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Coalitions and Dynamic Interactions between Fiscal and Monetary Authorities in the EMU*

By *Bas van Aarle*, *Giovanni Di Bartolomeo*,
Jacob Engwerda, and *Joseph Plasmans*

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I. Introduction

Three years after the start of the Economic and Monetary Union (EMU), already a considerable amount of experience has accumulated on the functioning of monetary and fiscal policy in this new framework of macroeconomic policy design in the European Union. Monetary policy has been delegated to a supranational authority, the European Central Bank (ECB), with a complex framework of objectives, policy instruments and decision making procedures. According to the Maastricht Treaty, the ECB should safeguard price stability in the Economic and Monetary Union and – subject to the condition that it does not interfere with price stability – promote economic growth in the union. Its policies are, therefore, directed at controlling economic developments of the EMU economy as a whole rather than on individual countries. The design of fiscal policies in the EMU is complicated by the set of constraints on national fiscal policy imposed by the Stability and Growth Pact. According to the Stability and Growth Pact, excessive deficits are to be avoided and are subject to sanctions. However, it is expected that the introduction of the Economic and Monetary Union, which im-

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plies a common monetary policy and restrictions on fiscal policy at the national level, increases the need for macroeconomic policy cooperation due to the various interactions and externalities from national macroeconomic policies.

To study the effects of policy cooperation we compare the impact of three alternative policy regimes in a stylized dynamic model of the EMU: (i) non-cooperative monetary and fiscal policies, (ii) partial cooperation, and (iii) full cooperation both in symmetric and asymmetric settings where countries differ in structural characteristics, policy preferences and/or bargaining power. We assume that the EMU consists of two (blocks of) asymmetric countries where the European Central Bank (ECB) is responsible for monetary policy and where its primary goal is to achieve price stability and to promote economic stabilization (preferably along a growth path) as long as price stability is not endangered. The governments of the two (blocks of) countries are assumed to determine fiscal policy in their countries such that output is stabilized under the restriction that no excessive deficits occur and that prices do not fluctuate too much. The objectives of each player are formalized by a loss function which she likes to minimize. In this way, the policy coordination problem is modeled as a dynamic game in which each player implements the strategy which minimizes its losses during the planning period.

In this paper policy-makers facing a stabilization problem play a two-stage game. In the first stage – the coalition game – they decide non-cooperatively whether or not to sign an agreement about policy-coordination after that an asymmetric price shock has been observed. In the second stage – the stabilization game – they (generally) play the non-cooperative Nash game, where the policy-makers who sign the agreement play as a single player sharing a common loss function. This paper is organized as follows. The next section summarizes the related literature. Section III outlines the model. Section IV discusses the different equilibria used for determining the emerging endogenous coalitions. Section V solves the game numerically and presents six numerical simulations. Section VI concludes.

II. Related Literature Review

Decision making procedures, coalition formation, voting power and rent sharing inside the EU institutions have been studied in detail. In an influential study Widgrén (1994) analyses voting power and coalition formation in the Council of Ministers and calculates using power indices how the balance of power in the Council changed by the entrance of Austria, Sweden and Finland in 1995. Similar studies are performed by Laruelle and Widgrén (1996), Hosli (1996) and Bindseil and Hantke (1997) and Levinsky and Silarsky (1998). These studies – while enabling us insights into issues of power distribution and coalition formation in communal policy formation – however, do not consider a next step, namely the analysis of the effects of coalition formation and power distribution on economic policies.

Several papers have studied the effects of coalition formation in an optimal currency area or monetary union formation, but mainly in static frameworks (e.g.

Kohler 1998). Alesina and Grilli (1993) develop a formal model in the setting of a 'multispeed' EMU where countries differ in their emphasis on the objective of price stability relative to that of full employment (i.e. degree of conservativeness). However, these papers are mainly concentrated on optimal currency areas formation or (EU) enlargement whereas our paper is focusing on full or partial cooperation among policy-makers inside a monetary union. Full and partial cooperation among the institutions (e.g. governments, central bank and workers' associations) in a monetary union has been analyzed by Demertzis et al. (1999) and Acocella and Di Bartolomeo (2001). Demertzis et al. (1999) illustrate that, at least when (output or inflation) shocks are symmetric, national governments make the largest gains by imposing strong forms of accountability, e.g. inflation targeting. But it is observed that these gains come at the expense of the ECB and those whose preferences are aligned with the ECB. Accountability can therefore go too far, but some degree of accountability is always desirable for everyone. This result emphasizes the obvious attraction of allowing a fiscal coalition to take responsibility for the design of monetary policy, which illustrates the weakness of an independent ECB. Acocella and Di Bartolomeo (2001) analyze partial cooperation among a common central bank, trade unions and governments in a monetary union in a static framework. These authors found that, if players' loss functions are distinguished according to different objectives, monetary policy can compensate the governments' actions and neutralize expected coordination benefits of governments, but not those of unions.

Approaches that use dynamic analysis of stabilization policies and coalition formation in the monetary union context are more rare, even if the importance of considering dynamic adjustments in the analysis of stabilization policies is clear. Hughes Hallett and Ma (1996) find – but they do not consider a monetary union – that asymmetries tend to increase the scope for policy cooperation. In their paper the asymmetric cases display for all players larger gains from cooperation than in the symmetric base scenario. Engwerda et al. (1999) have recently introduced a new dynamic approach suitable to investigate the effects of macroeconomic policies in the EMU (see also Engwerda et al. 2002). Their model basically adapts seminal studies of Turnovsky et al. (1988) and Neck and Dockner (1995) to a monetary union. Using this basic set up Engwerda et al. (2002) have analyzed macroeconomic stabilization among three players (two countries and the ECB). They only partially confirm Hughes Hallett and Ma's (1996) results, in the sense that the Hughes Hallett and Ma (1996) results are confirmed except for the case of asymmetric bargaining powers among players. In this case it was observed that the stronger the asymmetry in the bargaining powers the less probable policy-cooperation and coalitions become since policies will be biased towards the needs of the stronger player(s) and the smaller players are less likely to stay in such 'asymmetric' coalitions. Furthermore, Engwerda et al. (2002) find that the introduction of a fiscal transfer mechanism among countries deteriorates the internal stability of the economies, but considerably reduces welfare costs. The investigation in Engwerda et al. (2002) is extended to the more complex context of partial coalitions by van Aarle et al. (2001). The sustainability of a certain type of coalition and its implications for the optimal strategies and the resulting macroeconomic adjustment were seen to be highly sensitive to the initial settings of the preferences and the structural model parameters. They found that cooperation is often efficient for the fiscal players. On

the other hand, it was shown that full cooperation of all three players does not always induce a Pareto improvement for the ECB, and that a governments' coalition often implies a considerable loss for the ECB compared to the non-cooperative and full cooperative cases. In the cases that the ECB cooperates with one government against the other, it often gains a considerable Pareto-improvement but both governments loose. Therefore, in the experiments made in that paper a kind of dualism arises between the cooperative and the non-cooperative
solutions.

Our paper extends van Aarle et al. (2001) by considering how coalitions are formed (i.e. their self-enforcing properties) by considering different alternative European coordination institutions.

III. A Simple EMU Dynamic Model

The economy is represented by a dynamic two-country EMU model as in van Aarle et al. (2001). The model is expressed in deviations from the long term equilibrium (balanced growth path) that has been normalized to zero, for simplicity. The model consists of the following equations:

$$\begin{aligned} y_1(t) &= \delta_1 s(t) - \gamma_1 r_1(t) + \rho_1 y_2(t) + \eta_1 f_1(t) \\ \dot{p}_1(t) &= \xi_1 y_1(t) \\ y_2(t) &= -\delta_2 s(t) - \gamma_2 r_2(t) + \rho_2 y_1(t) + \eta_2 f_2(t) \\ \dot{p}_2(t) &= \xi_2 y_2(t) \\ s(t) &= p_2{}' - p_1(t) \end{aligned}$$

where y_j denotes real output in country j, s competitiveness of country 2 vis-à-vis country 1, $r_j := i_E(t) - \dot{p}_j(t)$ the real interest rate, p_j the price level and f_j the real fiscal deficit in country $j \in \{1,2\}$, and i_E the common nominal interest rate. All variables are in logarithms, except for the interest rate that is in perunages. A dot above a variable denotes its time derivative.

The above equations describe the structure of the two economies where the policy-makers are assumed to have intertemporal objective functions:

$$J^i(t_0) = \frac{1}{2}\int_{t_0}^{\infty} \left\{\alpha_i \dot{p}_i^2(t) + \beta_i y_i^2(t) + \chi_i f_i^2(t)\right\} e^{-\theta(t-t_0)} dt$$

for $i \in \{1,2\}$, and

$$J^E(t_0) = \frac{1}{2}\int_{t_0}^{\infty} \left\{\dot{P}^2(t) + Y^2(t) + \chi_E i_E^2(t)\right\} e^{-\theta(t-t_0)} dt$$

where $\dot{P}(t) := \sum_{i=1}^{2} \alpha_{iE}\dot{p}_i(t), Y(t) := \sum_{i=1}^{2} \beta_{iE}y_i(t)$ denote the EMU aggregate rate of inflation and the output gap, respectively. Here, the aggregate variables are defined in the most general way possible, allowing in principle for any scheme of weighting of countries and of their individual inflation rates and output gaps.

We assume that the fiscal authorities control their fiscal policy instrument $f_i(t)$ such as to minimize a quadratic loss function which features domestic inflation, output and fiscal deficit. Preference for a low fiscal deficit reflects the costs of excessive deficits. In both cases the total cost to be minimized is a discounted sum of the costs incurred at each period, with θ denoting the discount rate.

From the structural form of the model, we derive the reduced form by solving for $y_1(t), y_2(t)$ and $\dot{s}(t)$:

$$y_1(t) = b_1 s(t) - c_1 i_E(t) + a_1 f_1(t) + \frac{\rho_1}{k_1} a_2 f_2(t)$$

$$y_2(t) = -b_2 s(t) - c_2 i_E(t) + \frac{\rho_2}{k_2} a_1 f_1(t) + a_2 f_2(t)$$

where $k_i := 1 - \gamma_i \xi_i$, $a_i := \dfrac{\eta_i k_j}{k_i k_j - \rho_i \rho_j}$, $b_i := \dfrac{\delta_i k_j - \rho_i \delta_j}{k_i k_j - \rho_i \rho_j}$, $c_i := \dfrac{\gamma_i k_j - \rho_i \gamma_j}{k_i k_j - \rho_i \rho_j}$, and

$$\dot{s}(t) = \phi_4 s(t) - \phi_1 f_1(t) + \phi_2 f_2(t) + \phi_3 i_E(t)$$

where $s(0) =: s_0$, $\phi_i := \left(\xi_i - \xi_j \dfrac{\rho_j}{k_j} \right) a_i$, $\phi_3 := \xi_1 c_1 - \xi_2 c_2$ and $\phi_4 := -(\xi_2 b_2 + \omega_1 b_1)$ for $j \in \{1, 2\}$ and $i \neq j$. The last equation denotes the dynamics of the model: it is a first-order linear differential equation. The initial value of the state variable, s_0, measures any initial disequilibrium in competitiveness. Such an initial disequilibrium in competitiveness could be the result of differences in fiscal policies in the past or some initial supply side disturbance in one country.

Defining $x^T(t) := [s(t), f_1(t), f_2(t), i_E(t)]$, the objectives of the policy-makers can be written as:

$$J^i(t_0) = \frac{1}{2} d_i \int_0^\infty \left\{ x^T(t) M_i x(t) e^{-\theta(t-t_0)} dt \quad i \in \{1, 2\} \right.$$

$$J^E(t_0) = \frac{1}{2} d_i \int_0^\infty \left\{ x^T(t) M_E x(t) e^{-\theta(t-t_0)} dt \right.$$

where $M_i := m_i^T m_i + \dfrac{x^i}{d_i} e_{(i+1)}^T e_{i+1}$ for $(i = \{1, 2\})$ and $M_E := d_{1E} m_1^T m_1 + d_{2E} m_2^T m_2 + d_{3E} m_1^T m_2 + 2 d_{3E} m_2^T m_1 + \chi_E e_4^T e_4$ with $d_i := \alpha_i \xi_i^2 + \beta_i$, $d_{iE} := \alpha_{iE}^2 \xi_i^2 + \beta_{iE}^2$ for $(i = \{1, 2\})$, and $d_{3E} := \alpha_{1E} \alpha_{2E} \xi_1 \xi_2 + \beta_{1E} \beta_{2E}$; $e_l \in \Re^4$ is defined as the unit row vector with the l-th entry equal to 1 whereas the remaining values are equal to zero;

$m_1 := \left[b_1, a_1, \frac{\rho_1}{k_1} a_2, -c_1 \right]$ and $m_2 := \left[b_2, \frac{\rho_2}{k_2} a_2, a_2, -c_2 \right]$. Henceforth, for reasons of convenience, we assume that $t_0 = 0$ and $\theta = 0$ (if θ differs from zero, the model could easily be solved following the same procedure used in this paper after a simple transformation of variables[1]).

For each coalition Ω that the players can form, the problem that policy-makers face in the stabilization game can be summarized as the minimization of the following loss functions:

$$J^C = \frac{1}{2} \int_0^{\infty} \left\{ \sum_{i \in \Omega} \tau_i d_i x^T(t) M_i x(t) \right\} dt$$

$$J^S = \frac{1}{2} d_i \int_0^{\infty} \left\{ x^T(t) M_i x(t) dt \quad \forall i \notin \Omega \right.$$

with respect to the reduced form of the model (J^C for the cooperative (where the τ_i sum to 1) and J^S for each of the non-cooperative policy-makers with $d_E := 1$).

In the case of open-loop strategies, the solution of that problem consists of the following optimal controls:

$$\begin{pmatrix} f_1(t) \\ f_2(t) \\ i_E(t) \end{pmatrix} =: \Psi_{(\Omega)} s(t)$$

Then, using the above optimal controls we obtain the corresponding player's optimal costs:

$$J^i_{(\Omega)} = \frac{1}{2} d_i \left(1 \Psi^T_{(\Omega)} \right) M_i \begin{pmatrix} 1 \\ \Psi_{(\Omega)} \end{pmatrix} \frac{s_0^2}{2 \psi_{(\Omega)}}$$

for $i = \{1, 2, E\}$. The vector $\Psi_{(\Omega)}$ and the (eigen)value $\psi_{(\Omega)}$ are computed according to the algorithm reported in the appendix.

IV. Endogenous Coalition Formation

In a monetary union as described in this paper one can observe a singular mix of a centralized monetary policy and a decentralized fiscal policy. Looking at the European situation, this kind of institutional setting makes coordination procedures a necessity (Bayer 1999). However, the possible levels of coordination

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[1] That is, transforming $x(t)$ into $e^{-\frac{1}{2}\theta t} x(t)$ and substituting ϕ_4 by $\phi_4 - \frac{1}{2}\theta$ (see *Engwerda* et al.(2002) for further details).

are different as the ways to implement them are. Two different steps of policy coordination, for example, can be distinguished, even though in practice these steps might occur simultaneously (coordination between fiscal authorities in order to prevent regional spillovers and between the fiscal policy of the union-member countries and the single monetary policy in order to arrive at an optimal macro-policy mix (Bayer et al. 1998). However, the common fiscal policy is not always based on a real fiscal coordination. Furthermore, the real cooperation among institutional players is strongly dependent on the institutional characteristics of the monetary union. This kind of arguments is very relevant for the EMU as the recent political debate seems to confirm (see, among others, Visco 1998; Bayer 1999; Durand 1999 and Winkler 1999).

In our model, different equilibrium concepts can lead to different equilibrium coalition structures. However, different equilibrium concepts correspond to different initial assumptions that, in our context, can be interpreted as different institutional settings of the monetary union and can be justified on the basis of economic theory. However, the definitions of the different equilibria are very complex. Therefore, we prefer to present informal definitions of these equilibria before relating them to some real cases and using them in some numerical simulations. We restrict our attention to three possible mechanisms of coalition formation: the coalitional Nash equilibrium (CNE), the sequential negotiation equilibrium (SNE), and the farsighted coalitional equilibrium (FCE). These equilibria can be informally described as follows (for formal definitions see Di Bartolomeo and Plasmans 2001 and the references in that paper).

A CNE is an equilibrium of a one-shot game where each agent faces the problem of simultaneously accepting or rejecting a proposal that consists in sharing her utility function only by looking at the immediate consequence of her actions. After that all agents' decisions are taken, the CNE is formed. More formally the CNE is characterized by three properties: the profitability property (i.e. the coalition losses must be lower than or equal to the non-cooperative ones for all coalition members), the internal stability property (the loss of each coalition member must be lower than or equal to the loss of the same policy-maker if she defects from the coalition and the other members do not change their strategies – i.e. there is no incentive to leave the coalition) and the external stability property (the loss of each non coalition member must be higher than the loss of the same policy-maker if she decides to share her loss function with those of the other cooperating policy-makers given their strategies – i.e. there is no incentive to join the coalition). In general, we can refer to stability of a CNE, when both stability properties are met. The stability property guarantees that the equilibrium is self-enforcing.

The CNE implies a sort of the agents' myopic behavior since agents look only at the immediate consequence of their actions without forecasting the final implication of their strategies. Several game-theoretical economists have defined some solution concepts based on the idea of indirect domination. We follow their approach by simply defining the FCE as an equilibrium where players foresee the reaction of the other players to their actions (i.e. they make rational conjectures about the other players' behavior in replying to their actions). We simply assume that each policy-maker will consider how many policy-makers will leave the coalition if she will leave it. Formally, the FCE – in this simple 3 players' game – differs from the CNE only for the stability condition of the grand coalition. In other words, considering the FCE the grand coalition can be an equilibrium of the game even if it violates the stability condition when this violation leads to an unstable coalition, provided that the grand coalition is profitable.

An SNE is an equilibrium of an hierarchical multi-stage negotiation process. The negotiation starts with one policy-maker who proposes a coalition. The order of agents that can propose a coalition is given by an exogenous rule (i.e. a rule of order). Each prospective member can reject or accept the proposal in the order determined by this fixed rule. If one of the policy-makers rejects the proposal, that policy-maker must make a counter-offer. If all members accept, the coalition is formed and then all members of that coalition withdraw from the negotiations. When all agents exit from the negotiation the SNE is reached.

The main difference between the CNE and the FCE lies in the information that players have. In the CNE it is assumed that agents cannot communicate whereas in the FCE the opposite occurs. Thus, the CNE stresses a situation in which either an “institutional place”, where negotiations can be performed, does not exist or shocks need quick policy reactions and, therefore, time for consultation is limited. The FCE emphasizes the opposite situation and, therefore, it is linked to the assumption that a real mechanism of institutional coordination already exists (e.g. the ECOFIN Council in the EMU). However, both the above concepts do not capture the possible sequential features of the negotiation process. These features can be important in emphasizing the hegemony of a country or of a block of countries in the negotiation process. The SNE can be seen as a situation in which the monetary union is built on the basis of a strong determination of bargaining power of its members (e.g. it can be realistic if an optimal currency area with a leader country is considered).

The hegemony in the monetary union can be exercised by one country, a block of countries or even by the central bank. All these cases can be realistic under different points of view and/or under consideration of different situations. The European Monetary System, e.g., was driven by the German economic policy, and the same European Unionization process was based on the axis formed by Germany and France. An interesting application of the SNE is to consider the block of the largest countries as the leader and the block of the smallest countries as the follower and regarding the common central bank as in a different institutional setting (i.e. according to its position in the rule of order, an hegemonic, a neutral or an accommodating central bank). This classification can be seen as a new dimension in the study of central bank independence. However, for reason of brevity, in this paper we will limit our analysis to only some basic cases.

V. Numerical Simulations

1. Scenarios and Parameterization

Parameters are chosen on the basis of reasonable evidence (see Neck and Dockner 1995). The semi-elasticity of the demand for domestic output with respect to the real interest rate is γ =0.5, the elasticity of the demand for domestic output with respect to the competitiveness is δ =1, the elasticity of the demand for domestic output with respect to the foreign output is ρ =0.3, the elasticity of the demand for domestic output with respect to the fiscal index is η =1, the Phillips curve coefficient is ξ =0.75, the policy-makers' bargaining powers are assumed to be equal (i.e. τ = 1/3) and the intertemporal discount factor is θ =0.1. The initial state of the EMU economy is assumed to be at $s_0 = 0.05$ (implying an initial disequilibrium of 5% in competitiveness between the two countries).

In the simulation we focus on the policy-makers' priorities and on their bargaining power distribution. We assume that both governments' priority is real output stabilization while the ECB is mainly concerned about price stabilization. The following preference weights in the policy-makers' objective functions are assumed: $\alpha = 0.2$, $\alpha_E = 0.8$, $\beta = 0.4$, $\beta_E = 0.3$ and $\chi = 0.15$. In the analysis of asymmetric policy transmissions, we analyze the effects of different monetary policy transmissions between countries and the effects of different fiscal policy transmissions. Therefore, in the monetary transmission analysis the first country has a smaller output semi-elasticity of the real interest rate $(\gamma_1 = 0.4)$ than the second country $(\gamma_2 = 0.6)$. In the fiscal transmission analysis the first country is assumed to have a higher output elasticity of the fiscal deficit $(\eta_1 = 1.1)$ than the second country $(\eta_2 = 0.9)$. Finally, different bargaining powers are assumed according to the following scheme: $\tau^C = \{3/6, 1/6, 2/6\}, \tau^{12} = \{3/4, 1/4\}$, $\tau^{1E} = \{3/5, 2/5\}$, $\tau^{2E} = \{1/3, 2/3\}$.

Outcomes are analyzed for all the five different equilibria outlined in Sections III and IV: case 1 is the non-cooperative equilibrium, case 2 is the full cooperative equilibrium, and cases 3 to 5 are partial cooperative equilibria (case 3 refers to the fiscal coalition (1,2), and cases 4 and 5 to the coalitions between the ECB and a fiscal player, i.e. (1,E) and (2,E)).

We have checked the robustness of our results with respect to a set of different preferences for the policy-makers. Our findings are robust. However, it is not so when the robustness is checked with respect to the structural parameters; in fact, results are sensitive to the parametrization of the monetary union (compare our results with Engwerda et al. 2002).

2. The Symmetric EMU

In table 1 the resulting (optimal) losses in the five different cases of this benchmark case are given.

From table 1 we can represent the second stage of the game in a payoff matrix form (note that in this paper payoffs will be expressed in losses). Each policy-maker can cooperate (*c*) by sharing her loss function with that of the other cooperative policy-makers or defect (*d*) playing as a singleton. The payoff matrix is described by table 2. It reads as follows: the country 1's government chooses rows, the country 2's government chooses columns and the ECB chooses boxes (among A and B). Note that, if only one policy-maker follows the cooperative strategy, the equilibrium outcomes are clearly those of the non-cooperative (NC) case. In fact, in this case, this policy-maker will not find another policy-maker with whom to share her preference (see the problem defined by the J^C and J^S equations in Section III). Therefore, strategy profiles[2] {*c*, *d*, *d*}, {*d*, *c*, *d*}, {*d*, *d*, *c*} and {*d*, *d*, *d*} are associated with the same equilibrium in the second stage (i.e. NC in table 1).

Table 1

Cost Functions (multiplied by 1,000)[3]

	NC	*C*	(1, 2)	(1, *E*)	(2, *E*)
J^1	0.2248	0.1144	0.1144	2.1142	0.0613
J^2	0.2248	0.1144	0.1144	0.0613	2.1142
J^E	0	0	0	0.1608	0.1608
J^C	-	0.0763	-	-	-
$J^{(1,2)}$	-	-	0.1144	-	-
$J^{(1,E)}$	-	-	-	1.6375	-
$J^{(2,E)}$	-	-	-	-	1.6375
ψ	0.3260	0.8155	0.8155	0.1062	0.1062

[2] Each strategy profile is the vector of the policy-makers' strategies, the first entry is the strategy of Government 1, the second of Government 2 and the third of the ECB.

[3] In all tables, Rows 1 to 3 indicate the policy-makers' losses while rows 4 to 7 show the pay-offs of the coalition weighted by the bargaining powers (yielding as cost J^k for coalition *k*) of the corresponding cooperative players, while J^C indicates the pay-off of the grand coalition, and row 8 indicates the absolute values of the eigenvalues of the different coalition structures.

Table 2 shows the following points. a) if the ECB plays *d*, the dominant strategy of both governments is to play *c*; b) if the central bank plays *c*, the dominant strategy of both governments is to play *d*. For the central bank it is indifferent to play *d* or *c*. However, these alternative decisions have a very different impact on the other players' losses. Moreover, if we assume that players prefer to cooperate (if the losses associated with *d* and *c* are the same, given the other players' strategies) the ECB's "good intention" paradoxically leads to the non-cooperative solution. This result derives from a lack of communication (a common result in this kind of game – see Echia and Mariotti 1998). However, this could not be the case if the different assumptions about the endogenous coalition formation (and, therefore, about the agents' information set) are considered.

Table2

Payoff Matrix (multiplied by 1,000)

		2			
		d	*c*	*d*	*c*
1	*d*	0.22 0.22 0	0.22 0.22 0	0.22 0.22 0	0.06 2.11 0.16
	c	0.22 0.22 0	0.11 0.11 0	2.11 0.06 0.16	0.11 0.11 0
		A		B	
		d		*c*	
		ECB			

In fact, consider the endogenous coalition formation mechanisms described in the above section. The grand coalition and the governments' partial coalition satisfy profitability, and therefore, are the only candidates for the CNE. However, only the governments' partial coalition also satisfies the stability requirement. In fact both governments have an incentive to deviate from the grand coalition. Hence the fiscal coalition is the CNE. On the contrary, if the FCE is considered, also the grand coalition becomes an equilibrium since the ECB has no incentive in deviating and both governments foresee that non-cooperative behavior leads to an unstable position (i.e. partial cooperation between the ECB and one government). Therefore, by comparing their payoffs with the final stable position (i.e. the non-cooperative one), they prefer to remain in the grand coalition. Hence, both the grand coalition and the fiscal one are FCE. Considering the SNE we can observe that the non-cooperative solution, the grand coalition and the fiscal coalition are first best for the ECB. For both governments it is optimal to play as a singleton against a coalition formed by the two other policy-makers, while the grand coalition or a fiscal coalition is for both of them a second best choice. However, since there is no chance that a partial coalition with the ECB is formed[4], it is always optimal for the ECB as a first mover to propose the grand coalition and for the other agents it is optimal to accept that proposal. If one of the governments plays first, the optimal proposal can be either the grand coalition or the fiscal one and for the other agent(s) it is optimal to accept that proposal. The grand coalition (or the fiscal coalition if the ECB is not the first mover) represents the SNE of our game.

3. Asymmetric Monetary Policy Transmission

In this example asymmetric monetary transmission is analyzed: the base setting of case 2 is assumed, except that the first country has a smaller output semi-elasticity of the real interest rate $(\gamma_1 = 0.4)$ than the second country $(\gamma_2 = 0.6)$. This example illustrates the discussion about the effects of a common monetary policy in a situation where countries differ in the transmission of monetary policy.

Table 3 shows the (optimal) losses in this case.

Table 3

Cost Functions (multiplied by 1,000)

	NC	*C*	(1, 2)	(1, *E*)	(2, *E*)
J^1	0.2161	0.1156	0.1107	1.3367	0.2192
J^2	0.2357	0.1108	0.1241	0.0335	7.0550
J^E	0	0.0011	0.0006	0.7874	3.8200
J^C	-	0.0758	-	-	-
$J^{(1,2)}$	-	-	0.1174	-	-
$J^{(1,E)}$	-	-	-	1.0620	-
$J^{(2,E)}$	-	-	-	-	5.4380
ψ	0.3256	0.8098	0.9169	0.1324	0.0428

The first best of the ECB, governments 1 and 2 are the non-cooperative solution, the fiscal coalition, the coalition between the ECB and the first government,

[4] A policy-maker cannot propose to the other policy-makers a coalition where she is not involved. However, even if such a partial coalition between one government and the ECB were proposed, it will not be accepted since it is not profitable.

respectively. Considering a game of the kind described by table 3 the dominant strategy of the ECB is always to defect since this strategy always gives to the monetary authorities a lower loss. Looking at the optimal strategies of the governments, the fiscal coalition turns out to be the Nash equilibrium. Considering the CNE the same result is found. In fact, the ECB will leave all possible coalitions (no coalition is profitable for the ECB) whereas the fiscal coalition is stable and profitable for both governments. For the same reason the fiscal coalition is the equilibrium that emerges from the solution associated with the FCE and SNE.

4. Asymmetric Fiscal Policy Transmission

Not only differences in the transmission of monetary policy are likely to prevail under EMU, also different transmissions of fiscal policies are likely to be present. In this example, we analyze the consequences of such differences in fiscal policy transmission. To do so, assume that the first country has a higher output elasticity of the fiscal deficit $(\eta_1 = 1.1)$ than the second country $(\eta_2 = 0.9)$. Table 4 shows the (optimal) losses in this case.

Table 4

Cost Functions (multiplied by 1,000)

	NC	*C*	(1, 2)	(1, *E*)	(2, *E*)
J^1	0.2368	0.1118	0.1134	1.5703	0.0639
J^2	0.2099	0.1174	0.1152	0.0589	2.7100
J^E	0.3263	0.0006	0.0016	1.1007	1.1157
J^C	-	0.0766	-	-	-
$J^{(1,2)}$	-	-	0.1143	-	-
$J^{(1,E)}$	-	-	-	1.3355	-
$J^{(2,E)}$	-	-	-	-	1.9129
ψ	0.3263	0.8206	0.8178	0.1200	0.8987

Table 4 shows that partial coalitions with the ECB are not profitable whereas both the grand and fiscal coalitions are. However, both coalitions are not stable since, when the grand coalition is considered, both governments have an incentive to leave this coalition. On the contrary, when the fiscal coalition is considered, the ECB has an incentive to join the grand coalition. Therefore, the CNE turns out to be the very inefficient non-cooperative solution. Hence, the institutional set-up that supports the CNE implies a coordination failure since the losses of the non-cooperative final equilibrium are higher than for the full cooperative solution. Considering the set-up associated with an FCE, where more information is available to the policy-makers, the grand coalition turns out to be the equilibrium because each government, facing the decision of leaving the coalition, forecasts that the gain of this decision of leaving is an illusion, since the other government and the ECB will follow her decision driving the economy to the unfavorable non-cooperative solution.

The result of the SNE is more ambiguous. In fact, the first government and the ECB, as first proponents, have an incentive to propose the grand coalition, but the second government has an incentive to reject and to propose the fiscal coalition. The SNE will depend on the *ad hoc* technical assumptions introduced to solve this kind of cyclical patterns.

5. Asymmetric Bargaining Powers

Finally, different bargaining powers are assumed according to the following scheme: $\tau^C = \{3/6, 1/6, 2/6\}, \tau^{12} = \{3/4, 1/4\}, \tau^{1E} = \{3/5, 2/5\}, \tau^{2E} = \{1/3, 2/3\}$, implying that, in a coalition, country 1 has three times as many votes as country 2 and 1,5 as many votes as the ECB, whereas the ECB has two times as many votes as country 2.

Table 5 shows that none of the coalitions is profitable, and therefore, the equilibrium result is straightforward. All the equilibria coincide with the non-cooperative solution.

