{F}_pf_1 + \overline{F}'_pf_2 + \overline{S}_ps_1 + \overline{S}'_ps_2 - \overline{S}_pt_1 - \overline{S}'_pt_2\right) \neq 0$$

$$\frac{\partial L_2}{\partial t_1} = 2\overline{S}'_y\left(\overline{M}'_ym_1 + \overline{M}_ym_2 + \overline{F}'_yf_1 + \overline{F}_yf_2 - \overline{S}_ys_2 - \overline{S}'_ys_1 + \overline{S}_yt_2 + \overline{S}'_yt_1\right)$$

$$-2\pi_2\overline{S}_p'\left(\overline{M}_p'm_1+\overline{M}_pm_2++\overline{F}_p'f_1+\overline{F}_pf_2+\overline{S}_ps_2+\overline{S}_p's_1-\overline{S}_pt_2-\overline{S}_p't_1\right)\neq 0$$

THE BEGGAR-THY-NEIGHBOUR EFFECT

$$\frac{\partial L_1}{\partial t_2}=2\overline{S}_y'\left(\overline{M}_ym_1-\overline{M}_y'm_2+\overline{F}_yf_1-\overline{F}_y'f_2-\overline{S}_ys_1-\overline{S}_y's_2+\overline{S}_yt_1+\overline{S}_y't_2\right)$$

$$-2\pi_1\overline{S}_p'\left(\overline{M}_pm_1-\overline{M}_p'm_2+\overline{F}_pf_1+\overline{F}_p'f_2+\overline{S}_ps_1+\overline{S}_p's_2-\overline{S}_pt_1-\overline{S}_p't_2\right)\neq 0$$

$$\frac{\partial L_2}{\partial t_1}=2\overline{S}_y'\left(\overline{M}_ym_2-\overline{M}_y'm_1+\overline{F}_yf_2-\overline{F}_y'f_1-\overline{S}_ys_2-\overline{S}_y's_1+\overline{S}_yt_2+\overline{S}_y't_1\right)$$

$$-2\pi_2\overline{S}_p'\left(\overline{M}_pm_2-\overline{M}_p'm_1+\overline{F}_pf_2+\overline{F}_p'f_1+\overline{S}_ps_2+\overline{S}_p's_1-\overline{S}_pt_2-\overline{S}_p't_1\right)\neq 0$$

5.2 The model for a monetary union

5.2.1 The reduced form

We obtain the aggregate demand of country 1:

$$y_1^d=\tfrac{2\alpha}{D}m-\tfrac{\alpha+2\beta\psi}{D}p_1-\tfrac{\alpha-2\beta\psi}{D}p_2+\tfrac{2\delta\psi-\alpha\theta}{D}y_2+\tfrac{2\psi}{D}f_1 \qquad \text{(A.2.1)}$$

where $D=2\psi+\alpha\theta$

and, similarly, for country 2:

$$y_2^d=\tfrac{2\alpha}{D}m-\tfrac{\alpha+2\beta\psi}{D}p_2-\tfrac{\alpha-2\beta\psi}{D}p_1+\tfrac{2\delta\psi-\alpha\theta}{D}y_1+\tfrac{2\psi}{D}f_2 \qquad \text{(A.2.2)}$$

We also obtain the aggregate supply of country 1:

$$y_1^s=-\lambda(\varepsilon-1)p_1-\lambda\varepsilon\mu(p_2-p_1)-\lambda s_1+\lambda t_1 \qquad \text{(A.2.3)}$$

where $\lambda=\frac{1}{\eta+\varphi}$ and $s_1=z_1-v_1-\frac{1}{\lambda}l_1-\frac{1}{\lambda}prod_1$

and for country 2:

$$y_2^s = -\lambda(\varepsilon - 1)p_2 + \lambda\varepsilon\mu(p_2 - p_1) - \lambda s_2 + \lambda t_2 \qquad \text{(A.2.4)}$$

