MONETARY UNIONS UNDER FINANCIAL SHOCKS: DO FISCAL RULES MATTER?

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Abstract

The recent problems generated by the economic and financial crisis have led to some debate on the role of economic policies. The question is to which extent a specific monetary policy regime would impose a restriction to policymakers. In particular, the cost of losing independence in the use of the exchange rate and monetary policy, and the restrictions derived from the fiscal discipline required for supporting monetary agreements.

As an example we can think on the expected success of the European Economic and Monetary Union (EMU), related to the benefits of the single currency, the higher degree of integration of financial markets, and also to the sound public finances guaranteed by the set of fiscal rules provided by EMU. When signing the Stability and Growth Pact (SGP), Member States committed themselves to reach a medium-term budgetary position close to balance. The Maastricht Treaty stresses as basic that the Member States of the EMU should avoid excessive deficits, and the reference values for deficit-to-GDP and debt-to-GDP ratios have worked in fact as an explicit fiscal rule. But, in practice, the policy orientation of the SGP has not been fully satisfied. This has opened a debate about the utility and effectiveness of fiscal rules in EMU, and on their complementarities with discretionary fiscal policy measures and automatic stabilisers to deal with short-run fluctuations. The aim of this paper is to investigate how to deal with monetary (financial) shocks in a monetary union following fiscal rules. In particular, we will analyse the interaction among those members showing a relatively high level of public debt and those that seem to follow a more strict fiscal discipline.

Key words: fiscal discipline, stabilization, monetary unions.

JEL Classification: F10, F50.

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1. Introduction

The recent financial crisis is considered to be the worst crisis since the Great Depression of the 1930s. After the collapse of financial institutions there has been a decline in economic activity and an increase of unemployment that have contributed to a global economic recession. There are several explanations for such a big crisis (see Reinhart and Rogoff (2009) for a survey of financial crises), but there is no consensus about how it could be avoided.

The macroeconomic problems generated by the economic and financial crisis have led to some debate on the role of economic policies. But most of macroeconomic models do not seem to capture specifically the role of financial markets. As far as we know a financial crisis is generally modelled as a monetary negative shock, and theoretical findings reveal that the effects of the monetary (financial) shocks depend on the international linkages and channels of transmission of monetary policy, which are related to the particular exchange rate regime (see Díaz-Roldán (2004), for example).

Regarding exchange rate regimes, recent experiences (such as the speculative attacks on currencies in the European Monetary System in 1992-1993, the default on Mexican debt in 1994, the devaluations and the banking crises across Asia in 1997-1998, the Argentine crises in 2001 and the financial crisis of 2007... followed by a global recession) have shown the increasing difficulty for a country to build the reputation needed to sustain a fixed exchange rate system. The ultimate reason is the spectacular growth of world capital markets, following the continuous liberalization and deregulation of capital movements that occurred in last years. So, if a government's compromise of maintaining a certain exchange rate is not believed as credible by financial markets, huge speculative attacks at such a massive scale would occur. All this has led to some authors (e.g., Obstfeld and Rogoff, 1995) to suggest that, in the near future, the choice faced by a country would be either maintaining a flexible exchange rate or adopting a common currency, rather than a fixed exchange rate, with other related countries. Moreover, from a macroeconomic point of view it is clear that a system of fixed exchange rates (and full capital mobility) implies that there is only one system-wide monetary policy. National currencies would become perfect substitutes through the irrevocable fixing of exchange rates if they became equally appropriate for the three classical functions of money, namely: unit of account, store of value and medium of exchange. For those reasons, a monetary union has been suggested as an alternative to a system of fixed exchange rates.

As an example, the expected success of the European Economic and Monetary Union (EMU) was related to the benefits of the single currency, the higher degree of integration of financial markets, and also to the sound public finances guaranteed by the set of fiscal rules provided by EMU. When signing the Stability and Growth Pact (SGP), Member States committed themselves to reach a medium-term budgetary position close to balance. The Maastricht Treaty stresses as basic that the Member States of the EMU should avoid excessive deficits; and the reference values for deficit-to-GDP and debt-to-GDP ratios, have worked in practice as an explicit fiscal rule. But, in practice, the policy orientation of the SGP has not been fully satisfied. This has opened a debate about the utility and effectiveness of fiscal rules in EMU, and on their complementarities with discretionary fiscal policy measures and automatic stabilisers to deal with short-run fluctuations.

There is no a wide literature on fiscal rules. Ballabriga and Martínez-Mongay (2003) estimate monetary and fiscal rules for the euro-zone, concluding that monetary policy rules are not enough to guarantee price stability, and that they should be accompanied by an explicit public deficit objective. Debrun *et al.* (2008) study the relationship between fiscal discipline and fiscal rules in the EU-25, and they found that fiscal rules lead to more stable budget policies and less pro-cyclical fiscal policies. Brzozowski and Siwińska-Gorzelak (2010) analyse the impact of fiscal rules on fiscal policy volatility. From their results they conclude that rules based on deficit control are more destabilizing than those based on imposing a limit to public debt. More recently, Díaz-Roldán and Montero-Soler (2011) analyse the convenience of using fiscal rules for the New Member States (NMS) of the EMU. And they found that the success of fiscal policy decisions depend on the symmetric or asymmetric nature of the shocks to deal with.

The aim of this paper is to investigate how to deal with monetary (financial) shocks in a monetary union. In particular, we will analyse the interaction among those members showing a relatively high level of public debt and those that seem to follow a more strict fiscal discipline. We will examine the consequences of monetary (financial) shocks when there is a single monetary policy and the domestic authorities are constrained by the fiscal discipline imposed by the monetary agreements of a monetary union following an explicit fiscal policy rule.

