

IMF Working Paper

Financial Stability and Fiscal Crises in a Monetary Union

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Abstract

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The main tasks of central banks are to secure price and financial stability. These objectives can, in times of crises, conflict with one another, and the central bank may have to renounce one of them in order to secure the other. In a monetary union, this trade-off can be exacerbated by the presence of highly indebted countries or by the risk of loose fiscal policies. This paper offers a simple theoretical model that captures the trade-off. Different fiscal *institutions* are compared in order to evaluate their impact on the conduct of monetary policy. More specifically, the fiscal criteria of the Maastricht Treaty and the Pact for Stability and Growth in Europe are analyzed in light of this model. Fiscal mechanisms exist to help prevent or minimize the risk of fiscal crises and the corresponding risk of central bank financing and inflation.

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I. INTRODUCTION

The advent of the European Monetary Union has altered the risk profile of public debt. By losing the possibility to print money to pay off domestic currency debt, the default risk substitutes to the inflation risk (or currency risk). This point has been made by Goodhart (1997) and McKinnon (1997b). Arnold and Lemmen (1999) provide empirical evidence of a negative relationship between inflation and default, and Jahjah (2000) offers a theoretical model supporting the empirical evidence. This change, in the nature of the risk attached to public debt, has far-reaching consequences for the financial market, prudential regulation, as well as for the design of the European fiscal environment. As Arnold and Lemmen (1999) point out, banks' domestic claims on the government represent an important percentage of their total domestic assets, increasing their vulnerability to fiscal crises in an EMU country. It is not surprising then that, in designing the European Monetary Union, the policymakers' main concerns were to secure price stability and fiscal discipline. Essentially, two approaches have been pursued to prevent governments from having recourse to some form of inflation financing. The first approach focused on fiscal criteria as embodied in the Maastricht Treaty and in the Pact for Stability and Growth. The second approach rests on the creation of a monetary institution with a clear mandate for price stability.

If the no-bailout clause in the Maastricht Treaty is credible, the financial market should correctly price the risk of default, higher borrowing costs should discipline profligate government, and there should be no excessive debt accumulation. If the no-bailout clause is not credible, a fiscal crisis can force an easing of the monetary policy and can endanger price stability in the Union. In a monetary union, a crisis in one country can spread to other countries with the possibility of a higher inflation rate. In the model, the inability of the central bank to commit to the inflation target does not stem from the low level of natural output but from the possibility of a financial crisis. A secondary objective of the central bank is to promote the smooth operation of payment systems. That objective is included explicitly in the objective function of the central bank.² In this framework, fiscal criteria on would-be members of the monetary union or penalties imposed on countries running excessive deficits can prevent or reduce the likelihood of fiscal crises, putting less stress on the central bank. The present model supports the need for fiscal criteria and contingent penalties. On the other side, fiscal coordination can have ambiguous effects and may exacerbate the central bank trade-off between inflation and financial stability. We see how fiscal coordination can affect the risk of fiscal crisis and the optimal monetary policy of the central bank.

The paper is structured as follows. In the next section we look at some stylized facts of monetary integration in Europe. In Section III, we develop the model. In Section IV, we

² This presentation does not necessarily reflect the European Central Bank's claim that its sole objective is price stability.

look at the optimal fiscal and monetary policy in a monetary union without any fiscal criteria or penalties. In Section V, we see how fiscal criteria and fiscal coordination can affect the optimal monetary policy of the central bank. Section VI summarizes the main results. The appendices contains the formal analysis of the paper.

II. SOME STYLIZED FACTS

Stability in the financial system appears to be a second major preoccupation for central bankers. In Capie and others (1994), Paul Volcker states “the concept of price stability is to be treasured and enshrined as the prime policy priority; that objective is inextricably part of a broader concern about the basic stability of the financial and economic system.” Karl-Otto Pohl says nothing else when he states that “a central bank has to think more and more about the financial stability in a wider sense, not only price stability, but stability in the financial system.” Jacques de Larosi re pursues the same idea by stating that “preventing systemic risks has become one of the major concerns of any central banker,” but he is “conscious that in some cases a multiplicity of objectives may lead to some contradictions.” These considerations appear to have played an important role in the design of the EMU and the Maastricht treaty. The focus is placed on fiscal soundness and the avoidance of persistent deficits or high indebtedness. If a fiscal crisis occurs the central bank cannot ignore the possibility of default and contagion effects to the banking and payment system. This could force the central bank to adjust and ease its monetary policy.

The most debated issues in the run-up to the EMU were (i) which countries to admit to the club, (ii) what preconditions, if any, should be imposed on would-be participants to join the union, and (iii) once in the union, how best to warrant price stability. It was agreed that those countries meeting the so-called Maastricht criteria would be accepted in the union. These criteria imposed convergence of inflation and interest rates, ceilings on public debt and limits on budget deficits. Interpretation of the fiscal criteria turned out to be soft, in order to let some highly indebted countries join the Union. However, low-indebted countries required a mechanism to ensure good fiscal policy once in the union. One potential risk for fiscal crisis is the large exposure of commercial banks to government bonds throughout the union. As pointed out by Arnold and Lemmen (1999), it is not rare to find commercial banks with more than 20 percent of their assets in claims on their domestic government, even up to 60 percent in one particular case. While the risk of a fiscal crisis seems remote, its consequence could be serious for the European financial institution, the stability of its currency and economic growth. The Pact for Stability and Growth imposes penalties on countries that run excessive fiscal deficits under some specific conditions.