To obtain the reduced form, we need to solve the system given by equations (A.2.1) to (A.2.4):

$$\begin{pmatrix} 1 & -a & b & c \\ -a & 1 & c & b \\ -d & 0 & 1 & -e \\ 0 & -d & -e & 1 \end{pmatrix} \begin{pmatrix} y_1 \\ y_2 \\ p_1 \\ p_2 \end{pmatrix} = \begin{pmatrix} gm + hf_1 \\ gm + hf_2 \\ is_1 - it_1 \\ is_2 - it_2 \end{pmatrix}$$

where

$$a = \tfrac{2\delta\psi - \alpha\theta}{2\psi + \alpha\theta} \quad b = \tfrac{\alpha + 2\beta\psi}{2\psi + \alpha\theta} \quad c = \tfrac{\alpha - 2\beta\psi}{2\psi + \alpha\theta} \quad d = \tfrac{1}{\lambda(1 - \varepsilon(1-\mu))}$$

$$e = \tfrac{\varepsilon\mu}{1 - \varepsilon(1-\mu)} \quad g = \tfrac{2\alpha}{2\psi + \alpha\theta} \quad h = \tfrac{2\psi}{2\psi + \alpha\theta} \quad i = \tfrac{1}{1 - \varepsilon(1-\mu)}$$

being $0 < a < 1, b > c$ and $0 < e < 1$

The solution is given by equations (26) to (29) in the main text,

$$y_1 = M_y m + F_y f_1 \pm F'_y f_2 - S_y s_1 - S'_y s_2 + S_y t_1 + S'_y t_2$$

$$y_2 = M_y m + F_y f_2 \pm F'_y f_1 - S_y s_2 - S'_y s_1 + S_y t_2 + S'_y t_1$$

$$p_1 = M_p m + F_p f_1 \pm F'_p f_2 + S_p s_1 + S'_p s_2 - S_p t_1 - S'_p t_2$$

$$p_2 = M_p m + F_p f_2 \pm F'_p f_1 + S_p s_2 + S'_p s_1 - S_p t_2 - S'_p t_1$$

where the coefficients are

$$M_y = \frac{g(1-e)[(1+e)(1+a)+d(b-c)]}{\Delta} \qquad M_p = \frac{gd[d(b-c)+(1+a)(1+e)]}{\Delta}$$

$$F_y = \frac{h[(1+e)(1-e)+d(b+ec)]}{\Delta} \qquad F_p = \frac{hd(1+bd+ae)}{\Delta}$$

$$F'_y = \frac{h[a(1+e)(1-e)-d(c+eb)]}{\Delta} \qquad F'_p = \frac{hd(a-cd+e)}{\Delta}$$

$$S_y = \frac{i[d(c+b)(c-b)-b(1+ae)-c(a+e)]}{\Delta} \qquad S_p = \frac{i[(a^2-1)-d(ac+b)]}{\Delta}$$

$$S'_y = \frac{i[c(1+ae)+b(a+e)]}{\Delta} \qquad S'_p = \frac{i[e(a^2-1)+d(ab+c)]}{\Delta}$$

being $\Delta = (1-e^2)+2d(b+ce)+(ae+bd)^2-(a-cd)^2 > 0$

5.2.2 The coefficients of the reaction functions

The coefficients are equal, in absolute value, in both the "locomotive effect" and the "beggar-thy-neighbour effect" cases.

We have, for the reaction function of country 1:

$$R_1 = \frac{S_y S'_y + S_p S'_p \pi_1}{S_y^2 + S_p^2 \pi_1} \quad R_2 = \frac{S_y F_y + S_p F_p \pi_1}{S_y^2 + S_p^2 \pi_1}$$

$$R_3 = \frac{S_y F'_y + S_p F'_p \pi_1}{S_y^2 + S_p^2 \pi_1} \quad R_4 = \frac{S_y M_y + S_p M_p \pi_1}{S_y^2 + S_p^2 \pi_1}$$

5.2.3 The Nash-Cournot solution

Country 1:

$$N_{1,1} = \frac{\pm S'_y\left(S_y F'_y + S_p F'_p \pi_1\right) - S_y\left(S_y F_y + S_p F_p \pi_1\right)}{\left(S_y^2 + S_p^2 \pi_1\right)^2 - \left(S_y'^2 + S_p'^2 \pi_1\right)^2}$$

$$N_{1,2} = \frac{S'_y\left(S_y F_y + S_p F_p \pi_1\right) \pm S_y\left(S_y F'_y + S_p F'_p \pi_1\right)}{\left(S_y^2 + S_p^2 \pi_1\right)^2 - \left(S_y'^2 + S_p'^2 \pi_1\right)^2}$$

$$N_{1,3} = \frac{\left(S_y M_y + S_p M_p \pi_1\right)\left(S'_y - S_y\right)}{\left(S_y^2 + S_p^2 \pi_1\right)^2 - \left(S_y'^2 + S_p'^2 \pi_1\right)^2}$$