Table 5

Cost Functions (multiplied by 1,000)

	NC	*C*	(1, 2)	(1, *E*)	(2, *E*)
J^1	0.2248	0.0861	0.3271	2.1090	0.0624
J^2	0.2248	0.1467	0.1301	0.0604	2.1083
J^E	0	0.0111	0.0575	1.1628	1.1492
J^C	-	0.0813	-	-	-
$J^{(1,2)}$	-	-	0.2286	-	-
$J^{(1,E)}$	-	-	-	1.6359	-
$J^{(2,E)}$	-	-	-	-	1.6287
ψ	0.3260	0.8138	0.3412	0.1066	0.1061

Comparing the results of Table 5 with those of the symmetric benchmark case in table 1, we observe that the introduction of asymmetric bargaining powers crucially changes the results of the game. In fact, in table 5 no coalition is profitable and the CNE, FCE and SNE are, therefore, the non-cooperative solution. In general the asymmetry of bargaining powers tends to increase the costs of the country with the smaller bargaining power as its importance in a coalition is reduced, while it tends to decrease the costs of the other country. This effect can change a cooperative situation (as that depicted by table 1) in one where only the non-cooperative solution is an equilibrium (as in table 5). To put it in a general way: more asymmetric bargaining powers reduce the probabilities of coalitions – and therefore of policy cooperation – as policies will generallly be biased towards the needs of the stronger player(s), and the smaller players are less likely to stay in such ‘asymmetric’ coalitions. This last result differs from that found in Hughes Hallett and Ma (1996) in analyzing the full cooperation problem. We stress that the consideration of asymmetries in the bargaining power has a different effect on the need for cooperation than those in the model structure.

VI. Conclusion

The interaction of monetary and fiscal policies is a crucial issue in a highly integrated economic area as the European Union. This paper has studied the coalition formation issue among policy-makers and their effects. Decision making procedures, coordination outcomes, voting power and rent sharing inside the core institutions of a monetary union have already been studied in detail. However, this paper has introduced two further steps into the literature by analyzing how coalitions are formed under different institutional settings and what are the effects of coalition formation and policy-makers’ bargaining power distribution on economic policies. The issue is crucial in understanding policy-makers' behavior in highly integrated economic areas, like e.g. the EMU. In such contexts, in fact, policy cooperation is likely to be of essential importance because of various interactions, spillovers and externalities from national macroeconomic policies, which, furthermore, interact with the common monetary policy. However, even when the gains of coordination are present, cooperative solutions do not necessarily emerge because of the different processes that can govern the coalition formation.

We have investigated in which intensity the EMU, that introduced a common monetary policy and restrictions on fiscal policy at the national level, increases the need for macroeconomic policy cooperation due to the various interactions, spillovers and externalities from national macroeconomic policies. To study the effects of policy cooperation we have compared the impact of three alternative policy regimes in a stylized dynamic model of the EMU: (i) non-cooperative monetary and fiscal policies, (ii) partial cooperation, and (iii) full cooperation both in symmetric and asymmetric settings where countries differ in structural characteristics, policy preferences and/or bargaining power. The paper introduces an analysis of coalitional behaviour in a dynamic setting into the literature.

Using numerical examples, we illustrated the sometimes complex effects that are produced by the various coalitions. We started by considering an (a)symmetric benchmark case, where the countries are equally weighted in the ECB's loss function and symmetric values for the structural model parameters are used. An initial disequilibrium of 5% in competitiveness between the two countries is assumed. Afterwards, we have considered asymmetric fiscal and monetary policy transmissions, and different bargaining power schemes. In this way our analysis contributes to the important discussion about the effects of EMU in the case where countries differ in their structural characteristics. Contrary to the common belief that asymmetries tend to increase the scope for policy cooperation, we have found that asymmetries improve the need for such policy coordination only in some specific cases. First, we have found that the grand coalition is observed to be an equilibrium only in the (a)symmetric case, i.e. when countries and governments' preferences are symmetric. Cooperation is often efficient for the fiscal players. In addition, fiscal players' cooperation (against the ECB) often leads to a Pareto improvement for them. The non-cooperative Nash equilibrium is rarely chosen so that arguments can be found that EMU increases the need for macroeconomic cooperation. On the other hand, in some simulations full cooperation does not induce a Pareto improvement for the ECB, while the governments' coalitions imply a considerable loss for the ECB compared to the non-cooperative and full cooperative cases. In our simulations, the partial coalitions between the central bank and one government always leads to high losses for its members, but low for the non-cooperative government. This situation implies a stability problem for the grand coalition since the governments often have an incentive to deviate from it (low cost of the non-cooperative government in the partial coalitions involving the ECB). Furthermore, the high costs of the partial coalitions between the ECB and only one government finally lead to the non-cooperative solution that often implies the worst losses for the players.

We have tested our results with respect to different mechanisms of coalition formation. We have shown in some numerical simulations that, when the coalition formation game is played without communication among the policy-makers, full cooperation is either impossible or limited. On the contrary, when policy-makers can communicate, full cooperation (as well as partial cooperation between a subset of policy-makers) becomes a possible equilibrium, while the complete non-cooperative solution is generally not a sustainable equilibrium. This contrast begins to provide broad support for the view that institutions and international forums for discussions can play a crucial role in achieving international cooperation even when these institutions are not endowed with enforcement powers.

Summary

The EMU is an highly integrated economic area where externalities occur. Therefore, in this context interaction of monetary and fiscal policies is a crucial issue. This paper focuses on how coalitions among policy-makers are formed and what are their effects on the stabilization of output and price. We emphasize the role played by the institutional design of "cooperation forums" (as, e.g., the ECOFIN). If the coalition formation game is played without communication among the policy-makers full cooperation is either impossible or limited. On the other hand, if policy-makers can communicate, full cooperation becomes a possible equilibrium, while the complete non-cooperative solution is, in general, not a sustainable equilibrium. This contrast begins to provide broad support for the view that institutions and international forums for discussions can play a crucial role in achieving international cooperation even when these institutions are not endowed with enforcement powers.

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Appendix

A. The Non-cooperative Case

In the non-cooperative case players minimize their cost functions with respect to the dynamic law of motion of the system, which defining $A := \phi_4, B_1 := -\phi_1,$ $B_2 := \phi_2$ and $B_3 := \phi_3$ can be rewritten as: $\dot{s}(t) = As(t) + B_1 f_1(t) + B_2 f_2(t) + B_3 i_E(t)$; $s(0) = s_0$.

Then, the non-cooperative Nash solution is found as follows (see Engwerda et al. (1999) for details):

1) Factorize M_i as follows: $M_i =: \begin{pmatrix} Q_i & P_i & L_i & S_i \\ P_i^T & R_{1i} & N_i & T_i \\ L_i^T & N_i^T & R_{2i} & V_i \\ S_i^T & T_i^T & V_i^T & R_{3i} \end{pmatrix}$, where all entries are scalars.

2) Calculate $G := \begin{pmatrix} R_{11} & N_1 & T_1 \\ N_2^T & R_{22} & V_2 \\ T_3^T & V_3^T & R_{33} \end{pmatrix}$ and

$$M := \begin{pmatrix} -A & 0 & 0 & 0 \\ Q_1 & A^T & 0 & 0 \\ Q_2 & 0 & A^T & 0 \\ Q_3 & 0 & 0 & A^T \end{pmatrix} + \begin{pmatrix} B \\ -\tilde{P}_1 \\ -\tilde{P}_2 \\ -\tilde{P}_3 \end{pmatrix} G^{-1} \begin{pmatrix} P_1^T & B_1^T & 0 & 0 \\ L_2^T & 0 & B_2^T & 0 \\ S_3^T & 0 & 0 & B_3^T \end{pmatrix}.$$

Here $B := (B_1, B_2, B_3)$ and $\tilde{P}_i := (P_i, L_i, S_i)$.

3) Calculate the positive eigenvalue(s) of M. If $\psi_{(NC)}$ is a positive eigenvalue and $v =: (v_0, v_1, v_2, v_3)^T$ a corresponding eigenvector then, generically (see Engwerda et. al. (1999 for details), the equilibrium strategies are

$$\begin{pmatrix} f_1(t) \\ f_2(t) \\ i_E(t) \end{pmatrix} := -G^{-1} \begin{pmatrix} P_1^T & +B_1^T K_1 \\ L_2^T & +B_2^T K_2 \\ S_3^T & B_3^T K_3 \end{pmatrix} s(t),$$

where $K_i := \frac{v_i}{v_0}$. Using this equilibrium strategies the resulting open-loop system is described by $\dot{s}(t) = -\psi_{(NC)} s(t),\ s(0) = s_0$.

We find as equilibrium strategies in the non-cooperative open-loop case:

$$\begin{pmatrix} f_1(t) \\ f_2(t) \\ i_E(t) \end{pmatrix} = -G^{-1} \begin{pmatrix} a_1 b_1 - \phi_1 K_1 \\ -a_2 b_2 + \phi_1 K_2 \\ -b_1 c_1 d_{1E} + b_2 c_2 d_{2E} + (b_2 c_1 - b_1 c_2) d_{3E} + \phi_3 K_3 \end{pmatrix} s(t) =: H_{nc} s(t)$$

Then, using these equilibrium controls (14) we obtain the corresponding fiscal players' optimal costs:

$$
\begin{aligned}
J^i &= \frac{1}{2} d_i \int_0^\infty \{x_T(t) M_{F_i} x(t)\} dt = \\
&= \frac{1}{2} d_i \int_0^\infty \left\{ \left(sf_1 f_2 i^E\right) M_{F_i} \left(sf_1 f_2 i^E\right)^T \right\} dt = \\
&= \frac{1}{2} d_i \int_0^\infty \left\{ s(t) \left(1 H_j^T\right) M_{F_i} \begin{pmatrix} 1 \\ H_j \end{pmatrix} s(t) \right\} dt = \\
&= \frac{1}{2} d_i \left(1 H_j^T\right) M_{F_i} \begin{pmatrix} 1 \\ H_j \end{pmatrix} \int_0^\infty \{s^2(t)\} dt = \\
&= \frac{1}{2} d_i \left(1 H_j^T\right) M_{F_i} \begin{pmatrix} 1 \\ H_j \end{pmatrix} \int_0^\infty \{s_0^2 e^{-2acl,j} t\} dt = \\
&= \frac{1}{2} d_i \left(1 H_j^T\right) M_{F_i} \begin{pmatrix} 1 \\ H_j \end{pmatrix} s_0^2 \frac{1}{2\psi(NC)} \qquad i = \{1, 2\}
\end{aligned}
$$

In the same way we find the ECB's optimal cost:

$$
J^E = \frac{1}{2} \left(1 H_j^T\right) M_E \begin{pmatrix} 1 \\ H_j \end{pmatrix} s_0^2 \frac{1}{2\psi(NC)}
$$

B. The Cooperative Case

To determine the cooperative strategies for this model we have to consider: $J^C := \tau_1 J^1 + \tau_2 J^2 + \tau_3 J^E$ with $\tau_1 + \tau_2 + \tau_3 = 1$. τ_i measures here the relative strength of player *i* in the game. Introducing $\mu_1 := d_1 \tau_1, \mu_2 := d_2 \tau_2$ and $\mu_3 := \tau_3$, then $J^C = \frac{1}{2} \int_0^\infty \{x^T(t) M_C x(t)\} dt$, where $M_{C,i} := \mu_1 M_1 + \mu_2 M_2 + \mu_3 M_E$.

With the notation of the above subsection the unique equilibrium strategies are then obtained as follows (see e.g. Lancaster et. al. 1995):

1) Factorize matrix $M_{C,i}$ as $\begin{pmatrix} Q & S \\ S^T & R \end{pmatrix}$, where *Q* is a scalar; *S* a 1 x 3 matrix and *R* a 3 x 3 matrix.

2) Calculate the Hamiltonian matrix

$$
H_C := \begin{pmatrix} -\left(A - BR^{-1} S^T\right) & BR^{-1} B^T \\ Q - SR^{-1} S^T & \left(A - BR^{-1} S^T\right)^T \end{pmatrix}.
$$

3) Determine the positive eigenvalue $\psi(C)$ of H_c and its corresponding eigenvector $\upsilon =: (\upsilon_0 \upsilon_1)^T$. Calculate $K := \frac{v_1}{v_0}$.

Then the unique equilibrium strategies are

$$\begin{pmatrix} f_1(t) \\ f_2(t) \\ i_E(t) \end{pmatrix} := -R^{-1}\left(S^T + B^T K\right)s(t) =: H_c s(t),$$

and the resulting closed-loop system satisfies $\dot{s}(t) = -\psi_{(C)} s(t),\ s(0) = s_0$.

C. The Cooperative Case

To determine the equilibrium open-loop solution for the coalition of the fiscal players that cooperate upon fiscal policies but interact in a non-cooperative way with the ECB, we rewrite the dynamic law of motion as:

$$\dot{s} = \phi_4 s + \left(-\phi_1 \phi_2\right)\begin{pmatrix} f_1(t) \\ f_2(t) \end{pmatrix} + \phi_3 i_E(t) \quad s(0) := s_0$$

with cost functions: $J^{(1,2)} := \tau_1 J^1 + \tau_2 J^2$ and J^E , where $\tau_1 + \tau_2 = 1$.

Introducing $M_{(1,2),c} := \mu_1 M_1 + \mu_2 M_2$ where $\mu_1 := \tau_1 d_1$ and $\mu_2 := \tau_2 d_2$, the cost $J^{(1,2)} := \frac{1}{2}\int_0^\infty \left\{x^T(t) M_{(1,2),c}\, x(t)\right\} dt$. Let $B_1 := \left(-\phi_1 \phi_2\right);\ B_2 := \phi_3;\ B := \left(B_1 B_2\right)$ and $A := \phi_4$. Then the non-cooperative Nash equilibrium strategies for this game are obtained as follows:

1) Factorize matrix $M1 := M_{(1,2),c}$ and $M2 := M_{E,j}$ as $\begin{pmatrix} Q_i & P_i & L_i \\ P_i^T & R_{i1} & N_i \\ L_i^T & N_i^T & R_{i2} \end{pmatrix}$, where Q_i, L_i, R_{i2} are scalars; P_i, N_i^T are 1 x 2 matrices and R_{i1} are 2 x 2 matrices, i = 1, 2.

2) Calculate $G := \begin{pmatrix} R_{11} & N_1 \\ N_2^T & R_{22} \end{pmatrix}$ and

$$M_{(1,2)} := \begin{pmatrix} -A & 0 & 0 \\ Q_1 & A^T & 0 \\ Q_2 & 0 & A^T \end{pmatrix} + \begin{pmatrix} B \\ -\left(P_1 L_1\right) \\ -\left(P_2 L_2\right) \end{pmatrix} G^{-1} \begin{pmatrix} P_i^T & B_1^T & 0 \\ L_2^T & 0 & B_2^T \end{pmatrix}.$$

3) Determine the positive eigenvalue(s) of $M_{(1,2)}$. If $\psi_{(1,2)}$ is a positive eigenvalue and $\upsilon := \left(\upsilon_0, \upsilon_1, \upsilon_2\right)$ a corresponding eigenvector, then (generically) an

equilibrium strategy is $\begin{pmatrix} f_1(t) \\ f_2(t) \\ i_E(t) \end{pmatrix} := -G^{-1} \begin{pmatrix} P_1^T + B_1^T K_1 \\ L_2^T + B_2^T K_2 \end{pmatrix} =: H_{(1,2)} s(t)$, where $K_i := \frac{v_i}{v_0}$. The resulting closed-loop system is then $\dot{s}(t) = -\psi_{(1,2)} s(t),\ s(0) = s_0$.

D. Coalition (1, E)

To determine the equilibrium open-loop solution for a coalition of the fiscal authority of country 1 and the ECB that coordinate their policies but act in a non-cooperative fashion with the fiscal authority of country 2, we consider:

$$\dot{s} = \phi_4 s + \left(-\phi_1 \phi_3\right) \begin{pmatrix} f_1(t) \\ i_E(t) \end{pmatrix} + \phi_2 f_2(t) \quad s(0) := s_0$$

with cost functions: $J^{(1,E)} := \tau_1 J^1 + \tau_2 J^E$ and J^2, where $\tau_1 + \tau_2 = 1$. Introducing a redefinition of *x* (*t*) corresponding with this (1, E) coalition form:

$$\tilde{x}(t) := \begin{pmatrix} s(t) \\ f_1(t) \\ i_E(t) \\ f_2(t) \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \end{pmatrix} x(t) =: P_{(1,E)} x(t)$$

with $P_{(1,E)}$ an (orthogonal) permutation matrix, we can, basically, use the algorithm that we used in the (1,2) coalition case to determine the equilibrium controls.

In fact, first note that the inverse of the permutation matrix $P_{(1,3)}$ is $P_{(1,3)}^T$ so that $x(t) = P_{(1,3)}^T \tilde{x}(t)$. Then, with $M_i^{(1,E)} := P_{(1,E)} M_i P_{(1,E)}^T$, $i = \{1, 2, E\}$ (i.e. the matrices obtained from M_i by replacing the third and the fourth rows with the corresponding columns of this matrix) we find $M_{(1,E),c} := \tau_1 d_1 M_1^{(1,E)} + \tau_2 M_E^{(1,E)}$, so that $J_{(1,E)} = \frac{1}{2} \int_0^\infty \left\{ \tilde{x}^T(t) M_{(1,E),c} \tilde{x}(t) \right\} dt$.

Next, introduce $B_1 := \left(-\phi_1 \phi_3\right)$; $B_2 := \phi_2$ and $B := \left(B_1 B_2\right)$

Then, apply step 1) and 2) of the algorithm described in the above Appendix A.3 to find a corresponding matrix $M_{(1,E)}$.

Determine the positive eigenvalue(s) of $M_{(1,E)}$. If $\psi_{(1,E)}$ is a positive eigenvalue of this matrix and $\upsilon := \left(\upsilon_0, \upsilon_1, \upsilon_2\right)$ a corresponding eigenvector, then (generically) an equilibrium strategy is $\begin{pmatrix} f_1(t) \\ i_E(t) \\ f_2(t) \end{pmatrix} := -G^{-1}\begin{pmatrix} P_1^T + B_1^T K_1 \\ L_2^T + B_2^T K_2 \end{pmatrix} =: H_{(1,E)}s(t)$, where $K_i := \frac{v_i}{v_0}$. The resulting closed-loop system is then $\dot{s}(t) = -\psi_{(1,E)}s(t),\ s(0) = s_0$.

D. Coalition (1, E)

Finally, we consider the equilibrium open-loop solution for a coalition of the fiscal authority of country 2 and the ECB that coordinate their policies but act in a non-cooperative fashion with the fiscal authority of country 1. To determine this equilibrium we proceed analogously to the previous case. That is, we rewrite the system dynamics as:

$$\dot{s} = \phi_4 s + (\phi_2 \phi_3)\begin{pmatrix} f_2(t) \\ i_E(t) \end{pmatrix} - \phi_1 f_1(t) \quad s(0) := s_0$$

with cost functions: $J^{(2,E)} := \tau_1 J^2 + \tau_2 J^E$ and J^1, where $\tau_1 + \tau_2 = 1$. Now, introducing the permutation of $x(t)$:

$$\tilde{x}(t) = \begin{pmatrix} s(t) \\ f_2(t) \\ i_E(t) \\ f_1(t) \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 \end{pmatrix} x(t) =: P_{(2,E)}x(t)$$

we find the equilibrium controls in a similar way again as in the above coalition case. Note that in this case $x(t) = P_{(2,E)}^T \tilde{x}(t)$, so that with $M_i^{(2,E)} := P_{(2,E)} M_i P_{(2,E)}^T$, $i = \{1, 2, E\}$ and $M_{(2,E),c} := \tau_1 d_1 M_1^{(2,E)} + \tau_2 M_E^{(2,E)}$, we find that $J^{(1,E)} = \frac{1}{2}\int_0^\infty \{\tilde{x}(t) M_{(2,E),c} \tilde{x}(t)\} dt$. Introducing $B_1 := (\phi_2, \phi_3);\ B_2 := -\phi_1$ and $B := (B_1, B_2)$ we can proceed similarly as in the above algorithm to first find a corresponding matrix $M_{(2,E)}$. The equilibrium strategies are then again found by determining from this matrix a positive eigenvalue $\psi_{(2,E)}$ and its corresponding eigenvector $\upsilon := (\upsilon_0, \upsilon_1, \upsilon_2)$. Introducing $K_i := \frac{v_i}{v_0}$ (generically) an equilibrium strategy is $\begin{pmatrix} f_2(t) \\ i_E(t) \\ f_1(t) \end{pmatrix} := -G^{-1}\begin{pmatrix} P_1^T + B_1^T K_1 \\ L_2^T + B_2^T K_2 \end{pmatrix} =: H_{(2,E)}s(t)$, and the resulting closed-loop system is $\dot{s}(t) = -\psi_{(2,E)}s(t),\ s(0) = s_0$.

Strategic Interactions between Monetary and Fiscal Policies:

A Case Study for the European Stability Pact*

By *Jerome Creel*

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I. Introduction

In a recent paper, Leith and Wren-Lewis (2000) – hereafter LWL – examined the interactions between monetary and fiscal policies in a closed economy with sticky prices and non-Ricardian consumers (finitely-lived agents face a higher discount factor than the government). These deviations from the neo-classical framework implied a richer set of interactions between policies than the usual channel of seigniorage revenues or surprise inflation at the core of the Fiscal Theory of the Price Level (FTPL). LWL demonstrated that two stable policy regimes could be identified: in the first one, monetary policy would be 'active' in the sense determined by Leeper (1991), i.e. reacting toughly to inflation deviations from their steady-state value; while fiscal policy would be 'passive', i.e. reacting toughly to public debt deviations from their steady-state value. In the second one, monetary policy's reactions towards inflation would be smoother whereas the government would stabilise public debt very slowly. This case was the closest to Woodford's work (2001) dealing with the FTPL.

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This theory states that the price level can be determined through the fulfilment of the intertemporal government budget constraint. This implies that a government can exogenously fix his real spending and revenue plans, and that the price level will take on the value required to adjust the real value of its contractual nominal debt obligations to ensure government solvency. The mechanism underlying the FTPL is linked to a wealth effect (Woodford 2001): if the sequence of future primary fiscal *deficits* entails an increase in the contractual nominal debt obligations of the government, households will feel wealthier and will consume more, so that the general price level will be increased until the government budget constraint has been satisfied.[1]

The FTPL has already been extended to the case of a monetary union (Woodford 1996; Bergin 2000), but within a neo-classical framework and without nominal inertia in the price setting in the short run. Moreover, net external assets were not included, although they may help the stabilisation process of both economies after a shock.

We thus extend LWL model with sticky prices to the case of two countries engaged in a monetary union and in considering optimal policies as the outcome of a static game between the two fiscal authorities and the European Central Bank (ECB).[2] We also specifically study the possible asymmetric implications of the Stability and Growth Pact (SGP), i.e. the possibility that one country could be unable to react to a shock because it has no fiscal room for manoeuvre, whereas the other country could implement a fiscal policy to stabilise the economy.[3]

The fiscal framework in the model can be justified on two grounds. First, as regards the static-game approach in a dynamic model, justifications can bear on the following argument: it is straightforward to show that, in the Euro area, countries do not abide by strictly to the dispositions of the Broad Economic Policy Guidelines (BEPG) and move back each year the deadline for achieving a 'closed-to-balance' government budget (EC 2001). Governments thus seem to act rather inconsistently, without generally taking full account of their present policies for the future. Second, pragmatism can also be called up to justify the asymmetry in the fiscal framework between the two countries within the monetary union. Such an asymmetry in fiscal policy rules is not unlikely in the Euro area. Though the Maastricht's norm on public debt has been wiped out as regards the entry of some countries in the Euro area, the public finances in these countries (Belgium, Italy and Greece) are still carefully supervised by their EU

[1] Contrary to what *Buiter* (2002) claims about this constraint, it is usually not used as an "equilibrium condition" in the FTPL, and is valid for all possible values of the price level and output.

[2] Extending the model to a dynamic-game framework is beyond the scope of the present paper, though it might well lead to different results.

[3] Indeed, the Stability and Growth Pact prevents countries in the Euro area from increasing public deficits over 3% of their GDP, except in the case of a substantial slump. Countries which would not satisfy the Pact may incur fines (cf. *Beetsma* and *Uhlig* 1999, for a stylised rationale of this Pact). As fines may be long to come (the process under which European countries may order the fine lasts two years), the SGP may not appear 'credible'. In the following, we however consider that the SGP is so credible as to be satisfied by any country over the deficit limit.

partners[4], by the Commission, via the SGP and the implementation of the BEPGs, or by the ECB before it sets the European nominal interest rate. Not to speak, of course, of the recent difficulties of Germany and Portugal (1st quarter of 2002) to dampen the rise in their respective fiscal deficits… This supervision of indebted countries or temporary difficulties to satisfy the BEPGs necessitate that countries under close scrutiny limit their deficit and tend towards a balanced budget at least. Other countries with sound public finances do not, of course, face the same constraints when setting either receipts or expenditures.

Our main objective here is to assess the macroeconomic incidence of this peculiar fiscal setting when countries in the Euro area face symmetric shocks. Though these shocks are more easily circumvented than asymmetric shocks – the ECB should be able to stabilise the economy without fiscal policies –, uncoordinated policies with one government following a balanced-budget rule may be very counter-productive for the ECB and for the government with sound public finances. This thus gives a new argument in favour of coordinated monetary and fiscal policies.

The paper is structured as follows. In section II, we present LWL model briefly. In section III, we outline our analytical framework, stressing its most notable features. Section IV provides an assessment of the consequences of symmetric supply and demand shocks in the monetary union. The shocks are supposed to be permanent. For each shock, we study the Nash equilibrium between the three policy makers and then compare it to a cooperative equilibrium which we computed according to the Nash-bargaining procedure. Section V stresses the most substantial costs emerging from the implementation of the dispositions of the SGP. Section VI brings out some conclusions.

II. Leith and Wren-Lewis Model

LWL (2000) showed that independent central banks cannot ignore what the government is doing with fiscal policy in a closed economy. However, as long as government adjusts its spending or taxes to meet a target for government debt, central bankers can raise the real interest rates by as much as they want in order to hit their inflation targets. The direct implication of this process is that while fiscal policy must react to some extent to variations in government debt, their response needs not be dramatic. Stated briefly, this does not seem to legitimate the tight control of fiscal policy implied by the SGP.

The model of LWL originates in the Blanchard-Yaari (1985) perpetual youth model: since households face a finite life, they consider (a part of) public debt as

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[4] Quoted in the FT, June 5 2001: “The performance of Silvio Berlusconi’s centre-right government will be watched closely by its European Union partners over the next few months. No aspect will come under closer scrutiny than its management of Italy’s public finances. (…) The level of Italy’s sovereign debt is still nearly double that permitted by the Maastricht treaty (…). Many Europeans are, therefore, anxiously waiting to see whether Mr Berlusconi (…) can maintain the same level of fiscal rigour (…) as the centre-left did in years gone by.” (Italy Survey, p. II).

net wealth. Aggregate demand thus depends positively on public debt and public spending, negatively on taxation:

$Y_t = kB_t - cT_t + G_t$, where *B* represents public debt, *T* taxation, *G* public spending and parameters '*k*' and '*c*' are positive.

The Phillips curve is such that:

$\dot{\pi}_t = aY_t$, where $\dot{\pi}$ is the inflation rate in time difference.

With parameter 'a' negative (resp. positive), this equation is a forward-looking (resp. backward-looking) Phillips curve.

LWL consider two specifications for fiscal policy. If the government stabilises public debt via public spending, the fiscal framework is of the following form:

[Case 1] $G_t = \overline{G} + f\left[B_t - \overline{B}\right]$, and $T_t = \tau Y_t$,

where τ is the tax rate, a superscript is a target value, and a subscript is time. Government spending responds to public debt deviations from the target and taxation is applied at a constant rate.

The alternative framework is of the form:

[Case 2] $T_t = \overline{T} + f\left[B_t - \overline{B}\right]$ and $G_t = \overline{G}$. The government adjusts taxation to meet its public debt target; and government spending is assumed to be constant.[5]

On empirical grounds, one should favour case 1 for the fiscal framework. Alesina and Perotti (1995) demonstrated that fiscal adjustments were more efficient when expenditures had been reduced, rather than taxation increased. LWL also favour case 1 in their numerical simulations. Reason for this is the little influence of taxation on output and inflation, a situation which denies any substantial fiscal feedbacks on the optimal monetary policy (LWL p. C101).[6] In the model used below, introducing either a modified version of case 1 or a modified version of case 2 gives the same qualitative results.[7]

In their conclusion, LWL state that, if fiscal policy is relatively active in Leeper's sense – debt is stabilised very slowly, whatever the case for fiscal policy is chosen –, then this puts severe constraints on what monetary policy can do. If monetary policy responds to excess inflation by raising real interest rates, this will lead to destabilising movements in output as government debt "explodes". However, as long as fiscal policy is sufficiently passive, central bankers are free to raise real interest rates by as much as they want. The implication is

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[5] This fiscal framework owes to the seminal work on fiscal rules by *Sachs* and *Wyplosz* (1984).

[6] Adding a second country automatically increases the fiscal feedbacks on monetary policy, via the fiscal policy of the second country and, thus, tends to limit the above argument by LWL.

[7] In our model, in cases 1 and 2, the tax rate and public spending in each country are set respectively as the outcome of a game between the two governments and the ECB.

that one needs to ensure that fiscal policy responds to some extent to changes in government debt, but this response needs not be as tough as what the SGP seems to generate.

III. Some Extensions to the Previous Model

In the following, we concentrate on the implications of policy rules interactions in the open economy and, more explicitly, in a monetary union. Consumers therefore hold their wealth not only in the form of public debt but also in the form of external assets. In such a situation, within a monetary union, i.e. in the absence of any exchange rate risk, a target for public debt is needed in order to determine the allocation of wealth between net foreign assets and public debt. This is a technical reason for justifying the implementation of fiscal policy rules. Without a target on public debt, wealth could in fact be balanced with unstable and symmetric levels of public debt and external assets.[8]

LWL model is simplified in two respects, with minor consequences on their results: we do not take human wealth nor money into account. The latter exclusion is studied in LWL model. Finally, we extend it in seven respects. Four are linked to the open economy and policy rules: two countries and a common central bank (which we call the ECB) are introduced; we consider an asymmetry in the fiscal framework between the two governments; policy rules are the outcomes of a static game between the two governments and the ECB; and cooperative equilibria are computed. Two other assumptions deal with consumption: a wealth effect which resembles the Pigouvian “real balance” effect and a non-linear effect of the real interest rate on aggregate demand are included. Last, backward-looking inflation expectations are assumed.

1. The General Framework

We study a polar case in the EMU: two countries, identical as far as private behaviours are concerned, form a monetary union.[9] Households in both countries hold their wealth under the form of domestic public debt (D) and net foreign assets (F). The model drops the Blanchard (1985) specification of intertemporal consumption which is at the heart of LWL’s model and replaces it with a specification where (still non-Ricardian) consumers consume their current income (including interests received on net financial wealth), plus a proportion of their financial wealth. This specification can be found, for instance, in Creel (2002).

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[8] In a flexible exchange rate regime or in a EMS-type regime, the uncertainty regarding the future value of external assets denominated in foreign currencies and/or the risk aversion by households are sufficient conditions for determining the discrepancy between domestic and foreign assets.

[9] Asymmetric private interdependence between the two countries (for instance, different pace of adjustment for prices or wages after a shock, as in *Hughes Hallett*, 1986) are beyond the scope of the present paper.

As in Tobin & Buiter (1976)[10], private agents are assumed to form wealth plans $\dot{W}$ which positively depend on disposable income net of wealth interests $((1-\tau Y))$, but also on the real interest rate (ρ). If actual real wealth differs from planned wealth, households behaviour makes it adjust to its desired level at speed μ. The demand block of the model is therefore given by a somewhat usual IS curve.[11]

(1) $$Y_t = (1-\tau_t)Y_t + \rho_t W_t + \mu\left[W_t - \dot{W}_t\right] + \eta(Y_t{}^* - Y_t) + \eta\varepsilon(\pi_t{}^* - \pi_t) + G_t + X_t$$

where: $\dot{W}_t = (\alpha + \beta\rho_t)(1-\tau_t)Y_t$, and α and β are positive parameters.

Aggregate demand increases with disposable income plus interests on wealth (ρW), with the gap between actual and planned wealth, with public spending (G) and with a private demand shock (X). The additional terms in output and inflation differentials reflect spillovers from the second country through the trade balance. The ε parameter represents the elasticity of the trade balance to the variations of the inflation differential; it is positive; η is the degree of openness.