Accounting for the stability of the financial system in the central bank’s objective function provides an interesting framework to analyze different issues related to the monetary integration. First, it gives rationale for the entry criteria of the Maastricht Treaty as well as for the Pact for Stability and Growth in which penalties are imposed on countries with loose fiscal policies. Second, it brings some insight in the debate on the feasibility and desirability

of fiscal coordination at the union level. Risk-sharing through a fiscal union could be an advantage as it may reduce the likelihood of a fiscal crisis in case of a bad shock to the economy; if this is true, the central bank is less likely to be distracted from its objective of price stability. On the other hand, such a transfer may weaken the fiscal discipline in the union (see Beetsma and Bovenberg, 2001) and therefore increase the risk of fiscal crises; in this case, the fiscal coordination could jeopardize the achievement of price stability. Whether or not that presentation accurately reflects the European Central Bank, it provides a stylized framework to assess current and future institutional aspects of monetary integration.

To sum up, the present model discussed below captures the main objectives of the European Central Bank, which are to achieve price stability and promote the smooth operation of the payment systems.³ Given the high exposure of banks towards government default, avoiding a financial crisis could force the central bank to intervene by directly buying government securities or by providing liquidity in troubled banks. In an attempt to prevent this, Articles 104 and 104a of the Maastricht Treaty ban direct central bank financing and access to favorable financing. Article 104b takes the constraint one step further, making each member responsible for servicing its own public debt, even in a fiscal crisis. If a member state fails to service its debt, neither the central bank nor other member states will bail the country out. The objective is to cut any potential link between the fiscal policy of a member state and the conduct of monetary policy. Whether these articles can credibly be enforced remains uncertain, but their existence is evidence that the policymakers were aware of this kind of financial risk.

III. THE MODEL

We develop a model with $n+1$ players, the central bank and n national governments. In period 0, the representative agent holds b_0 bonds, with a gross interest factor of R_b . That is, in period 1, the representative agent receives R_b units of output per unit of bonds held (expressed in per capita units of output). The representative agent holds physical capital k_0 that yields R (the constant interest factor of holding capital k) and holds cash m_0 (money bears no interest). Money demand is constant (inelastic to the interest rate), so real cash holdings are given by $M_0/P_0 = m_0$. Assuming perfect foresight, the agent is indifferent between bonds and capital, so we have:

$$(1 - \theta)(1 - \pi)R_b = R \quad (1)$$

The return of bonds, adjusted for the expected inflation tax π and the expected share of the debt that is not repaid θ , equals the return of the risk-free asset.

³ Per Article 105 of the Maastricht Treaty.

The inflation rate \hat{p} determines the inflation tax π and the seigniorage revenues. Seigniorage revenues s for the government are defined as the revenues from money growth. Let M_t be the money supply and P_t the price level. The amount of real resources that the government can obtain by increasing the money supply is:

$$\frac{M_1 - M_0}{P_1} = \frac{M_1}{P_1} - \frac{M_0}{P_0} \frac{P_0}{P_1},$$

so that seigniorage revenues s are equal to πm_0 with π equal to $\frac{\hat{p}}{1 + \hat{p}}$.⁴ For simplicity, we

assume that the agent's holdings of b_0 and M_0 are given. b_0 is the outstanding public debt before the advent of the monetary union. M_0 is the monetary base on which some seigniorage revenue can be derived.

Each government sets the tax rate τ and can default a share $\theta \in [0,1]$ of its bonds. The repudiation of one unit of real bond debt service incurs a cost to the government of $\alpha \in [0,1]$. The costs of outright default can be seen as some form of deadweight loss. They can also represent the costs of loss of credibility that would be reflected in future higher risk premiums. The cost of default explicitly enters the government budget constraint, which is given by:

$$\tau_i y_i + \pi m_{0i} = g_{1i} + (1 - \theta_i)(1 - \pi)R_{bi}b_{0i} + \alpha\theta_i(1 - \pi)R_{bi}b_{0i} \quad i = 1, \dots, N \quad (2)$$

where $(1 - \theta_i)(1 - \pi)R_{bi}b_{0i}$ is the total reimbursement of country i , net of default and the inflation tax. On the left-hand side of the budget constraint are the resources available to the government, [i.e. the tax receipts (τy) and the seigniorage revenue (πm_0)]. Government expenditures are exogenous. Using equation 2, total default on bonds is given by:

$$\theta_i R_{bi} b_{0i} = \frac{g_{1i} - \pi m_{0i} + (1 - \pi)R_{bi}b_{0i} - \tau_i y_i}{(1 - \alpha)(1 - \pi)} \quad i = 1, \dots, N \quad (3)$$

In period 1, the agent consumes all his wealth. The benevolent government maximizes the agent's consumption:

$$c_{1i} = (1 - \tau_i) y_i + (1 - \theta_i)(1 - \pi) R_{bi} b_{0i} + (1 - \pi) m_0 - z(\tau_i) - \Psi(\pi) \quad i = 1, \dots, N \quad (4)$$

⁴ $\pi=1$ corresponds to an infinite inflation rate, with the government appropriating all the possible revenue from seigniorage.

where y_i is the random consumers' endowment of labor income in period 1. With probability p and $1-p$, output is respectively low (y^L) or high (y^H). The second term represents the revenue from capital, and the third the cash holding net of the seigniorage tax. In this case τy represents tax paid to the government and $z(\tau_i)$ the deadweight cost of taxation. The welfare costs of inflation are represented by $\Psi(\pi)$. We assume that both $\Psi(\pi)$ and $z(\tau)$ are convex.^{5,6}

All countries in the union are completely identical except for their outstanding debt. Having said this, we will omit the subscript i on these variables that are identical. Each country has the same expected output, y , and the same structure of shock. The probability of being affected by a shock is identical across countries as well.