Country 2:

$$N_{2,1} = N_{1,2} \qquad N_{2,2} = N_{1,1} \qquad N_{2,3} = N_{1,3}$$

5.2.4 The cooperative solution

Country 1:

$$C_{1,1} = \frac{\left(S_y F_y + S'_y F'_y + S_p F_p \pm S'_p F'_p\right) - \left(S_y F'_y + S'_y F_y + S_p F'_p + S'_p F_p\right) A}{A-1}$$

$$C_{1,2} = \frac{\pm\left(S_y F'_y + S'_y F_y + S_p F'_p + S'_p F_p\right) - \left(S_y F_y + S'_y F'_y + S_p F_p + S'_p F'_p\right) A}{A-1}$$

$$C_{1,3} = \frac{\left[M_y\left(S_y + S'_y\right) + M_p\left(S_p + S'_p\right)\right](1-A)}{A-1}$$

$$C_{1,4} = \frac{S_y^2 + S_y'^2 + S_p^2 + S_p'^2 + 4 S_y^2 S_y'^2 S_p^2 S_p'^2 \pi_1^2 \pi_2^2}{A-1}$$

$$C_{1,5} = \frac{\left[\left(S_y^2 + S_y'^2 + S_p^2 + S_p'^2\right) + 1\right] A}{A-1}$$

being $A = 2 S_y S'_y S_p S'_p \pi_1 \pi_2$

Country 2:

$$C_{2,1} = C_{1,2} \qquad C_{2,2} = C_{1,1} \qquad C_{2,3} = C_{1,3} \qquad C_{2,4} = C_{1,5} \qquad C_{2,5} = C_{1,4}$$

5.2.5 Externalities

THE LOCOMOTIVE EFFECT

$$\frac{\partial L_1}{\partial t_2} = 2S_y' \left(M_y m + F_y f_1 + F_y' f_2 - S_y s_1 - S_y' s_2 + S_y t_1 + S_y' t_2\right)$$

$$- 2\pi_1 S_p' \left(M_p m + F_p f_1 + F_p' f_2 + S_p s_1 + S_p' s_2 - S_p t_1 - S_p' t_2\right) \neq 0$$

$$\frac{\partial L_2}{\partial t_1} = 2S_y' \left(M_y m + F_y f_2 + F_y' f_1 - S_y s_2 - S_y' s_1 + S_y t_2 + S_y' t_1\right)$$

$$- 2\pi_2 S_p' \left(M_p m + F_p f_2 + F_p' f_1 + S_p s_2 + S_p' s_1 - S_p t_2 - S_p' t_1\right) \neq 0$$

THE BEGGAR-THY-NEIGHBOUR EFFECT

$$\frac{\partial L_1}{\partial t_2} = 2S_y' \left(M_y m + F_y f_1 - F_y' f_2 - S_y s_1 - S_y' s_2 + S_y t_1 + S_y' t_2\right)$$

$$- 2\pi_1 S_p' \left(M_p m + F_p f_1 - F_p' f_2 + S_p s_1 + S_p' s_2 - S_p t_1 - S_p' t_2\right) \neq 0$$

$$\frac{\partial L_2}{\partial t_1} = 2S_y' \left(M_y m + F_y f_2 - F_y' f_1 - S_y s_2 - S_y' s_1 + S_y t_2 + S_y' t_1\right)$$

$$- 2\pi_2 S_p' \left(M_p m + F_p f_2 - F_p' f_1 + S_p s_2 + S_p' s_1 - S_p t_2 - S_p' t_1\right) \neq 0$$

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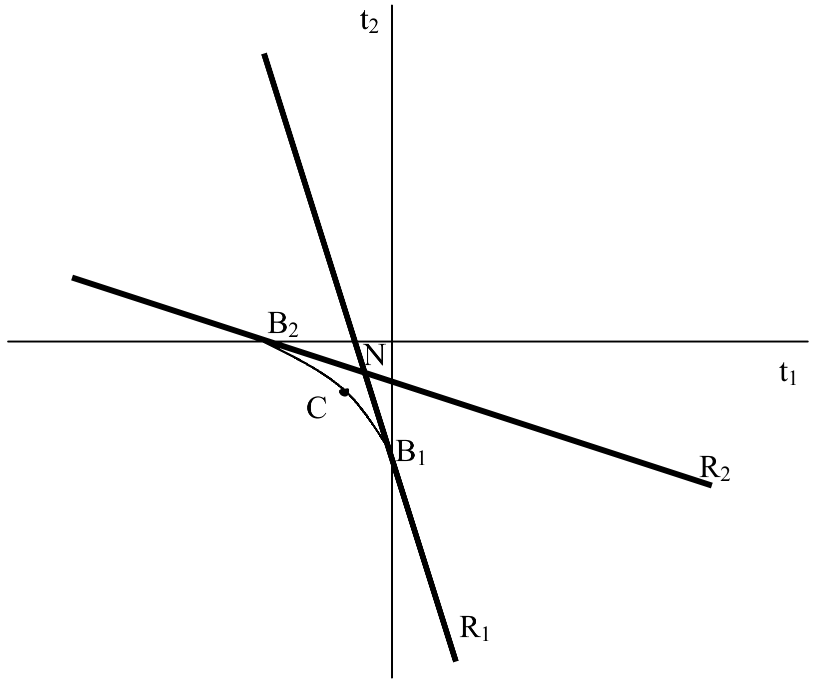