Aggregate demand depends negatively on the real interest rate in the short run, and positively in the long run. In short, the substitution effect overcomes the wealth effect in the short run while the reverse is true in the long run. The wealth effect is close to the Pigouvian or "real balance" effect: if actual wealth is beneath its planned level, because of an increase in the real interest rate, private consumption will be reduced until savings has reached the desired equilibrium level. In the long run, households will use this savings in order to boost their own consumption.

The existence of a net wealth effect in private consumption has been proven to be a necessary condition for LWL's model to be stable insofar as backward-looking expectations are assumed (see Creel and Sterdyniak 2002). In the following, we will hinge on Fuhrer (1997) or Mankiw (2001) and thus favour adaptive expectations as our specification for inflation dynamics, although some recent results favour rational expectations on empirical grounds (see Gali et al. 2001).[12] Here, we wish to concentrate on the interactions between fiscal and monetary policies only, without any interference with a fourth player, namely households. Assuming adaptive expectations, we can neglect this fourth player while in the meantime being assured that in the long run, inflationary expectations will be met (Blake and Weale 1998). Another way to motivate the adaptive expectations assumption would be to argue that the private sector may act

[10] They stated that savings shall be regarded as a process which adjusts wealth towards some target value relative to income.

[11] Equations in country B are obtained by circular permutation; this country's variables are starred.

[12] *Gali* et al. (2001) claim that they provide evidence that a forward-looking Phillips curve "fits very well Euro data" but, in their study, the expected inflation depends only on past variables. Note that *Benigno* and *Lopez-Salido* (2001), hinging on the methodology developed by *Gali* et al. (2001), show that only Germany out of five European countries support the forward-looking Phillips curve. In the other four countries (France, Italy, Spain, the Netherlands), they find a substantial inertial behaviour in inflation.

adaptively during the early stages of Monetary Union as they learn more about the new policy regime.

Aggregate supply is thus derived according to a standard Phillips curve in the open economy (eq. (2)). Real wages are indexed on the consumer price index (inputs are not imported).

(2) $$\pi_t = \pi_{t-1} + \lambda Y_t + \eta(\pi_t * - \pi_t) + z_t \text{ .,}$$

where z is a supply shock and λ is positive.

Wealth (eq. 3) is the sum of public debt and net foreign assets which grow after a trade deficit:

(3) $$W_t = D_t + F_t \text{ .}$$

Equations (4) and (5) describe the dynamics of these two assets:

(4) $$D_t = (1+\rho_t)D_{t-1} + G_t - \tau_t Y_t \text{ ;}$$

(5) $$F_t = (1+\rho_t)F_{t-1} + \eta(Y_t * - Y_t) + \eta\varepsilon(\pi_t * - \pi_t) \text{ .}$$

The model is supposed to be quarterly. Shocks occur in the first quarter of 2000 and are permanent.

2. Governments and the ECB

The two countries, named respectively A and B, share a common currency. The ECB implements the monetary policy in the union. The rest of the world is neglected. The fiscal policy framework is asymmetric.

2.1. Government A

Government A uses its tax rate to minimise its loss function (eq. 6) each quarter so that its policies are strategic, rather than *ad hoc* as in LWL.[13] The quadratic loss function depends on the differences between respectively, output, inflation, tax rate and public debt, on the one hand; and their initial steady-state values, on the other. Public debt is expressed in percent of the GDP.

(6) $$LG_t = a_0 \Delta Y_t^2 + a_1 \Delta \pi_t^2 + a_2 \Delta \tau_t^2 + a_3 \Delta (D_t / Y_t)^2$$

Parameters a_0, a_1, a_2 and a_3 are positive weights on respective targets. Targets for output and inflation are uncontroversial. The loss function also includes a term which captures the costs of tax collection (Barro 1979). In country A, the government has to stabilise public debt over GDP, at least in the long run. This

[13] In order to simplify notations, an intertemporal discount rate was not added in the loss functions. We do not intend to compare losses from one period to the other but, rather, at a certain time, from one equilibrium (Nash) to the other (cooperation).

is in line with LWL's conclusions according to which fiscal authorities have to respond somewhat to changes in government debt.

2.2. Government B

Government B implements a fiscal rule which keeps public deficits in line with the stability of its debt to GDP ratio. It is thus assumed that country B has already reached the ceiling of the SGP, considered here as the steady state level of the public deficit ratio. As stated earlier, case 1 for fiscal instruments in LWL (cf. section II) is favoured to case 2. Public spending, rather than taxes, are set in order to stabilise public debt (in GDP share). A lag in government spending is also introduced and represents the relative inertial behaviour of expenditures. Moreover, government B is able to use its tax rate τ to minimise the same loss function as government A:

$$LG^*_t = a_0 \Delta Y_t^{*2} + a_1 \Delta \pi_t^{*2} + a_2 \Delta \tau_t^{*2} + a_3 \Delta \left(D_t^* / Y_t\right)^{*2}; \tag{7}$$

$$G_t^* = (1-\chi) G_{t-1}^* + \chi \left[\tau_t^* Y_t^* - \rho_t D_t^* + \mu_g \left(\Phi - D_t^*\right)\right]. \tag{8}$$

The Φ letter represents the public debt target of government B; it is exogenous. The $\mu_g \chi$ parameter represents the speed of adjustment of the public deficit to the level required to reach Φ.

This fiscal framework is a bit more complicated than case 1 in LWL, because both fiscal instruments (tax rate and public spending) are endogenous: one is set as the outcome of a game with the other authorities (eqn. 7), whereas the other is set according to a feedback rule which is set such that the fiscal deficit remains under control (eqn. 8), in the spirit of LWL.

The introduction of these two equations in the fiscal framework of government B aims at three objectives, plus that of being as close as possible to LWL formulation. First, we compute Nash-bargaining equilibria to assess the gains from coordination; we thus need a loss function of type (7). Second, the cost of tax collection is not sufficient to limit fiscal policy toughly in the short run, so that we need equation (8) which is more stringent. Third, some macroeconomic models in the EMU adopt equation (8) as the sole strategic behaviour for all governments involved in the model[14] and it is interesting to shed light on the differences between the results obtained via equation (8) with that obtained via the policy design for government A (eq. 6).

Of course, the fact that government B controls two instruments (rather than one for government A[15]) and has the same number of targets as government A should not lead to the conclusion that the "constrained" authority is freer than

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[14] See *Barrel* and *Sefton* (1997), *Capoen* and *Villa* (1997), *Jensen* and *Jensen* (1995), *Mitchell* et al. (2000), *van der Ploeg* (1995).

[15] Actual public spending in country A is supposed to be constant and set equal to a target level, G_A.

government A.[16] In our short-run Keynesian framework, a limit on public deficit is a strong constraint for a government as far as the stabilisation of output and inflation to their respective steady states is concerned.

2.3. The ECB

The monetary union is characterised by the uniqueness of the nominal short run interest rate (i) and the independence of the ECB. The ECB is assumed to implement its monetary policy through the setting of this nominal rate. Difficulties regarding the definition and level of money supply in a monetary union and the complications due to the instability of money demand in financial economies are thus avoided. The ECB minimises the respective average and squared deviations of inflation and output from their initial steady states:

(9) $$LM_t = k_0\Delta\left(\frac{Y_t + Y_t^*}{2}\right)^2 + k_1\Delta\left(\frac{\pi_t + \pi_t^*}{2}\right)^2 + k_2\Delta\rho_{t,M^2} \text{ with } \rho_{t,M} = i_t - \frac{\pi_t + \pi_t^*}{2}$$

The ECB is also supposed to be reluctant to deviate the real interest rate from the steady state. Large deviations of the real interest rate have costly effects on the patrimonial equilibrium: if the real interest rate soars in the short run, this will provoke a steep increase in public debt in both countries, unless government A increases its tax rate dramatically and government B decreases its public spending sharply. Both moves in fiscal policy are costly for the governments, but they are also for the ECB: they reduce the future capacity of governments to stabilise output and inflation, so that the burden of future shocks might fall on the central bank. More generally, the reluctance of the ECB towards large variations in the real interest rate could be justified by the ECB's concern for a stable aggregate private investment. Or, the ECB may want to prevent the banking system from being weakened by frequent and large swings in the Repo rate which they would have to pass on to their customers.

2.4. A Remark

Macroeconomic models usually give the priority to inflation in the central bank loss function, according to the "credibility" argument: the government inflation bias needs a tough reaction by Central bankers (Rogoff 1985). Although our model does not bear on such imperfections as the inflation bias, we have made sure that our specifications for fiscal and monetary policies do not depart on this point from mainstream literature. With no costs for the use of fiscal or monetary instruments, k_1 should have been superior to k_0 and (k_1 / k_0) should have been superior to (a_1 / a_0). In our formulation with costs, this latter condition can be rewritten as:

(10) $$(k_1 - k_2) / k_0 > a_1 / (a_0 + a_2 - a_3),$$

[16] I thank *Campbell Leith* and *Henri Sterdyniak* for raising this issue.

since the cost for using the interest rate reduces the capacity of the ECB to curb inflation, and the cost for using the tax rate and the cost for increasing public debt reduce the capacity of governments to stabilise output. We will choose parameters which verify this condition.

3. Parameters

Since analytical solutions of the model in the face of shocks are intractable, we set the model in deviation from the steady-state and we adopted a parameter set in order to study the dynamic paths of model variables following the shocks. Our central parameter set is given in table 1. We chose some of them so that fiscal and monetary short-term multipliers match those of the macroeconometric international model MIMOSA (see Le Bihan and Lerais 1998).

Output is normalised at unity, and steady-state government spending is 19.7% of GDP, i.e. the amount of funds for net expenditures in the general budget of France in 1999. Initial steady state public debt is equal to 30% of GDP and corresponds to net public debt in France in 1994, thus before the cyclical rise in public deficits in the early nineties had been converted in public debt. The real equilibrium interest rate is 1% and corresponds to the gap between the interest rate and the GDP growth rate in France in 1999.[17]

Table 1

Parameters and Steady-State Values of Variables

Parameters	α	β	χ	ε	λ	η	μ	μ_g
	0.35	2.50	0.85	0.20	0.25	0.20	0.30	0.30
Loss functions	a_0	a_1	a_2	a_3	k_0	k_1	k_2	
	0.90	0.50	1.00	1.00	0.1	2.50	1.00	
Initial values	D/Y	F/Y	W/Y	ρ	τ	Φ /Y		
	0.30	0.00	0.30	0.01	0.20	0.30		

[17] It has been checked that results were not sensitive to the initial value of the public debt to GDP ratio. The fact that both countries apparently share the same basic parameters and that the model is set in deviations from the initial steady state is not inconsistent with one of them being more constrained (country B) than the other (country A). Stated differently, making both countries explicitly different (one would have a higher debt than the other) would not change the outcomes.

IV. Shocks and Policies

We now analyse the reactions of the two governments and the ECB after a symmetric supply or demand shock. The supply shock consists in a 1 point increase in the inflation rate. The demand shock takes the form of a permanent increase in the planned wealth to GDP ratio which reduces consumption in the short run. We show that most conclusions at Nash equilibrium are robust whatever the specification of the shock, be it a supply or a demand one.

The numerical simulations below are computed under two different specifications for policies. In the first one, we compute non-cooperative Nash equilibrium between the three authorities[18], whereas in the second, we compute cooperative Nash bargaining solutions between the three policy makers. These cooperative solutions are reached after the product of the game earnings for the three players has been maximised. Game earnings for each player are equal to the difference between the loss incurred at the Nash equilibrium and the one incurred at the cooperative equilibrium. It has always been checked that net earnings were positive.

1. A Symmetric Supply Shock

Contrary to the case of a demand shock, the supply shock always creates a tension between the inflation and output targets. The tension is not only between the instruments – which instrument can offset the shock at the least cost? – but also within each authority – which target will be preferred?

1.1. The Dynamics at the Nash Equilibrium

The supply shock provokes a steadily decrease in the output of both countries which is equal to 4% in the long run for each (see table 2). Inflation increases immediately from 3 and 2 percentage points for countries A and B, respectively, and stabilises 4 percentage points higher than in the pre-shock situation.

Since the ECB has been supposed to have a preference for inflation stability over output stability[19], the nominal interest rate is raised so that the real interest rate is increased by almost 200 basis points in the short run, and almost 300 in the long run. This policy has two types of effects in the model: first, it dampens inflationary trends in the short run through its negative effect on the aggregate demand. Second, it raises net interests sharply and is likely to put heavy pressure on fiscal policy.

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[18] When implementing its policy, each player considers the others' actions as given.

[19] In the statutes of the ECB (Treaty establishing the European Community, art. 105), it is specified that the primary objective for the Bank is "to maintain price stability" and that output stability might be a second objective as far as it does not jeopardise the primary one.

Table 2

Effects of a Symmetric Private Supply Shock

	Nash equilibrium				Nash bargaining			
	Country A 2001	Country A 2010	Country B 2001	Country B 2010	Country A 2001	Country A 2010	Country B 2001	Country B 2010
Y (%)	-1,90	-4,12	-4,19	-3,87	-2,99	-4,00	-3,07	-4,00
Pi (points)	3,04	3,61	2,06	3,75	2,37	3,09	2,40	3,09
Tau (points)	-0,36	0,98	-0,39	-0,34	-0,01	0,01	0,03	0,02
G (points of GDP	-	-	-0,96	-1,21	-	-	-0,01	0,01
B/Y (points of GDP)	3,92	11,34	0,07	0,00	-0,29	0,14	0,00	0,00
F/Y (points of GDP)	-1,80	-5,92	1,80	5,92	0,16	-0,07	-0,16	0,07
Losses	23,33	151,28	18,07	20,66	10,95	19,20	11,36	19,16
ECB's losses	20,77	43,85			15,17	25,45		
Real interest rate (points)	1,89	2,90			0,11	0,04		

NB1: results are set in deviations from the initial steady state values.

NB2: country B is fettered by the dispositions of the Stability Pact.

Government A tries to focus on the output deviations and to offset the negative shock: the tax rate is reduced in the short run. But the resulting steep growth in public debt (which is also due to the feedbacks of the higher real interest rate on public net interests) leads government A to increase the tax rate sharply in the long run (+1 point). This way, it reduces the inflationary consequences of public debt accumulation. Public debt however stabilises at an unprecedented peak: 11 points of GDP over its initial steady-state value!

The reversal of fiscal policy in country A between the short and the long run is quite enlightening on the effects of public debt on inflation: debt is inflationary, not because of the existence of seigniorage or inflation surprise, but because debt is incorporated into a wealth effect. The existence of non-Ricardian consumers enables government A to be also non-Ricardian: it does not have to satisfy *ex ante* its present value budget constraint because it is well aware that macroeconomic mechanisms at equilibrium will bear the costs of satisfying its constraint *ex post.*

As for government B, it is able to reduce the tax rate in the short and in the long run, because its spending is set in accordance with the satisfaction of a constant public debt to GDP ratio. In the short run, the constraint on its public deficit puts a heavy weigth on its capacity to stabilise the output: it departs in absolute value by more than 4% from its initial steady state level, whereas the deviation of output in country A is below 2%. In the mid-run, however, the stability of the public debt ratio reduces inflationary pressures as well as their negative consequences on competitiveness: the trade balance thus increases and in the long run, country B's net external position has grown by almost 6 points of the GDP. *In fine*, output in country B stabilises slightly closer to the initial steady state in comparison with country A.

Losses for both governments are quite similar in the short run, but at odds in the long run: the difference between both depends quite exclusively on fiscal instruments and public debts. The short term fiscal policy by government A is very costly in the longer run: as stated earlier, public debt soars and necessitates that the tax rate be increased by almost 1 point – in comparison, the tax rate in country B moves by 0.3 point in absolute value. Note also that the more restrictive monetary policy, the costlier fiscal policy in country A.

What could be learned from this equilibrium? First, in our setting, the government with sound public finances, and thus able to make its public deficit depart from the steady state, is more able to stabilise the output the closest to the initial equilibrium in the short run. Second, it is less able to curb inflation. In this strategy, it is outpaced by the government whose hands are tied. In the long run, the government with initial sound public finance incurs a reversal in its fiscal policy: public debt has increased so much that stopping its growth has become the primary objective of the fiscal policy maker.

1.2. The Gains from Coordination

Coordination between the three policy makers make each country face a more equitable share of the burden of the shock in the short run and increases the homogeneity in their business cycles in the long run. Output decreases more in country A with coordinated policies in comparison with the Nash equilibrium, whereas it decreases less in country B; inflation increases less in country A in comparison with the Nash equilibrium, whereas it increases more in country B (table 2).

Consequently, losses for both governments are now close one to the other in the short and in the long run, quite at odds with the situation at the Nash equilibrium. Coordination is very productive for government A in the short run in that its loss is now lower than the one incurred by government B; this situation was the opposite with uncoordinated policies. This new result depends heavily on fiscal and monetary policies. The latter is very slightly restrictive (the real interest rate rises by 10 basis points, in comparison with 200 when policies were non cooperative), so that fiscal policy is initially restrictive (rather than expansionary in the Nash equilibrium) – between 2000 and 2001, the tax rate increases by 0.3 point from its initial value –, and then neutral (rather than restrictive in the Nash equilibrium). Public debt therefore remains almost stable in proportion to the GDP.

Coordinated policies also give rise to a change in the assignment of instruments – monetary and fiscal – to targets. Whereas government A had a preference for the output target while the ECB had a preference for the inflation target at the Nash equilibrium, they now seem to have switched their preferences: government A tries to offset the inflationary consequences of the shock via a reduction in consumption (the disposable income is reduced) and the ECB does not have to implement a monetary policy restrictive enough to curb inflation as early as in the short run.

Due to the homogeneity of the business cycles in the monetary union, trade balances and the net external positions are stable at their initial steady state values. Whereas a substantial part of the stabilisation process was realised through the real wealth effect at the Nash equilibrium, it is no longer the case when policies are coordinated; the convergence of both economies in the face of a symmetric shock has been thus greatly improved.

2. A Symmetric Demand Shock

A demand shock is easier to stabilise than a supply one thanks to the absence of tension between the inflation and output targets. In the long run, the output comes back to its initial steady state level.

2.1. The Nash Equilibrium

After a negative symmetric private demand shock (table 3), at Nash equilibrium between the three policy-makers, the nominal interest rate decreases in the monetary union and government 1 implements an expansionary fiscal policy. In country B, the lack of fiscal room for manœuvre results in larger decreases in the output level and the inflation rate than in country A.

After this demand shock, government A has decreased immediately its tax rate, so that its public debt has risen up to almost 1 point of GDP. The consequences of this fiscal policy are twofold: they dampen the domestic negative shock but, meanwhile, they raise a trade deficit *vis-à-vis* country B. This latter element provokes an increase in the net external assets of country B (F is negative) and therefore helps to dampen the shock in this country through the 'real wealth effect'. Nonetheless, as government B is unable to implement an expansionary fiscal policy, the economic crises are long to overcome and the ECB has to reduce its interest rate sharply, the real interest cut being up to almost 80 basis points in the long run. This leads finally to a steep reduction in the public debt to GDP ratio (in country A) which comes back to its initial level.

Contrary to the case of a symmetric supply shock, differences between both governments' losses are very small in the long run. In the short run however, the government with sound public finances suffers from the highest losses, in comparison with government B.

2.2. The Nash Bargaining Solutions

Cooperative solutions give rise to more expansionary fiscal and monetary policies in the short run. These thus permit to reduce the scope of the negative shock at the monetary union level.

Consequently, the ECB faces less incentive to implement an expansionary policy in the long run – the decrease in the real interest rate is smaller (in absolute values) than at the Nash equilibrium –, so that public debt is 0.5 point of GDP higher than at the initial steady state. Hence, government A's loss in the long run is only slightly inferior to its loss at the Nash equilibrium.

Moreover, differences between both governments' losses in the long run are still substantial, whereas they were only marginal after a supply shock at the cooperative equilibrium. Contrary to the case with a supply shock, policies here are more expansionary in the short run than at the Nash equilibrium: the subsequent debt rise quite heavily burdens government A.

V. The Costs of the Stability Pact

At the Nash equilibrium, in the case of a symmetric shock, either a supply or a demand one, the fact that one government is constrained by the dispositions of the SGP may force the other, more solvent, government to bear the brunt of shocks – it is this government, and not the constrained one, that bears the major part of these shocks. This appears clearly in graphs 1 and 2. As early as 4 and 3 quarters after the supply or demand shock, respectively, government A faces a higher loss than government B, due notably to the substantial increase in the public debt to GDP ratio.

Table 3

Effects of a Symmetric Private Demand Shock

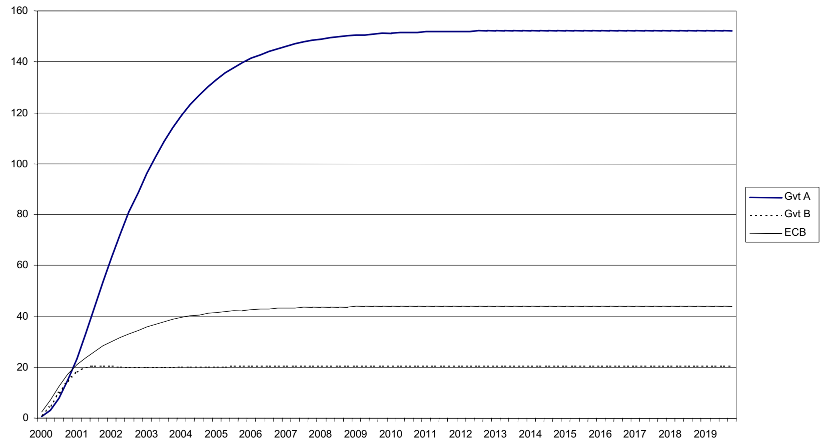
	Nash equilibrium				Nash bargaining			
	Country A 2001	Country A 2010	Country B 2001	Country B 2010	Country A 2001	Country A 2010	Country B 2001	Country B 2010
Y (%)	-0,28	0,00	-0,32	0,00	-0,09	-0,01	-0,16	0,00
Pi (points)	-0,53	-0,80	-0,68	-0,79	-0,23	-0,41	-0,32	-0,,41
Tau (points)	-0,18	-0,22	-0,04	-0,01	-0,22	-0,20	-0,22	-0,23
G (points of GDP	-	-	0,14	0,22	-	-	-0,02	-0,03
B/Y (points of GDP)	0,82	0,07	-0,01	0,00	0,50	0,48	0,00	0,00
F/Y (points of GDP)	-0,41	0,00	0,41	0,00	-0,25	-0,25	0,25	0,25
Losses	0,91	0,37	0,32	0,32	0,33	0,36	0,12	0,14
ECB's losses	1,32	2,15			0,64	0,87		
Real interest rate (points)	-0,63	-0,76			-0,67	-0,67		

NB1: results are set in deviations from the initial steady state values.

NB2: country B is fettered by the dispositions of the Stability Pact.

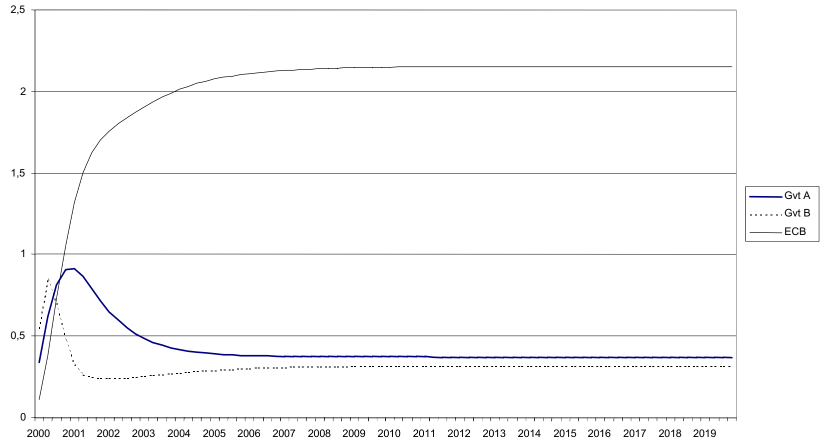
Graph 1

Losses – Symmetric Supply Shock – Nash Equilibrium



Graph 2

Losses – Symmetric Demand Shock – Nash Equilibrium

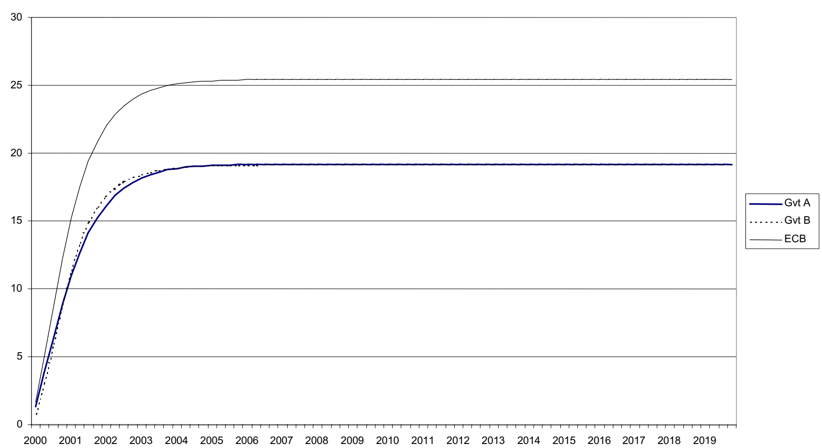


The country with sound public finances thus clearly undergoes feedback effects of the Stability Pact. These are twofold. First, as already mentioned, this country has to participate in the stabilisation of the whole monetary union. The interdependence between the economies increases the strategic interactions between fiscal policies. This interdependence is, of course, more intense as one country lacks fiscal room for manœuvre. Second, these interactions also involve monetary policy. In this peculiar setting, which hinges on an extended version of the macroeconomic model of the FTPL developed by LWL (2000), the government of country A has to stop the public debt to GDP ratio from increasing because monetary policy is active (the nominal interest rate reacts more than one for one with the inflation rate). Government A is therefore fettered in its policy choices by the growth in its debt and by the relative stringency of monetary policy: a higher debt entails more inflationary pressure which the government intends to curb; and a restrictive monetary policy prevents output stabilisation.

Nash bargaining solutions in the case of a supply shock give very interesting results: as already mentioned, coordination totally cancels the costs emerging from the Stability Pact (graph 3): losses for both governments are exactly similar.

Graph 3

Losses – Symmetric Supply Shock – Nash Bargaining

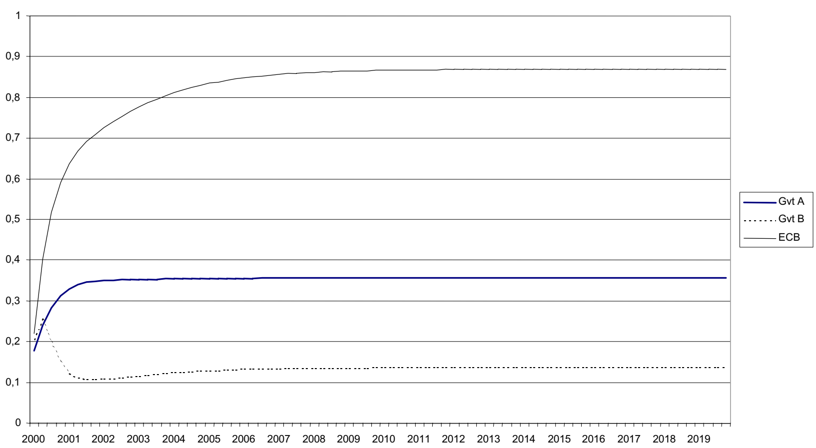


The share of the burden has thus been greatly improved by the coordination of fiscal and monetary policies. This is an important result in our framework. Though the situation of the so-called 'fiscally-constrained' country had appeared more favourable than that of the country with sound public finance (see the loss functions at the Nash equilibrium), it is no longer the case when policies are co-ordinated. Having its fiscal hand tied is beneficial only to the extent that policies are non-cooperative. It becomes detrimental to the constrained country if Nash-bargaining solutions are implemented. Although losses for the government of this country are minimised at the cooperative equilibrium, in comparison with the non-cooperative one, this government would be in a better position if its public deficits had not been limited.

The improvement in the situation of the country with sound public finance does not emerge after a demand shock though (see graph 4). Government A remains in a worse situation than government B (see section IV.2).

Graph 4

Losses – Symmetric Demand Shock – Nash Bargaining



As for the ECB, its losses are higher than both governments', except at the Nash equilibrium after a supply shock (see graphs 1 to 4). Though loss functions differ – the ECB's includes EMU-average output and inflation deviations and deviations of the real interest rate, while governments' incorporate domestic targets, tax rate and public debt deviations –, it is obvious that the costs of using the interest rate are the most prominent one in the losses incurred by the central bank.[20] They show by how much the ECB is being involved in the stabilisation of the Euro-area macroeconomic shocks. Consider no government had been fettered by a balanced-budget rule: the symmetric shock could have been compensated by appropriate fiscal policies without any increase in the public debt to GDP ratio.[21] The ECB would not have been forced into a more stringent policy. In an asymmetric fiscal framework like ours, the ECB has to compensate for the inability of one government to implement the appropriate fiscal policy.

Public debt implications in this model are thus substantial: first, they change the timing of fiscal policy. From 'active' in the short run, they can become 'passive' in the long run, undergoing progressively the "law" of an active monetary policy. Depending on the reactions of governments in the long run, the ECB also is progressively being fettered in the timing as well as the scope of its policy choices, and its ability to smooth economic fluctuations is affected by the constraints of the Pact (see also Hughes Hallett and Vines 1993, and Jensen 1997).

VI. Conclusion

In this paper, we have used an open economy version of Leith and Wren-Lewis (2000) model. This model enables a precise and comprehensive analysis of the interactions between monetary and fiscal policies. The most recent contributions concerning monetary rules, fiscal rules, and the net wealth effect are incorporated and shed light on the possible effects of public debt on the inflation rate, without having to introduce seignoriage or an inflationary tax. We also considered the specific case of an asymmetric fiscal framework in order to illustrate some possible drawbacks of the SGP, namely, that it may reduce the ability of governments and the ECB to implement stabilisation policies in the Euro area.

In fact, an asymmetric fiscal framework between countries forming a monetary union could well have strong feedback policy effects on the implementation of fiscal as well as monetary policies. First, the country whose fiscal policy is aimed at stabilising the economy may suffer from its interdependence with the other country: a negative shock in the latter country may provoke a higher public debt in the first country; and this may impede its future capacities to implement an

[20] EMU-average output and inflation deviations in the mid and long run do not depart much from domestic ones.

[21] The GDP slumps which reduce tax revenues would have been compensated by lower tax rates which would have increased tax revenues either through higher incentives to produce (Laffer argument, see *Canto* et al. 1978) or through rising demand (*Christ* argument, see *Christ* 1968).

active fiscal policy.[22] Hence, the country with initial sound public finances has to intervene in order to stabilise the whole monetary union, but it is more and more fettered in its policy choices as time moves forward if monetary policy is stringent.

Second, the ECB, in its goal of “price stability”, may not be immune either against the consequences of fiscal policies. It may have to “substitute” for the absence of fiscal policy in the country under the rule of the Pact. In the long run, if public debt increases in relation to GDP because of the restrictive monetary policy, the ECB has to choose between reducing the interest rate to curb debt’s accumulation or increasing it further to prompt “good” governments to accumulate primary surpluses. If monetary policy is very stringent in the long run and the “good” government is unable to reduce its deficit further, the economy of the whole monetary union might well follow an unstable path.

Third, coordination in the case of a symmetric supply shock is productive in that it cancels the costs emerging from the Stability Pact. A more equitable share of the burden of the shock now falls on both governments, the “good” and the “bad”. This result does not emerge after a demand shock.

Fourth, after a symmetric supply shock, the coordination of policies give rise to a change in the assignment of instruments – monetary and fiscal – to targets. The government with initial sound public finances dampens the inflationary consequences of the shock and the monetary policy is substantially less restrictive than at the uncoordinated equilibrium. This switch in the assignment of instruments does not occur after a symmetric demand shock.