The central bank's objectives are to stabilize inflation around its target and to promote the stability of the payment system. The first objective is standard and aimed at limiting the cost of inflation. A natural way to formalize the second objective is to have the central bank attach a cost to default in its objective function. In a monetary union with n countries, the central bank loss function Ω is defined by:

$$\Omega = \frac{a}{2} (\Pi - \Pi^*)^2 + \sum_{i=1}^n \gamma_i \theta_i \quad (5)$$

where a is the weight attached to price stability relative to financial stability (default), and γ_i is the relative country size in the union.⁷ Such a formulation has several advantages. First, in the absence of a fiscal crisis the unique objective is to stabilize inflation.⁸ When a fiscal crisis does occur, the central bank cannot ignore the possibility of default and may be forced to adjust its monetary policy. Second, the approach recognizes the central bank's roles as lender of last resort and banker to the government. The central bank does not hold government bonds, but it values the cost associated to a fiscal crisis.

⁵ $\Psi(\pi)$ is such that $\Psi(0) = \Psi'(0) = 0$ and $\Psi''(\pi) > 0$ for all π .

⁶ Following Calvo (1988), $z(\tau)$ is such that $z(0) = 0 = z'(0)$; $z''(\tau) > 0$ for all τ and $\lim_{\tau \rightarrow 1} z'(\tau) = \infty = - \lim_{\tau \rightarrow -1} z'(\tau)$

⁷ γ_i can be defined by country i 's GDP in the union's GDP or by the share of country i debt in the aggregate debt of the union.

⁸ The literature traditionally assumes that the objective function of the central bank is to stabilize inflation and output around some potential level. In our model output is exogenous.

IV. OPTIMAL FISCAL AND MONETARY POLICY IN A MONETARY UNION

We look at Stackelberg equilibria, in which each government sets its fiscal policy after the central bank has implemented its monetary policy π . The government chooses τ_i to maximize c_{1i} , subject to the budget constraint (2), taking R_{bi} as given, and subject to $\theta_i \in [0, 1]$. Therefore τ_i must satisfy:

$$\frac{1}{y_i} z'(\tilde{\tau}_i) = \frac{\alpha}{1 - \alpha} \quad (6)$$

The optimal level of tax rate $\tilde{\tau}_i$ determines the optimal fiscal policy $(\theta_i(\pi), \tau_i^*)$ with:

$$\theta_i(\pi) = \begin{cases} 0 & \text{if } \tilde{\tau}_i y_i \geq g_{1i} + (1 - \pi) R_{bi} b_{0i} - \pi m_{0i} & \tau_i^* = \frac{g_{1i} + (1 - \pi) R_{bi} b_{0i} - \pi m_{0i}}{y_i} \\ 1 & \text{if } \tilde{\tau}_i y_i \leq g_{1i} + \alpha(1 - \pi) R_{bi} b_{0i} - \pi m_{0i} & \tau_i^* = \tilde{\tau}_i \\ \theta_i^* & \text{otherwise} & \tau_i^* = \tilde{\tau}_i \end{cases} \quad (7)$$

where:

$$\theta_i^* = \frac{g_{1i} - \pi m_{0i} + (1 - \pi) R_{bi} b_{0i} - \tilde{\tau}_i y_i}{(1 - \alpha)(1 - \pi) R_{bi} b_{0i}} \quad (8)$$

Assuming α is identical across countries, the optimal tax rate is identical and the default rate varies across countries depending on the stock of debt. If α is different across countries without affecting the results.

Given (8) and (9), there exist $\underline{\pi}_i$ and $\bar{\pi}_i$, so that for any inflation rate below $\underline{\pi}_i$, $\theta_i(\pi) = 1$. For any inflation rate above $\bar{\pi}_i$, $\theta_i(\pi) = 0$.^{9, 10} Figure 1 represents the default

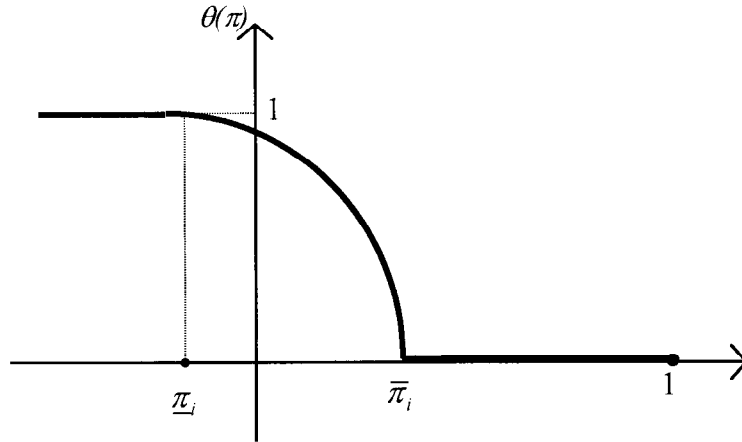
⁹ $\underline{\pi}_i = \frac{\alpha R_{bi} b_{0i} + g_{1i} - \tilde{\tau}_i y_i}{\alpha R_{bi} b_{0i} + m_{0i}}$ and $\bar{\pi}_i = \frac{R_{bi} b_{0i} + g_{1i} - \tilde{\tau}_i y_i}{\alpha R_{bi} b_{0i} + m_{0i}}$. Note that as α increases, $\underline{\pi}_i$ converges towards $\bar{\pi}_i$.