The paper is structured as follows: the macroeconomic model is presented in section 2; section 3 shows the empirical results; and, finally, section 4 concludes.

2. The Macroeconomic Model

We will follow Díaz-Roldán and Montero-Soler (2009). Our starting point is a "small" monetary union formed by two symmetric countries, where nominal exchange rate disappears among countries. Variables are defined as logarithmic deviations from their equilibrium levels (see Appendix for details). The aggregate demand and the aggregate supply functions for each country are as follows:

$$y_1 = -a\Delta p_1 \pm b\Delta p_2 \pm cy_2 + hg_1 + v_1 \qquad (1)$$

$$y_2 = -a\Delta p_2 \pm b\Delta p_1 \pm cy_1 + hg_2 + v_2 \qquad (2)$$

$$y_1 = t\Delta p_1 - s_1 \qquad (3)$$

$$y_2 = t\Delta p_2 - s_2 \qquad (4)$$

Equations (1) and (2) represent the aggregate demand function for each member country of the monetary union, where y_1, y_2 are outputs, Δp_1, Δp_2, inflation rates, g_1, g_2 the budget deficits, i.e., the fiscal policy instrument, and v_1, v_2 capture any kind of expansionary demand shock. Equations (3) and (4) represent the aggregate supply function for each member country of the monetary union, where s_1, s_2 capture any kind of contractive supply shock.

We find that a contractive supply shock (s_1, $s_2 > 0$), always leads to a fall in output in both countries, while positive demand shocks (v_1, $v_2 > 0$) lead to positive effects on the output and prices of the country of origin of the shock. But when the demand shock is transmitted across the two countries, the sign of the coefficients depends on which channel of transmission prevails.

The channels of transmission of such disturbances are those related with the international trade: the aggregate demand, the interest rate, and the real exchange rate (i.e., relative prices in monetary unions). When a country's aggregate demand increases, also increases foreign goods' imports, and the result is the called "*locomotive*" effect, i.e., 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. In our case, we would find an aggregate demand expansion with an output expansion and a rise in prices in the two countries.

Regarding the interest rate, the development and integration of financial markets implies that interest rates are determined by world markets. High interest rates attract cross-border investments until the equilibrium is reached, but under imperfect capital mobility, domestic interest rates will diverge from world interest rates, inducing capital inflows or outflows depending on whether they are higher or lower than the world rates.

When changes in the real exchange rate prevail, the result is the "*beggar-thy-neighbour"* effect, i.e., the effects on the output and prices of one country are transmitted abroad with the opposite sign. The reason is that a real exchange rate depreciation (appreciation) in an economy means an appreciation (depreciation) in the other, which leads to an aggregate demand expansion (recession) in that economy, and to a recession (expansion) in the other.

Looking at the coefficients of the equations of the model (see Appendix) the "*beggar-thy-neighbour"* effect prevails when countries are particularly concerned by inflation targeting and output stabilization. This would be the case for a monetary union following a monetary policy rule.

Solving (1) to (4), we obtain the reduced forms:

$$y_1 = \mathrm{A}\, hg_1 + \mathrm{A}\, v_1 \pm \mathrm{B}\, hg_2 \pm \mathrm{B}\, v_2 - \mathrm{C}\, s_1 - \mathrm{D}\, s_2 \qquad (5)$$

$$y_2 = \mathrm{A}\, hg_2 + \mathrm{A} v_2 \pm \mathrm{B}\, hg_1 \pm \mathrm{B}\, v_1 - \mathrm{C}\, s_2 - \mathrm{D}\, s_1 \qquad (6)$$

$$\Delta p_1 = \mathrm{A}' hg_1 + \mathrm{A}' v_1 + \mathrm{B}' hg_2 + \mathrm{B}' v_2 + \mathrm{C}' s_1 + \mathrm{D}' s_2 \qquad (7)$$

$$\Delta p_2 = \mathrm{A}' hg_2 + \mathrm{A}' v_2 + \mathrm{B}' hg_1 + \mathrm{B}' v_1 + \mathrm{C}' s_2 + \mathrm{D}' s_1 \qquad (8)$$

To take into account the role of fiscal rules, we will follow Ballabriga and Martínez-Mongay (2003). So, we will consider a fiscal rule which relates an explicit public deficit target (in terms of the GDP), g^o, with public debt deviations (in terms of the GDP) respect to its optimal level ($d_{-1} - d^o$), and the output level y:

$$g_i^o = -\ [\delta(d_{i,-1} - d_i^o) + \theta y_i] \qquad i = 1, 2 \qquad (9)$$

The public deficit adjusts according to the following path, where $0 \leq \rho \leq 1$:

$$g_i = (1-\rho) g_i^o + \rho g_{i,-1} \qquad (10)$$

Adding together the variables that are given in period 1, we obtain the simplified fiscal rules for each member country of the union:

$$g_1 = k_1 - \lambda y_1 \qquad (11)$$

$$g_2 = k_2 - \lambda y_2 \qquad (12)$$

Notice that if $(d_{i,-1} - d_i^o) > 0$, then $k_i < 0$, indicating a country with a relatively high level of debt. And the opposite holds for $k_i > 0$, indicating a country with a relatively low level of debt.

We will assume that fiscal authorities will try to minimize their loss function constrained by the economic framework (given by the reduced form of the macroeconomic model), and the explicit fiscal rule. Their goals are to minimize output changes, with stabilization purposes, and to minimize public deficit changes, in order to achieve fiscal discipline. Regarding inflation, since our model describes a monetary union, we assume full delegation of prices control to the monetary authority; therefore, public deficit will be the only policy instrument available.