Figure 1: Expansionary shock in both countries. Cooperation undesirable.

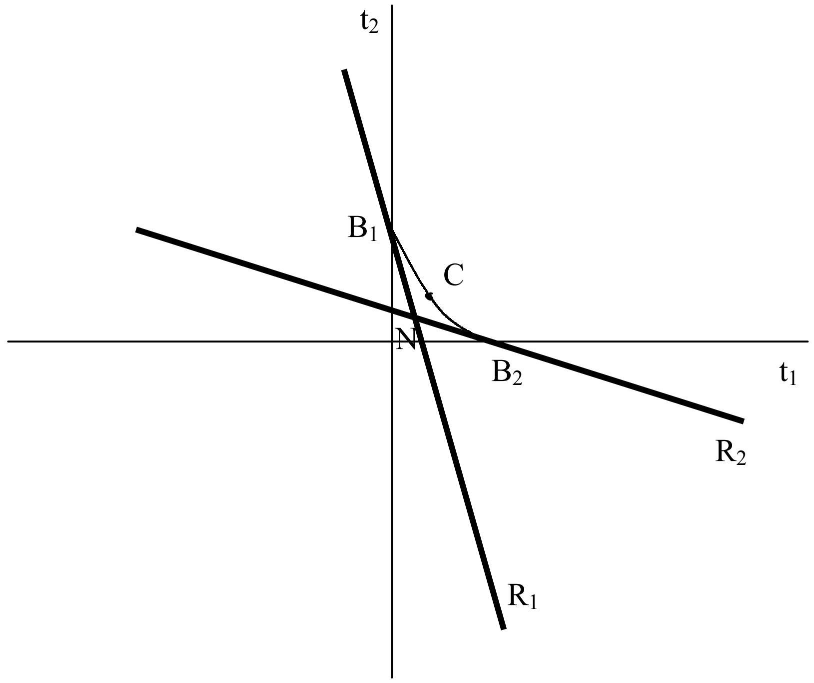

Figure 2: Contractionary shock in both countries. Cooperation undesirable.

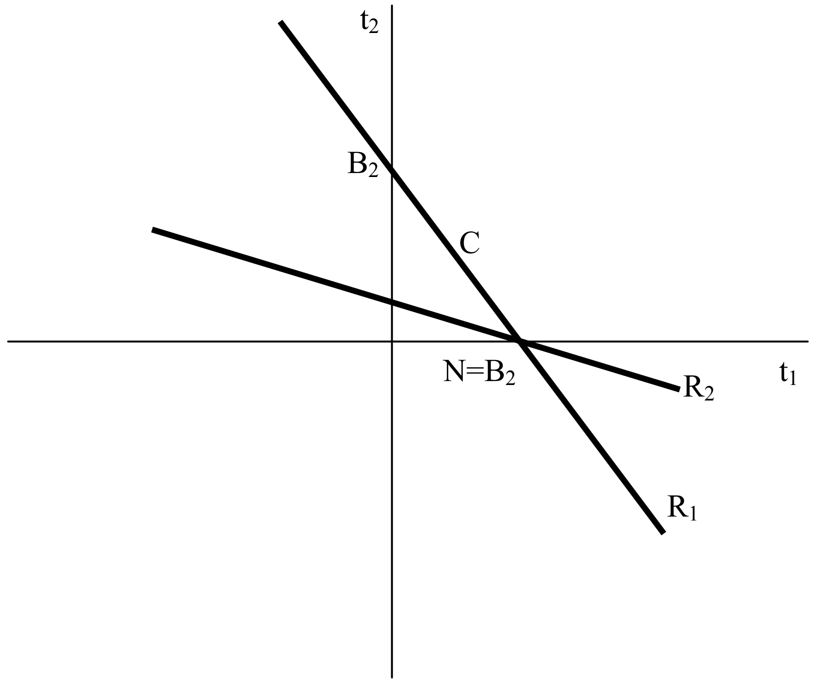

Figure 3: Contractionary supply shock in country 1. Cooperation desirable for country 1 and undesirable for country 2.