At last, using a dynamic-game approach might well lead to different conclusions. The huge welfare losses suffered by country A in the wake of a supply shock, for instance, might be avoided if that country could fully take into account the negative consequences of its debt build-up, which in turn would require looking ahead (instead of considering only the current period) when setting taxes. This way, the relative ‘gains’ from being fettered by the dispositions of the SGP at the Nash equilibrium would be reduced, but overall gains from coordination would not; this time, government B, rather than A, would undoubtedly benefit most from the Nash-bargaining solution. However, introducing this new theoretical setting has been left to future research. Moreover, the short-sighted or time-consistent way to implement fiscal policy is still under debate as French public authorities seem about to renege in mid-2002 on their promise to reach a balanced government budget no later than 2004, a promise they had made in March 2002 in Barcelona!

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[22] Note that, contrary to “mainstream literature” (see, for instance, *Chari* and *Kehoe*, 1998), debt monetisation is not part of the story. This is probably on this point that the FTPL is the most attractive.

Summary

We extend the model of Leith and Wren-Lewis (2000) to the case of a two-country monetary union, incorporating adaptive expectations. An asymmetry between the stabilisation properties of the two fiscal policies is introduced: only one country is fiscally-constrained by the dispositions of the Stability Pact. Monetary and fiscal policies are set as the outcomes of a game between the two governments and the common central bank. We show that in case of negative symmetric shocks with a stringent monetary policy, the government with sound public finances is more and more fettered in his policy choices as time moves forward while the reverse is true for the fiscally-constrained government. The costs implied by the Stability Pact for the common central bank are also substantial. Coordinating monetary and fiscal policies after a symmetric supply shock is also shown to be sufficient to cancel the costs emerging from the Pact, but it is not after a demand shock.

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Term Structure of Interest Rates with Monetary and Fiscal Policy*

By *Massimiliano Marzo*

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I. Introduction

The present paper derives an equilibrium model of the term structure of nominal interest rates by considering an explicit role for both fiscal and monetary policy in the determination of the position of the term structure curve. The traditional approaches to term structure modelling so far considered in the literature have modelled the term structure as directly dependent from two essential factors: technology and inflation or a diffusion process for the growth rate of money supply. Leading contributions for the 'equilibrium' approach to the determination of the term structure have devoted scarce attention to the role of fiscal factors as additional elements to explain the position of the term structure in the plane.

The present paper proposes an integrated model where both monetary and fiscal factors play a significant role – together with the exogenous technological factors – in the determination of the term structure. The inclusion of fiscal factors is here realized by the explicit design of an active role for fiscal policy, by using the properties of the Government Budget Constraint as described by a recent stream of literature denominated Fiscal Theory of the Price Level (FTPL, hence-

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forth). This approach was inaugurated by the contributions by Leeper (1991), Sims (1994), and recently extended by Woodford (1996, 2000), Cochrane (1998, 1999, 2000), Canzoneri, Cumby and Diba (1998). The main results from FTPL state that in order to guarantee a stable path for the inflation rate, it is not enough to define a set of conditions on the rules showing the behavior of the monetary authority, in terms, for example, of a good reputation of being aggressive against expected inflationary sources. Rather, the most important condition to guarantee the existence of a stable price level (and inflation) path is about fiscal policy: the government must set taxes in order to react to the existing stock of the outstanding stock of public debt. This ensures the solvency of the government and a full stability of the inflation path. It is clear, then, that according to the degree of reaction of the tax revenue to the shocks to pubic debt, it is possible to design a full set of fiscal policy rules, each of them will have a different impact on nominal interest rates, price level and inflation.

What are the effects of such policy rules on the term structure of nominal interest rates? Is it possible to derive the stochastic process of the price level as a function of the relevant fiscal and monetary policy parameters? These are the main questions that this paper tries to address.

The framework here adopted follows closely the work by Bakshi and Chen (1996), who, by themselves rely on a well consolidated literature on equilibrium models of the term structure of interest rates inaugurated by Cox, Ingersoll and Ross (1985a,b) and extended by Marshall (1992) and Sun (1992). The model is solved in closed form and the methodology here chosen allows to highlights the various links existing between the price level, the inflation rate, the equity returns and the nominal and real terms structures to the core economic forces. Monetary and fiscal policy parameters are endogenized in the determination of the equilibrium of the model. On these grounds it is natural to see that inflation is partially a monetary phenomenon, because other elements (such as the variables form the real side of the model, like, for example, the volatility of output and especially the degree of tightness of fiscal policy parameters), can generate an inflationary pressure.

By introducing an explicit role for fiscal policy, the present model develops the idea that pressures on the (expected) inflation can come also from a loose fiscal policy, i.e. a fiscal policy set independently from the stock of outstanding bonds. Therefore, a particular set of policies on the management of public debt might have an impact on the inflation rate and on the nominal equilibrium of the model, as pointed out by Cochrane (1998, 1999, 2000), in a different context.

These features allow to disentangle the parameter of the money supply process leading the monetary policy function. From this point of view, this is a further step ahead with respect of the existing literature. In fact, in term structure of interest rates literature, we can distinguish at least two types of models: the 'traditional' models, such as the consumption-based CAPM by Breeden (1979), Stulz (1986), and the term structure models by Cox, Ingersoll and Ross (1985a, b), Costantinides (1992), Longstaff and Schwartz (1992), and Sun (1992), where there is not a crucial and really explicit role for money. In these models the nominal equilibrium is obtained through the inclusion of exogenously given processes for the price level and the expected inflation rate.

A second class of models, instead, assume a more explicit role for money. Works in this area has been done by Danthine and Donaldson (1986), Foresi (1990), Marshall (1992), Bakshi and Chen (1996) and Balduzzi (2000). These studies were empirically motivated by the attempt to solve out some of the puzzling correlations found in the empirical literature. None of these papers, however, did endogenize the process of money supply at the core of the model. In this paper, instead, the inclusion of an explicit fiscal policy channel will allow to provide a deeper analysis of the source of monetary dynamics, adding also another degree of freedom to policy making.

In this article, I assume, as in the tradition of monetary models, that rea1 money balances directly enter into the utility function. As in the most recent set of papers in this area (Sun 1992, Bakshi and Chen 1996 and Balduzzi 2000), the equilibrium is firstly derived in discrete time, then the continuous time is obtained by taking the limit of the discrete time equilibrium relationships. This allows to easily get the solution in closed form, showing the relationships among the existing variables such as the price level, inflation, equity prices and term structures, all jointly determined.

Two types of equilibrium are derived: the first is for a Cobb-Douglas type utility function in consumption and real money balances, with simple stochastic processes for output endowment and money supply. The second equilibrium, instead, assumes a simpler utility function (log-separable in both consumption and real money balances), but with more realistic stochastic processes. In both cases, simple simulations will highlight the underlying dynamic of the model as function of the key policy parameters.

In particular, for the second type of model, a complete set of pictures for the spot curves (nominal and real) and for the nominal term structure, will clearly show the main result of the model: both monetary and fiscal policy parameters affect the spot curve of nominal interest rates and the nominal term structure, in a way coherent with the logic of both monetary theory and of the recent results from the FTPL. In particular, an expected tighter fiscal policy pushes both nominal curves (spot interest rates, and term structure) down: a more aggressive fiscal policy makes the government more solvable. This will allows the government to renew the outstanding debt at a lower nominal interest rate, because of the reduction of the solvency risk premium. In fact, if the government adopts 'Ricardian' or 'Passive' fiscal policies (as they are defined by FTPL theorists), then the investors do not require a premium over the return from government bonds to cover for capital losses, due to the increased probability of government's failure. In this sense, if the government adopts a tighter fiscal policy and is credible in doing so, the value of bonds increase, because of the better protection imposed by a certain expected flow of taxes: the price of bonds raises and their yield decreases.

In the same way, a contractionary monetary policy (here identified with a reduction of the expected growth rate of money supply) will imply a reduction of both nominal spot curve and the term structure of interest rates. The reason is due to the effects induced by the expected inflation: a tighter monetary policy today will imply a lower expected inflation, and a lower expected nominal interest rate, when fiscal policy is set according to the criteria of FTPL.

An important feature of the model is given by the asymmetric behavior of the nominal and real term structure. When a separable log utility function is assumed (in consumption and real money balances), the real term structure is dependent only upon the process leading the 'real side' of the economy, given by the parameters of the diffusion processes assumed for both output and technology, and is independent upon monetary and fiscal policy factors. This, however, is true if monetary shocks are assumed to be independent upon output shocks, and vice-versa. Therefore, the real term structure is perfectly correlated only with the output process, while the nominal term structure is correlated with money growth rate, fiscal policy parameters and the technological parameters. This result is in contrast with the existing model of the term structure of interest rates. In any case, given the flexibility of the framework adopted here, it is possible to amend the model for a more general class of stochastic processes designed to respond to more stringent empirical questions.

The proved dependence of the nominal term structure upon fiscal policy factors can be empirically observed by the huge drop in interest rates registered for many countries after their joining to the EMU.[1] In Italy, for example, after the fiscal retrenchment imposed by *Maastricht* Treaty and the *Stability and Growth Pact* implemented for the joining of the EMU, we observed a remarkable reduction in interest rates from average values of 10 per cent (before 1996/1997) to average of 5 per cent (in 2000). This, despite the fact that monetary policy did not show any dramatic changes. This paper tries to offer a theoretical explanations of similar phenomena where fiscal retrenchments play a crucial role in building up the reputation of the government.

The present paper is organized as follows. The next section introduces the reader to the main assumptions underlying the model together with the description of the portfolio allocation problem faced by the representative agent/ investor. Two sections follows on the analysis of monetary and fiscal authorities, respectively. Then, the description of the equilibrium in discrete time follows together with its representation in the continuous time, obtained at the limit. An example of the equilibrium relationships in continuous time is derived for a particular utility function with specific assumptions on the main stochastic processes leading the economy. The main results of the paper are derived by considering a set of more realistic stochastic processes for technology, output and money supply: this will deliver the analytical expressions for the spot rate curves and terms structure equations to be simulated. The simulation results are reported in a separate section. The last section concludes the article. The proof of all the results are collected in the Appendix at the end of the paper.

[1] For a critical analysis about fiscal policy rules adopted by EMU, with the Stability and Growth Pact and the Maastricht Treaty, see *Sims* (1999) and *Corsetti* and *Pesenti* (1999).

II. The Model

1. The Representative Agent

The present model builds on the work by Bakshi and Chen (1996) in structuring an equilibrium model for the term structure of both nominal and real interest rates including the interactions between monetary and fiscal policies.

A representative agent optimally decides the allocation of his (her) portfolio across a wide number of assets, including nominal and real bonds and a set of shares of stocks describing the whole set of property rights on privately-owned companies. The setup is described in discrete time intervals of length Δt , then it is passed in continuous time later on.

The utility function of the representative agent is given by:

$$\text{(1)} \qquad \sum_{t=0}^{\infty} e^{-\beta t} E_0 \left\{ \left(C_t , \frac{M_t}{P_t} \right) \right\} \Delta t$$

The function (1) depends upon consumption C_t over the interval $[t, t+\Delta t]$, and M_t indicates the nominal money stock, while P_t indicates the CPI (Consumer Price Index), i.e. the general price level of the final consumption good. The instantaneous discount rate is given by $e^{-\beta t}$, where β represents the discount factor. In (1) real money balances M_t / P_t brings directly utility to the representative agent, as in Bakshi and Chen (1996): this choice has been done in order to simplify algebra. As pointed out by Feenstra (1990), we may insert money in a general equilibrium model either through transaction costs in the Representative Agent's budget constraint, or by using Cash in Advance Constraint. In the term structure literature, Marshall (1992) considers a model with transaction costs, while Balduzzi (2000), in a framework similar to the present, adopts a Cash in Advance model. Obviously, the highest empirical reliability is provided by the transaction costs model. In the present framework, the inclusion of real money balances directly in the utility function helps to simplify algebra.

I assume also that the utility function is twice continuously differentiable and concave in both consumption and real balances. Formally, this means that:

$$\text{(2)} \qquad u_c > 0, \quad u_m > 0, \quad u_{cc} < 0, \quad u_{mm} < 0, \quad u_{cm} < 0, \quad u_{cc}u_{mm} - (u_{cm})^2 > 0$$

where $m_t = \frac{M_t}{P_t}$ is the demand for real money balances. In (2) the subscript to u indicates the arguments with whom the partial derivative is taken. The portfolio allocation problem has been previously studied by Grossmann and Shiller (1982) and Bakshi and Chen (1996).

The optimal choice problem of the representative agent consists in maximizing the utility function (1) subjected to the following intertemporal budget constraint:

$$M_t + \left(P^z_{g,t} + P_t Y_t \Delta t\right) g_t + P_t z_{1,t} + z_{2,t} + \sum_{i=3}^{N} P^z_{i,t} z_{i,t} = P_t C_t \Delta t + M_{t+\Delta t} + P^z_{g,t} g_{t+\Delta t}$$

(3)

$$+ P_t \frac{z_{1,t+\Delta t}}{1+R_t \Delta t} + \frac{z_{2,t+\Delta t}}{1+i_t \Delta t} + \sum_{i=3}^{N} P^z_{i,t} z_{i,t+\Delta t}$$

From equation (3) each investor can choose among a wide range of assets traded on the market. At each time *t*, the agent demands M_t for cash, C_t, for consumption (in real terms), and equity holdings g_t (shares). The vector $z_t = \left(z_{1,t}, z_{2,t}, ..., z_{N,t}\right)'$ indicates the financial holdings of the representative agent, where $z_{i,t}$, for *i* = 1, …, *N* indicates the number of units of financial assets *i* held from $(t-\Delta t)$ to *t*. In particular, $z_{1,t}$ is the number of units of risk-free real bonds paying a real interest rate R_t, issued at time *t* and maturing at $t+\Delta t$. Similarly, $z_{2,t}$ is the number of units of risk-free nominal bonds paying a nominal interest rate i_t, issued at time *t* and maturing at $t+\Delta t$. Each agent can invest $z_{i,t}$ number of units in risky financial activities (stocks) whose nominal price (including dividend payments) is given by $P_{i,t}$, for *i* = 3, …, *N*.

Additionally, each representative agent is allowed to invest in one (single) equity share g_t which gives to the holder the property right on all the output Y_t produced through a single technology, which, expressed in units of the final good is given by:

(4)
$$\frac{\Delta Y_t}{Y_t} = \frac{Y_{t+\Delta t} - Y_t}{Y_t} = \mu_{y,t}\Delta t + \sigma_{y,t}\Omega_{y,t}\sqrt{\Delta t}$$

where $\mu_{y,t}$ and $\sigma_{y,t}$ are, respectively, the conditional expected value and the standard deviation of the output growth per unit of time while $\{\Omega_{y,t} : t = 0, \Delta t, ...\}$ is an i.i.d. standard normal random process. From (4) $\mu_{y,t}$ and $\sigma_{y,t}$ can be time variants, as in Cox, Ingersoll and Ross (1995a, b) and Sun (1992). In the present framework, I consider only a pure endowment economy. Thus, equation (4) indicates the evolution of the stochastic process leading the output endowment.

The real price in terms of the consumption goods of asset *i* at time *t* is defined as $p^z_{i,t} = \frac{P^z_{i,t}}{P_t}$. I assume that real asset prices follow a vector diffusion process described by:

(5)
$$\frac{\Delta p^z_{i,t}}{p^z_{i,t}} = \mu^z_{i,t}\Delta t + \sigma^z_{i,t}\Omega^z_{i,t}\sqrt{\Delta t}$$

where $\mu_{i,t}^{z}$ and $\sigma_{i,t}^{z}$ are, respectively, the conditional expected value and the standard deviation of real return on asset *i* per unit of time and $\{\Omega_{i,t}^{z} : t = 0, \Delta t, ...\}$ is a standard normal random process.

For expository reasons, let us also define the following stochastic process for the Price level, or CPI, as follows:

$$\frac{\Delta P_t}{P_t} = \mu_{p,t}\Delta t + \sigma_{p,t}\Omega_{p,t}\sqrt{\Delta t} \tag{6}$$

where the drift term $\mu_{p,t}$ and the standard deviation $\sigma_{p,t}$ term are taken as given for the moment, and will be derived later on as function of the core parameters of the economy. As before, $\{\Omega_{p,t} : t = 0, \Delta t, ...\}$ is a standard normal random process.

2. Monetary Policy

The crucial novelty of the present paper is represented by an explicit design of monetary and fiscal policy interactions. According to the recent literature on the Fiscal Theory of the Price Level, it is not possible to achieve a stable inflation rate if monetary policy is not accompanies by a fiscal policy which makes taxes as reacting to the level of the outstanding real public debt.

In what follows, I will describe the simplest possible framework to introduce monetary and fiscal policy interactions.

Money supply M_t^s is defined by:

$$M_t^s = M_{1t} + M_{2t} \tag{7}$$

According to equation (7) money supply M_t^s is divided up in two components M_{1t}, M_{2t}. The first component M_{1t} indicates the monetary base or high powered money, while M_{2t} indicates the amount of money employed by the government in order to balance its budget. Therefore, M_{2t} represents a source of additional financing for the government. It is known, however, that the amount of government deficit financed by direct money issuance is very low. Nevertheless it does exist and is well documented, as discussed by Walsh (1998). For example, in the United States, the amount of money financing is given by the interest rate proceedings derived from government bond holding in the Federal Reserve portfolio holdings.

To keep things as simple as possible, let us assume that monetary base M_{1t} is non-stochastic. Thus, the growth rate of monetary base is a deterministic process given by:

(8) $$\frac{\Delta M_{1t}}{M_{1t}} = \frac{M_{1t+\Delta t} - M_{1t}}{M_{1t}} = \mu_{1,t}\Delta t$$

where $\mu_{1,t}$ is the mean of the monetary base growth rate. This type of assumption on monetary policy rule is defined by Leeper (1991) as 'Active' monetary policy, meaning the fact that monetary authority sets the amount of money supply independently upon any kind of consideration in terms of expected inflation.

The only stochastic source to total money supply M_t^s come from the process specified for M_{2t} for which I assume the following Brownian motion with drift:

(9) $$\frac{\Delta M_{2t}}{M_{2t}} = \frac{M_{2t+\Delta t} - M_{2t}}{M_{2t}} = \mu_{2,t}\Delta t + \sigma_{2,t}\Omega_{2,t}\sqrt{\Delta t}$$

where $\mu_{2,t}$ and $\sigma_{2,t}$ are, respectively, the mean and the standard deviation of the stochastic process leading the growth rate of the money supply aggregate M_{2t} and $\{\Omega_{2,t} : t = 0, \Delta t, ...\}$ is again an i.i.d. standard normal random process. Combining (8) and (9) with the definition given to money supply (7) we get the stochastic process of money supply given by:

(10) $$\frac{\Delta M_t^s}{M_t^s} = \frac{M_{t+\Delta t}^s - M_t^s}{M_t^s} = \mu_{M,t}\Delta t + \sigma_{M,t}\Omega_{M,t}\sqrt{\Delta t}$$

where:

(11) $$\mu_{M,t} = \omega\mu_{1,t} + (1-\omega)\mu_{2,t}$$

(12) $$\sigma_{M,t}\Omega_{M,t} = \sigma_{2,t}\Omega_{2,t}$$

The money supply function is jointly determined by (10)-(12). The drift term given by (11) is the sum of the two components of the monetary policy rule, and the stochastic component (12) is exclusively given by the stochastic fluctuations in the transfers from Central Bank to the Government, $\sigma_{2,t}$. In equation (11) the parameter $\omega \in [0,1]$ indicates the fraction M_1 over the total amount of money issued by monetary authority. Of course, if $\omega = 0$, the only source for monetary base comes from the Treasury Channel (M_2), while if $\omega = 1$, then the only source of monetary base comes from monetary authority. Obviously, it is not difficult to verify that ω follows a motion law which is derived from the stochastic processes specified for M and M_2. In what follows, I posit $\omega = 0.9$.

The stochastic process for money supply given in equation (10) is standard in the term structure literature. Here, however, I show a way to endogenize both the drift term and the second order term of (10). This will open up an explicit role for fiscal policy. The trick employed here allows to distinguish between two sources of money supply. The composition of money supply is decided residually from Central Bank, who can fix $\mu_{1,t}$ or $\mu_{2,t}$, say by institutional arrangement[2] and let the other follows automatically.

3. Fiscal Policy

I start by defining the Government Budget Constraint in real terms is given by:

(13) $$\Delta b_t + \Delta m_{2t} = \Delta R_t b_t - \Delta T_t$$

In (13) b_t is the stock of nominal public debt issued in period $t-\Delta t$ and maturing in t, while $\Delta T_{t+\Delta t}$ indicates the change in fiscal revenue and $\Delta R_t b_t$ is the burden of interest-rate payment on the outstanding debt. In equation (13) we can identify three source of stochastic volatility: (i) shocks to the stochastic process defined for m_{2t}; (ii) shocks to fiscal revenue ΔT_t and shocks to the burden of interest payments originating from shocks to the stochastic process specified for the real interest rate R_t. Note that I assume that the level of public expenditure net of interest rate payments is zero. This does not affect the results in a dramatic way, and is done in order to simplify algebra.

A large body of literature has recently stressed the importance of introducing in monetary models a set of fiscal policy rules which are at the core of the solvency requirement of the government. According to the Fiscal Theory of the Price Level (FTPL, henceforth) given the types of monetary policy rules adopted in this paper (see the previous section), the level of taxation (or the primary surplus) must be set to promptly react to the outstanding level of public debt in order to avoid an explosive path for the price level. A typical example of such kind of fiscal policy rule is given by the following equation:

(14) $$\Delta T_t = \phi_1 b_t \Delta t + \phi_1 b_t \sigma_{T,t} \Omega_{T,t} \sqrt{\Delta t}$$

In (14) we have a description of the stochastic process leading taxes. The drift of the stochastic process is a level of taxation exactly proportional to the outstanding level of public debt, the stochastic component is given by a stochastic shock to taxes following a i.i.d. standard normal process $\{\Omega_{T,t} : t = 0, \Delta t, ...\}$.

The rule described in equation (14) individuates a set of fiscal policies defined as ‘Ricardian’ or ‘Passive’, as opposed to ‘Active’ fiscal policies which sets taxes independently upon the level of the outstanding public debt. These type of rules have been studied by Leeper (1991), Sims (1994) and Woodford (1996, 2000) and Cochrane (1998) as the only to be able to insert a bound on the price level, independently upon monetary policy specification. In rule (14) the tightness on

[2] A type of institutional arrangement of this sort could be for example given by a particular law which fixes an upper bound for deficit financing. In Italy, for example, until 1992 Central Bank was allowed to print money to finance the budget deficit until the 14% of the entire budget deficit specified by the financial law stated in each year. This limit could be also implicitly taken by Central Banks. Incidentally, in almost all G8 countries, Central Banks can play as an active dealer in the government bond market.

fiscal policy is described by the parameter ϕ_1 for which Sims (1994) established a bound given by: $0 \le \phi_1 < \beta^{-1}$.

The discussion on fiscal policy can be completed by the definition of the following stochastic process for the real rate:

$$\Delta R_t = \mu_{R,t}\Delta t + \sigma_{R,t}\Omega_{R,t}\sqrt{\Delta t} \tag{15}$$

Equation (15) introduces a stochastic process exogenous for the nominal interest with a drift $\mu_{i,t}$ and $\Omega_{i,t}$ as i.i.d. normal variable $\{\Omega_{R,t} : t = 0, \Delta t, ...\}$, whose expression will be determined later, after having obtained the closed form solution of the model.

If we combine (14) and (15) with (13) we get the following expression for the motion law of the public debt:

$$\Delta b_{t+\Delta t} + \Delta m_{2t+\Delta t} = (\mu_{R,t} - \phi_1)b_t\Delta t + b_t\sigma_{R,t}\Omega_{R,t}\sqrt{\Delta\Delta t} - \phi_1 b_t\sigma_{T,t}\Omega_{T,t}\sqrt{\Delta t} \tag{16}$$

To get a semi-closed solution for the parameter of money supply, let us specify a generic motion law for real public debt by introducing a simple deterministic process given by:

$$\frac{\Delta b_t}{b_t} = \frac{b_{t+\Delta t} - b_t}{b_t} = \mu_{b,t}\Delta t \tag{17}$$

In (17) we have that $\mu_{b,t}$ indicates the expected growth rate of real public debt. From (17) I assumed a trend deterministic component in order to simplify the model. To get a semi reduced form of the public debt equation, let us assume now that the Government aims to maintain a constant ratio of money with respect to real bonds $\psi \equiv m_2 / b$. In other words, the parameter ψ indicates the relative importance of money over bonds.[3]

III. The Equilibrium in Discrete Time

I assume that the present economy is populated by a plurality of identical agents. Thus, the behavior of the representative agent is a good proxy of all the agents living in this economy. Moreover, in a representative agent economy optimal consumption, money demand and portfolio holdings must adjust such that the following equilibrium conditions are verified:

$$C_t = Y_t \tag{18}$$

$$M_t = M_t^s \tag{19}$$

$$g_t = 1 \tag{20}$$

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[3] In *Woodford* (1996), $\psi = 0.1$.

(21) $$z_{i,t} = 0, \quad \forall i = 1, 2, ..., N$$

Condition (18) is the usual condition of equality between consumption demand and output endowment, while condition (19) equates money demand to supply. Moreover, condition (20) and (21) are the usual equilibrium conditions in the portfolio holdings markets. Thus, solving the optimization process for the representative agent, and using the equilibrium relationships (18)-(21), we find the following set of first order conditions:

(22) $$u_c(Y_t, m_t) = e^{-\beta\Delta t} E_t\left[u_c(Y_{t+\Delta t}, m_{t+\Delta t})(1 + R_t \Delta t)\right]$$

(23) $$u_c(Y_t, m_t) = e^{-\beta\Delta t} E_t\left\{\left[u_c(Y_{t+\Delta t}, m_{t+\Delta t}) + u_m(Y_{t+\Delta t}, m_{t+\Delta t})\right]\frac{P_t}{P_{t+\Delta t}}\right\}$$

(24) $$\frac{u_c(Y_t m_t)}{P_t} = e^{-\beta\Delta t} E_t\left[\frac{u_c(Y_{t+\Delta t}, m_{t+\Delta t})}{P_{t+\Delta t}}(1 + i_t \Delta t)\right]$$

(25) $$u_c(Y_t, m_t) = e^{-\beta\Delta t} E_t\left[u_c(Y_{t+\Delta t}, m_{t+\Delta t})\frac{P^z_{i,t+\Delta t}}{P^z_{i,t}}\right]$$

Recall that $p^z_{i,t}$ is the real price in terms of the consumption good of asset *i* at time *t*. In (22)-(25) I used the fact that $\frac{\Delta p^z_{i,t+\Delta t}}{p^z_{i,t}} = \frac{p^z_{g,t+\Delta t} + Y_{t+\Delta t}}{p^z_{g,t}}$, with $p^z_{g,t} = \frac{P^z_{g,t}}{P_t}$.

In addition to first order conditions (22)-(25), to guarantee the existence of an interior optimum we need the following sufficient conditions:

(26) $$\lim_{T\to\infty} E_t\left\{e^{-\beta\Delta t}\frac{u_c(Y_T, m_T)}{u_c(Y_T, m_t)}p^z_{i,t}\right\} = 0$$

(27) $$\lim_{T\to\infty} E_t\left\{e^{-\beta\Delta t}\frac{u_c(Y_T, m_T)}{u_c(Y_T, m_t)}\frac{1}{P_t}\right\} = 0$$

The transversality conditions (26) is added in order to rule out bubbles in the price level of risky assets, while the other transversality conditions (27) is added to rule out bubbles in the general price level. If condition (26) is violated, the agent will be willing to reduce consumption today in exchange of future consumption, without any bound, with the proceeds derived from the investment in risky assets. A similar interpretation works for condition (27): if violated, the agent will be willing to reduce consumption today in exchange of an increased future money service, without any bound at all, if equation (27) is violated.

From the way in which conditions (26)-27) are presented here, the bound on the utility function is crucial in determining the respect of both conditions. These conditions are important in order to exclude situations where the utility increases (decreases) without bound for an excess (low level) of consumption derived from a steady state increase (decrease) of real money balances, due to a reduction of the price level.

In this type of model the stability of the price level is guaranteed by the adoption of a particular fiscal policy rule, like rule (14). All these considerations should convince the reader of the existence and of the stability of the steady state equilibrium.

IV. The Equilibrium in Continuous Time

In what follows, I am going to derive the core relationships of the model. It should be noted that the results collected in this section do not necessarily depend upon any particular assumptions made on the utility function.

Let us start with the following Proposition defining the risk premium.

Proposition 1. The equilibrium risk premium for any risky asset over the real interest rate is given by:

$$\mu_{i,t}^{z} - R_t = -\frac{Y_t u_{cc}}{u_c} cov_t\left(\frac{dp_{i,t}^{z}}{p_{i,t}^{z}}, \frac{dY_t}{Y_t}\right) - \frac{m_t u_{cm}}{u_c} cov_t\left(\frac{dp_{i,t}^{z}}{p_{i,t}^{z}}, \frac{dm_t}{m_t}\right) \tag{28}$$

Proof. See Appendix.

From equation (28) we observe that both production and monetary policy risk enter in the definition of the risk premium of asset *i* over the real interest rate. Additionally, the risk premium is linear in both the covariance between the price of real assets and output and the covariance between the price of real asset and money.

A second proposition will describe how to derive the price level and stochastic process of the inflation rate.

Proposition 2. In the continuous time limit equilibrium, the commodity price level is given at time *t* by:

$$\frac{1}{P_t} = E_t \int_t^{\infty} e^{-\beta(s-t)} \frac{u_m(Y_s, m_s)}{u_c(Y_t, m_t)} \frac{1}{P_s} ds \tag{29}$$

The expected inflation rate is given by:

$$\begin{aligned} \pi_t &\equiv \frac{1}{dt} E_t\left\{\frac{dP_t}{P_t}\right\} = \\ &= i_t - R_t + var_t\left\{\frac{dP_t}{P_t}\right\} - \frac{u_{cc} Y_t}{u_c} cov_t\left(\frac{dY_t}{Y_t}, \frac{dP_t}{P_t}\right) - \frac{u_{cm} m_t}{u_c} cov_t\left(\frac{dP_t}{P_t}, \frac{dm_t}{m_t}\right) \end{aligned} \tag{30}$$

Proof. See Appendix.

From equation {29) we have that the price level equates the future discounted value of all the marginal benefits provided by holding one unit of dollar cash.

This equation is one of the key elements to solve for the price level as a function of the stochastic processes of money and output. Note also that the inflation rate is the conditional mean of the stochastic process of the price level given in equation (6). The derivation of the inflation is conducted by setting exactly $\mu_{p,t} = \pi_t$.

After rearranging equation (30) we have that Fischer equation does not hold when second order terms are included.

In fact, the risk premium on bonds given by $\left\{ i_t - \pi_t + var_t \left\{ \frac{dP_t}{P_t} \right\} - R_t \right\}$ becomes a function of the overall riskiness structure of the economy. Nominal risk free assets – like nominal bonds – become 'risky' assets, through the role played by the stochastic process of the price level, which is a function of the risky parameters of the economy, including monetary and fiscal policy parameters. In the examples provided below, I will make clearer this point through the help of some examples.

Consider now the derivation of real and nominal interest rates.

Proposition 3. The equilibrium real interest rate is given by:

$$R_t = \beta - \frac{u_{cc} Y_t}{u_c} \frac{1}{dt} E_t \left\{ \frac{dY_t}{Y_t} \right\} - \frac{1}{2} \frac{u_{cc} Y_t^2}{u_c} var_t \left\{ \frac{dY_t}{Y_t} \right\} - \frac{u_{cm} m_t}{u_c} \frac{1}{dt} E_t \left\{ \frac{dm_t}{m_t} \right\} + \\ - \frac{1}{2} \frac{u_{cmm} m_t^2}{u_c} var_t \left\{ \frac{dm_t}{m_t} \right\} - \frac{Y_t m_t u_{ccm}}{u_c} cov_t \left(\frac{dY_t}{Y_t}, \frac{dm_t}{m_t} \right) \tag{31}$$

The equilibrium nominal interest rate is given by:

$$i_t = \frac{u_m(Y_t, m_t)}{u_c(Y_t, m_t)} \tag{32}$$

Proof. See Appendix.