In this framework, the set of policy makers decisions are the following: (i) Independent decision and no fiscal rule in any country, (ii) Coordinated decision and no fiscal rule in any country, (iii) Independent decision and fiscal rule in both countries, (iv) Coordinated decision and fiscal rule in both countries, and (v) Coordinated decision and fiscal rule only in one country. Notice we are assuming that coordination (the cooperative symmetric solution) means to implement an identical policy response.

The most interesting is case (v), because (i) to (iv) result trivial. For the case of no country adopting fiscal rules (or the adoption of fiscal rules in both countries), cooperation would not the best solution when the shocks have asymmetric effects on the output. The reason is that when facing shocks, leading to different effects the best policy response would be using different fiscal policies. When both countries adopt a fiscal rule, the results differ from the case with no fiscal rules only in the size of the coefficients: graphically it is just a change of scale.

Next we show the optimization problems. Solving them, we will obtain the set of optimal (fiscal) policies, i.e., the optimal level of public deficit (see Appendix for details).

(i) Independent decision and no fiscal rule in any country

$$\min_{g_i} \quad L_i = y_i^2 + \sigma g_i^2$$

s.t. $y_i = y_i\,(\ldots)$ $i = 1,2.$

where $L_i = y_i^2 + \sigma g_i^2 \quad i = 1,\ 2$ is the loss function of the fiscal authority. In order to describe the concern on deficit control, we assume $\sigma > 1$.

Solution (see Appendix): $g_1^N = -G_1^N v_1 \pm G_2^N v_2 + G_3^N s_1 \pm G_4^N s_2$

(ii) Coordinated decision and no fiscal rule in any country

$$\min_{g_1, g_2} \quad \ell = \left[\frac{1}{2} L_1 + \frac{1}{2} L_2\right]$$

s.t. $y_1 = y_1\,(\ldots)$

$y_2 = y_2\,(\ldots)$

Solution (see Appendix): $g_1^C = -G_1^C v_1 \pm G_2^C v_2 \pm G_3^C s_1 \pm G_4^C s_2$

(iii) Independent decision and fiscal rule in both countries

$$\min_{g_i} \quad L_i = y_i^2 + \sigma g_i^2$$

s.t. $y_i = y_i\,(\ldots)$

$g_i = g_i\,(\ldots)$ $i = 1,2.$

Solution (see Appendix): $g_1^{N,R} = -G_1^{N,R} v_1 \pm G_2^{N,R} v_2 + G_3^{N,R} s_1 \pm G_4^{N,R} s_2$

(iv) Coordinated decision and fiscal rule in both countries

$$\min_{g_1, g_2} \quad \ell = \left[\frac{1}{2} L_1 + \frac{1}{2} L_2\right]$$

s.t. $y_1 = y_1\,(\ldots)$

$y_2 = y_2\,(\ldots)$

$g_1 = g_1\,(\ldots)$

$g_2 = g_2\,(\ldots)$

Solution (see Appendix): $g_1^{C,R} = -G_1^{C,R} v_1 \pm G_2^{C,R} v_2 \pm G_3^{C,R} s_1 \pm G_4^{C,R} s_2$

(v) Coordinated decision and fiscal rule only in one country, we assume that country 1 follows the fiscal rule:

$$\min_{g_1, g_2} \ \ell = \left[\frac{1}{2}L_1 + \frac{1}{2}L_2\right]$$

$$\text{s.t.} \quad y_1 = y_1(...)$$

$$y_2 = y_2(...)$$

$$g_1 = k_1 - \lambda y_1$$

Solution (see Appendix): Notice we found no symmetric solution.

$$g_1^{C,R} = -G_1^{C,R} v_1 - G_2^{C,R} v_2 \pm G_3^{C,R} s_1 \pm G_4^{C,R} s_2$$

$$g_2^{C} = -G_1^{C} v_2 \pm G_2^{C} v_1 \pm G_3^{C} s_2 \pm G_4^{C} s_1$$

Given that fiscal authorities are aimed to minimize public deficit changes, in order to achieve fiscal discipline, the best response would be the one showing the minimal deviation from the equilibrium level. Since it would be tedious to compare the coefficients for each solution, in the next section we will perform an empirical application. We will assign numeric values to the coefficients, in order to evaluate the loose of adopting the policy responses given by the analytical solutions.

3. The costs and benefits of following a fiscal rule

As we mentioned in the introduction, there is a debate about the utility and effectiveness of fiscal rules, and on their complementarities with discretionary fiscal policy measures and automatic stabilisers to deal with short-run fluctuations. Particularly, in EMU, the Maastricht Treaty stressed as basic that the Member States of EMU should avoid excessive deficits; and the reference values for deficit-to-GDP and debt-to-GDP ratios, have worked in practice as an explicit fiscal rule. But the success of any kind of policy remains an empirical question.

In Table 1 the government deficit (+)/surplus(–) and government debt in percentage of GDP is shown for the EU-27. In 2010 the government deficit and the government debt of EU-27 was 6.6 and 80.1 respectively (both in percentage of the GDP)[1]. These figures are above the 3 and 60 limits required by the Maastricht Treaty. Moreover, the recent financial crisis is not a good environment, and contributes to

[1] Source: Eurostat.

create difficulties when deciding how to finance the public deficit. In such a context, the scope of fiscal policies in a monetary union seems to be reduced. If we look at the figures, 14 of the EU-27 countries show debt figures above 60% (Belgium, Germany, Ireland, Greece, Spain, France, Italy, Cyprus, Hungary, Malta, The Netherlands, Austria, Portugal and United Kingdom). Regarding the deficit ratio, only 5 countries (Denmark, Estonia, Luxembourg, Finland and Sweden) show figures below 3%.