¹⁰ The first and second derivatives of $\theta(\pi)$ are shown respectively:

(continued...)

function with respect to inflation. Note that $\underline{\pi}_i$ and $\bar{\pi}_i$ depend positively on the cost of default, the stock of debt, and the interest rate on public debt.

Figure 1: Default and Inflation



An excessively tight monetary policy makes servicing and repaying the debt so costly that the optimal choice is to default, either partially or fully.

The central bank anticipates the governments' strategies. It minimizes its loss function (5) with respect to π , given (8) and (9). The following first-order condition determines the optimal monetary policy:

$$\Pi = \pi^* - \frac{1}{a} \sum_{i=1}^n \gamma_i \frac{\partial \theta_i}{\partial \Pi} \quad (9)$$

Since $\frac{\partial \theta_i}{\partial \Pi}$ is not positive, the optimal monetary policy is such that $\pi \geq \pi^*$. The following summarizes the results.

$$\theta'_i(\pi) = \begin{cases} 0 & \text{if } \pi < \underline{\pi}_i \\ 0 & \text{if } \pi > \bar{\pi}_i \\ \frac{g_{li} - m_{0i} - \tilde{\tau}_i y_i}{(1-\alpha) R_{bi} b_{0i} (1-\pi)^2} \leq 0 & \text{if } \underline{\pi}_i \leq \pi \leq \bar{\pi}_i \end{cases} \quad \text{and} \quad \theta''_i(\pi) \begin{cases} = 0 & \text{if } \pi < \underline{\pi}_i \\ = 0 & \text{if } \pi > \bar{\pi}_i \\ \leq 0 & \text{if } \underline{\pi}_i \leq \pi \leq \bar{\pi}_i \end{cases}$$

In the one-country case, the optimal monetary policy of the central bank simplifies to:

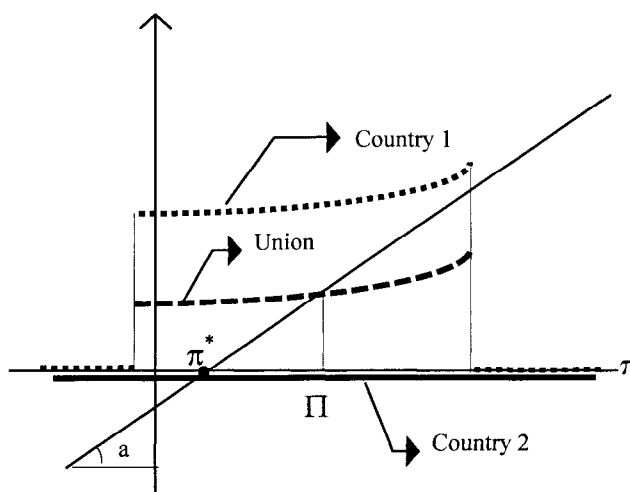
$$\Pi = \pi^* - \frac{1}{a} \frac{\partial \theta_1}{\partial \Pi}$$

The solution is given in Appendix I. The optimal monetary policy depends positively on the debt service, and negatively on the weight attached by the central bank to price stability, and the cost of default.

When debt service is sufficiently low, the central bank achieves its target. When debt service is high and the central bank does not attach an infinite weight to price stability, the central bank accommodates its monetary policy. The central bank adopts this strategy as long as the marginal cost of inflation is below the marginal benefit of limiting default. As the debt increases, an accommodating monetary policy simply increases the deviation from the inflation target, up to the point where the marginal gain of higher inflation is lower than its marginal cost. This result follows from the concavity of $\theta(\pi)$. The weight the central bank attaches to price stability determines the threshold level of debt above, which the central bank refuses to accommodate its monetary policy.

In the n -country case, the optimal monetary policy depends on the relative size of the countries forming the union. Inflation in equilibrium is higher than the target if, in one country at least, the debt service is too high. The deviation of the inflation rate from the target increases with the relative size of the highly indebted country(ies) in the union. We represent the first order condition 9 in Figure 2. Countries 1 and 2 respectively have a high and low level of debt service. Country 2 would achieve price stability outside the union but with country 1 in the union, the optimal monetary policy is Π .

Figure 2: Monetary Policy in a Union



A highly indebted country joining a monetary union can thus threaten both objectives of price stability and financial stability as the union's inflation rate is higher and the fiscally weak country cannot get enough financing from the central bank. In the next section, we analyze how fiscally strong countries can devise entry mechanisms that leave out fiscally-weak countries as well as mechanisms that prevent fiscal crises once in the union.

V. APPLICATION: THE EUROPEAN MONETARY INTEGRATION

In this section, we use the above framework to analyze the rationale for the Maastricht Treaty and the fiscal criteria that were imposed on future members of the EMU. Next, we see how the Pact for Stability and Growth can be effective in promoting fiscal discipline. In the same vein, we see how the conditional redistribution of seigniorage revenue can be used to discipline government. Finally, we look at simple forms of fiscal coordination and their impact of fiscal discipline and monetary policy.