From equation (31) we observe that the stochastic process of money supply affects the real interest rate, if the utility function is non-separable in money and output. However, if the utility function is logarithmic in both money and output – like, for example, in Stulz (1986) – (this is equivalent to say that $u_{cm} = u_{ccm} = u_{cmm} = 0$) there is no way by which monetary and fiscal policy can affect real interest rate.

The right hand side of equation (32) is the marginal benefit of holding one additional unit of cash balance, or the marginal rate of substitution between consumption and real cash holdings.

The term structure of interest rate is defined according to the following proposition.

Proposition 4. (a) The nominal term structure equation is defined as:

(33) $$\frac{N(t,r)}{P_t} = e^{-\beta\tau} E_t\left[\frac{u_c(Y_{t+\tau}, m_{t+\tau})}{u_c(Y_t, m_t)} \frac{1}{P_{t+\tau}}\right]$$

where $N(t,\tau)$ is the time t nominal price of a discount bond paying a dollar in τ periods.

(b) The real term structure is:

(34) $$b(t,\tau) = e^{-\beta\tau} E_t\left[\frac{u_c(Y_{t+\tau}, m_{t+\tau})}{u_c(Y_t, m_t)}\right]$$

where $b(t,\tau)$ is the time t nominal price of a discount bond paying a unit of consumption good in τ periods.

Proof. The results here showed follow directly from the Euler equation (22).

After having established all the above results, we can now consider some example to show how the concepts exposed so far will apply to a specific set of assumptions on the utility function and the stochastic processes.

V. A Specialized Economy

1. A Cobb-Douglas Utility Function

In this section I will explore the characteristics of an equilibrium under a particular specification of the utility function and for the stochastic process of output and money. Taking the limit for $\Delta t \to 0$ of the discrete stochastic process for the output growth as in (4) and money supply equation (10), we obtain the following respective continuous-time representation:

(35) $$\frac{dY_t}{Y_t} = \mu_{y,t} dt + \sigma_{y,t} \Omega_{y,t} \sqrt{dt}$$

(36) $$\frac{dM_t}{M_t} = \mu_{M,t} dt + \sigma_{M,t} \Omega_{M,t} \sqrt{dt}$$

where $\mu_{M,t}$ will be defined later on.

Assume that the instantaneous utility function of the representative investor is given by the following Cobb-Douglas type:

(37) $$u\left(C_t, \frac{M_t}{P_t}\right) = \frac{\left[C_t^{\eta}\left(\frac{M_t}{P_t}\right)^{1-\eta}\right]^{1-\varsigma}}{1-\varsigma}$$

where η is the fraction of utility derived from consumption c_t, and $1-\eta$ derived from real money balances $\frac{M_t}{P_t}$. Moreover, ρ indicates the inverse of the risk aversion, i.e. the intertemporal elasticity of substitution.

If we apply the results from the previous section we can derive the following Proposition:

Proposition 5. Given the utility function (37) and the stochastic processes for output and money supply money supply given respectively by (35) and (36) we derive the following set of results:

(i) The risk premium is:

(38) $$\mu_{i,t}^{z} - R_t = [1-\eta(1-\rho)]cov_t\left(\frac{dp_{i,t}^{z}}{p_{i,t}^{z}}, \frac{dY_t}{Y_t}\right) - (1-\eta)(1-\rho)cov_t\left(\frac{dp_{i,t}^{z}}{p_{i,t}^{z}}, \frac{dm_t}{m_t}\right)$$

(ii) The Real Rate of Return is:

(39) $$R_t = \beta - \eta\alpha_1\mu_y - \frac{\alpha_1[\eta(1-\rho)-2]\sigma_y^2}{2} - \alpha_2\mu_M - \frac{\alpha_2[\alpha_2-1]\sigma_M^2}{2} - \alpha_1\alpha_2\sigma_y\sigma_M\rho_{y,M}$$

where $\alpha_1 = \eta(1-\rho)-1; \quad \alpha_2 = (1-\eta)(1-\rho)$.

(iii) The real price of equity share is:

(40) $$p_{g,t}^{z} = \frac{Y_t}{\beta}$$

(iv) The dynamic of the real price of equity share is governed by:

(41) $$\frac{dp_{e,t}^{a}}{p_{e,t}^{a}} = \mu_{y,t}dt + \sigma_{y,t}\Omega_{y,t}\sqrt{dt}$$

(v) The price level is:

(42) $$P_t = \frac{\eta}{1-\eta}\left(\beta + \mu_{M,t} - \sigma_{M,t}^2\right)\frac{M_t}{Y_t}$$

(vi) The dynamic of the price level is:

(43) $$\frac{dP_t}{P_t} = \pi_t dt + \sigma_{M,t}\Omega_{M,t}\sqrt{dt} - \sigma_{y,t}\Omega_{y,t}\sqrt{dt}$$

(vii) The inflation rate is:

(44) $$\pi = \mu_M - \left(\mu_y - \sigma_y^2\right) - \sigma_y\sigma_M\rho_{y,M}$$

where $\rho_{y,M}$ is the correlation coefficient between output and money, and μ_M is defined as in (65).

Proof. See Appendix.

The reduced form solutions for the variance of the price level is given by:

(45) $$var\left(\frac{dF_t}{P_t}\right)=\sigma_M^2+\sigma_y^2-2\sigma_y\sigma_M\rho_{y,M}$$

Moreover, a closed form solution of $cov\left(\frac{dP_t}{P_t},\frac{dY_t}{Y_t}\right)$ is:

(46) $$cov\left(\frac{dP_t}{P_t},\frac{dY_t}{Y_t}\right)=\sigma_y\sigma_M\rho_{y,M}-\sigma_y^2$$

Recall from equation (12) that the volatility of money supply is entirely due to the volatility of M_2, the part of money which goes in the Government budget constraint. This implies that $\sigma_y\sigma_2\rho_{y,2}=\psi\left[\sigma_y\sigma_i\rho_{y,i}-\phi_1\sigma_y\sigma_T\rho_{y,T}\right]$.

Given these relationships, it is not difficult to find that the reduced form of the variance of the CPI is given by:

(47) $$var\left(\frac{dP_t}{P_t}\right)=\psi^2(\sigma_i-\phi_1\sigma_T)^2+\sigma_y^2-2\psi\left(\sigma_y\sigma_i\rho_{y,i}-\phi_1\sigma_y\sigma_T\rho_{y,T}\right)$$

From (47) we observe that fiscal policy parameters directly enter in the definition of the volatility of the stochastic process leading the growth in the price level: fiscal policy does not only have level effect, but also is of second order importance. Now it comes natural to ask: what is the impact of the fiscal policy parameter ϕ_1 on the volatility of the CPI? From (47) we get that:

$$\frac{\partial\left[var\left(\frac{dP_t}{P_t}\right)\right]}{\partial\phi_1}\underset{>}{<}0\Leftrightarrow\psi(\sigma_i-\phi_1\sigma_T)\sigma_T\underset{<}{>}\sigma_y\sigma_T\rho_{y,T}$$

which is equivalent for establishing an upper bound for ϕ_1:

$$\frac{\partial\left[var\left(\frac{dP_t}{P_t}\right)\right]}{\partial\phi_1}\underset{>}{<}0\Leftrightarrow\phi_1\underset{>}{<}\frac{\psi\sigma_1-\sigma_y\rho_{y,T}}{\psi\sigma_T}=\overline{\phi_1}$$

Thus, the effect of ϕ_1 on the volatility of the price level strictly depends upon the magnitude chosen for ϕ_1 itself.

Let us look at the correlation between inflation and real asset return:

(48) $$cov\left(\frac{dp_{g,t}^z}{p_{g,t}^z},\frac{dP_t}{P_t}\right)=cov\left(\frac{dM_t}{M_t},\frac{dY_t}{Y_t}\right)-var\left(\frac{dY_t}{Y_t}\right)=$$
$$=\sigma_y\sigma_M\rho_{y,M}-\sigma_y^2$$

Thus, by exploiting some of the above relationships, we get:

$$cov\left(\frac{dp_{g,t}^{z}}{p_{g,t}^{z}},\frac{dP_t}{P_t}\right)=\psi\sigma_y\sigma_i\rho_{y,i}-\psi\phi_1\sigma_y\sigma_T\rho_{y,T}-\sigma_y^2= \tag{49}$$

$$=\psi\sigma_{yi}-\psi\phi_1\sigma_{yT}-\sigma_y^2 \tag{50}$$

The covariance between the inflation and the growth rate of real asset pricing is negative if $\psi\sigma_{yi}<\psi\phi_1\sigma_{yT}+\sigma_y^2$. This condition is certainly verified because $\psi<1$ by construction and in the data the correlation between output and nominal interest rate is much lower than the sum of the output volatility and the correlation between output and taxes multiplied by $\psi\phi_1$. In general, in the asset allocation practice, stocks with a negative correlation with the inflation rate will serve in hedging practice against the inflation. The negative correlation between the real stock price and the inflation rate has been carefully documented by several empirical studies, such as Fama (1981), Geske and Roll (1983) and Marshall (1992).

In particular, we can define the nominal spot rate as follows:

Proposition 6. The nominal spot interest rate is given by:

$$i_t=R_t+\pi_t-var\left(\frac{dF_t}{P_t}\right)+\rho\left(\sigma_y^2-\sigma_M\sigma_y\rho_{M,y}\right) \tag{51}$$

Proof. To get (51), we can directly apply the definition of nominal interest rate obtained after reworking the result given in equation (30), taking the derivative of the utility function (37) and the result given in (46) and (43).

From these relationships it is not difficult to verify (by using the definitions given in (64) and (65), later on) the impact of a tighter fiscal policy on the mean of the stochastic process of money growth supply and nominal interest rate (from (51)): $\partial\mu_M/\partial\phi_1<0$ and $\partial i_t/\partial\phi_1<0$. Thus, a tighter fiscal policy implies a lower value for both nominal interest rate and the growth rate of money supply.

The approach taken here is very general: all the results nests the case with a separable utility (with logs of its arguments), by setting in all the above relationships $\rho=1$, as it is common in the literature on the term structure.

To have an idea of the impact effect generated by the fiscal policy parameter ϕ_1 I reported in figure 1 some static plots for the nominal interest rate, the inflation rate and the volatility of the inflation rate with respect to changes in parameter ϕ_1. To do so, I have chosen a set of parameters according to a recent contribution by Balduzzi (2000). The values of the parameters are collected in the following table.

The parameters collected in table 1 and 2 are chosen in part from Balduzzi (2000) and in part from the contributions from RBC literature by Cooley and Prescott (1995). In particular, the parameters from table 1 are the estimated means and stochastic processes for US economy, while parameters from table 2 are standard. In particular, I have chosen a parameter for fiscal policy ϕ_1 equal to 0.55, which is lower than the upper bound provided by the Real Interest Rate, as suggested by Sims (1994).

Figure 1

Fiscal Policy Parameter, Cobb Douglas Utility

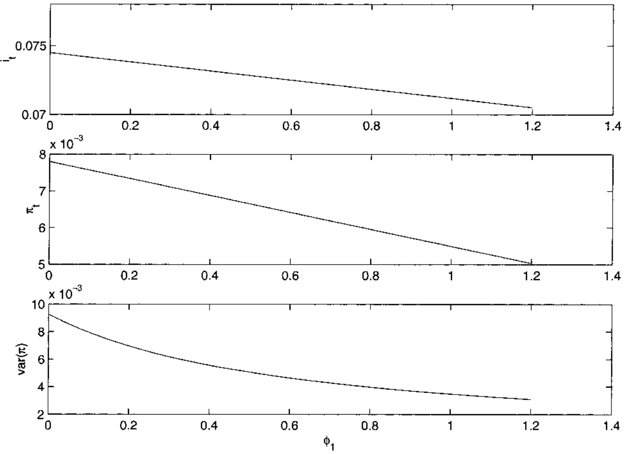


Table 1

Parameters for Stochastic Processes

μ_M	μ_R	μ_1	σ_M	σ_y	σ_R	σ_T	$\rho_{y,T}$	$\rho_{y,M}$
2.1	1.15	6.4	3.95	4.82	2.73	2.39	0.03	0.04

Table 2

Preferences

β	η	ρ	ψ
0.998	0.5	2	0.1

By using the parameter values reported in table 1 and 2 I conducted some static simulations whose results are reported in figure 1, for the impact effect of changing ϕ_1 on the nominal rate of return i_t, the inflation rate π_t and the volatility of inflation rate $var(\pi_t)$. The pictures show that if we raise ϕ_1, i.e. if we adopt a tighter fiscal policy, we observe a steady reduction of the nominal interest rate, the inflation rate and inflation volatility. This result is perfectly in accord with the Fiscal Theory of the Price Level: the adoption of a tighter fiscal policy allows the government to reduce nominal rate paid on nominal bonds, which become more valuable, given the increase of government reputation.

The results showed in figure 1 are somehow obvious and they can be also interpreted along a simple IS-LM from an undergraduate textbook. I decided to represent these results pictorially in order to show the internal coherence of the model.

To include the temporal dimension in the model, we need to add some additional assumptions on the driving stochastic processes. The price to pay for that is to use a simpler utility function.

2. Some Useful Relationships

For further convenience, let us consider the stochastic process of money expressed in real terms. Define real money supply m_t^s as $m_t^s = \frac{M_t^s}{P_t}$, where P_t is the price level (or CPI), whose stochastic process is given by equation (6). Also the other component of money supply M_{1t} and M_{2t} can be expressed in real terms as $m_{1t} = M_{1t} / P_t$, or $m_{2t} = M_{2t} / P_t$. Thus, by taking the limit for $\Delta t \to 0$ and applying Ito's Lemma to the stochastic processes of nominal money supply (8) and (9), we get the following representation for the stochastic processes of real money supply:

(52) $$\frac{dm_t}{m_t} = \mu_{mr,t} dt + \sigma_{mr,t} \Omega_{m,t} \sqrt{dt}$$

(53) $$\frac{dm_{1t}}{m_{1t}} = \mu_{1r,t} dt + \sigma_{1r,t} \Omega_{1,t} \sqrt{dt}$$

(54) $$\frac{dm_{2t}}{m_{2t}} = \mu_{2r,t} dt + \sigma_{2r,t} \Omega_{2,t} \sqrt{dt}$$

where the drift terms are given by (after having dropped for the time subscript index to save notation):

(55) $$\mu_{mr} = \mu_M - \mu_p + 2\sigma_p^2 - \sigma_{pM}$$

(56) $$\mu_{1r} = \mu_1 - \mu_p + 2\sigma_p^2$$

(57)
$$\mu_{2r} = \mu_2 - \mu_p + 2\sigma_p^2 - \sigma_{pm2}$$

and the stochastic terms are given by:

(58)
$$\sigma_{mr} = \sigma_M - \sigma_p$$

(59)
$$\sigma_{1r} = -\sigma_p$$

(60)
$$\sigma_{2r} = \sigma_2 - \sigma_p$$

Starting from the above relationships we can now describe the role of fiscal policy and we will discover how the interactions between fiscal and monetary policy can be introduced in the model.

For what concerns fiscal policy side, by applying Ito's Lemma to the definition of ψ, by using also the stochastic processes for m_t, m_{2t}, and b_t in equations (52), (54), and (17). From these calculations, we easily get (equating the deterministic and the stochastic part of the resulting expressions):

(61)
$$\mu_b = \mu_{2r} - \sigma_{2r}^2$$

Moreover, by using the definition of the stochastic process of b_t and m_{2t} into the government budget constraint (16), and equating the deterministic with the stochastic part, we get:

(62)
$$\mu_{2r} = \frac{\left(\mu_R - \phi_1 + \psi\sigma_{2r}^2\right)}{1+\psi}$$

(63)
$$\sigma_{2r} = \psi\left(\sigma_R - \phi_{1\sigma_T}\right)$$

Equations (61)-(63) indicates a set of equilibrium relationships among the drift terms of the relevant stochastic process. To highlight the role of these equation plug (62) into (11) to obtain the following expression for the conditional mean of the diffusion process for the money supply growth (equation (10)):

(64)
$$\mu_{mr} = \mu_{1r} + \frac{\left(\mu_R - \phi_1 + \psi\sigma_{2r}^2\right)}{1+\psi}$$

In nominal terms we can rewrite equation (64) as follows:

(65)
$$\mu_M = \mu_1 + \sigma_{pM} + \frac{\left(\mu_R - \phi_1 + \psi\sigma_{2r}^2\right)}{1+\psi}$$

Equations (64)-(65) are the crucial for our purposes: both highlight the various links between fiscal and monetary policy. When fiscal policy is tightened (i.e. if ϕ_1 raises), then, the conditional mean of the stochastic process of both nominal and real money growth supply is reduced. Thus, there is a negative relationship between μ_M and ϕ_1 (through the effect of ϕ_1 on μ_{2r}, from (62)).

A final observations pertains the link existing between real and nominal equilibrium, given by the presence of μ_R (the conditional mean of the real interest process). When the model will be solved after having made particular assumptions on the utility function, μ_R will be a function of the 'core' parameter of the economy.

VI. A More Realistic Economy

In what follows, I will introduce a general setup characterizing a more realistic economy from which I derive the main equilibrium properties, such as nominal and real term structure, along the same lines discussed previously. It is worth to remember that the approach taken here is in line with the equilibrium models of the term structure of nominal interest rates[4] à la Cox, Ingersoll and Ross (1985).

In order to simplify algebra and to have closed form solutions of the model, let us assume a strongly separable log utility function for the representative agent, given by:

$$u = \left(C_t, \frac{M_t}{P_t} \right) = \phi \log C_t + (1-\phi) \log m_t \tag{66}$$

where $m_t = M_t / P_t$.

Let us consider now a general stochastic process for output given by:

$$dY_t = (\mu_Y + \eta_Y x_t)dt + \sigma_Y \sqrt{x_t}\, dW_{x,t} \tag{67}$$

where the driving force is represented by the technology factor x_t for which I assume the following mean-reverting diffusion process:

$$dx_t = a(b - x_t)dt + \sigma_x \sqrt{x_t}\, dW_{x,t} \tag{68}$$

where $(W_{x,t})_t$ is a unidimensional **Q**-Brownian motion, and $\mu_Y, \eta_Y, \sigma_Y, a, b,$ and σ_x are fixed real numbers.

Given the definition of total money supply as in (7), I specify, two different stochastic processes for nominal monetary aggregates M_{1t} and M_{2t} :

$$d \ln M_{1t} = \mu_1^* dt + d \ln (q_t) \tag{69}$$

$$d \ln M_{2t} = \overline{\mu}_2 dt + d \ln (q_t) \tag{70}$$

where q_t is the detrended money supply process. Basically, from (69)-(70) we see that the stochastic process for the two types of money supply has two com-

[4] A similar model can be solved following a more general methodology described in a companion paper by *Marzo* (2001).

ponents: a drift term and a stochastic component q_t given by the detrended component. In particular, μ_1^* is assumed to be constant and positive, while $\bar{\mu}_2$ is the drift term for M_{2t}, which will be endogenized by using the Government Budget Constraint. Following Bakshi and Chen (1996), q_t is assumed to follow the stochastic process:

(71) $$\frac{dq_t}{q_t} = k_q\left(\mu_q - q_t\right)dt + \sigma\sqrt{q_t}\,dW_{i,t}, \quad i = 1,2$$

where $\left(W_{i,t}\right)_t$ is a unidimensional **Q**-Brownian motion independent upon $\left(W_{x,t}\right)_t$, for each of the two monetary aggregates M_{1t} and M_{2t}.

Therefore, by using the definition of money supply (7) and the above equations (69)-(70) and (71), we find the stochastic process leading nominal money supply given by:

(72) $$\frac{dM_t}{M_t} = \mu_{M,t}dt + \sigma_q\sqrt{q_t}\,dW_{M.t}$$

where $\left(W_{M,t}\right)_t$ is a unidimensional **Q**-Brownian motion independent upon $\left(W_{x,t}\right)_t$ and $\left(W_{i,t}\right)_t$. Following exactly the same steps described to get equations (61)-(63) and (64)-(65), we now obtain the following expressions for the drift term of the growth rate of nominal money supply:

(73) $$\mu_M = \mu_M^* + 2k_q\left(\mu_q - q_t\right)$$

with: $\mu_M^* = \omega\mu_1^* + \sigma_{pM} + (1-\omega)\bar{\mu}_2$, and $dW_{M,t} = \omega dW_{1,t} + (1-\omega)dW_{2,t}$, where, as before, ω indicates the fraction of M_{1t} over M_t, and $(1-\omega)$ is the fraction of M_{2t} over M_t. On the other hand, $\bar{\mu}_2$ is given by:

(74) $$\bar{\mu}_2 = \frac{\left(\mu_R - \phi_1 + \psi\sigma_q^2\right)}{1+\psi}$$

At this stage, equipped with the above assumptions, we can derive the main results about the stochastic process for the commodity price level and the inflation process. The following Proposition collects the results of interest:

Proposition 7. Given the utility function of the representative agent as described by equation (66), then the equilibrium price level is given by:

(75) $$P_t^c = \frac{\phi}{1-\psi}\,\frac{q_t^2\left(\beta + \mu_M^*\right)\left(\beta + \mu_M^* + 2k_q\mu_q\right)}{\left(\beta + \mu_M^*\right) + \left(k_q + 3\sigma_q^2\right)q_t 2k_q\mu_q}\,\frac{M_t}{Y_t}$$

The stochastic process of the CPI is given by:

(76)
$$\frac{dP_t^c}{P_t^c} = \pi_t dt + \sigma_q \sqrt{q_t}\left[1 + \frac{\left(\Delta_q \Psi - \Delta \Psi_q\right)}{\Delta \Psi} q_t\right] dW_{M,t} - \sigma_y \sqrt{x_t} dW_{x,t}$$

where the inflation rate is given by:

(77)
$$\pi_t = \mu_M^* - \mu_y + \left(\sigma_y^2 - \eta_y\right)x_t + \frac{\left(\Delta_q \Psi - \Delta \Psi_q\right)}{\Delta \Psi} q_t \left(k_q\left(\mu_q - q_t\right) + \frac{\sigma_q^2 q_t}{2}\right) + \\ + \frac{\left[2\left(\Delta_{qq}\Psi - \Delta\Psi_{qq}\right) - \Delta_q \Psi + \Delta \Psi_q\right]\sigma_q^2 q_t^{3/2}}{2\Psi^2 \Delta}$$

with:

(78)
$$\Delta(q) = \frac{\phi}{1-\phi}\left[q_t^2\left(\beta + \mu_M^*\right)\left(\beta + \mu_M^* + 2k_q \mu_q\right)\right]$$

(79)
$$\Psi(q) = \left(\beta + \mu_M^*\right) + \left(k_q + 3\sigma_q^2\right) q_t 2k_q \mu_q$$

and $\Delta_q = \frac{\partial \Delta(q)}{\partial q}; \quad \Psi_q = \frac{\partial \Psi(q)}{\partial q}; \quad \Delta_{qq} = \frac{\partial \Delta(q)}{\partial q}$.

Proof. See Appendix.

Both the price level (75)) and especially the expression of the inflation rate given in equation (77) are function of both fiscal and monetary parameters in a very complicated way. In the section dedicated to the simulation analysis I will provide an intuitive explanation o the pattern behavior of such variables.

The real price of the equity share is given by the following equation for a logarithmic utility function:

$$p_{x,t} = \frac{Y_t}{\beta}$$

In this case, we get that the price of the equity share is:

$$P_{z,t} = p_{x,t} P_t^C = \frac{Y_t}{\beta} P_t^C = \\ = \frac{\phi}{1-\phi} \frac{q_t^2\left(\beta + \mu_M^*\right)\left(\beta + \mu_M^* + 2k_q \mu_q\right)}{\left(\beta + \mu_M^*\right) + \left(k_q + 3\sigma_q^2\right) q_t 2k_q \mu_q} M_t$$

In the same way, it is not difficult to find the real money demand function, which, by using equation (75):

(80)
$$m_t^d = \frac{1-\phi}{\phi}\left[\frac{\left(\beta + \mu_M^*\right) + \left(k_q + 3\sigma_q^2\right) q_t 2k_q \mu_q}{q_t^2\left(\beta + \mu_M^*\right)\left(\beta + \mu_M^* + 2k_q \mu_q\right)}\right] Y_t$$

We can now ask what is the impact of changes in the growth rate of money supply in the real demand function as described by equation (80). Thus:

$$\frac{\partial m_t^d}{\partial \mu_M^*} = -Y_t\left(\frac{1-\phi}{\phi}\right)\left[\frac{\left(\beta+\mu_M^*\right)^2+\left(k_q+3\sigma_q^2\right)q_t 4k_q\mu_q\left(1+\beta+\mu_M^*\right)}{\left(\beta+\mu_M^*\right)^2\left(\beta+\mu_M^*+2k_q\mu_q\right)^2}\right]$$

As in Bakshi and Chen (1996), an increase in the expected growth rate of money supply leads to a decrease in the demand for real money balances. This is due to the discounted effect of an higher price level. In fact, an higher growth rate of money implies an higher expected inflation effect, which implies a reduction in real money balances. On the other hand, the effect of a tighter fiscal policy on money demand is exactly the opposite of the effect on money demand, due to the increase of the growth rate of the money supply. In fact:

$$\frac{\partial m_t^d}{\partial \phi_1} = -\frac{\phi}{(1-\phi)}\left[\frac{\partial m_t^d}{\partial \mu_M^*}\right] > 0$$

a tighter fiscal policy will positively affect real money balances, through the reduction of the expected inflation rate. In fact, we have already seen that a tighter fiscal policy implies a reduction of the price level and, consequently, a reduction of the expected inflation rate. This increases the money demand and depresses the demand for interest bearing assets.

What are the consequences on money velocity v_t ?

Let us consider the following definition of money velocity:

$$v_t = \frac{M_t}{P_t Y_t} = \frac{1-\phi}{\phi}\left[\frac{\left(\beta+\mu_M^*\right)+\left(k_q+3\sigma_q^2\right)q_t 2k_{q_q}}{q_t^2\left(\beta+\mu_M^*\right)\left(\beta+\mu_M^*+2k_q\mu_q\right)}\right]$$

As in Bakshi and Chen (1996), it is not difficult to verify that money velocity is strictly increasing in the drift of the diffusion process of money supply μ_M^*. However, money velocity is a decreasing function of the technological parameter q_t :

$$\frac{\partial v_t}{\partial q_t} = \frac{-(1-\phi)}{\phi q_t^3\left(\beta+\mu_M^*\right)\left(\beta+\mu_M^*+2k_q\mu_q\right)} < 0$$

It is worth to remark that the technology here is linked to output productivity and does not have to be intended as a technology to speed up the transactions. The stochastic process leading money velocity is given by:

$$\frac{dv_t}{v_t} = \left\{\theta_1 - \theta_2 k_q\left(\mu_q - q_t\right)\right\}dt + \theta_3\sigma_q q_t^{-1/2} dW_{M.t} \tag{81}$$

where:

$$\theta_1 = \frac{2\left[2k_q\mu_q q_t\left(k_q+3\sigma_q^2\right)+3\left(\beta+\mu_M^*\right)\right]\ \sigma_q^2}{\left[\left(\beta+\mu_M^*\right)+\left(k_q+3\sigma_q^2\right)q_t 2k_q\mu_q\right]\ q_t}$$

$$\theta_2 = \frac{2\left[\beta + \mu_M^* + k_q \mu_q q_t \left(k_q + 3\sigma_q^2\right)\right]}{\left[\left(\beta + \mu_M^*\right) + \left(k_q + 3\sigma_q^2\right) q_t 2 k_q \mu_q\right] \; q_t}$$

The stochastic process for money velocity given by equation (81), has a central tendency toward the drift of the diffusion process of the technology.

With these results at hand, we can easily find the covariance between the real stock prices and the inflation rate. Let us start by considering the following findings:

$$cov_t\left(\frac{dp_{z,t}}{p_{z,t}}, \frac{dP_t}{P_t^C}\right) = cov_t\left(\frac{dY_t}{Y_t}, \frac{dP_t}{P_t^C}\right) =$$

$$= 1 + \frac{\left(\Delta_q \Psi - \Delta \Psi_q\right)}{\Delta \Psi} q_t \, cov_t\left(\frac{dY_t}{Y_t}, \frac{dM_t}{M_t}\right) - var\left(Y_t\right) =$$

$$\leq cov_t\left(\frac{dY_t}{Y_t}, \frac{dM_t}{M_t}\right) - var_t\left(\frac{dY_t}{Y_t}\right)$$

According to (81), we find that the correlation between the real stock price and the inflation rate is negative if the volatility of output growth rate is bigger than the correlation between the growth rate of output and the drift term of the diffusion process of the money supply. In general, (at least for US data), it is true that $var_t\left(\frac{dY_t}{Y_t}\right) > cov_t\left(\frac{dY_t}{Y_t}, \frac{dM_t}{M_t}\right)$. In particular, this is especially true for the recent sample periods where the correlations between the growth rate of nominal money supply and the growth rate of output has been diminishing for a considerable amount of time.

The next steps include the analysis of the term structure of both real and nominal interest rates.

VII. The Term Structure of Interest Rates

In this section I will derive the analytical expressions for both nominal and real terms structure equations with some related results.

1. The Real Term Structure

Let us start by establishing the real price of a pure discount bond.

Proposition 8. The equilibrium real interest rate in the continuous time limit is given by:

(82) $$R_t = \beta + \mu_y + \left(\eta_y - \sigma_y^2\right) x_t$$

Also, the real price of a pure discount bond that pays one unit of the good in τ periods is given by:

(83) $$h(t,\tau) = \exp\left[-d_1(\tau) - d_2(\tau)x_t\right]$$

where:

$$d_1(\tau) = \left(\beta + \mu_y\right)\tau + \frac{2ab}{\sigma_x^2}\left\{\ln\left[1 + \frac{\left(1-e^{-d_3\tau}\right)\left(a+\sigma_x\sigma_y - d_3\right)}{2d_3}\right] + \frac{\tau}{2}\left[d_3 - \left(a + \sigma_x\sigma_y\right)\right]\right\}$$

$$d_2(\tau) = \frac{2\left(\eta_y - \sigma_y^2\right)\left(1-e^{-d_3\tau}\right)}{2d_3 + \left[a+\sigma_x\sigma_y - d_3\right]\left(1-e^{-d_3\tau}\right)}$$

$$d_3 = \sqrt{\left(a+\sigma_{xy}\right)^2 + 2\sigma_x^2\left(\eta_y - \sigma_y^2\right)}$$

Proof. See Appendix.

From Proposition 8, we get that the real spot rate is increasing in both the time preference parameter β and the expected output growth. By applying Ito's lemma to equation (82) we get the following dynamic equation for the real rate:

(84) $$dR_t = a\left(\gamma_R - R_t\right)dt + \sigma_R\sqrt{x_t}\,dW_{x,t}$$

where $\gamma_R \equiv \beta + \mu_y + \left(\eta_y - \sigma_y^2\right)$, and $\sigma_R \equiv \left(\eta_y - \sigma_y^2\right)\sigma_x$. From these results we get that the real interest rate follows a mean reverting square root process, with the same speed of adjustment, but with a different long run mean. Additionally, we can now properly define the drift term of the stochastic process of the real interest rate entering also in equations (64) and (65). Thus:

(85) $$\begin{aligned}\mu_R &= a\left(\gamma_R - R_t\right) = \\ &= a\left(\eta_R - \sigma_y^2\right)\left(1 - x_t\right)\end{aligned}$$

where I made use the definition of γ_R. Thus, through μ_R given in (85) in we have that the technology process parameters affect also the nominal equilibrium of the economy, as displayed in (64) and (65). This fact is independent upon the choice of the utility function, and the link is provided by the role of the Government Budget Constraint. This is in accord with the traditional models of the term structure of interest rates, but is in contrast with the results from Bakshi and Chen (1996), where nominal and real term structures appear to be completely separated the one from the other.