In order to make an empirical application of our theoretical findings, we will make the following assumptions. The shocks suffered by the countries are identical in size (normalized to 1); in other words, they are perfectly symmetric in size. The shocks may differ in the sign: expansive (+) or contractive (–); so they are perfectly asymmetric in their effects. Next, we will give numerical values to the parameters of the reduced form according to the following criteria: In the fiscal rule, the response of the public deficit to changes in output will be neutral ($\lambda = 0.5$) to underline the relevance of the debt level: higher than the target ($k = -0.9$) or lower ($k = 0.9$). For comparability reasons we assign the value 1 to the aggregate supply slope ($t = 1$), and in the loss function we assume that fiscal authorities are more concerned about fiscal discipline, than about stability ($\sigma = 1.3$)[2].

[2] For the rest of the values see Appendix.

Table 1
Government deficit (-)/surplus (+) and debt in the EU-27 (% of GDP)

	2006	2007	2008	2009	2010
EU-27					
Deficit/surplus	-1.5	-0.9	-2.4	-6.9	-6.6
Debt	61.5	59	62.5	74.7	80.1
BELGIUM					
Deficit/surplus	0.1	-0.3	-1.3	-5.8	-4.1
Debt	88	84.1	89.3	95.9	96.2
BULGARIA					
Deficit/surplus	1.9	1.2	1.7	-4.3	-3.1
Debt	21.6	17.2	13.7	14.6	16.3
CZECH REPUBLIC					
Deficit/surplus	-2.4	-0.7	-2.2	-5.8	-4.8
Debt	28.3	27.9	28.7	34.4	37.6
DENMARK					
Deficit/surplus	5.2	4.8	3.2	-2.7	-2.6
Debt	32.1	27.5	34.5	41.8	43.7
GERMANY					
Deficit/surplus	-1.6	0.2	-0.1	-3.2	-4.3
Debt	68.1	65.2	66.7	74.4	83.2
ESTONIA					
Deficit/surplus	2.5	2.4	-2.9	-2.0	0.2
Debt	4.4	3.7	4.5	7.2	6.7
IRELAND					
Deficit/surplus	2.9	0.1	-7.3	-14.2	-31.3
Debt	24.7	24.8	44.2	65.2	92.5
GREECE					
Deficit/surplus	-5.7	-6.5	-9.8	-15.8	-10.6
Debt	106.1	107.4	113	129.3	144.9
SPAIN					
Deficit/surplus	2.4	1.9	-4.5	-11.2	-9.3
Debt	39.6	36.2	40.1	53.8	61
FRANCE					
Deficit/surplus	-2.3	-2.7	-3.3	-7.5	-7.1
Debt	63.7	64.2	68.2	79	82.3
ITALY					
Deficit/surplus	-3.4	-1.6	-2.7	-5.4	-4.6
Debt	106.1	103.1	105.8	115.5	118.4
CYPRUS					
Deficit/surplus	-1.2	3.5	0.9	-6.1	-5.3
Debt	64.7	58.8	48.9	58.5	61.5
LATVIA					
Deficit/surplus	-0.5	-0.4	-4.2	-9.7	-8.3
Debt	10.7	9	19.8	36.7	44.7

Source: Eurostat

Table 1 (cont.)
Government deficit (-)/surplus (+) and debt in the EU-27 (% of GDP)

	2006	2007	2008	2009	2010
LITHUANIA					
Deficit/surplus	-0.4	-1	-3.3	-9.5	-7
Debt	17.9	16.8	15.5	29.4	38
LUXEMBOURG					
Deficit/surplus	1.4	3.7	3	-0.9	-1.1
Debt	6.7	6.7	13.7	14.8	19.1
HUNGARY					
Deficit/surplus	-9.3	-5.1	-3.7	-4.6	-4.2
Debt	65.9	67	72.9	79.7	81.3
MALTA					
Deficit/surplus	-2.8	-2.4	-4.6	-3.7	-3.6
Debt	64.1	62.1	62.2	67.8	69
NETHERLAND					
Deficit/surplus	0.5	0.2	0.5	-5.6	-5.1
Debt	47.4	45.3	58.5	60.8	62.9
AUSTRIA					
Deficit/surplus	-1.5	-0.9	-0.9	-4.1	-4.4
Debt	62.3	60.2	63.8	69.5	71.8
POLAND					
Deficit/surplus	-3.6	-1.9	-3.7	-7.3	-7.8
Debt	47.7	45	47.1	50.9	54.9
PORTUGAL					
Deficit/surplus	-4.1	-3.1	-3.6	-10.1	-9.8
Debt	63.9	68.3	71.6	83	93.3
ROMANIA					
Deficit/surplus	-2.2	-2.9	-5.7	-9	-6.9
Debt	12.4	12.8	13.4	23.6	3.1
SLOVENIA					
Deficit/surplus	-1.4	0.0	-1.9	-6.1	-5.8
Debt	26.4	23.1	21.9	35.3	38.8
SLOVAKIA					
Deficit/surplus	-3.2	-1.8	-2.1	-8	-7.7
Debt	30.5	29.6	27.8	35.5	41
FINLAND					
Deficit/surplus	4.1	5.3	4.3	-2.5	-2.5
Debt	39.6	35.2	33.9	43.3	48.3
SWEDEN					
Deficit/surplus	2.3	3.6	2.2	-0.7	0.2
Debt	45	40.2	38.8	42.7	39.7
UNITED KINGDOM					
Deficit/surplus	-2.7	-2.7	-5	-11.5	-10.3
Debt	43.4	44.4	54.8	69.6	79.9

Source: Eurostat

According to the loss functions of the optimization problems described in section 2, in Table 2 we have computed looses when the countries of the monetary union are hit by a common contractive demand shock ($v_1 < 0 + v_2 < 0$), leading to contractive effects on output ($y_1 = -1.4103$, $y_2 = -0.2565$) and on inflation ($\Delta p_1 = -1.7317$, $\Delta p_2 = -1.0372$), but different in size.