A. The Maastricht Treaty and the Fiscal Criteria

It is in the interest of low-inflation countries to impose fiscal criteria on would-be participants. These criteria should be such that the central bank is not under pressure to accommodate its monetary policy. Therefore from (9) it should be true that

$$\frac{\partial \theta_i}{\partial \Pi} = 0, \forall i, i = 1, \dots, n, \text{ which simplifies to:}$$

$$\bar{\pi}_i \leq \pi^*, \forall i, i = 1, \dots, n \quad (10)$$

The latter conditions prevent the inflation rate from being higher than the target, regardless of what the preferences of the central bank may be. The economy achieves the equilibrium with no default $[\Pi = \pi^*; \theta_i(\Pi) = 0, \forall i = 1, \dots, n]$. Given the definition of $\bar{\pi}_i$, conditions (10) translate into the following fiscal criteria:

$$b_{0i} \leq \frac{\pi^* m_{0i} + t^*(\alpha) - g_{li}}{(1 - \pi^*) R_{bi}}, \forall i, i = 1, \dots, n \quad (11)$$

Conditions (11) relate the size of the public debt to the size of the government primary budget deficit and the nominal factor rate. It gives strong support to the fiscal criteria embodied in the Maastricht Treaty as well as to the required convergence in interest rates and factor rates. Conditions 11 are as close as we can get to the original criteria linking the deficit and the debt. The required convergence of inflation, and interest rate would, for a given deficit, provide a clear ceiling for the level of debt. (If three percent is the limit on the deficit (the numerator), and if inflation should converge to 2 percent and the nominal interest rate to 5 percent, the ceiling on the debt would be about 61 percent).

In a monetary union, these criteria have no rationale if one accepts the idea that the financial market exerts more discipline, imposing a tighter budget constraint such that the government cannot accumulate as much debt as is possible outside the union (Jahjah, 2000). However, in the transition towards a Monetary Union, these criteria are relevant: only those countries that have a stock of debt consistent with the new monetary regime are allowed to join the union. Conditions 11 set the limit beyond that to which a government is likely to default. As such, these criteria seriously reduce the risk of fiscal crises.

B. An Analysis of the Pact for Stability and Growth

To prevent poor fiscal policies from affecting the monetary policy of the central bank, fiscal criteria associated with the threat of sanctions or penalties can be designed to limit or prevent fiscal crises. However, to be effective, these penalties should increase the incentives for fiscal discipline. We show that such an optimal penalty exists.

Assume that a country is penalized whenever it repudiates its debt. The amount of the penalty is conditional on θ_i (the share of debt that is repudiated), and equal to $\theta_i S_i$, where S_i is the penalty paid when the government fully repudiates its debt. In this simple two-period model, this is the equivalent of imposing a penalty conditional on the deficit. The budget constraint of the government becomes:

$$\tau_i y + \pi m_{0i} = g_{1i} + (1 - \theta_i)(1 - \pi) R_{bi} b_{0i} + \alpha \theta_i (1 - \pi) R_{bi} b_{0i} + \theta_i S_i \quad (12)$$

The government's optimal fiscal policy becomes $\tau_i^*(\alpha, S_i)$ such that for any positive $S_i > S_j$, we have $\tau_i^*(\alpha, S_i) > \tau_i^*(\alpha, S_j)$, i.e., the higher the penalty, the higher the optimal level of taxes. There exists an optimal penalty S_i^* such that the optimal tax rate is equal to the tax rate which balances the budget, τ_i^b , at the central bank's inflation target. The optimal penalty S_i^* is increasing with the debt overhang and public expenditure, but decreasing with the cost of default. In the specific case of quadratic costs of taxation, $z(\tau) = \frac{d}{2} \tau^2$, the optimal penalty is:

$$S_i^* = d(1 - \alpha)(1 - \pi^*) R_{bi} b_{0i} \frac{(\tau_i^b - \tilde{\tau}_i(\alpha, 0)) y}{1 + d \tau_i^b y} \quad (13)$$

The threat of sanctions is therefore effective in increasing the optimal tax rate in the union, avoiding fiscal crises and central bank accommodation. This result holds for any value of the preference parameter of the central bank. The penalty, by increasing the tax rate, eliminates the risk of default. To be effective, however, the threat of penalty must be credible.

How can the penalty be enforced upon a country that would default? The above scheme is *ex ante* optimal. However, one might question the incentive for a country in a fiscal crisis to pay a penalty that would only aggravate the crisis. One might question the credibility of such a scheme. One solution is to require each government to deposit an initial amount S_{0i} prior to entry in a monetary union. Conditional on their fiscal policy, each country gets this amount back (plus an interest factor R) in period 1. Suppose this deposit is financed by new debt, then the initial stock of debt becomes $b_{0i} + S_{0i}$. Therefore the representative agent's consumption becomes:

$$c_i = (1 - \tau_i) y + Rk_i + (1 - \theta_i)(1 - \pi^*) R_{bi} (b_{0i} + S_{0i}) + (1 - \pi^*) m_{0i} - z(\tau_i) - \Psi(\pi^*)$$

The government budget constraint is:

$$\tau_i y + \pi^* m_{0i} + (1 - \theta_i) R S_{0i} = g_{li} + (1 - \theta_i)(1 - \pi^*) R_{bi} (b_{0i} + S_{0i}) + \alpha \theta_i (1 - \pi^*) R_{bi} (b_{0i} + S_{0i}) \quad (14)$$

The last term of the LHS of (14) is the amount that the government gets back in period 1, conditional on its fiscal policy. If there is no default, the full amount is transferred. We can solve for an optimal initial payment S_{0i}^* such that, in equilibrium, the government implements a fiscal policy with no default. In the quadratic case:

$$S_{0i}^* = \frac{S_i^*}{R - \frac{S_i^*}{b_{0i}}}$$

where S_i^* is defined by (13).

Such a scheme presents two advantages. First, the deposit signals the willingness to pursue a sound fiscal policy. Second, a fiscally-weak government has no direct control on the deposit and on the disbursement, which alleviates the credibility issue of the first scheme.