Given the above results it is not difficult to obtain the equation for the term structure for real interest rates $r(t,\tau)$:

(86) $$r(t,\tau) = \frac{d_1(\tau)}{\tau} + \frac{d_2(\tau)}{\tau}$$

with $d_1(\tau)$ and $d_2(\tau)$ defined as in Proposition 8.

The patterns for the term structure for real interest rates $r(t,\tau)$ defined in equation (86) will be visualized with the help of simulations, after having assigned certain parameters values.

2. The Nominal Term Structure

Given the properties of the utility function under (66), we get the following results for the nominal term structure of interest rate, collected in the following Lemma:

Lemma 9. In the continuous time limit the nominal interest rate is:

$$i_t = \frac{q_t^2\left(\beta+\mu_M^*\right)\left(\beta+\mu_M^*+2k_q\mu_q\right)}{\left(\beta+\mu_m^*\right)+\left(k_q+3\sigma_q^2\right)q_t 2k_q\mu_q} \tag{87}$$

The nominal price of a discount bond paying one dollar in τ periods is given by:

$$\begin{aligned} Nb(t,\tau) &= f_1\left\{f_2 e^{-2k_q\mu_q\tau}\frac{2k_q^2\mu_q^2}{q_t}(1-f_2)+2f_2^2k_q^2\mu_q^2\right\}+ \\ &+f_1\frac{\left(\beta+\mu_{M^*}\right)}{q_t^3}e^{-3k_q\mu_q\tau}(1-f_2) \end{aligned} \tag{88}$$

where:

$$f_1(\tau)=\frac{\exp\left[-\left(\beta+\mu_M^*\right)\tau\right]}{\left(\beta+\mu_M^*\right)+\left(k_q+3\sigma_q^2\right)2k_q\mu_q}$$

$$f_2=\frac{\left(k_q+3\sigma_q^2\right)}{k_q\mu_q}$$

Proof. See Appendix.

From the above results, we easily get the following dynamic equation for the nominal interest rate, by applying Ito's Lemma to equation (87):

$$\frac{di_t}{i_t}=\mu_{i,t}(q)dt+\sigma_{i,t}(q)\sigma_q q_t^{1/2}dW_{M,t}$$

where:

$$\mu_{i,t}(q)=\left[\frac{(2g_0+g_1)k_q\left(\mu_q-q_t\right)}{\left(g_0+g_1q_t\right)}+\frac{\left[2g_0(1-q_t)+2g_1q_t-g_1q_t^2\right]}{\left(g_0+g_1q_t\right)^2}\sigma_q^2\right]$$

$$\sigma_{i,t}(q)=\frac{\left(2g_0+g_1q_t\right)}{\left(g_0+g_1q_t\right)}\sigma_q q_t^{1/2}$$

Given the more complex structure of the model assumed here, it is not easily possible to link the structure of the above process to standard stochastic processes for the nominal interest rates, as, for example, in Bakshi and Chen (1996). For this reason, in the following section I am going to consider some simulations to highlight the main relationships existing among the variables.

Finally, the nominal term structure of interest rates is given by:

$$N(t,\tau) = -\frac{1}{\tau}\ln\left[Nb(t,\tau)\right] \tag{89}$$

with $Nb(t,\tau)$ given in equation (88).

VIII. Simulation Results

The results reported in an analytic form can be better understood by considering some simulations which will shed light on the mechanics of the transmission channels among the variables. To do so, I decided to parametrize the model by following the work by Balduzzi (2000) who estimated the parameters of the stochastic process leading the model by using methods of moments. The parameters chosen for this model are collected in table 3.

Table 3

ϕ	k_q	μ_q	a	b	μ_Y	η_Y	σ_γ	σ_X	σ_q
0.01	0.56	0.11	0.86	0.06	1.3	0.7	0.06	0.03	0.02

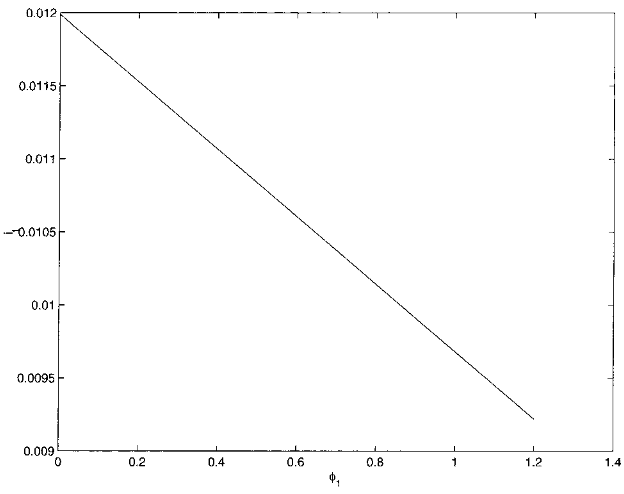
The parameter β is set equal to 0.998, as considered in the previous model, and the fiscal policy parameter is set equal to $\phi_1 = 0.55$. However, it should be remembered that the main goal of the present paper is to show the joint role of monetary and fiscal policy in the determination of the term structure of interest rates. Thus, I do not pretend that the parameters here considered represent the best choice in absolute terms, rather it should be regarded as a working hypothesis. The search for the model which could best fit the data is not the goal of the present paper.

In order to run the simulations, I integrated the diffusion processes for money supply, output growth, technology and the stochastic process describing the stochastic trend in money supply, and I initialized them by setting an initial condition equal to $x_0 = Y_0 = M_0 = q_0 = 1$.

In figure 2 we observe the effect of changing ϕ_1 on the nominal interest rate as fiscal policy gets tighter, the nominal rate reduces: a higher fiscal policy makes the government more solvable, making possible to issue debt at a lower cost. This result should be read together with what has been reported in figures 3 and 4.

Figure 2

Nominal Interest Rate: Static Simulation for ϕ_1



In figures 3-4 I reported the pictures to detect the effect of changes in the price level and the inflation rate for changes in fiscal policy parameter ϕ_1 and monetary policy parameter μ_1. The simulations reported in figures 3 and 4 are conducted within an *a-temporal* context, without considering the intertemporal dimension. This is done in order to show the impact effect on both the price level and the inflation rate induced by changes in parameters ϕ_1 and μ_1. In figure 3 we observe that a progressive increase in ϕ_1 creates a steady reduction of the level of the price index and, at the same time, of the inflation rate. Thus, even in this case with a more complex structure we find a confirmation of the results found in the previous section: a tighter fiscal policy has a deflationary impact. Differently from the simple case considered before, these results cannot be observed by directly referring to the equations in the model, so the simulation well visualize the impact effect due to fiscal and monetary policy.

In figure 4, I show the effects on the same variables after changing the monetary policy parameter μ_1, by keeping the fiscal policy parameter fixed at 0.55, as benchmark parameter. In this case, we observe an almost reversed effect: the increase of the drift term of the stochastic process of money supply growth held by private agents has an inflationary impact, as expected. These static simulations are coherent with what we would expect from a simple macroeconomic model.

Figure 3

Effects of Changes in ϕ_1 on *P* and π

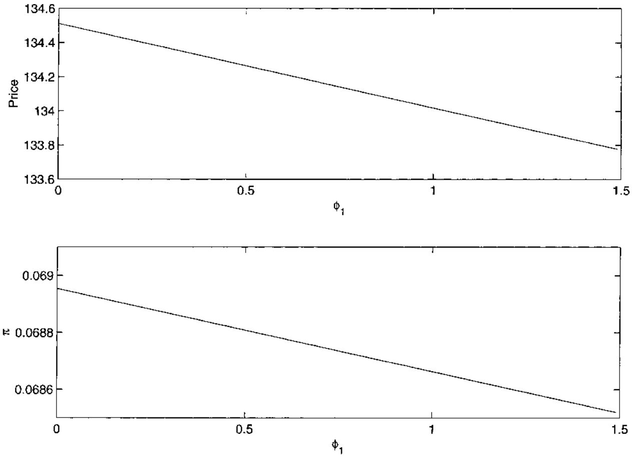
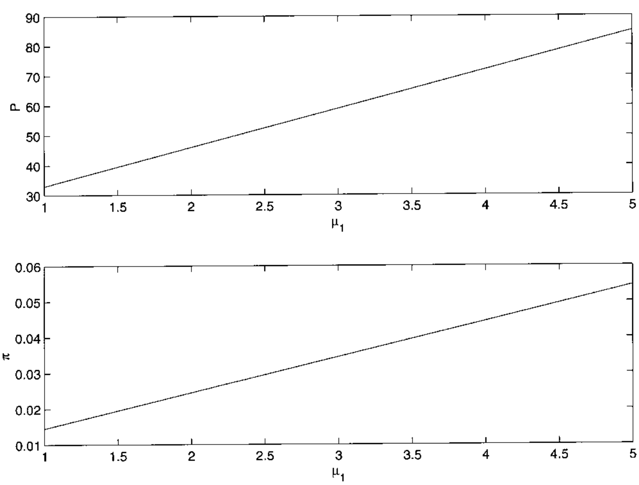


Figure 4

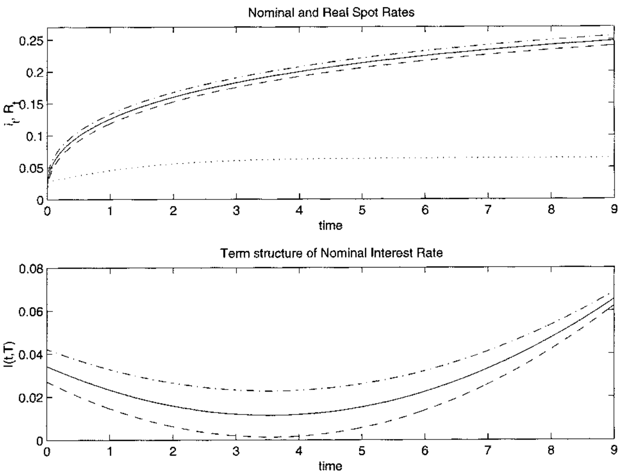
Effects of Changes in μ_1 on P and π



When we include the temporal dimension into the model the results are more interesting. In Figures 5-7 I reported the pictures for the nominal and real spot interest rate, together with the nominal term structure, for different values of the monetary and fiscal policy parameters.

Figure 5

Monetary Policy



In figure 5, I considered how the change in the drift of the diffusion process affects the nominal curve and the position of the term structure of interest rate.[5] In both panels reported in figure 5, the continuous dark line is drawn for the benchmark values of the drift for the diffusion process, by using for μ_1 a value equal to $\mu_1 = 6.4$. The dashed line is drawn for a lower value such as $\mu_1 = 5$, while the dot-dashed line is drawn for $\mu_1 = 8$.

Let us concentrate on the top panel. The dotted line represents the spot real interest rates, which is not influenced at all by changes in the monetary policy parameter, given the utility function assumed in (66). If we concentrate on the nominal curves, we observe that position of the spot cure in the plane is affected by the size of μ_1. In particular, a monetary contraction, given by a reduction in μ_1 shifts the curve of nominal rate downwards (dot-dashed line), while a monetary expansion shifts the curve upwards (dashed line). These results are due to the expected inflation effect: a monetary expansion today will imply an increase

[5] The simulation goes for 9 periods with a step of 0.01.

of the expected inflation (see equation (77)), this will make government bonds less attractive, making their price decreasing and the nominal interest rate increasing.

In the bottom panel of figure 5 I reported the effects of changing the drift of the diffusion process of the growth rate of nominal money supply μ_1 in the term structure of nominal interest rates. In particular, we observe that even in this case different values of the parameter μ_1 shifts the position of the term structure equation: contractionary monetary policy shifts the entire term structure downwards (dotted/dashed line), while a monetary policy expansion moves the curve upwards. The results showed in figure 5 are coherent with the traditional approaches for the term structure highlighted by Cox, Ingersoll and Ross (1985): the term structure depends from both technological parameters and monetary policy parameters. However, this model has an additional feature: movements of the term structure and of the spot curve of nominal rates can be also justified by looking at the impact of the fiscal policy parameter ϕ_1. It is clear, however, that all these movements are due to the expected change in a particular monetary policy or fiscal policy parameter.

As before, in figure 6, I have reported the curve of the nominal spot rates for different values of the fiscal policy parameter ϕ_1. In particular, the dark line is drawn for $\phi_1 = 0.55$, assumed to be the benchmark value.[6] Moreover, the dashed line is drawn for $\phi_1 = 0.8$, the dashed-dotted line is for $\phi_1 = 0.2$, the dotted line is for $\phi_1 = 0.0005$. The bold line indicates the real rates, not influenced by fiscal policy parameters, as discussed previously for monetary policy parameter. Basically, if we expects the Government to adopt a tighter fiscal policy, by making the level of taxes reacting more vigorously to the outstanding level of public debt, (higher ϕ_1), the spot rate curve will move down. Instead, when we expect a softer fiscal policy (lower ϕ_1), the curve will shift up. This is because the market will require an higher level of the nominal interest rate in order to be willing to buy bonds, issued by a government which adopted a loose fiscal policy, to compensate the investor from expected capital losses due to scarce government solvency. Instead, if fiscal policy is expected to be tight (high level of ϕ_1), the lower level of the curve is implied by the increase in the price of government bonds, which now are more valuable. This implies a reduction of nominal interest rate paid on the outstanding level of government bonds.

Similar considerations can be done for the term structure curve represented in figure 7. The picture shows that the position in the plane of the term structure strictly depends upon the value assumed for ϕ_1. In particular, it is evident that if the fiscal pressure decreases (i.e. if ϕ_1 decreases), the curve of the nominal term structure zero coupon bond shifts down.

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[6] In all the simulations reported in figures 6 and 7, I assumed a benchmark value for the monetary policy parameter, set equal to its estimated mean value, given by $\mu_1 = 6.4$.

Figure 6

Nominal and Real Spot Interest Rates

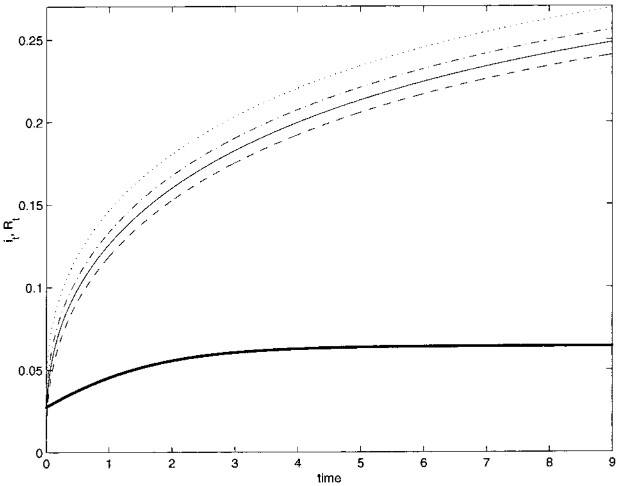
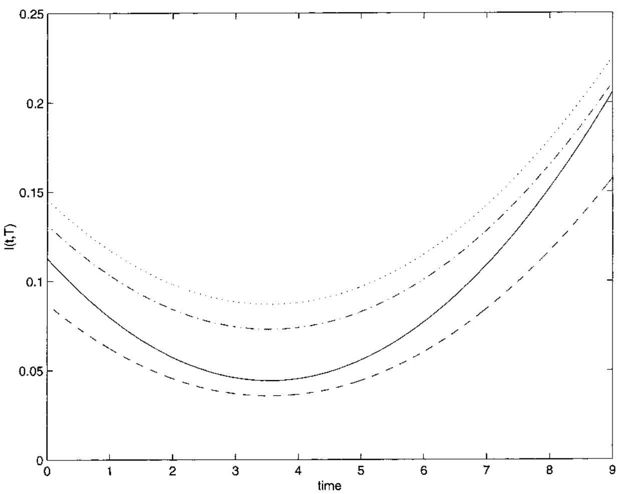


Figure 7

Term structure of Nominal Interest Rates



The picture shows that the position in the plane of the term structure strictly depends upon the value assumed for ϕ_1. In particular, it is evident that if the fiscal parameter ϕ_1 decreases, the curve of the nominal term structure shifts up, even if for very high values of ϕ_1 the curve appears to loose its sensitiveness to this parameter. The behavior of the curve is coherent with both the results from Fiscal Theory and the empirical evidence. In fact, if the tax rate raises, this means that it will be possible to reduce the number of issue of new public debt in order to finance the current position of the government. This will call for a lower interest rate, and for a bigger government credibility.

A final aspect that should be stressed out is related to the relationship between ϕ_1 and the term structure for different maturity dates: from figure 7 we see that this is a monotone relationship. When ϕ_1 raises (lowers) the term structure curve shifts down (up) for all the maturity dates.

These results clearly show that the position of the term structure in the plane depends also upon fiscal policy parameters in the same way as for monetary policy parameters. Thus, both fiscal and monetary policy are important for position of the term structure, on the plane. Empirically, this has been verified as true in the experience of Italy after 1996-1997 episode of fiscal retrenchment which shifted down the position of the nominal term structure after a crucial fiscal consolidation, necessary to get into the EU. These results have extended the traditional term structure approach by Cox, Ingersoll and Ross (1985a,b), and Bakshi and Chen (1996) by including a specific role for fiscal policy, by exploiting the role of the government budget constraint.

1. An Empirical Example: the Italian Experience

The theory presented in this paper helps to explain the phenomena underlying the fiscal retrenchment occurred in Italy during the past years. Around 1995-1998 Italy had to adopt a serious fiscal retrenchment in order to satisfy the requirements necessary to join EMU on January 1, 1999. According to *Maastricht* Treaty, Italy had to show a deficit/GDP ratio no higher than 3% and a serious commitment towards the reduction of debt/GDP ratio in order to reach the target of 60%. In order to fulfil these requirements, the Italian government adopted several restrictive measure on public finances in order to make credible the aggressive policy towards deficit and debt reduction and allow to Italy to participate to the third stage of construction of EMU.

In tables 4 and 5, respectively, I reported data on the fiscal variables and on bonds returns. In table 4 I reported annual time series values for the Debt/GDP and Deficit/GDP ratios from 1994 to 1999. This information should be read together with data presented in Table 5, where I collected the mean of some selected bonds returns.

From table 4 we see that the highest value for Debt/GDP ratio and the highest value of the deficit was in 1994. From 1995 Italy started an important process of fiscal consolidation which began with the Social Security Reform. However, the true fiscal retrenchment was between 1996 and 1997 where a sharp increase of fiscal pressure and a reduction of public expenditure made the Deficit/GDP ratio dropping from 7.1% to 2.7% within only one year, as showed in table 4. A similar, but more gradual effect can be seen on the pattern observed for Debt/GDP ratio which shows a constant tendency towards the reduction. However, two aspects remain to be explored. First, what is the impact of the fiscal retrenchment documented in table 4 on interest rates? Secondly, what is the impact of the announcement released in mid 1998 that Italy was accepted to be member of EMU?

Table 4

Data on Fiscal Variables

	Debt/GDP	Deficit/GDP
1994	124	-9.3
1995	123.1	-7.6
1996	121.8	-7.1
1997	119.6	-2.7
1998	117.2	-2.8
1999	115.7	-1.8

To understand these aspects, in table 5 I reported data on bond returns over three different subsamples: 1984:1-1996:12, 1997:1-1998:6, 1998:7-2001:12. I also reported the Maximum and Minimum reached by each variables over the all sample period (1984:1-2001:12) and in brackets the periods where they were reached. The numbers in columns refer to the mean of the respective variable over each of the subsample periods. The variables under exam are: the Gross Auction Return (GAR) for 3, 6, 12 months bonds, the Auction Price of 3, 6, 12 months.[7] BOT (PBOT), the return on Bonds on the Secondary Market. Data were collected with monthly frequency. The choice of the subsample is motivated according to several reasons. The first subsample describes the situation before the implementation of fiscal policies towards EMU. The last subsample starting from July 1998 detects the impact on bonds prices and returns derived from the announcement that Italy was accepted into EMU: this sample captures also a reputational effects on the behavior of bonds returns, derived from the expectation of a more rigorous fiscal policy. The subsample 1997:1-1998:6 reflects the effects on bond returns and prices impressed by a strong fiscal restriction occurred in the last quarter on 1996 when a new Government in Italy took place after elections held in Spring 1996. In order to reach the goal of joining

[7] The acronymn 'BOT' stays for 'Buoni Ordinari del Tesoro' and refers to short term Treasury Bills.

EMU the Government announced since June 1996 a strong fiscal restriction, which was effectively implemented with the Tax Law licensed in November 1996. This fiscal retrenchment was approximately of the order of 40 millions of Euro and included an extraordinary personal tax called ‘Tax for Europe’ due by each household to support deficit reduction and increasing the chances of getting Italy into EMU at the first round.

Table 5

Data on Bond Returns

	1984:1-1996:12	1997:1-1998:6	1998:7-2001:12	Max	Min
GAR 3-M	11.85	6.10	3.82	18.23 (1992:9)	2.45 (1999:9)
GAR 6-M	11.77	5.97	3.87	18.52 (1992:9)	2.57 (1999:5)
GAR 12-M	11.76	5.78	3.93	17.02 (1992:9)	2.67 (1999:5)
PBOT 3-M	97.24	98.56	99.01	99.39 (1999:8)	95.91 (1992:9)
PBOT 6-M	94.59	97.12	98.10	98.72 (1999:4)	91.83 (1992:9)
PBOT 12-M	89.49	94.63	96.16	97.34 (1999:4)	85.3 (1992:9)
Bond Ret. on Sec. Mkt	12.14	6.03	4.68	16.92 (1984:1)	3.54 (1999:4)

By looking at data reported in table 5 we find exactly the effect predicted by the theory: the fiscal retrenchment sharply reduces the returns on all types of bonds, for all maturities. In fact, after the fiscal retrenchment occurred at the end of 1996, we observe a sharp reduction of all bond returns and a correspondent increase in bond prices in the sample 1997:1-1998:6, if compared with the previous sample 1984:1-1996:12. As further evidence corroborating the conclusion offered by the theoretical model, the reduction of bond returns and the increase in bond prices is even stronger in the following sample starting from July 1998, after the official announcement that Italy was admitted to EMU. In some cases, the reduction of the return is really remarkable, as in the case of the Gross Auction Rate on 3-months bonds which drops from 6.1% to 3.82%, after July 1998. This further reduction occurred after the announcement that Italy was admitted into EMU, can be interpreted as the fact that the restrictive fiscal policy adopted by Italy in previous years were no longer considered as an isolated episode, but as the necessary premise for a more sound fiscal policy for the future, given the restriction imposed by *Stability and Growth Pact* on all EMU members. Thus, the further drop on bond returns is determined by the expectation of a continuing rigorous fiscal policy to be adopted thereafter.

As a further remark, bond prices move closely to returns: bond prices were low and bond returns high in the subsample 1984:1-1996:12 because the Italian fiscal policy was loose during that period. Thus, financial market were discounting an implicit risk on the solvency of the Italian government.

The highest value for the Gross Auction Returns for all three types of maturities (3,6 and 12 months) is registered to occur in September 1992 during the huge speculative attack on the Italian Lira (subsequent to the attack against the British Pound) which forced Italy to abandon the fixed exchange rate regime managed by EMS. The lowest value of the returns and the highest value for bond prices can be observed in 1999, when the fiscal policy effects were fully reflected in bond financial data..

The example above treated has been focused on Italy because this is the only country which in the recent past experienced a strong fiscal retrenchment of the type described in the theoretical part of the present paper. The descriptive evidence here reported represents a confirmation of the pervasive role of Fiscal policy on bond returns: both direct and in expectation. A similar impact can be observed on the inflation rate: the average inflation rate over the subsample 1984:1-1996:12 was 9.4%, but 2.2% for the sample 1998:7-2001:12. This is another example of the direct role of fiscal policy on interest rates and on inflation rate, as discussed in the theory exposed in previous pages.

IX. Concluding Remarks

In this paper I addressed a basic question: given the importance of fiscal retrenchment episodes in the recent past of some European countries and the observed contemporaneous drop of nominal interest rates, is it possible to construct a general equilibrium model for the term structure of interest rate which would depend upon both monetary and fiscal policy parameters? Borrowing many features from Bakshi and Chen (1996) and Balduzzi (2000), I constructed a model which, through the explicit design of fiscal policy as suggested by the contributions of the Fiscal Theory of the Price Level (FTPL), shows that inflation is not necessarily a monetary phenomena. In this framework, fiscal policy together with monetary policy plays a crucial rule in the determination of the position of the nominal term structure. An expected tighter fiscal policy shifts down the nominal term structure curve and the nominal spot curve. In a simple case with a strongly separable utility function in both output and real money balances, nominal and real term structures depend upon different set of parameters: the real curve depends only upon the technological factors, but not upon policy (monetary and fiscal) policy parameters. However, the nominal curve depends also upon the parameters which determine the drift of the stochastic process of the real interest rate.

All the variables of the model (such as price level inflation, nominal and real interest rates) were jointly derived as function of the ‘core’ parameter of the economy, within a general equilibrium approach. The results appears to be in line with the recent experience of some countries, like for example Italy, which after a fiscal retrenchment and the adoption of particular fiscal policy rules, showed a marked reduction in nominal interest rates.

These results generalize two types of literature that were considered independent so far: the literature on the term structure and asset prices in a general equilibrium framework and the Fiscal Theory of the Price Level. Given the simplicity and the generality of the model, there is enough room to further generalize the model to allow different diffusion processes leading the money growth supply, output and technology, as those assumed by the various models of the term structure of interest rates.

Summary

In this paper I jointly derive the stochastic process of the price level, the inflation rate, the nominal and real term structures, as function of monetary, fiscal and technological parameters within a general equilibrium framework. The novelty of the present approach is given by the possibility of obtaining closed form solutions for all the variables and by the explicit design of fiscal policy as crucial parameter in addition to monetary policy. Thus, inflation is not uniquely a monetary phenomenon, but also fiscal policy plays a crucial role in determining the position of the nominal spot rate curve and the term structure of interest rates. The riskiness of the nominal and real term structures is a function of different sources of risk, depending whether the utility function is strongly separable or not in consumption and real money balances. With a strongly separable utility monetary and fiscal parameters affect only nominal equilibrium. All the main relationships derived in the model are simulated for various values of policy parameters. The main results make fiscal policy as a crucial element in determining the patterns of the term structure behavior. This is also supported by a simple descriptive analysis of the recent fiscal retrenchment implemented by Italy during the process of joining EMU in 1996–1998.

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Appendix

Proof of Proposition 1

Subtract equation (22) from equation (25). Then manipulate the resulting expression and use the definition of the stochastic process for $p_{i,t}^{z}$ given in (5) to get::

(90) $$e^{-\beta\Delta t}E_t\left\{\frac{u_c(Y_{t+\Delta t}, m_{t+\Delta t})}{u_c(Y_t, m_t)}\left[\left(\mu_{i,t}^{z}-R_t\right)\Delta t+\sigma_{i,t}^{z}\Omega_{i,t}^{z}\sqrt{\Delta t}\right]\right\}=0$$

Take now a Taylor expansion of the equation (90) around the steady state, we obtain:

(91) $$e^{-\beta\Delta t}E_t\left\{\left[\left(\mu_{i,t}^{z}-R_t\right)\Delta_t+\sigma_{i,t}^{z}\Omega_{i,t}^{z}\sqrt{\Delta t}\right]\cdot\left[1+\frac{u_c(Y_{t+\Delta t}, m_{t+\Delta t})Y_t}{u_c(Y_t, m_t)}\frac{\Delta Y_t}{Y_t}+\right.\right.$$
$$\left.\left.+\frac{u_{cm}(Y_{t+\Delta t}, m_{t+\Delta t})m_t}{u_c(Y_t, m_t)}\frac{\Delta m_t}{m_t}\right]\right\}\frac{1}{\Delta t}=0$$

letting $\Delta t \to 0$ in (91) and applying the Ito's multiplication rule, we easily derive (28).

Proof of Proposition 2

Rewrite the first order condition (23) as follows:

(92) $$\frac{1}{P_t}=e^{-\beta\Delta t}E_t\left\{\left[\frac{u_c(Y_{t-\Delta t}, m_{t+\Delta t})}{u_c(Y_t, m_t)}\frac{1}{P_{t+\Delta t}}+\frac{u_m(Y_{t+\Delta t}, m_{t+\Delta t})}{u_c(Y_t, m_t)}\right]\frac{\Delta t}{P_{t+\Delta t}}\right\}$$

then, iterate equation (92) to get:

(93) $$\frac{1}{P_t}=E_t\left\{\sum_{j=1}^{\infty}e^{-\beta(j\Delta t)}\frac{u_m(Y_{t+j\Delta t}, m_{t+j\Delta t})}{u_c(Y_t, m_t)}\frac{\Delta t}{P_{t+j\Delta t}}\right\}$$

Taking the limit of the equation (93) we get the result under (29).

To obtain the expression for the inflation rate, divide the two first order conditions (22) and (24), to get:

$$E_t\left\{\frac{u_c(Y_{t+\Delta t}, m_{t+\Delta t})}{u_c(Y_t, m_t)} + (1+R_t\Delta t)\right\} = E_t\left[u_c(Y_{t+\Delta t}, m_{t+\Delta t})(1+i_t\Delta t)\frac{P_t}{P_{t+\Delta t}}\right] \tag{94}$$

Expand equation (94), in Taylor's series to get, after rearrangement:

$$(i_t - R_t)\Delta t = \left[1 + \frac{u_{cc}Y_t}{u_c}\left(\frac{\Delta Y_t}{Y_t}\right) + \frac{u_{cm}}{u_c} m_t\left(\frac{\Delta m_t}{m_t}\right)\right]\left[\frac{\Delta P_t}{P_t} - \left(\frac{\Delta P_t}{P_t}\right)^2\right] + o(\Delta t)^{3/2} \tag{95}$$

Thus, by taking the limit of equation (95), for $\Delta t \to 0$ we have:

$$i_t - R_t = \frac{1}{dt}E_t\left\{\frac{dP_t}{P_t}\right\} - var_t\left\{\frac{dP_t}{P_t}\right\} + \frac{u_{cc}Y_t}{u_c}cov_t\left(\frac{dY_t}{Y_t}, \frac{dP_t}{P_t^C}\right) + \frac{u_{cm}m_t}{u_c}cov_t\left(\frac{dP_t}{P_t}, \frac{dm_t}{m_t}\right)$$

Thus, by using $\pi_t = \frac{1}{dt}E_t\left\{\frac{dP_t}{P_t}\right\}$, and rearranging we easily get the equation (30).

Proof of Proposition 3

Consider the First Order Condition in equation (22) and take a Taylor expansion around the equilibrium, to get:

(96)

$$u_c(Y_t, m_t)(1+R_t\Delta t) = E_t\{[u_c(Y_t, m_t) + u_{cc}(Y_t, m_t)\Delta Y_t + u_{cm}(Y_t, m_t)\Delta m_t + \\ + \frac{u_{ccc}(Y_t, m_t)}{2}(\Delta Y_t)^2 + \frac{u_{ccm}(Y_t, m_t)}{2}\Delta Y_t \Delta m_t + \frac{u_{cmm}(Y_t, m_t)}{2}(\Delta m_t)^2\Big](1+R_t\Delta t)\Big\} + o(\Delta t)^{3/2}$$

Thus, simplifying, we get:

(97)

$$R_t = \beta - \frac{1}{\Delta t}E_t\left\{\frac{u_{cc}(Y_t, m_t)Y_t}{u_c(Y_t, m_t)}\left(\frac{\Delta Y_t}{Y_t}\right) + \frac{u_{cm}m_t}{u_c}\left(\frac{\Delta m_t}{m_t}\right) + \frac{u_{ccc}Y_t^2}{2u_c}\left(\frac{\Delta Y_t}{Y_t}\right)^2 + \right. \\ \left. + \frac{u_{ccm}Y_t m_t}{2u_c}\left(\frac{\Delta Y_t}{Y_t}\right)\left(\frac{\Delta m_t}{m_t}\right) + \frac{u_{cmm}Y_t m_t^2}{2u_c}\left(\frac{\Delta m_t}{m_t}\right)^2\right\} + o(\Delta t)^{3/2}$$

Recall that:

$$\frac{1}{dt}E_t\left\{\left(\frac{dY_t}{Y_t}\right)^2\right\}=var_t\left(\frac{dY_t}{Y_t}\right);$$

$$\frac{1}{dt}E_t\left\{\left(\frac{dm_t}{m_t}\right)^2\right\}=var_t\left(\frac{dm_t}{m_t}\right);$$

If we now take the limit of equation (97) for $\Delta t \to 0$ and apply the Ito's Lemma, we finally get (31).