Table 2

Looses after a common contractive demand shock ($v_1 < 0 + v_2 < 0$)

	NO FISCAL RULES IN ANY COUNTRY	FISCAL RULES IN BOTH COUNTRIES	FISCAL RULE ONLY IN ONE COUNTRY (Country 1)	
			High debt $k_1 < 0$	Low debt $k_1 > 0$
BEGGAR-THY-NEIGHBOUR EFFECT	$L_1 = 2.7155$	$L_1 = 2.9522$	$L_1 = 2.0594$	$L_1 = 3.0522$
	$L_2 = 2.0448$	$L_2 = 2.1147$	$L_2 = 0.0643$	$L_2 = 2.1233$
	$\ell = 2.0076$	$\ell = 2.0359$	$\ell = 2.6688$	$\ell = 2.0433$
LOCOMOTIVE EFFECT	$L_1 = 2.8646$	$L_1 = 2.9575$	$L_1 = 3.9831$	$L_1 = 3.8749$
	$L_2 = 0.0564$	$L_2 = 0.0483$	$L_2 = 3.4963$	$L_2 = 3.2447$
	$\ell = 3.2466$	$\ell = 3.1298$	$\ell = 3.2749$	$\ell = 3.1316$

Note: L_1 and L_2 are looses when countries act individually (Nash solution). While ℓ indicates looses when countries act in a coordinated way (Cooperative solution). In the coloured cases, the best response is not to implement an identical fiscal policy.

From figures in Table 2 we can conclude that the best fiscal policy response would be:

- Not cooperate when only those countries having a high debt adopt a fiscal rule (but not the rest of the countries), the whole union has suffered a common financial shock (losses are larger for the cooperative solution), and the *beggar-thy-neighbour* effect prevails. In that cases, the cooperative solution (ℓ) shows a higher loose than Nash solution (L_1 and L_2).
- Not cooperate if none country (or all the countries) have adopted a fiscal rule, and the whole union has suffered a common financial shock (losses are larger for the cooperative solution), when the *locomotive* effect prevails. The cooperative solution (ℓ) shows a higher loose than Nash solution (L_1 and L_2), again.

4. Summary and conclusions

In this paper, we have studied the implications of monetary (financial) shocks in monetary unions under different fiscal policy regimes. In particular we have analysed the interaction among member countries allowing them, on one hand, to exhibit higher or lower level of public debt and, on the other hand, to following or not an explicit fiscal rule. After solving the optimization problems, from the results given by the non-cooperative and cooperative solutions, we have found that for the case of either no country adopting fiscal rules or all countries adopting fiscal rules, cooperation is not the best solution when monetary shocks are transmitted leading to the *"locomotive"* effect. But for the case of only one country adopting the rule, cooperation is not the best solution when the shocks are transmitted leading to the *"beggar-thy-neighbour"*, and the country adopting the fiscal rule exhibits a high level of debt.

According to our model, the *"beggar-thy-neighbour"* effect prevails when countries are particularly concerned by inflation targeting and output stabilization. And we could think that this would be the case for a monetary union following a monetary policy rule. Therefore, we could conclude that for EU-27 countries it not would be desirable to implement an identical policy response when facing financial shocks and the countries with a higher level of debt follow an explicit fiscal rule.

APPENDIX

The macroeconomic model

$$y_1 = -\alpha r + \beta(p_2 - p_1) + \gamma y_2 + g_1 + f_1 \qquad (1.A)$$

$$y_2 = -\alpha r + \beta(p_1 - p_2) + \gamma y_1 + g_2 + f_2 \qquad (2.A)$$

$$r = \mu\left[\frac{1}{2}(\Delta p_1 + \Delta p_2) - \Delta p^o\right] + \frac{\varepsilon}{2}(y_1 + y_2) \qquad (3.A)$$

From (1.A) to (3.A) we obtain the aggregate demand for each country

$$\Delta w_1 = \Delta p_{1c}^E - \varphi u_1 + \phi \Delta prod_1 + z_1^w \qquad (4.A)$$

$$\Delta p_1 = \Delta w_1 - \phi \Delta prod_1 + z_1^p \qquad (5.A)$$

$$n_1 = y_1 - prod_1 \qquad (6.A)$$

$$p_{1c}^E = p_{1c,-1} \qquad (7.A)$$

$$p_{1c} = \eta p_1 + (1-\eta) p_2 \qquad (8.A)$$

$$u_1 \equiv l_1 - n_1 \qquad (9.A)$$

From (4.A) to (9.A) we obtain the aggregate supply for each country

The *"beggar-thy-neighbour"* effect prevails when countries are particularly concerned by inflation targeting and output stabilization (μ and ε, in the monetary rule — equation (3.A) — are high enough).