C. Redistribution of Seigniorage Revenues as a Discipline Device

Sinn and Feist (2000) show that the redistribution of seigniorage wealth, as suggested by article 32 of the Protocol No. 18 on the Statute of the European System of Central Banks, implies a net transfer from countries with a large monetary base to countries with a small monetary base. To increase the incentives of running sound fiscal policies, the distribution of

seigniorage revenues can be made conditional on the realized fiscal policy.¹¹ The budget constraint of the government becomes:

$$\tau_{1i} y_i + (1 - \theta_i) \pi m_{0i} = g_{1i} + (1 - \theta_i)(1 - \pi) R_{b_i} b_{0i} + \alpha \theta_i (1 - \pi) R_{b_i} b_{0i} \quad (15)$$

where the last term on the LHS of (15) represents the seigniorage revenues received by country i corrected by the share of the debt on which the government defaults. The optimal level of taxation is given by $\tau_i^*(\alpha, \pi)$. For any positive π we have $\tau_i^*(\alpha, \pi) > \tau_i^*(\alpha, 0)$. Moreover, for any $\pi_2 > \pi_1 > 0$, we have $\tau_i^*(\alpha, \pi_2) > \tau_i^*(\alpha, \pi_1) > \tau_i^*(\alpha, 0)$. A conditional distribution of seigniorage revenue increases the optimal level of taxes.

Interestingly, the (non-inflation) fiscal revenue increases with the inflation rate. In Sargent and Wallace (1981), an accommodating monetary policy alleviates the burden of the debt service without affecting the government's fiscal policy. In our framework, inflation not only alleviates the debt service, it also has a disciplinary effect on the fiscal policy. The default strategy of the government becomes:

$$\theta_i(\pi) = \frac{g_{1i} + (1 - \pi) R_{b_i} b_{0i} - \pi m_0 - \tau_i^*(\alpha, \pi) y_{1i}}{(1 - \alpha)(1 - \pi) R_{b_i} b_{0i} - \pi m_0}$$

Therefore, the size of the default is reduced when the distribution of seigniorage is conditional on the fiscal policy of the government. The conditional distribution of seigniorage revenue affects the optimal monetary policy in two ways. First, the central bank has a stronger incentive to be accommodating. Second, the accommodating inflation rate $\bar{\pi}_i$ is lower than the accommodating inflation rate under unconditional redistribution of seigniorage revenues.

D. Fiscal Coordination and Default

Fiscal coordination can affect the fiscal policy of each national government, depending on the nature of the coordination. For illustrative purpose we look at two simple cases of coordination. First, a government hit by a bad shock can receive a transfer from other governments in order to achieve its fiscal policy and to avoid a fiscal crisis. In a second kind

¹¹ There are different ways of measuring seigniorage revenues. We only consider the revenues from money creation (the flow approach). In doing so, we ignore the wealth (or stock) approach: the monetary base (which bears no interest rate) is backed by assets held in the central bank which bears positive returns that more than compensate the tiny costs of printing money. In this acceptance, it is also clear that the international use of such a currency considerably increases the seigniorage revenues.

of coordination, the representative agent gets a transfer if his country is hit by a bad shock. For example, a federal unemployment agency could distribute benefits to unemployed people. In what follows, we focus on the direct impact of such transfers to the optimal fiscal policy.

Direct Transfer to the Government

In this case, the representative agent's utility is captured by equation (4). A fraction c of his taxes finances the union-wide solidarity scheme. The budget constraint of the government becomes:

$$\tau_i y + \pi m_0 + \underbrace{t(y^H - y_i)\tau_i - c\tau_i y_i}_{\text{Net transfer}} = g_i + (1-\theta)(1-\pi)R_b b_0 + \alpha\theta(1-\pi)R_b b_0 \quad (16)$$

The transfer depends on the discrepancy between the output in the good state of nature y^H and the realized output y_i . The parameter t determines the degree of risk sharing. If $t=1$, the government recovers all the lost income tax caused by a bad shock. To finance this scheme, each government must renounce to a fraction c of its tax revenues. The government maximizes the representative agent's utility on its tax rate τ . Isolating θ in equation 16 and substituting it in equation 4 yields:

$$\theta_i(\pi) = \frac{g_{1i} + (1-\pi)R_{bi}b_{0i} - \pi m_0 - \tau_i(y_{1i} + t(y^H - y_{1i})) - c\tau_i y_{1i}}{(1-\alpha)(1-\pi)R_{bi}b_{0i}}$$

The optimal tax rate is determined by the first-order condition:

$$z'(\tau) = y_i \frac{\alpha + t \left(\frac{y^H - y_i}{y_i} \right) - c}{1-\alpha} \quad (17)$$

The solidarity scheme has an ambiguous impact on the optimal fiscal policy of the government, depending on the cost u associated to the solidarity scheme, on the degree of risk sharing t , and on the magnitude of the output shock. The higher the risk sharing and the size of the shock, the higher is the optimal level of taxes. However the ex ante tax rate c , imposed to finance the transfer, is such that the sum of all net transfers equals to zero. Therefore the tax rate c is given by:

$$c = t \frac{\sum_{i=1}^N p(y^H - y^L)\tau_i}{\sum_{i=1}^N (py^L - (1-p)y^H)\tau_i} = t \frac{p(y^H - y^L)}{py^L - (1-p)y^H} \quad (18)$$

The tax rate c increases with the degree of risk-sharing t and the output uncertainty p . Substituting (18) into (17), we have that the optimal tax rate in each country is determined by (6). Each country will set its optimal rate at the same level, irrespective of the existence or not of fiscal coordination.