Proof of Proposition 4

Subtract First Order Condition (24) from (23) to get:

$$E_t\left[\frac{u_m(Y_{t+\Delta t},m_{t+\Delta t})}{u_c(Y_t,m_t)}\frac{P_t}{P_{t+\Delta t}}\right]=E_t\left[\frac{u_c(Y_{t+\Delta t},m_{t+\Delta t})}{u_c(Y_t,m_t)}\frac{P_t}{P_{t+\Delta t}}i_t\right] \tag{98}$$

Consider now a Taylor expansion of the price ratio, to get:

$$\frac{P_t}{P_{t+\Delta t}}=1-\frac{\Delta P_t}{P_t}+\left(\frac{\Delta P_t}{P_t}\right)^2+o(\Delta t)^{3/2} \tag{99}$$

Expand also in Taylor series the LHS of equation (98) so that:

$$E_t\left[\frac{u_c(Y_{t+\Delta t},m_{t+\Delta t})}{u_c(Y_t,m_t)}\frac{P_t}{P_{t+\Delta t}}i_t\right]=E_t\left\{\underbrace{\left[1+\frac{u_{cc}Y_t}{u_c}\left(\frac{\Delta Y_t}{Y_t}\right)+\frac{u_{cm}m_t}{u_c}\left(\frac{\Delta m_t}{m_t}\right)\right]}\left(1-\frac{\Delta P_t}{P_t}\right)+o(\Delta t)^{3/2}\right\}i_t \tag{100}$$

Note that the term underbraced in the first line of equation (100) tends to 1, as $\Delta t \to 0$, after having applied the Ito's multiplication rule. Moreover, we have that:

$$\lim_{\Delta t\to 0}\left\{\frac{u_m(Y_{t+\Delta t},m_{t+\Delta t})}{u_c(Y_t,m_t)}\frac{P_t}{P_{t+\Delta t}}\right\}=\frac{u_m(Y_t,m_t)}{u_c(Y_t,m_t)} \tag{101}$$

which proves the proposition.

Proof of Proposition 5

(i) To prove result (38) it is enough to apply the result in Proposition 1, by substituting the derivative of the utility function into their respective expressions.

(ii) To get real rate in (39) we just need to apply the results from Proposition 2, after having plugged the expression for the derivative into equation (31).

iii) To prove result (39) recall that from Proposition 2 and equation (29) we have a formula directly usable for the present case. Taking the appropriate derivatives of the utility function (37) in equation (29) we get:

$$p_{g,t}^{z} = E_t \int_t^{\infty} e^{-\beta(s-t)} \frac{C_s^{\eta} m_s^{1-\eta}}{C_t^{\eta-1} m_t^{1-\eta}} ds = \tag{102}$$

$$= \frac{1}{Y_t^{\eta-1} m_t^{1-\eta}} E_t \int_t^{\infty} e^{-\beta(s-t)} Y_s^{\eta} m_s^{1-\eta} ds \tag{103}$$

where I also inserted the equilibrium condition $C_t = Y_t$. After taking the integral of (103) we get exactly the result given in equation (40).

(iv) The dynamics of $p_{g,t}^{z}$ can be obtained by simply applying the Ito's Lemma to equation (40).

(v) To obtain the price level in (42) recall that from Proposition 3 a general definition of the price level is given by equation (29). In our case, this implies that:

$$\frac{1}{P_t} = \left(\frac{1-\eta}{\eta}\right) \frac{1}{Y_t^{\eta(1-\rho)-1} m_t^{(1-\eta)(1-\rho)}} E_t \int_t^{\infty} e^{-\beta(s-t)} Y_s^{\eta(1-\rho)} m_s^{(1-\eta)(1-\rho)} \frac{1}{P_s} ds \tag{104}$$

which can be rewritten as:

$$\frac{1}{P_t Y_t} = \left(\frac{1-\eta}{\eta}\right) \frac{1}{Y_t^{\eta(1-\rho)-1} m_t^{(1-\eta)(1-\rho)}} \int_t^{\infty} e^{-\beta(s-t)} Y_s^{\eta(1-\rho)} m_s^{(1-\eta)(1-\rho)} E_t\left[\frac{1}{M(s)}\right] ds \tag{105}$$

To calculate the expectation term $E_t\left[\frac{1}{M(s)}\right]$ in (105) we need to integrate the stochastic process for $M(t)$ given by equation (36) so:

$$M(s) = M(t) \exp\left\{-\left[\left(\mu_M - \frac{\sigma_M^2}{2}\right)(s-t) - \sigma_M \int_t^s d\omega_{M,t}\right]\right\} \tag{106}$$

where $d\omega_{M,t} = \Omega_{M,t}\sqrt{dt}$. So that:

$$E_t\left[\frac{1}{M(s)} \middle| M(t)\right] = \frac{1}{M(t)} \exp\left\{-\left[\left(\mu_M - \sigma_M^2\right)(s-t)\right]\right\} \tag{107}$$

Plugging equation (107) into (105) and integrate the resulting equation, we get exactly the result given by (42).

(vi) To get the dynamics of the price level (43) it is enough to apply the Ito's Lemma to equation (42).

(vii) The inflation rate (44) is the drift term of the stochastic process found in (vi).

Proof of Proposition 7

I start by showing how to get (75). From (72) we have that:

$$\ln M_t = \mu_M^* + 2\ln q_t$$

so that:

$$M_t = e^{\mu_M^*} q_t^2$$

inverting it:

$$\frac{1}{M_t} = e^{-\mu_M^*} q_t^{-2}$$

Define $G(q) = \frac{1}{q_t^2}$. Thus by using Ito's Lemma, we get:

$$d\left[\frac{e^{2k_q\mu_q}}{q_t^2}\right] = \frac{2}{q_t}\left(k_q + 3\sigma_q^2\right)e^{2k_q\mu_q t}dt - \frac{2\sigma_q}{q_t\sqrt{q_t}}dW_{M,t}$$

Thus, let us consider the expected value, as follows:

$$E_t\left[\frac{1}{q_s^2}\right] = E_t\left[\frac{1}{q_s^2}\middle| q_t\right] =$$
$$= E_t\left[e^{-2k_q\mu_q s}\left\{\int_t^s d\left[\frac{e^{2k_q\mu_q z}}{q_z^2}\right] + \frac{e^{2k_q\mu_q t}}{q_t^2}\right\}\middle| q_t\right] =$$
$$= \frac{e^{-2k_q\mu_q(s-t)}}{q_t} + \frac{\left(k_q + 3\sigma_q^2\right)}{q_t k_q \mu_q}\left(1 - e^{-2k_q\mu_q(s-t)}\right)$$

Finally, from the FOC of the problem of the representative agent, we get:

$$\frac{1}{P_t^C Y_t} = \frac{1-\phi}{\phi}\int_t^\infty E_t\left[\frac{1}{q_s^2}\right]e^{-\beta(s-t)-\mu_M^*}ds$$

which, after solving for the integral, we get exactly the result under (76).

To get the expression of the inflation rate, it is enough to apply Ito's lemma to (76) by setting $V(M_t, Y_t, q_t) = \frac{\Delta(q_t)}{\Psi(q_t)}\frac{M_t}{Y_t}$, so that:

$$dP_t^c = G_M dM_t + G_Y dY_t + G_q dq_t + \frac{1}{2}\left[G_{YY}(dY_t)^2 + G_{qq}(dq_t)^2 + G_{Mq}(dM_t)(dq_t)\right]$$

thus, performing the calculations by taking into account (78), (79) and the definitions of the stochastic processes for Y_t, q_t and M_t (67), (71), (72) we get exactly the result given by (77).

Proof of Proposition 8

I follows closely the approach by Bakshi and Chen (1996). After having integrated the stochastic process for output, taking advantage of the utility function relationships we get:

$$
\begin{aligned}
h(t,\tau) &= e^{-\beta\tau} E_t\left(\frac{Y_t}{Y_{t+\tau}}\right) = \\
&= e^{-[\beta+\mu_y]\tau} E_t\left\{ \exp\left[-\left(\eta_y - \frac{1}{2}\sigma_y^2\right)\int_t^{t+\tau} x_s ds - \sigma_y \int_t^{t+\tau} \sqrt{x_s}\, dw_{x,s} \right]\right\} = \\
&= e^{-[\beta+\mu_y]\tau} \tilde{h}(t,\tau)
\end{aligned}
$$

Thus, according to Richard (1978), the term $\tilde{h}(t,\tau)$ is a solution to the following PDE:

$$
\frac{1}{2}\sigma_x^2 x_t \tilde{h}_{xx} + \left[a(b - x_t) - \sigma_x \sigma_y x_t\right]\tilde{h}_x - \tilde{h}_\tau - \left(\eta_y - \sigma_y^2\right) x_t \tilde{h} = 0
$$

Thus, by using a standard separation of variables technique, the unique solution subjected to the boundary condition, $\tilde{h}(t+\tau,0) = 1$ is the real bond price formula in Proposition 8, equation (83). Finally, equation (82) is then obtained by taking the limit of $R_t = \lim_{\tau\to 0}\left\{-\frac{1}{\tau}\ln\left[h(t,\tau)\right]\right\}$.

Proof of Proposition 9

Recall that from the equilibrium conditions we get:

$$
\frac{N(t,\tau)}{P_t^c} = e^{-\beta\tau} E_t\left[\frac{u_c(Y_{t+\tau}, m_{t+\tau})}{u_c(Y_t m_t)} \frac{1}{P_{t+\tau}^c}\right]
$$

Thus, by using the properties of the log-utility function given in (66), we get:

$$
N(t,\tau) = e^{-\beta\tau} P_t^c Y_t E_t\left[\frac{1}{P_{t+\tau}^c Y_{t+\tau}}\right]
$$

Now from (75) we get:

$$\frac{1}{P_t^c Y_t} = \frac{1-\phi}{\phi}\left[\frac{\left(\beta+\mu_M^*\right)+\left(k_q+3\sigma_q^2\right)q_t 2k_q\mu_q}{q_t^2\left(\beta+\mu_M^*\right)\left(\beta+\mu_M^+ + 2k_q\mu_q\right)}\right]\frac{1}{M_t}$$

From the definition of the stochastic process for M_t, we can integrate to get: $M_t = q_t e^{\mu_M^* t}$. Therefore, using these features and rearranging, we obtain the following expression for the term structure of nominal interest rates:

$$N(t,\tau) = \frac{e^{-\left(\beta+\mu_M^*\right)\tau} q_t^2}{\left\{\frac{\beta+\mu_M^*}{q_t} + \left(k_q+3\sigma_q^2\right)2k_q\mu_q\right\}} E_t\left\{\left(k_q+3\sigma_q^2\right)\frac{2k_q\mu_q}{q_{t+\tau}^2} + \frac{\beta+\mu_M^*}{q_{t+\tau}^3}\right\}$$

Thus, integrate $E_t\left[\frac{1}{q_{t+\tau}^2}\middle|q_t\right], E_t\left[\frac{1}{q_{t+\tau}^3}\middle|q_t\right]$ and rearrange the resulting expression, we finally obtain the expression under (88).

Currency Composition and Public Debt in EMU

By *Natacha Gilson* and *Marcel Gérard*[*]

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I. Introduction

The share of government debt denominated in foreign currency has recently decreased in all the countries of the European Monetary Union (EMU). In this paper, we explain this evolution and relate it to the credibility of the fixed exchange rate during EMU process and to the credibility of the European Central Bank (ECB).

When a central bank is not credibly committed to low inflation, government debt denominated in domestic currency can be a source of inflation: when a price increase is unexpected, it makes it possible to reduce the real value of payments associated with the debt. Nevertheless, as soon as private agents believe that a government will inflate its public debt away, they will require higher nominal interest rates. Consequently, the real value of payments associated with the debt may not be reduced and the higher inflation may be useless and harmful due to distortions associated with it. A response to this problem has been given by several authors who demonstrated that time inconsistencies generated by public debt denominated in domestic currency could be reduced in two ways: (i) by limiting the pressure on the central bank for an unexpected increase in inflation (either by setting up an independent central bank, by the appointment of a conservative central banker as proposed by Rogoff (1985), or by the adoption of an exchange rate pegged to a strong foreign currency as stressed by Giavazzi and Pagano (1988) and Herrendorf (1997, 1999), or (ii) by

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managing the public debt structure: in particular the role of foreign currency debt as a commitment device is a well-known result in the literature on debt management (e.g. Bohn 1990, Calvo and Guidotti 1990, Goldfajn 1998, Missale and Blanchard 1994, De Fontenay et al. 1995, Miller 1997a, 1997b, Missale 1999); in this literature, the management of the debt composition can be used as a commitment device making it possible to rule out excessive inflation.

In this paper, we use the results developed by this literature to analyze the consequences of the creation of the European Monetary Union on the public debt structure of countries belonging to Euroland and compare this situation with the previous one in which an anchor country (Germany) was leading the monetary policy of the exchange rate mechanism (ERM). We examine the consequences of this regime shift for inflation and currency denomination of public debts. Analyzing empirical evidence in the light of those theoretical insights, we find that the road towards EMU increased the credibility of fixed exchange rates and that the ECB is perceived as a credible institution able to commit to low inflation.

We first present stylized facts showing the evolution of foreign currency denominated debt in EU countries since the beginning of the eighties, next we state the core assumptions of our model and explain in which circumstances the currency composition of the public debt can improve the credibility of a pegged exchange rate regime. We then model the regime shift associated with the decision to share a common currency. Finally, we draw our conclusions.

II. Stylized Facts

Table 1 shows the evolution of central government debt denominated in foreign currency for EU countries.[1] We can notice that debt denominated in foreign currency has decreased in recent years. This decrease is particularly marked after 1998 for most countries that joined EMU on 1st January 1999. In Greece, a similar decrease is only observed later, once it also joined EMU.[2] Moreover, a slight decrease in the share of the debt denominated in foreign currency has also occurred in Denmark, Sweden and the United Kingdom. Finally, we can also observe in table 1 that some countries decreased the share of their foreign currency denominated debt well before the advent of EMU.

[1] Luxembourg is not included in table 1 but is, by far, the EU country with the lowest public debt ratio. In 2001, the Luxembourg public debt as a percentage of the GDP amounted only to 5.14%. In the same year, this ratio amounted to 62.33 in Austria, 107.0 in Belgium, 43.16 in Denmark, 60.0 in Germany, 100.45 in Greece, 42.7 in Finland, 57.15 in France, 34.39 in Ireland, 108.21 in Italy, 51.78 in the Netherlands, 53.53 in Portugal, 57.96 in Spain, 52.3 in Sweden and 39.25 in the United Kingdom (Belgian Ministry of Finance).

[2] Of course, in EMU countries, a part of this decrease is due to the fact that, with the launch of the euro, the foreign currency denominated debt has been reduced since debt denominated in the currency of other EMU members has been automatically transformed into euro, i.e. into domestic currency denominated debt.

Table 1

Foreign Currency Denominated Debt as a Percentage of Total Central Government Debt. Evidence from EU Countries

	Austria	Belgium	Denmark	Finland	France	Germany	Greece	Ireland	Italy	Neth.	Portugal	Spain	Sweden	UK
1980	27.8	7.8	36.0	57.6	0.0	0.0	16.1	30.2	2.0	0.0	20.3	6.1	18.4	4.2
1985	22.6	20.2	21.1	54.7	4.2	0.0	30.6	44.8	4.4	0.0	31.4	6.5	21.6	1.9
1990	15.7	15.4	24.4	43.5	2.2	0.0	28.4	33.5	6.8	0.0	11.3	3.3	12.3	3.4
1995	22.0	11.4	16.4	46.4	3.8	0.0	22.8	34.9	8.2	0.0	17.4	8.7	27.9	4.9
1996	21.2	9.7	15.3	42.4	4.6	0.0	20.6	30.6	7.8	0.0	19.8	8.8	28.2	4.4
1997	20.4	8.1	14.0	38.4	5.4	0.0	18.5	26.3	7.4	0.0	22.3	9.0	27.0	2.8
1998	25.0	7.2	11.9	15.0	0.0	0.0	22.0	5.9	5.1	0.0	4.9	11.1	25.0	3.5
1999	13.7	4.1	12.2	16.0	0.0	0.0	23.2	6.3	3.6	0.0	7.7	3.9	21.2	2.7
2000	13.9	3.3	12.0	14.4	0.0	0.0	7.8	5.8	4.5	0.0	6.2	4.2	18.8	2.6
2001	13.3	2.3	12.1	14.0	0.0	0.0	5.6	5.8	3.2	0.0	6.8	4.4	19.0	1.3

Source: Missale (1999), Favero, Missale and Piga (2000), OECD and EU treasuries' web sites.

Our theoretical model explains those facts. It shows that once the credibility of fixed exchange rates increases (this can be due to an increase in inflation costs or in devaluation costs, a decrease in inflationary incentives, or a shift in private agents' expectations), we should observe a decrease in foreign currency denominated debt. Our model also explains that a decrease in foreign currency denominated debt should be observed when a central bank starts to be perceived as a credible institution able to commit to low inflation.

Before the advent of EMU, countries wishing to become members of the currency union had to meet several criteria (amounting to achieving price stability, sound public finances and central bank independence). Our model explains that the fulfilment of those criteria led to an increase in the credibility of fixed exchange rates, therefore decreasing the role of foreign currency denominated debt. Since the advent of EMU, the ECB is well known for the priority it gives to price stability. Moreover, in the meantime, Sweden and the United Kingdom have also increased the independence of their independence of their respective central bank.[3]

Finally, Denmark is the only EU country participating in ERM II (the ERM disappeared with the advent of EMU, a new ERM II was then created for EU members outside EMU wishing to fix their exchange rate to the euro). So, Denmark has a fixed exchange rate with respect to the euro, which means that the Danish Central bank has to tune its monetary policy to decisions taken by the ECB. So, in all those countries, a decrease in the part of their foreign currency debt could be explained by an increase in the priority given to price stability, but we will focus especially on the case of countries who have joined EMU.

III. The Model

We consider the financial relations between 3 countries: the home country, the neighboring – or partner country –, also called the foreign state; the third one is another country in the world. We respectively denote those countries by *h*, *f* and *w*.

We model the monetary regime between the home and the foreign country, which are supposed to be two small open economies. The real world interest rate, like all variables related to country *w*, is exogenously determined. Governments of countries *h* and *f* respectively minimize the following loss function (1) subject to their budget constraint (2a and b),

(1) $$L_j = \frac{x_j^2 + \beta_j p_j^2}{2} + c, \quad j = h, f, \beta_j > 0$$

[3] On 1st January 1999, the new Sveriges Risbank Act came into force. It entailed increased independence and responsibility by law for price stability. The 1998 Bank of England Act was brought into force on 1 June 1998. It also establishes price stability as the core purpose. The UK central bank has an operational independence to meet the inflation target of 2.5%.

where x_j is real tax revenue as a percentage of the GDP, p_j is the inflation rate. Like Obstfeld (1994) and Velasco (1996), we assume that the policymakers face a fixed cost of devaluation, $c > 0$, if they renege on fixed exchange rate in a fixed exchange rate regime; while in a floating exchange rate c is always zero.

The government budget constraints can be written in the following way,

(2a)
$$x_h = g_h + \eta_h b_h \frac{1+i_h}{1+p_h} + \mu_h b_h \frac{(1+i_w)(1+e_{hw})}{1+p_h} + (1-\eta_h-\mu_h) b_h \frac{(1+i_f)(1+e_{hf})}{1+p_h} + \phi_h (E[p_h] - p_h)$$

(2b)
$$x_f = g_f + \eta_f b_f \frac{1+i_f}{1+p_f} + \mu_f b_f \frac{(1+i_w)(1+e_{fw})}{1+p_f} + (1-\eta_f-\mu_f) b_f \frac{(1+i_h)(1+e_{fh})}{1+p_f} + \phi_f (E[p_f] - p_f)$$

where g_j is primary government expenditure in country *j*, b_j is the public debt. Those variables are measured as a percentage of the GDP and are assumed to be strictly positive. In each country, government expenditure is stochastic and fluctuates around its mean $\overline{g}_j$ with a white noise process ε_j. We assume that the debt can be denominated in domestic currency, in the currency of the partner country *f* or in that of country *w*. The part of country *j*'s public debt denominated in domestic currency is denoted by η_j, while the part of country *j*'s public debt denominated in the rest of the world's currency is denoted by μ_j. Consequently, the part of country *j*'s public debt denominated in the currency of the partner country corresponds to $(1-\eta_j-\mu_j)$.

Moreover, *i* is the nominal interest rate, *p* is the inflation rate and e_{js} is the variation as a percentage of the nominal exchange rate (expressed in unit of currency *s*) between currencies *j* and *k*. The inflation rate in country *w*, p_w, is supposed to be a stochastic variable with a zero mean and a constant variance, $\sigma^2_{p_w}$. We assume a zero correlation between the shock associated with country *j*'s government expenditure and inflation in country *w*.[4] The last term in those governments' budget constraints, $\phi_j(p_j - E[p_j])$, represents government reve-

[4] This simplification is motivated by the fact that there is no a priori reason to consider this correlation as systematically positive or negative. More precisely, we assume that ε_j takes the value $-\hat{\varepsilon}$ or $+\hat{\varepsilon}$, each with probability 1/2 and that p_w takes the value $-\hat{p}_w$ or $+\tilde{p}_w$ each with probability 1/2. So that $E[\varepsilon_j p_w] = 0 = E[\hat{\varepsilon} p_w]$. The hypothesis of a zero correlation is also motivated by the fact that in our setting the possibility to issue debt denominated in the currency of country *w* is particularly introduced in order to keep the possibility to issue debt in foreign currency even when countries *h* and *f* adopt a common currency.

nues (other than the erosion of the real value of the nominal public debt) associated with surprise-inflation. These revenues correspond to an increase in tax proceeds due either to the non-adjustment of tax-brackets to expected inflation or to revenues generated by a short-term stimulation of the economy caused by surprise-inflation (as in the Phillips curve setup). For simplicity, revenues from cash balance holdings are ignored.[5]

We also suppose that the currency of the rest of the world keeps floating with currencies used in countries *h* and *f* while the exchange rate regime between them is either fixed or corresponds to a common currency regime.

In a fixed – or pegged – exchange rate regime, the home country must not devalue, which implies $e = 0$. As we assume that country *f* can credibly commit to price stability so that $p_f = E[p_f] = 0$, the domestic inflation rate, p_h, must also be zero if the purchasing power parity holds. In a single currency regime, a common institution determines the common monetary policy, characterized by a single money growth rate[6], *p*.

For the sake of simplicity, we also assume that the real world interest rate, *r*, is zero. Taking a first order Taylor expansion of the budget constraints around point $i_h = i_f = p_h = p_f = p_w = e_{hf} = e_{fh} = e_{hw} = e_{fw} = 0$ assuming that relative purchasing power parity, uncovered interest rate parity and Fisher relation hold, the government budget constraints become[7],

$$\begin{aligned} x_h = {} & g_h + b_h + (\eta_h b_h + \phi_h)(E[p_h] - p_h) + \mu_h b_h (E[p_w] - p_w) \\ & + (1 - \mu_h - \eta_h) b_h (E[p_f] - p_f) \end{aligned} \tag{2a'}$$

$$\begin{aligned} x_f = {} & g_f + b_f + (\eta_f b_f + \phi_f)(E[p_f] - p_f) + \mu_f b_f (E[p_w] - p_w) \\ & + (1 - \mu_f - \eta_f) b_f (E[p_h] - p_h) \end{aligned} \tag{2b'}$$

To simplify the exposition, we consider parameters and variables of the rest of the world as given and focus on a two-country, two-period model in which the timing of actions is as follows. In period 0, each government issues a debt b_j, partly denominated in domestic or in foreign currencies. Then private agents set their inflationary expectations in order to determine nominal interest rates required to hold those public bonds. The shock ε_j – hitting government expenditure – and the inflation rate in country *w*, p_w, are then realized and observed by the authorities, who finally, in period 1, choose the rate of money growth, p_j, and the conventional tax rate, x_j, minimizing their loss function.

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[5] This assumption is quite frequent, see for example *Calvo* and *Guidotti* (1992), *Watanabe* (1992), *Drudi* and *Giordano* (2000).

[6] To simplify the exposition, we follow a widespread approach in the literature and treat inflation as if it were the central bank or government's choice variable and as if it exactly corresponded to the rate of money growth.

[7] Computations permitting to get those budget constraints are presented in the appendix, section A.1. These hypotheses are quite usual, see for example *Miller* (1997a) and (1997b), or *Goldfajn* (1998).

IV. Pegged Exchange Rate Regime

As we have mentioned above, exchange rate pegging and public debt structure management can reduce the government's incentive to create inflation. But as pegged exchange rates are never irrevocably fixed, the public debt structure could have an influence on the decision to stick to a fixed exchange rate or to renege on it by succumbing to the temptation to inflate. In order to examine the impact of the public debt composition on the credibility of fixed exchange rate, we use a two-period model based on the analyses by Velasco (1996) and Falcetti and Missale (1999). In period 1, the home government has to decide whether or not to stick to a pegged exchange rate. In period 0, it has to choose the part of its debt denominated in domestic or in foreign currency. In this section, we start with the examination of the conditions under which a government decides to give up the fixed parity. We show that private agents' expectations are a key element in this decision. Next, we highlight that the credibility of the peg depends on several variables and explain that, in some circumstances, government debt denominated in foreign currency enhances the credibility of the peg.

1. Home Government Decision in Period 1

In period 1, the home government decides to stick to a fixed exchange rate when its loss function is lower in this case than when it devalues. So, the decision whether or not to devalue is taken by comparing L_h^1 (fixed exchange rate) with L_h^1 (devaluation). In order to perform this comparison, we need to examine the government's budget constraint.

Using our hypothesis relative to inflation in country *f* and to shocks on government expenditure and on inflation rate in country *w*, we can rewrite equation (2a') in the following way,

(3) $$x_h = u_h + v_h + \theta_h\left(E[p_h] - p_h\right)$$

where $u_h = \bar{g}_h + b_h$ can be interpreted as the government's total financial needs net of interest payments, in the absence of shock on government expenditure. We will further refer to u_h as being the government's core financial needs.[8] Otherwise, $v_h = \varepsilon_h - \mu_h b_h p_w$ represents the sum of the shocks hitting the economy. Moreover, $\theta_h = \eta_h b_h + \phi_h$ corresponds to the global inflation tax base.

The credibility of a fixed exchange rate is quite often conditional to the occurrence of some specific events. For example, it could be more difficult to sustain a fixed exchange rate regime in a slowdown period, as the government might feel a stronger temptation to resort to unexpected devaluation in order to relax its budget constraint. In our analysis, a devaluation can in fact be conditional on government expenditure being higher than expected (i.e. private agents may

[8] In order to ensure $x_h \geq 0$, we assume that $u_h \geq \hat{\varepsilon}$.

believe that a devaluation might only take place if bad shocks affect government expenditure). In this setup, we get multiple equilibria[9] and observe, like Obstfeld (1994) and Falcetti and Missale (1999), that foreign currency denominated debt can sometimes lead to higher devaluation if the government finally reneges on the fixed exchange rate.[10]

We will limit our attention to two cases: private agents can either believe that a fixed rate is perfectly credible or that fixed parity will be sustained only if the good shock hits their domestic economy (i.e. $-\hat{\varepsilon}$ occurs).

As private agents are rational, it is important to determine in which cases such expectations can be observed at equilibrium.

The decision whether or not to devalue is taken at the end of the final period once the occurrence of shocks ε_h and p_w has been observed. Consequently, the government devalues when,

$$L_h^1 \text{ (fixed exchange rate)} > L_h^1 \text{ (devaluation)}$$

where by (1) to (3),

$$L_h^1 \text{ (fixed exchange rate)} = \frac{(u_h + \varepsilon_h - \mu_h b_h p_w + \theta_h (E[p_h]))^2}{2} \text{ as } p_h = 0$$

$$L_h^1 \text{ (devaluation)} = \frac{(u_h + \varepsilon_h - \mu_h b_h p_w + \theta_h (E[p_h] - p_h))^2}{2} + \beta_h \frac{p_h^2}{2} + c \text{ ,}$$

with p_h chosen in order to minimize L_h^1 (devaluation), so that $p_h = \frac{(u_h + \varepsilon_h - \mu_h b_h p_w + \theta_h E[p_h])\theta_h}{\beta_h + \theta_h^2}$.

Hence, the government will devalue when

$$(u_h + \varepsilon_h - \mu_h b_h p_w + \theta_h E[p_h]) > k_h \tag{4}$$

with $k_h = \sqrt{\frac{2c}{1-\lambda_h}}, \quad \lambda_h = \frac{\beta_h}{\beta_h + \theta_h^2}$.

We will examine the two cases of private agents' expectations mentioned earlier and determine in which circumstances those expectations can be formulated. Next, we will analyze the effect of the debt structure on those expectations and outline some implications relative to the influence of the currency composition of public debt on the credibility of the peg.

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[9] In the sense that the same values of the government's core financial needs can either lead to a devaluation or not according to private agents' expectations.

[10] We recall in the appendix – section A.2 – that, as those authors demonstrated, in some circumstances, foreign currency denominated debt could exacerbate the crisis if a devaluation was to occur.

Perfect credibility Let us first assume that the government can credibly commit to a fixed exchange rate and that private agents expect the government to maintain the fixed exchange rate anyway, i.e. even if the bad shock hits the domestic economy. In this case, $E[p_h]=0,\quad p_h=0$ and $c = 0$.

By means of equation (4), we know that this kind of expectations can be observed when

(4a) $$u_h+\hat{\varepsilon}-\mu_h b_h p_w \le k_h \Rightarrow u_h \le l_{pc}, \quad \text{with} \quad l_{pc}=k_h-\hat{\varepsilon}+\mu_h b_h p_w$$

Hence, it is rational to expect $E[p_h]=0$ if the shock ε_h is low enough.

Conditional credibility Let us also suppose that a contingent devaluation could be observed. In this case, private agents expect the government to devalue only if the bad shock hits the domestic economy (i.e. $+\hat{\varepsilon}$ occurs). Moreover, the government is credibly committed to a fixed exchange rate when the good shock hits the domestic economy. The domestic inflation rate finally observed under an expectation of contingent devaluation will further be denoted by p_h^{cc}. It will be positive in the event of a bad shock.

Consequently, the home government sticks to a fixed exchange rate (i.e. $p_h^{cc}=0$) if the good shock occurs, which happens with probability $\frac{1}{2}$, and the home government devalues (i.e. $p_h^{cc}>0$) if the bad shock is observed, which also happens with probability $\frac{1}{2}$. In the latter situation, the government endures the cost c and the size of the devaluation will be chosen so as to minimize the government's loss function in the last period. In other words, the government will choose p_h^{cc} minimizing equation (1) s.t. (3) or,

$$\min_{p_h^{cc}} \frac{x_h^2+\beta_h\left(p_h^{cc}\right)^2}{2}+c \quad \text{s.t.} \quad x_h=\mathrm{u_h}+\hat{\varepsilon}-\mu_\mathrm{h}\mathrm{b_h}\mathrm{p_w}+\theta_\mathrm{h}\left(\mathrm{E}\left[\mathrm{p_h^{cc}}\right]-p_h^{cc}\right)$$

From the first order condition associated with this problem, we found that

$$p_h^{cc}=\frac{\theta_h\left(u_h+\hat{\varepsilon}-\mu_h b_h p_w+\theta_h E\left[p_h^{cc}\right]\right)}{\beta_h+\theta_h^2},$$

which happens with probability $\frac{1}{2}$.