Aggregate demand coefficients

$$a = \frac{\alpha\mu + 2\beta}{2div} \quad b = \frac{\alpha\mu - 2\beta}{2div} \quad c = \frac{\alpha\varepsilon - 2\gamma}{2div}, \text{ siendo } div = \frac{2 + \alpha\varepsilon}{2},\ h = \frac{1}{div}$$

$$v_i = -\frac{\alpha}{div} r_A + \frac{\alpha\mu}{div}\Delta p^O + \frac{\beta}{div} p_{2,-1} - \frac{\beta}{div} p_{1,-1} + \frac{f_i}{div}$$

Aggregate supply coefficients

$$t = \frac{1}{\varphi}$$

$$s_i = -\frac{1}{\varphi}\Delta p_{c,-1} + l + prod - \frac{1}{\varphi}(z^p + z^w)$$

Reduced form

$$y_1 = -\frac{(a+t)}{den}\, t\,(hg_1 + v_1) \pm \frac{(b+ct)}{den}\, t\,(hg_2 + v_2) - \frac{(a-bc)t + a^2 - b^2}{den}\, s_1 - \frac{(b-ac)}{den}\, t\, s_2 \qquad (10.A)$$

$$y_2 = -\frac{(a+t)}{den}\, t\,(hg_2 + v_2) \pm \frac{(b+ct)}{den}\, t\,(hg_1 + v_1) - \frac{(a-bc)t + a^2 - b^2}{den}\, s_2 - \frac{(b-ac)}{den}\, t\, s_1 \qquad (11.A)$$

$$\Delta p_1 = -\frac{(a+t)}{den}\,(hg_1 + v_1) + \frac{(b+ct)}{den}\,(hg_2 + v_2) + \frac{(b+ct)c-(a+t)}{den}\, s_1 + \frac{(b-ac)}{den}\, s_2 \qquad (12.A)$$

$$\Delta p_2 = -\frac{(a+t)}{den}\,(hg_2 + v_2) + \frac{(b+ct)}{den}\,(hg_1 + v_1) + \frac{(b+ct)c-(a+t)}{den}\, s_2 + \frac{(b-ac)}{den}\, s_1 \qquad (13.A)$$

$den = (ct + b)^2 - (a + t)^2 < 0$

A $= -\dfrac{(a+t)}{den}\, t > 0$, B $= \dfrac{(b+ct)}{den}\, t > 0$, C $= \dfrac{(a-bc)t + a^2 - b^2}{den} > 0$ y D $= \dfrac{(b-ac)}{den}\, t > 0$

A' $= -\dfrac{(a+t)}{den} > 0$, B' $= \dfrac{(b+ct)}{den} > 0$, C' $= \dfrac{(b-ct)c-(a+t)}{den} > 0$ y D' $= \dfrac{(b-ac)}{den} > 0$

Independent decision and no fiscal rule in any country

Reaction functions:

$$q_1^N = \frac{ABh^2}{[A^2h^2+\sigma]},\ q_2^N = \frac{ABh}{[A^2h^2+\sigma]},\ q_3^N = \frac{A^2h}{[A^2h^2+\sigma]},\ q_4^N = \frac{ACh}{[A^2h^2+\sigma]},\ q_5^N = \frac{ADh}{[A^2h^2+\sigma]}$$

Nash:

$$G_1^N = -\frac{A^2h(A^2h^2+\sigma) - A^2B^2h^3}{(A^2h^2+\sigma)^2 - (ABh^2)^2}$$

$$G_2^N = \frac{ABh\sigma}{(A^2h^2+\sigma)^2 - (ABh^2)^2}$$

$$G_3^N = \frac{A^2BDh^3 + ACh(A^2h^2+\sigma)}{(A^2h^2+\sigma)^2 - (ABh^2)^2}$$

$$G_4^N = \frac{A^2BCh^3 + ADh(A^2h^2+\sigma)}{(A^2h^2+\sigma)^2 - (ABh^2)^2}$$

Coordinated decision and no fiscal rule in any country

$$g_1^C = g_1(g_2) = q_1^C g_2 + q_2^C v_2 - q_3^C v_1 + q_4^C s_1 + q_5^C s_2$$

$$q_1^C, q_2^C, q_3^C, q_4^C > 0, q_5^C\ ?$$

$$q_1^C = \frac{2ABh^2}{[(A^2+B^2)h^2+\sigma]}, q_2^C = \frac{2ABh}{[(A^2+B^2)h^2+\sigma]}, q_3^C = \frac{(A^2+B^2)h}{[(A^2+B^2)h^2+\sigma]}$$

$$q_4^C = \frac{(AC-BD)h}{[(A^2+B^2)h^2+\sigma]}, q_5^C = \frac{(AD-BC)}{[(A^2+B^2)h^2+\sigma]}$$

Cooperative solution:

$$G_1^C = -\frac{(A^2+B^2)h[(A^2+B^2)h^2+\sigma]-(2ABh)^2 h}{[(A^2+B^2)h^2+\sigma]^2-(2ABh^2)^2}$$

$$G_2^C = \frac{2ABh[(A^2+B^2)h^2+\sigma]^2 - h^2(A^2+B^2)}{[(A^2+B^2)h^2+\sigma]^2-(2ABh^2)^2}$$

$$G_3^C = \frac{2ABh^3(BC-AD)+[(A^2+B^2)h^2+\sigma]h(BD-AC)}{[(A^2+B^2)h^2+\sigma]^2-(2ABh^2)^2}$$

$$G_4^C = \frac{2ABh^3(BD-AC)+[(A^2+B^2)h^2+\sigma]h(BC-AD)}{[(A^2+B^2)h^2+\sigma]^2-(2ABh^2)^2}$$

Independent decision and fiscal rule in both countries

Reaction functions:

$$q_1^{N,R} = \frac{B}{A}, q_2^{N,R} = \frac{B}{Ah}, q_3^{N,R} = \frac{1}{h}, q_4^{N,R} = \frac{C}{Ah}, q_5^{N,R} = \frac{D}{Ah}, q_6^{N,R} = \frac{k_1\lambda\sigma}{Ah(1+\lambda^2\sigma)}$$