Redistributive Transfers

In this case, the representative agent directly receives a transfer to alleviate the burden caused by the bad shock. The agent's utility is captured by the following equation:

$$c_1 = (1 - \tau - u) y_i + t(y^H - y_i) + (1 - \theta)(1 - \pi) R_b b_0 + (1 - \pi) m_0 - z(\tau + u) - \Psi(\pi) \quad (19)$$

where the transfer is $t(y^H - y_i)$ if output is low, and zero if output is high. t is the degree of insurance provided by the union. However, the representative agent faces a union tax, u , to finance the union solidarity scheme. The budget constraint of the government is unchanged:

$$\tau y + \pi m_0 = g_1 + (1 - \theta)(1 - \pi) R_b b_0 + \alpha \theta (1 - \pi) R_b b_0 \quad (20)$$

The government is not directly involved in the financing of this federal transfer mechanism. The representative agent pays the union tax and, in case of a bad shock, he is partially or totally compensated. However, the new tax has a negative impact on the optimal fiscal policy as each government reduces its optimal tax rate, which is now determined by the first-order condition:

$$\frac{1}{y_i} z'(\tilde{\tau}_i + u) = \frac{\alpha}{1 - \alpha}.$$

The impact is to reduce fiscal discipline at the national level, therefore increasing the possibility of a fiscal crisis, and possibly more inflation.

The fiscal costs of this mechanism depend on the nature of the shock. If the countries face *common* shocks, the expected transfers at the union level are $p t(y^H - y^L) N$; that is the probability p that the union experiences a bad shock multiplied by the magnitude of the shock adjusted by the degree of insurance. However, the federal union has to balance its budget and therefore, in case of common shock, in the present model, these transfers do not make sense as each country would only recover its contribution, rendering participation to the scheme not attractive.

If the countries face idiosyncratic shocks, the expected transfers in the union are given by $t(y^H - y^L)p^N \left\{ \sum_{i=0}^{N-1} \left(\frac{1-p}{p} \right)^i (N-i) \right\} N$, i.e., the probability that 1, 2, ... or N countries are hit by a bad shock, multiplied by the size of the transfer. Fiscal transfers at the union level can help achieve a certain level of insurance against output shock. However, the possibility of fiscal crises increases.

V. CONCLUSION

In a context in which the central bank's primary objectives are price and financial stability, the possibility of fiscal crises can force the central bank to trade inflation for more financial stability. This is truer in a monetary union where the public debt cannot be inflated away, leaving an increased likelihood of default. The central bank dilemma is further exacerbated when commercial banks own a sizable part of their assets in government securities. In a monetary union the risk profile of government bonds changes. The current paper addresses these issues by focusing on the link between inflation and fiscal crises (default) and how different mechanisms can affect that link in one way or another.

In this paper, we start from a central bank with a mandate for price and financial stability. This captures the trade-off a central bank could face in case of commercial banks exposed to government securities. The government sets its optimal tax policy and default strategy (if any). Default on the outstanding stock of bonds is the source of the financial instability in the model. Since the root of the financial instability is the fiscal policy, the model is well suited to determining the impact of different fiscal mechanisms on the optimal fiscal policy and the monetary policy.

Within this framework, there is a rationale to the Maastricht-type criteria, which prevent countries with high debt and loose monetary policy from joining a monetary union. These criteria reduce, at the outset of the monetary union, the risk of fiscal crises. Penalties, as developed in the Pact for Stability and Growth, can trigger sound fiscal policy and fully prevent fiscal crises. However, one assumption is crucial to have this result: the sanctions must be credible and enforceable. Redistributing seigniorage revenue conditional on the fiscal policy implemented by the government gives more incentive to implement a sound fiscal policy.

The possibility of fiscal coordination in a monetary union can have ambiguous impacts on the optimal fiscal and monetary policy. The nature of this coordination is also important. If the coordination is more of a solidarity mechanism between the governments, in which transfers are designed such that, in a bad state of nature, the shortfall in tax revenue is partially or completely compensated by the other member of the union, the optimal level of taxes is not affected. However, coordination directly aimed at the representative agent affected by a bad shock reduces the fiscal discipline at the national level, therefore increasing

the possibility of fiscal crises. The idea is that any fiscal mechanism that insures the representative agent alleviates some of the government responsibilities vis-à-vis its representative agent. The impacts of these transfers on the monetary policy are also ambiguous, depending on the outstanding stock of debt. In any case, reduced fiscal discipline increases the accommodating inflation rate.

If European integration has to deepen, fiscal coordination should be designed such that it does not exacerbate the conflicting objectives of the European Central Bank. The present model shows that fiscal coordination can have different impacts on the monetary policy of the central bank. A poorly designed fiscal federalism could complicate the conduct of the monetary policy. This is however beyond this paper and future research should focus further to the links between fiscal coordination and monetary policy.

Solution to the Optimization Problem of the Central Bank

A. $n=1$

The first-order condition can be written in the form $(\pi - \pi^*) = \frac{k}{(1 - \pi)^2}$, where

$k = \frac{t^*(\alpha) + m_0 - g_1}{a(1 - \alpha)R_b b_0} > 0$. Since $\frac{k}{(1 - \pi)^2}$ is strictly convex in $(-\infty, 1)$ and $(\pi - \pi^*)$ is linear, they will intersect at 0, 1 or 2 points. Tangency between the straight line and the curve occurs if $k = \frac{4}{27}(1 - \pi^*)^3$ in which case the point of contact is $\left(1 - \sqrt[3]{2k}, \frac{\sqrt[3]{2k}}{2}\right)$.

Remark 1: when $\frac{k}{(1 - \pi)^2} > (\pi - \pi^*)$, $\Omega'(\pi) < 0$, i.e., the central bank loss function is decreasing.