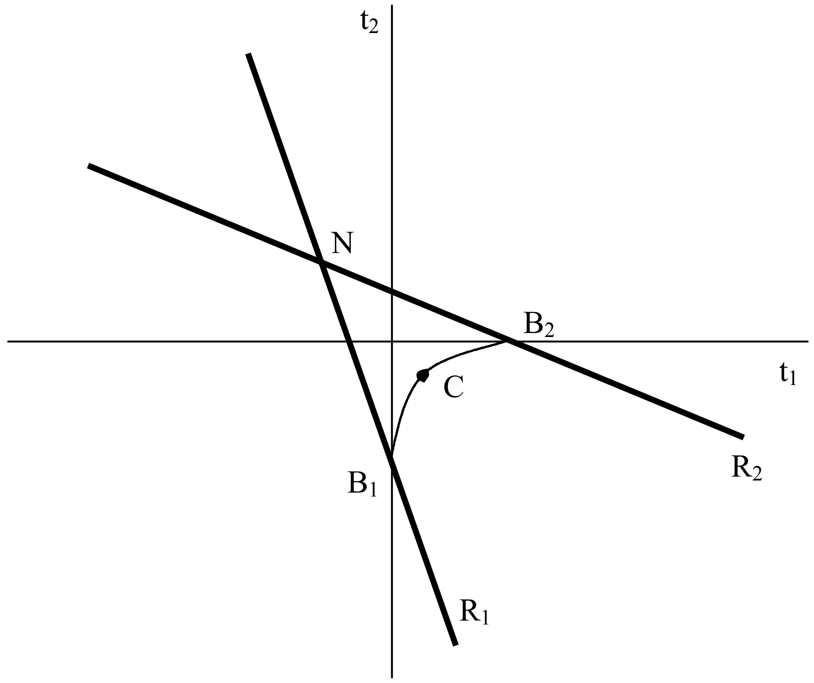

Figure 4: Expansionary demand shock in country 1, contractionary in country 2. Cooperation desirable.

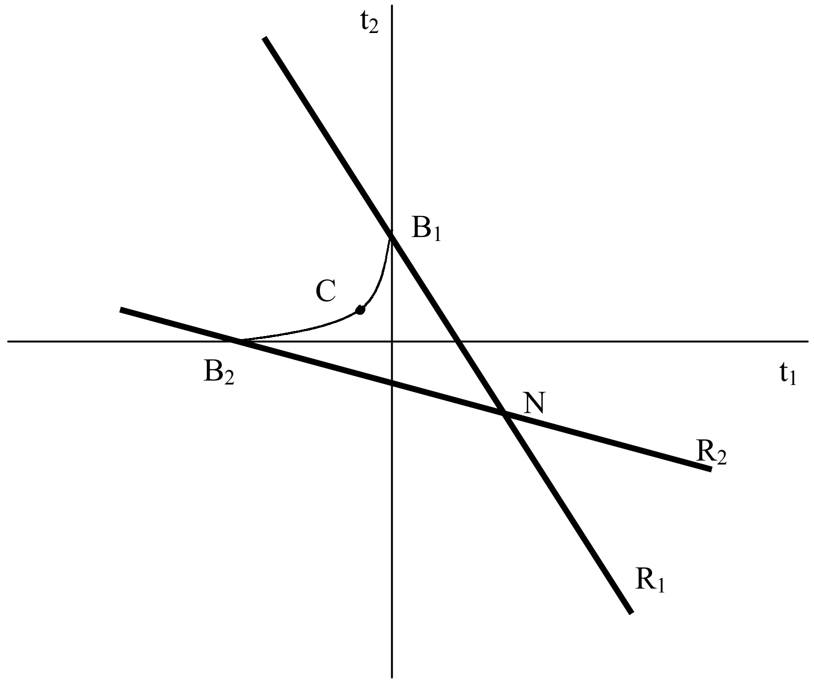

Figure 5: Expansionary demand shock in country 2, contractionary in country 1. Cooperation undesirable.