Nash:

$$G_1^{N,R} = -\frac{1}{h} - \frac{k_1\sigma\lambda}{h(1+\sigma\lambda^2)(A-B)} = \frac{(B-A)(1+\sigma\lambda^2)-k_1\sigma\lambda}{h(1+\sigma\lambda^2)(A-B)}$$

$$G_2^{N,R} = 0 - \frac{k_1\sigma\lambda}{h(1+\sigma\lambda^2)(A-B)}$$

$$G_3^{N,R} = \frac{(BD+AC)}{h(A+B)(A-B)} - \frac{k_1\sigma\lambda}{h(1+\sigma\lambda^2)(A-B)} = \frac{(BD+AC)(1+\sigma\lambda^2) - k_1\sigma\lambda(A+B)}{h(1+\sigma\lambda^2)(A+B)(A-B)}$$

$$G_4^{N,R} = \frac{(BC+AD)}{h(A+B)(A-B)} - \frac{k_1\sigma\lambda}{h(1+\sigma\lambda^2)(A-B)} = \frac{(BC+AD)(1+\sigma\lambda^2) - k_1\sigma\lambda(A+B)}{h(1+\sigma\lambda^2)(A+B)(A-B)}$$

Coordinated decision and fiscal rule in both countries

$$g_1^{C,R} = g_1(g_2) = q_1^{C,R} g_2 + q_2^{C,R} v_2 - q_3^{C,R} v_1 + q_4^{C,R} s_1 + q_5^{C,R} s_2 - q_6^{C,R}$$

$q_1^{C,R}, q_2^{C,R}, q_3^{C,R}, q_4^{C,R} > 0, q_5^{C,R}$ y $\left|q_6^{C,R}\right| > 0$ si $(Ak_1 - Bk_2) < 0$, $\left|q_6^{C,R}\right| < 0$ si $(Ak_1 - Bk_2) > 0$

$$q_1^{C,R} = \frac{2AB}{(A^2+B^2)},\quad q_2^{C,R} = \frac{2AB}{(A^2+B^2)h},\quad q_3^{C,R} = \frac{1}{h},\quad q_4^{C,R} = \frac{(AC-BD)}{(A^2+B^2)h}$$

$$q_5^{C,R} = \frac{(AD-BC)}{(A^2+B^2)h},\quad q_6^{C,R} = \frac{(Ak_1-Bk_2)\lambda\sigma}{(A^2+B^2)h(1+\lambda^2\sigma)}$$

Cooperative solution:

$$G_1^{C,R} = -\frac{1}{h} - \frac{(Ak_1-Bk_2)\sigma\lambda}{h(1+\sigma\lambda^2)(A-B)^2} = -\frac{(1+\sigma\lambda^2)(A-B)^2 + (Ak_1-Bk_2)\sigma\lambda}{h(1+\sigma\lambda^2)(A-B)^2}$$

$$G_2^{C,R} = 0 - \frac{(Ak_1-Bk_2)\sigma\lambda}{h(1+\sigma\lambda^2)(A-B)^2}$$

$$G_3^{C,R} = \frac{2AB(BC-AD) + (A^2+B^2)(BD-AC)}{h(A+B)^2(A-B)^2} - \frac{(Ak_1-Bk_2)\sigma\lambda}{h(1+\sigma\lambda^2)(A-B)^2} =$$

$$= \frac{[2AB(BC-AD) + (A^2+B^2)(BD-AC)](1+\sigma\lambda^2) - (A+B)^2(Ak_1-Bk_2)\sigma\lambda}{h(1+\sigma\lambda^2)(A+B)^2(A-B)^2}$$

$$G_4^{C,R} = \frac{2AB(BD-AC) + (A^2+B^2)(BC-AD)}{h(A+B)^2(A-B)^2} - \frac{(Ak_1-Bk_2)\sigma\lambda}{h(1+\sigma\lambda^2)(A-B)^2} =$$

$$= \frac{[2AB(BD-AC) + (A^2+B^2)(BC-AD)](1+\sigma\lambda^2) - (A+B)^2(Ak_1-Bk_2)\sigma\lambda}{h(1+\sigma\lambda^2)(A+B)^2(A-B)^2}$$

Coordinated decision and fiscal rule only in one country, we assume that country 1 follows the fiscal rule:

$$g_1^{C,R} = g_1(g_2) = q_1^{C,R} g_2 + q_2^{C,R} v_2 - q_3^{C,R} v_1 + q_4^{C,R} s_1 + q_5^{C,R} s_2 - q_6^{C,R}$$

$$q_1^{C,R}, q_2^{C,R}, q_3^{C,R}, q_4^{C,R}, q_5^{C,R} > 0 \text{ y } \left|q_6^{C,R}\right| > 0 \text{ when } k_1 > 0$$

$$q_1^{C,R} = \frac{AB(2+\sigma\lambda^2)}{(A^2(1+\sigma\lambda^2)+B^2)},\quad q_2^{C,R} = \frac{AB(2+\sigma\lambda^2)}{(A^2(1+\sigma\lambda^2)+B^2)h},\quad q_3^{C,R} = \frac{1}{h}$$

$$q_4^{C,R} = \frac{(AC(1+\sigma\lambda^2)-BD)}{(A^2(1+\sigma\lambda^2)+B^2)h},\quad q_5^{C,R} = \frac{(AD(1+\sigma\lambda^2)-BC)}{(A^2(1+\sigma\lambda^2)+B^2)h},\quad q_6^{C,R} = \frac{\sigma\lambda k_1 A}{(A^2(1+\sigma\lambda^2)+B^2)h}$$

$$g_2^C = g_2(g_1) = q_1^C g_2 + q_2^C v_2 - q_3^C v_1 + q_4^C s_1 + q_5^C s_2 - q_6^C$$

$$q_1^C, q_2^C, q_3^C, q_4^C, q_5^C > 0 \text{ y } \left|q_6^C\right| > 0 \text{ when } k_1 > 0$$