The reverse also applies, if $\frac{k}{(1 - \pi)^2} < (\pi - \pi^*)$, $\Omega'(\pi) > 0$ and the central bank loss function is increasing.

Therefore,

1. if $k = \frac{4}{27}(1 - \pi^*)^3$, the first-order condition has a unique solution, $\tilde{\pi} = \frac{1}{3}(1 + 2\pi^*)$.

Given remark 1, the optimal monetary policy is therefore $\pi = \tilde{\pi}$. Taking the monetary policy as given, the government responds by $\theta^*(\tilde{\pi}) = 0$.

2. if $k > \frac{4}{27}(1 - \pi^*)^3$, the first-order condition is never satisfied. Since $\frac{k}{(1 - \pi)^2} > (\pi - \pi^*)$, by remark 1, the unique minimum is to set $\pi = \tilde{\pi}$. The government responds with $\theta^*(\pi_H) = 0$.

3. if $k < \frac{4}{27}(1 - \pi^*)^3$, the first-order condition has two real solutions in $(-\infty, 1)$ and one in $(1, \infty)$. Rewriting the first-order condition, we have

$$\pi^3 + \pi^2(-\pi^* - 2) + \pi(1 + 2\pi^*) - \pi^* - k = 0. \text{ Using Cardan's solution of cubic}$$

equations¹², substitute $\pi = y + \frac{\pi^* + 2}{3}$ such that the square term disappears. Therefore, the

first-order condition becomes, $y^3 - \underbrace{\frac{1}{3}(\pi^* - 1)^2}_{p}y - \underbrace{\frac{2}{27}\pi^{*3} + \frac{2}{9}\pi^{*2} - \frac{2}{9}\pi^* + \frac{2}{27} - k}_{q} = 0$. Actually,

$q = \frac{2}{27}(1 - \pi^*)^3 - k$. Since the coefficients are real numbers and we are in the case of three

¹² Borofsky, Samuel (1950) "Elementary Theory of Equations," Macmillan, pp.114–127.

real roots, we know that the roots are given by:

$$\pi^{(1)} = \frac{2}{3}(1 - \pi^*) \cos \rho + \frac{\pi^* + 2}{3},$$

$$\pi^{(2)} = \frac{2}{3}(1 - \pi^*) \cos\left(\rho + \frac{2\pi}{3}\right) + \frac{\pi^* + 2}{3},$$

$$\pi^{(3)} = \frac{2}{3}(1 - \pi^*) \cos\left(\rho + \frac{4\pi}{3}\right) + \frac{\pi^* + 2}{3}$$

with ρ solving $\cos 3\rho = \frac{27}{2} \frac{k}{(1 - \pi^*)^3} - 1$. Since $3\rho \in [0, \pi]$, $\rho \in [0, \pi/3]$. Therefore,

$\pi^{(1)} > 1 > \pi^{(3)} > \pi^{(2)}$. With respect to our problem, and given remark 1, there is a local minimum at $\pi^{(2)}$, a local maximum at $\pi^{(3)}$. We can derive the range for these two solutions. Given that

$\cos(\pi/3) = 1/2$, we have $\pi^{CB} = \pi^{(2)} \in (\pi^*, \frac{1 + 2\pi^*}{3})$ and $\pi^{(3)} \in (\frac{1 + 2\pi^*}{3}, 1)$ where π^{CB} is the

optimal response for the CB. The government responds by $\theta^*(\pi^{CB}) > 0$. If debt is very high, it is possible that $\pi = \pi_H$ is the minimum for the central bank although there is a local minimum at π^{CB} . Let's call that equilibrium the *inflation trap equilibrium*. In this case the CB sets $\pi = \pi_H$ and the government responds by $\theta(\pi_H) = 0$. ■

Remark 2: in the low inflation equilibrium [$\pi = \pi^{CB}$; $\theta^*(\pi^{CB}) > 0$], a positive shock on g_1 (or a rising debt b_0) decreases k , which increases ρ therefore decreasing π^{CB} . The intuition is that in this case we are at equilibria where marginal costs of increasing inflation are not matched by marginal gains in terms of lower default.

To sum up, as far as the debt service satisfies $R_b b_0 \leq \frac{i^*(\alpha) + m_0 - g_1}{4a(1 - \alpha) \left(\frac{1 - \pi^*}{3}\right)^3}$ (points 1 and 2 here

above), there is no default and the CB is accommodating. When total reimbursement exceeds this threshold value, the CB is no longer accommodating and default occurs.

B. $n > 1$

When there are two or more countries in the union, the technical solution is identical with

parameter k given by $\frac{1}{N} \sum_{i=1}^N k_i$. To simplify the algebra and to refer to the previous solution,

we assume that for all but one country the level of debt is low such that no accommodation or no default occurs in equilibrium. In that case, the demonstration developed in the previous section remains valid. Without that assumption, discontinuity occurs, rendering the discussion of the solution more complicated without however changing the results.

Measuring the Impact of Fiscal Transfers on Monetary Policy

With reference to the demonstration in Appendix I, one needs to evaluate the impact of the different fiscal transfers on the parameter k .

Remember that $k = \frac{\tilde{t}(\alpha) + m_0 - g_1}{a(1-\alpha)R_b b_o}$ (we ignore the country subscript i to simplify notation). k

determines the level of the curve of the marginal gain of inflation. A higher (lower) k shifts the curve leftwards (rightwards), therefore decreasing (increasing) the equilibrium inflation rate if the debt is not too high. If the debt is high, the reverse occurs. Depending on the impact of the transfer on the optimal tax policy, we can therefore determine the orientation of the optimal monetary policy given the initial level of debt.

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