$$q_1^C = \frac{ABh^2(2+\sigma\lambda^2)}{h^2[A^2+B^2(1+\sigma\lambda^2)]+\sigma^2},\quad q_2^C = \frac{[A^2+B^2(1+\sigma\lambda^2)]h}{h^2[A^2+B^2(1+\sigma\lambda^2)]+\sigma^2},\quad q_3^C = \frac{ABh(2+\sigma\lambda^2)}{h^2[A^2+B^2(1+\sigma\lambda^2)]+\sigma^2}$$

$$q_4^C = \frac{(AC-BD(1+\sigma\lambda^2))}{h^2[A^2+B^2(1+\sigma\lambda^2)]+\sigma^2},\quad q_5^C = \frac{(AD-BC(1+\sigma\lambda^2))}{h^2[A^2+B^2(1+\sigma\lambda^2)]+\sigma^2},\quad q_6^C = \frac{\sigma\lambda k_1 B}{h^2[A^2+B^2(1+\sigma\lambda^2)]+\sigma^2}$$

Cooperative solution:

Country 1:

$$reg_1 = \frac{\sigma\lambda k_1 A[B^2(2+\sigma\lambda^2)+h(A^2+B^2(1+\sigma\lambda^2))+\sigma^2]}{h[(A^2(1+\sigma\lambda^2)+B^2)(h^2(A^2+B^2(1+\sigma\lambda^2))+\sigma^2)-(ABh(2+\sigma\lambda^2))^2]}$$

$$G_1^{C,R} = -\frac{1}{h} - reg_1$$

$$G_2^{C,R} = -\frac{AB(2+\sigma\lambda^2)\sigma^2}{(A^2(1+\sigma\lambda^2)+B^2)(h^2(A^2+B^2(1+\sigma\lambda^2))+\sigma^2)-(ABh(2+\sigma\lambda^2))^2} - reg_1$$

$$G_3^{C,R} = \frac{ABh(2+\sigma\lambda^2)[AD-BC(1+\sigma\lambda^2)]+[AC(1+\sigma\lambda^2)-BD](h^2(A^2+B^2(1+\sigma\lambda^2))+\sigma^2)}{(A^2(1+\sigma\lambda^2)+B^2)(h^2(A^2+B^2(1+\sigma\lambda^2))+\sigma^2)-(ABh(2+\sigma\lambda^2))^2} - reg_1$$

$$G_4^{C,R} = \frac{ABh(2+\sigma\lambda^2)[AC-BD(1+\sigma\lambda^2)]+[AD(1+\sigma\lambda^2)-BC](h^2(A^2+B^2(1+\sigma\lambda^2))+\sigma^2)}{(A^2(1+\sigma\lambda^2)+B^2)(h^2(A^2+B^2(1+\sigma\lambda^2))+\sigma^2)-(ABh(2+\sigma\lambda^2))^2} - reg_1$$

Country 2:

$$reg_2 = \frac{\sigma\lambda k_1 B[A^2(2+\sigma\lambda^2)h+A^2(1+\sigma\lambda^2)+B^2]}{(A^2(1+\sigma\lambda^2)+B^2)(h^2(A^2+B^2(1+\sigma\lambda^2))+\sigma^2)-(ABh(2+\sigma\lambda^2))^2}$$

$$G_1^C = \frac{(ABh(2+\sigma\lambda^2))^2-(A^2+B^2(1+\sigma\lambda^2))(A^2(1+\sigma\lambda^2)+B^2)h}{(A^2(1+\sigma\lambda^2)+B^2)(h^2(A^2+B^2(1+\sigma\lambda^2))+\sigma^2)-(ABh(2+\sigma\lambda^2))^2} - reg_2$$

$$G_2^C = -reg_2$$

$$G_3^C = \frac{ABh(2+\sigma\lambda^2)[AD(1+\sigma\lambda^2)-BC]+[AC-BD(1+\sigma\lambda^2)](h^2(A^2+B^2(1+\sigma\lambda^2))+\sigma^2)}{(A^2(1+\sigma\lambda^2)+B^2)(h^2(A^2+B^2(1+\sigma\lambda^2))+\sigma^2)-(ABh(2+\sigma\lambda^2))^2} - reg_2$$

$$G_4^C = \frac{ABh(2+\sigma\lambda^2)[AC(1+\sigma\lambda^2)-BD]+[AD-BC(1+\sigma\lambda^2)](h^2(A^2+B^2(1+\sigma\lambda^2))+\sigma^2)}{(A^2(1+\sigma\lambda^2)+B^2)(h^2(A^2+B^2(1+\sigma\lambda^2))+\sigma^2)-(ABh(2+\sigma\lambda^2))^2} - reg_2$$

Values for the empirical application

Beggar-thy-neighbour	Locomotive
$\varepsilon = 0.6$ $\mu = 0.8$	$\varepsilon = 0.6$ $\mu = 0.8$
$\alpha = 0.9$ $\beta = 0.1$ $\gamma = 0.1$	$\alpha = 0.9$ $\beta = 0.1$ $\gamma = 0.1$
$\varphi = 1$	$\varphi = 1$
$a = 0.3622$	$a = 0.9126$
$b = 0.2047$	$b = -0.8349$
$c = 0.1338$	$c = -0.0679$
$h = 0.7874$	$h = 0.9708$
A = 0.7824	A = 0.6727
B = 0.1944	B = 0.3175
C = 0.2436	C = 0.3488
D = 0.0897	D = 0.2718
$\sigma = 1.3$ $\lambda = 0.5$	$\sigma = 1.3$ $\lambda = 0.5$
$k_1 = -0.9$ or $k_1 = 0.9$	$k_1 = -0.9$ or $k_1 = 0.9$

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