Consequently, the expected inflation under a contingent devaluation outcome can be expressed as $\theta_h E\left[p_h^{cc}\right]=\frac{1}{2}E\left[(1-\lambda)\left(u_h+\hat{\varepsilon}-\mu_h b_h p_w+\theta_h E\left[p_h^{cc}\right]\right)\right]$, which implies that, defining $\Lambda=\frac{1}{2}(1-\lambda)$,

$$\theta_h E\left[p_h^{cc}\right] = \frac{\Lambda}{1-\Lambda}\left(u_h + \hat{\varepsilon}\right)$$

By inserting this result in equation (4), we can determine the condition associated with a devaluation contingent to the occurence of the bad shock,

(4b) $$l_{cc_1} < u_h, \text{ with } l_{cc_1} = k_h(1-\Lambda) - \hat{\varepsilon} + \mu_h b_h p_w (1-\Lambda)$$

On the contrary, in the event of a good shock, the government maintains its fixed parity. Thus, by inserting private agents' expectations $\left(\theta_h E\left[p_h^{cc}\right] = \frac{\Lambda}{1-\Lambda}\left(u_h + \hat{\varepsilon}\right)\right)$ in relation (4) and by assuming that the good shock is observed, the fixed exchange rate regime holds if the following condition is fulfilled,

$$u_h - \hat{\varepsilon} - \mu_h b_h p_w + \frac{\Lambda}{1-\Lambda}\left(u_h + \hat{\varepsilon}\right) \leq k_h$$

So that, after some manipulations, we can consider that the exchange rate is held fixed when,

(4c) $$u_h \leq l_{cc_2}, \text{ with } l_{cc_2} = \left(k + 2\hat{\varepsilon} + \mu_h b_h p_w\right)(1-\Lambda) - \hat{\varepsilon}$$

2. Home Government Decision in Period 0

In period 0, the government chooses η_h and μ_h in order to minimize its loss function.

By using our previous results, we can determine the government's loss function in period 0, under perfect and conditional credibility.

The government's period zero loss function, associated with perfect credibility of a fixed exchange rate, is equal to,

(5a) $$L_0^{pc} = \frac{1}{2}\left\{E\left[x_h^2\right] + \beta_h E\left[p_h^2\right]\right\} = \frac{1}{2}\left\{u_h^2 + \sigma_\varepsilon^2 + \mu_h^2 b_h^2 \sigma_{p_w}^2\right\}$$

The government's period zero loss function, associated with conditional credibility of a fixed exchange rate, can be written,

(5b) $$L_0^{cc} = \frac{1}{2}\left\{\frac{u_h^2 + \lambda_h \sigma_\varepsilon^2}{1-\Lambda}\right\} + = \frac{(1-\Lambda)}{2}\mu_h^2 b_h^2 \sigma_{p_w}^2 + \frac{c}{2}$$

By examining L_0^{pc} and L_0^{cc}, we can determine that, in our setting, it is optimal to choose $\mu_h = 0$.[11] The intuition of this result is based on the fact that foreign

[11] The observed debt structure could differ from the optimal debt structure presented in this paper because some elements are missing in our model. For example, the covariance between shocks is not necessarily zero; this covariance can be specific to some countries

currency denominated debt acts as a commitment device to low inflation, but the variability of the payments associated with foreign currency denominated debt is reduced when the latter is denominated in the currency of the partner country rather than in a currency that floats against the home currency. Hence, we can state that in a fixed exchange rate regime it is optimal to denominate the public debt in the domestic currency or in the currency of the partner country. Moreover, by (5a and b) we can state that in the case of multiple equilibria "perfect credibility" is preferable to "conditional credibility" as $L_0^{pc} \leq L_0^{cc}$ when $\mu_h = 0$ whatever η_h.

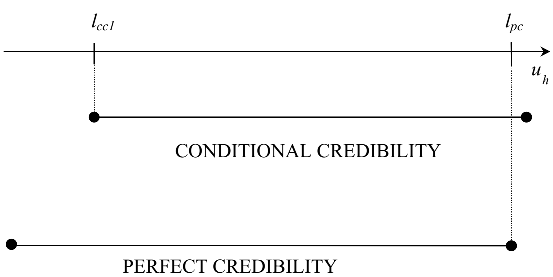
In order to determine further the influence of the currency composition of the public debt on the credibility of the peg, we first need to carefully examine the private agents' expectations towards the credibility of the peg.

Private Agents' Expectations and Credibility of the Peg

For the sake of brevity, let us only consider the case where perfect credibility could always be a possible outcome, which means that $u_h \leq l_{pc}$, see equation (4a). Thanks to equations (4a), (4b) and (4c), we know that $l_{cc_1} < l_{pc}$ and that $l_{cc_1} < l_{cc_2}$ when $\mu_h = 0$. Moreover, let us assume that $l_{pc} < l_{cc_2}$. We can summarize our developments by showing that for some values of the government's core financial needs, u_h, different types of private agents' expectations can be observed as shown in the figure.

Figure 1

Multiple Equilibria



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or some periods. The multiplicity of shocks observed in reality could explain that issuing debt in various currencies could be motivated by the will to diversify the government's debt portfolio. Despite this simplification, our model highlights that the observed changes in foreign currency denominated debt can be explained by an increase in credibility.

Figure 1 summarizes the potential credibility of the fixed exchange rate regime according to the government's core financial needs. We have multiple equilibria when the same values of u_h can be associated with a devaluation or a non devaluation equilibrium depending on private agents' expectations. This figure shows that when the government's core financial needs, u_h, are situated between l_{cc_1} and l_{pc}, there are two possible equilibria depending on private agents' expectations. Finally, when u_h are below l_{cc_1}, a fixed exchange rate is perfectly credible.

It is possible to show that

$$\frac{\partial l_i}{\partial \beta} > 0, \frac{\partial l_i}{\partial c} > 0, \frac{\partial l_i}{\partial b} < 0, \frac{\partial l_i}{\partial \phi} < 0, \forall l_i$$

This means that increases in the cost of inflation or in the cost of devaluation (respectively β and c) enhance the credibility of the peg and that stronger incentives to devalue (increases in b or ϕ) damage the credibility of the peg. The transition process towards EMU has increased inflation costs and has reduced inflationary incentives by imposing criteria relative to price stability, sound public finances, and central bank independence. Those criteria could moreover induce private agents to believe that their central bank could always abide by price stability, which amounts to a shift in private agents' expectations towards perfect credibility.

As k_h, θ_h and λ_h depend on the part of the domestic debt denominated in the home currency, we also have to analyze the impact of public debt management on the credibility of the peg.

Currency Composition of Public Debt and Credibility of the Peg

We demonstrate in the appendix, section A.3, that

$$\frac{\partial l_{pc}}{\partial \eta_h} < 0, \frac{\partial l_{cc_1}}{\partial \eta_h} < 0, \frac{\partial l_{cc_2}}{\partial \eta_h} < 0$$

Consequently, foreign currency denominated debt, whatever the currency used – that of country *f* or *w* – seems to increase the credibility of the fixed exchange rate.[12,13] Nevertheless, we have shown that, under our hypothesis, the

[12] This result is well known in the literature examining the impact of debt management policies on fixed exchange rate credibility. It has been highlighted by *Giavazzi* and *Pagano* (1990), *Obstfeld* (1994) and *Falcetti* and *Missale* (1999) and (2000). Recent empirical evidence seems to support this hypothesis as *Amato* and *Tronzano* (2000) have shown that an increase in the share of foreign-denominated debt makes it possible to stabilize the Lira exchange rate.

[13] By using *Velasco's* model, we neglect the fact that foreign currency denominated debt can be used as a way to intervene on the exchange rate market in order to sustain the currency. Nevertheless, as an increase in foreign currency denominated debt devoted to performing exchange rate market interventions may temporarily improve the credibility of a

domestic government prefers to issue debt denominated in the domestic currency or in the currency of the partner country. In the appendix – section A.4. –, we explain in which cases, debt denominated in the currency of the partner country can effectively be used in order to achieve a unique equilibrium of perfect credibility.

We have shown that foreign currency denominated debt may, in some circumstances, help to improve the credibility of the fixed exchange rate regime. We have also demonstrated that the role of foreign currency denominated debt as a commitment device to low inflation may disappear with the increase in inflation costs, with the decrease in inflationary incentives, or with a shift in private agents' expectations towards perfect credibility. This could explain the decrease in foreign currency denominated debt observed during EMU process.

In the next section, we demonstrate that the enhancing credibility role of foreign currency denominated debt completely vanishes when the common central bank is a credible institution able to commit to low inflation.

V. Common Currency Regime

In this section, we assume that countries *h* and *f* decide to share the same currency and delegate their monetary policy to a common central bank. Consequently, when those countries share a single currency, their monetary growth rate, *p*, is chosen by their common central bank.

The share of each country's public debt denominated in the world currency will still be denoted by μ_h and μ_f. As countries *h* and *f* now share the same currency, the part of their respective public debt denominated in the new common currency corresponds to the part which is not denominated in another currency: $\eta_h = 1-\mu_h$ and $\eta_f = 1-\mu_f$.

1. Common Central Bank Decision in Period 1

In period 1, the common central bank minimizes the following loss function subject to relations (2a') and (2b').

(6) $$L^1_{EMU} = \frac{\alpha_h x_h^2 + \alpha_f x_f^2 + \beta p^2}{2}, \quad \alpha_h, \alpha_f, \beta > 0$$

This relation is similar to relation (1), but *c* disappears because of floating. The optimal inflation rate can be found by minimizing L^1_{EMU} with respect to *p* subject to relations (2a') and (2b').

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peg, it does not necessarily refute the above-described impact of the currency composition of public debt on the credibility of the peg.

When the common central bank can perfectly commit to a zero-inflation outcome, $E[p]=0$ and the optimal inflation rate is zero.

When the common central bank cannot credibly commit to no-inflation, the optimal inflation rate is positively related to inflation incentives and negatively related to inflation costs.[14] In this case, foreign currency denominated debt should be used in order to reduce inflation.

2. Common Central Bank Decision in Period 0

Unsurprisingly, the decisions of the common central bank in period zero depend on its capacity to commit to zero-inflation.

When the common central bank can perfectly commit to no-inflation, the expected loss function can be written,

$$L_{EMU}^{0}\ (\text{commitment}) = \frac{\alpha_h}{2}\Omega_h + \frac{\alpha_f}{2}\Omega_f \quad (7)$$

where $\Omega_j = u_j^2 + \sigma_{\varepsilon_j}^2 + \mu_j^2 b_j^2 \sigma_{p_w}^2$.

In this case, the optimal debt structure corresponds to a debt which is completely denominated in common currency in order to escape shock from country *w*.

When the common central bank cannot commit to no-inflation, the loss function in period zero corresponds to L_0 (non-commitment), which is presented in the appendix, section A.5. In this case, the optimal public debt structure depends not only on inflation incentives and inflation costs, but also on the variance of shocks hitting the home government expenditure and the world price level.

So, this model shows that foreign currency denominated debt is not attractive when the common central bank is fully committed to no-inflation. Consequently, countries deciding to join a monetary union endowed with an independent central bank strongly committed to price stability should decrease the part of their public debt denominated in foreign currency. This observation is consistent with the empirical evidence presented in section II. According to our theoretical results, this means that the ECB can be considered as a credible institution able to commit to low inflation.[15]

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[14] The expression of the optimal inflation rate, in the non-commitment case, is presented in the appendix, section A.5., equation (8b).

[15] We can also note that the case of countries (such as Sweden and the United Kingdom) which are not members of the EMU and do not participate in ERM II could be modeled as the common central bank case, except that $\alpha_f = 0$. Consequently, for those countries, the recent increase in their central bank's independence should also be associated with a decrease in the share of their public debt denominated in foreign currency as observed in table 1. Finally, within our theoretical model presented in section IV, the decrease in debt denominated in foreign currency, since the mid-nineties in Denmark, could

VI. Conclusion

In this paper, we have investigated the role of the currency composition of public debts under a peg and in a monetary union. The idea that foreign currency debt can rule out inflationary temptations is not new, but the contribution of this paper is to show that moving from an asymmetric fixed exchange rate to a single currency regime has an influence on the role of the public debt structure. First, we have shown that the credibility of a peg may depend on the management of the public debt structure. Second, we have analyzed the creation of a single currency as a regime shift in which a new common central bank sets the monetary policy. Our model explains that the share of debt denominated in foreign currency should be reduced when countries decide to abide by criteria improving the credibility of their fixed exchange rates. It also shows that when this new common central bank is credibly committed to no-inflation, public debt denominated in foreign currency should be reduced. Knowing that this trend has been observed in EMU countries, this means that the ECB can be considered as a credible institution able to commit to low inflation.

Summary

We analyze the consequences of the creation of EMU on the currency composition of public debts and compare this situation with the pre-EMU one in which an anchor country (Germany) was leading the monetary policy of the ERM. Empirical evidence shows that the foreign currency public debt of some EMU members has decreased during the EMU process. Within the paper's theoretical framework, this is an indication that the road towards EMU increased the credibility of fixed exchange rates. This also means that the ECB is perceived as a credible institution able to commit to low inflation.

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be explained by a switch in private agents' expectations, by the decrease in its public debt ratio, by an increase in inflation costs or by a decrease in inflationary incentives. As expounded above, the evolution of the share of the public debt denominated in foreign currency, for all participants in the ERM before 1999, could also be explained by those elements.

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Appendix

A. 1 Budget Constraint

In order to simplify equations (2a and b), we assume that the real world interest rate, *r*, is zero. Taking a first order Taylor expansion of the budget constraints around the point $i_h = i_f = p_h = p_f = p_w = e_{hf} = e_{fh} = e_{hw} = e_{fw} = 0$ yields,

$$
\begin{aligned}
&x_h = g_h + b_h + \eta_h b_h (i_h - p_h) + \mu_h b_h (i_w - p_h + e_{hw}) \\
&+ (1 - \mu_h - \eta_h) b_h (i_f - p_h + e_{hf}) + \phi_h (E[p_h] - p_h) \\
&x_f = g_f + b_f + \eta_f b_f (i_f - p_f) + \mu_f b_f (i_w - p_f + e_{fw}) \\
&+ (1 - \mu_f - \eta_f) b_f (i_h - p_f + e_{fh}) + \phi_f (E[p_f] - p_f)
\end{aligned}
$$

Moreover, we assume that the relative purchasing power parity holds, which means that the rates of currency depreciation are,

(Ia) $$e_{hf} = p_h - p_f = -e_{fh}$$

(Ib) $$e_{hw} = p_h - p_w$$

(Ic) $$e_{fw} = p_f - p_w$$

We also assume perfect capital mobility so that the uncovered interest parity condition is verified. Consequently, the domestic nominal interest rate can be expressed as the sum of the foreign nominal interest rate plus the expected rate of depreciation. Rational expectations and equations (I) imply that the expected rate of depreciation is equal to the expected inflation differential. The equilibrium domestic interest rate can therefore simply be expressed as

(IIa) $$i_h = i_f + E[e_{hf}] = i_f + E[p_h] - E[p_f]$$

(IIb) $$i_f = i_w + E[e_{fw}] = i_w + E[p_f] - E[p_w]$$

(IIc) $$i_h = i_w + E[e_{hw}] = i_w + E[p_h] - E[p_w]$$

If we replace i_j and e_j in the linearized budget constraint with their values in equations (I) and (II), if we assume that private agents require nominal interest rates consistent with the Fisher relation and that country *f* can credibly commit to price stability (which means that $p_f = E[p_f] = 0$), then governments' budget constraints can be expressed by equations (2a') and (2b').

A.2 Foreign Currency Denominated Debt and Size of the Devaluation

As we assume that purchasing power parity holds and that the foreign currency inflation rate is always zero, i.e. $p_f = 0$, the domestic currency devaluation rate corresponds to the domestic inflation rate p_h . A self-fulfilling exchange rate crisis can take place when $l_{cc_1} \le u_h \le l_{cc_2}$. In this case, the devaluation rate can be,

$$p_h^{cc} = \frac{\theta_h}{\beta_h + \theta_h^2}\left(\frac{2(u_h + \hat{\varepsilon})}{(1+\lambda_h)} - \mu_h b_h p_w\right)$$

Assuming that $\mu = 0$ (as we demonstrate in this paper, this is the optimal policy under our hypothesis), the sensitivity of the conditional rate of devaluation, p_h^{cc}, with respect to the part of the public debt denominated in domestic currency corresponds to,

$$\frac{\partial p_h^{cc}}{\partial \eta_h} = 2\left(2\beta_h - \theta_h^2\right)(u_h + \hat{\varepsilon})\frac{b_h}{\left(2\beta_h + \theta_h^2\right)^2}$$

We can observe that this expression can be negative when devaluation is especially attractive due to its low cost (i.e. β_h weak) and to high benefit from surprise-inflation (i.e. θ_h high). In this case, the higher the part of the government's debt denominated in domestic currency, the lower the devaluation rate will be.

This effect can be understood by looking at equation (3): we can observe that in the event of a devaluation, the existence of some bonds denominated in domestic currency makes it possible to absorb a bad shock hitting the economy $(\varepsilon_h > 0)$ as this type of shock is associated with surprise-inflation. This effect, which is called the *hedging role* of domestic currency denominated debt, corresponds to the fact that in the event of a bad shock, the existence of domestic currency denominated debt makes it possible to ease the budget constraint as the shock is associated with surprise-inflation, which increases with the part of the debt denominated in domestic currency. In the event of a bad shock,

$$\frac{\partial\left|\theta_h\left(E\left[p_h^{cc}\right] - p_h^{cc}\right)\right|}{\partial \eta_h} > 0$$

Consequently, as the hedging role of domestic currency denominated debt makes it possible to compensate the adverse shock hitting the economy, the optimal devaluation rate can be lower.

A.3 Credibility Regimes Depend on the Debt Structure

Let us first recall that $l_{cc_1} = (k_h + \mu_h b_h p_w)(1-\Lambda) - \hat{\varepsilon},\ l_{pc} = k_h - \hat{\varepsilon} + \mu_h b_h p_w$, $l_{cc_2} = (k + 2\hat{\varepsilon} + \mu_h b_h p_w)(1-\Lambda) - \hat{\varepsilon},$

where $k_h = \sqrt{\frac{2c}{1-\lambda_h}} = \left(2c\left(1 + \frac{\beta_h}{\eta_h^2 b_h^2 + 2\eta_h b_h \phi + \phi^2}\right)\right)^{\frac{1}{2}}$ and $\lambda_h = \frac{\beta_h}{\beta_h \eta_h^2 b_h^2 + 2\eta_h b_h \phi + \phi^2}$.

From this we can calculate that,

$$\frac{\partial k_h}{\partial \eta_h} < 0 \text{ and } \frac{\partial \lambda_h}{\partial \eta_h} < 0$$

Notice that $\Lambda = \frac{1}{2}(1-\lambda)$ and thus $(1-\Lambda) = \frac{1}{2}(1+\lambda)$.

Consequently,

$$\frac{\partial l_{cc_1}}{\partial \eta_h} = (1-\Lambda)\frac{\partial k_h}{\partial \eta_h} + \frac{1}{2}(k_h + \mu_h b_h p_w)\frac{\partial \lambda_h}{\partial \eta_h} < 0$$

$$\frac{\partial l_{pc}}{\partial \eta_h} = \frac{\partial k_h}{\partial \eta_h} < 0$$

$$\frac{\partial l_{cc_2}}{\partial \eta_h} = (1-\Lambda)\frac{\partial k_h}{\partial \eta_h} + \frac{1}{2}(k_h + 2\hat{\varepsilon} + \mu_h b_h p_w)\frac{\partial \lambda_h}{\partial_h} < 0$$

A.4 Some Precisions Relative to Currency Composition of Public Debt and Credibility of the Peg

It is important to note that debt denominated in the currency of the partner country can only be used to achieve a unique equilibrium of perfect credibility when $\underline{l_{cc_1}} \leq u_h \leq \overline{l_{cc_1}}$, where $\underline{l_i}$ corresponds to the minimum of l_i reached when $\eta = 1$ and $\overline{l_i}$ corresponds to the maximum of l_i reached when $\eta = 0$.

In our setting, we have to consider the following cases:

- When the spending shock is so low that $u_h < \underline{l_{cc_1}}$ whatever the debt structure, the latter plays no role and perfect credibility can then be taken for granted.
- When $\underline{l_{cc_1}} \leq u_h \leq \overline{l_{cc_1}}$, we could have multiple equilibria, but the government can induce private agents to believe in price stability by increasing the share of its debt denominated in foreign currency.[16]

[16] By noting that $\overline{l_{cc_1}}$ is always lower than $\underline{l_{pc}}$ and that $\frac{\partial \overline{l_{cc_1}}}{\partial \beta} > 0$, $\frac{\partial \overline{l_{cc_1}}}{\partial c} > 0$, $\frac{\partial \overline{l_{cc_1}}}{\partial \phi} < 0$, $\frac{\partial \overline{l_{cc_1}}}{\partial \hat{\varepsilon}} < 0$ we know that foreign debt helps to eliminate devaluations associated with the occurrence of bad shocks when u_h is not too large; nevertheless larger values of u_h remain compatible with perfect credibility the larger β and c and the smaller ϕ and $\hat{\varepsilon}$. This means that perfect credibility can more easily be achieved when the costs of inflation and devaluation (β and c) are high and when the incentive to devalue is weak (ϕ and $\hat{\varepsilon}$).

- Finally, when $\overline{l_{cc_1}} < u_h$ (which can happen as $\overline{l_{cc_1}} < \underline{l_{pc}}$), we have multiple equilibria, but the currency composition of the public debt cannot be used in order to induce private agents to believe in perfect credibility. As public debt denominated in domestic currency is not the only source of inflationary incentives, inflationary expectations could remain positive even when the whole debt is denominated in foreign currency.

A.5 Common Central Bank's Decision – Non-commitment Case

- In period 1, in the absence of a pre-commitment to price stability, the common monetary policy consists in choosing p minimizing the loss function (6) s.t. budget constraints (2a') and (2b').

By taking the expectation of the first order condition with respect to p, we find the expected inflation rate in the absence of commitment,

(8a) $$E\left[p_{EMU}^{nc}\right] = \frac{\alpha_h u_h \theta_h + \alpha_f u_f \theta_f}{\beta}$$

By inserting (8a) in the first order condition with respect to p, we get the equilibrium consistent inflation rate when the common central bank cannot credibly commit to price stability,

(8b) $$p_{EMU}^{nc} = \frac{\alpha_h u_h \theta_h + \alpha_f u_f \theta_f}{\beta} + \frac{\alpha_h(\varepsilon_h - \mu_h b_h p_w)\theta_h + \alpha_f(\varepsilon_f - \mu_f b_f p_w)\theta_f}{\beta + D}$$

with $D = \alpha_h \theta_h^2 + \alpha_f \theta_f^2, \theta_h = (\phi_h + (1-\mu_h)b_h)$ and $\theta_f = (\phi_f + (1-\mu_f)b_f)$.

- In period 0, the loss function of the common monetary authorities, which is equal to the mathematical expectation of loss function (6), can be written,

$$L_{EMU}^{0}\,(\text{non-commitment}) = \frac{1}{2}\alpha_h u_h^2\left(1+\frac{\alpha_h\left(\phi_h^2+2\phi_h(1-\mu_h)b_h+(1-\mu_h)^2 b_h^2\right)}{\beta}\right)$$

$$+\frac{1}{2}\alpha_f u_f^2\left(1+\frac{\alpha_f\left(\phi_f^2+2\phi_f(1-\mu_f)b_f+(1-\mu_f)^2 b_f^2\right)}{\beta}\right)$$

$$+\alpha_h\alpha_f u_h u_f\,\frac{\left(\phi_h+(1-\mu_h)b_h\right)\left(\phi_f+(1-\mu_f)b_f\right)}{\beta}$$

$$+\frac{1}{2}\left\{\frac{\alpha_h\left(\sigma_{\varepsilon_h}^2+\mu_h^2 b_h^2\sigma_{p_w}^2\right)\left(\beta+\alpha_f\left(\phi_f^2+2\phi_f(1-\mu_f)b_f+(1-\mu_f)^2 b_f^2\right)\right)}{\beta+\alpha_h\left(\phi_h^2+2\phi_h(1-\mu_h)b_h+(1-\mu_h)^2 b_h^2\right)+\alpha_f\left(\phi_f^2+2\phi_f(1-\mu_f)b_f+(1-\mu_f)^2 b_f^2\right)}\right\}$$

$$+\frac{1}{2}\left\{\frac{\alpha_f\left(\sigma_{\varepsilon_f}^2+\mu_f^2 b_f^2\sigma_{p_w}^2\right)\left(\beta+\alpha_h\left(\phi_h^2+2\phi_h(1-\mu_h)b_h+(1-\mu_h)^2 b_f^2\right)\right)}{\beta+\alpha_h\left(\phi_h^2+2\phi_h(1-\mu_h)b_h+(1-\mu_h)^2 b_h^2\right)+\alpha_f\left(\phi_f^2+2\phi_f(1-\mu_f)b_f+(1-\mu_f)^2 b_f^2\right)}\right\}$$

$$-\frac{\alpha_h\alpha_f\left(\phi_h+(1-\mu_h)b_h\right)\left(\phi_f+(1-\mu_f)b_f\right)\mu_h b_h\mu_f b_f\sigma_{p_w}^2}{\beta+\alpha_h\left(\phi_h^2+2\phi_h(1-\mu_h)b_h+(1-\mu_h)^2 b_h^2\right)+\alpha_f\left(\phi_f^2+2\phi_f(1-\mu_f)b_f+(1-\mu_f)^2 b_f^2\right)}$$

A Reform Proposal for EMU Institutions*

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I. Introduction

EMU macroeconomic institutions have been widely criticised. The ECB lack of transparency and accountability has been often remarked in the press. Commentators have pointed out that some national interests might have excessive influence within the ECB Governing Council (Casella 2000a, 2000b; Gruner 1999). Moreover, the ECB stabilisation policy appears to some observers weak and inconsistent, as if its decision-making procedures were not up to the task (Favero, Freixas, Persson and Wyplosz 2000a, b). The Stability and Growth Pact (SGP) reputation appears tarnished and revisions are recurrently suggested.[1]

Instead of the SGP, Casella (1999) advocates the creation of a market for tradable deficit permits. In the same vein, Casella (2000a) proposes a reform of the ECB decision-making rule within the Governing Council. The market solutions approach is presented as an alternative to the "explicit co-ordination required by the collective decision-making procedure …" (Casella 2000a, p. 9). In our view, such an approach denies the very essence of the European integration process, which relies on co-ordination and agreement among the member states over far more numerous issues than macro-economic policies (Von Hagen and Mundschenk 2001, p. 1).

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[1] The Economist (2001b, p. 13) is even in favour of scrapping the SGP. Politicians have begun to float their interest for more flexible arrangements despite routine statements of their commitment to the SGP (The Economist 2001c, p. 60).

In this paper, we discuss a reform proposal for EMU macroeconomic institutions which rests on the generalised adoption of targets, for both monetary and fiscal policies, to be integrated by a system of checks and balances. The new arrangements for fiscal policies should induce EMU countries to internalise the external effects of their own policies, therefore allowing a partial relaxation of the SGP limits to national debt policies. As for monetary policy, we propose the adoption of an inflation target, the assignment of ex-post assessing powers to the Euro12-group and an internal reform of the ECB. The latter should limit undue nationalistic influences within the ECB governing bodies.

The paper is organised as follows. Section II and III discuss the institutional design for fiscal policies and monetary policy, respectively. Section IV concludes.

II. Reshaping National Fiscal Policies within EMU

To begin with, we recall the key aspects of EU institutional arrangements. The Maastricht Treaty posits that EU fiscal policies are run nationally, following EU-wide objectives defined on an yearly base by the Council of Economic and Finance Ministers in the Broad Economic Policy Guidelines (BEPGs) and within the limits set by the SGP. According to Art. 99 of the Maastrich Treaty, the Council of Economic and Finance Ministers (Ecofin) approves by majority voting the adoption of guidelines and recommendations proposed by the European Commission on matters of deficits, taxation and spending. National fiscal policies are regularly scrutinised to assess their conformity with the BEPGs. The supervision task is assigned to the European Commission, which co-operates with the Economic and Financial Committee and reports to the Ecofin. In 1997 the European Council established what is now known as the Euro12-group. The latter provides a forum where, in connection to Ecofin meetings, the EMU finance ministers gather to assess EMU macroeconomic developments. The Euro12-group has no legislative powers.

The SGP sets an upper limit on national deficits as a proportion of GDP (3%). Countries are required to submit yearly their Stability and Convergence Programmes (SCPs) to the European Council. The European Commission evaluates each SCP consistency with the medium-term objective of a budget close to balance or in surplus. On these matters the Commission reports to Ecofin. Countries failing to comply with the BEPGs or the SCPs are subject to censorship by the other EU members. Only unjustified breaches of the 3% ceiling set in the SGP cause the adoption of sanctions towards a country.

Out of this complex arrangements, the SGP has received most of the attention by commentators as well as academics. The SGP presupposes a link between fiscal discipline, monetary stability and growth. The economic literature identifies different channels through which such a relation can work.[2]

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[2] For a comprehensive survey, see *Beetsma* and *Debrun* (2002).

1. The Pros and Cons of the SGP

Excessive deficits and the accumulation of debt occur because governments underestimate the future consequences of current deficits (Alesina and Tabellini 1990) and have an incentive to use debt strategically (Persson and Svensson 1989). High levels of debt service force a country to increase its fiscal pressure over time. To the extent that taxation is distortionary, output losses are incurred. The ECB might therefore be pressured into accommodating monetary policy (Artis and Winkler 1998). Beetsma and Uhlig (1999) show that, by acting non-cooperatively, each union member underestimates the equilibrium debt levels and the ensuing inflationary pressures. As a consequence, fiscal discretion within a monetary union will generate larger debt levels than without a union.

If the transmission of fiscal shocks is negative, uncoordinated national fiscal policies cause an undesirable policy mix (excessive deficits, taxation and interest rate) and raise inflation expectations (Eichengreen and Wyplosz 1998; Debrun 2000).[3]

The *Fiscal Theory of the Price Level* (Woodford 1995, 1998) identifies a third channel: if both the monetary and fiscal authority stick to inconsistent paths for their policy instruments, the price level adjusts to ensure that the inter-temporal government budget constraint is fulfilled. Hence, in a “fiscal dominance” regime, the monetary authority looses control over the price level. In this framework, rules such as the SGP are needed to avoid a situation of fiscal dominance.[4]

Despite the consensus on the need for fiscal constraints, the specific features of the SGP have been widely criticised.

The adoption of a uniform deficit ceiling does not take into account structural differences across countries, such as different stocks of outstanding debt or the asymmetric output effects of national fiscal stimuli. Buti and Sapir (1998) give operational content to the notion of medium-term deficit objectives that would at least allow for the correct functioning of the automatic stabilisers. They show that adherence to the Pact requires very different structural balances across EMU countries. In defence of the Pact, it might be argued that some asymmetries will disappear once debt levels have been harmonised below 60% and automatic stabilisers are reformed and made more effective where necessary. However, correcting excessive debt levels in countries like Italy and Belgium will probably take a long time even if one takes at face value the official stabilisation plans. Furthermore, it is not obvious that the SGP provides sufficient incentives to induce a re-organisation of national welfare systems consistent with a flexible use of fiscal policies.

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[3] Under these circumstances, current deficits are too high for two reasons. On the one hand, governments are not able to internalise the adverse consequences of their actions on expectations. On the other hand, non-cooperation with the other national fiscal authorities causes a deficit bias.

[4] *Leith* and *Wren-Lewis* (2002) investigate the specific features of fiscal constraints designed to ensure price stability in a monetary union. They argue that the SGP ceilings are exceedingly restrictive.

Focusing on the size of the budget deficits, the SGP provides at best limited discipline for national fiscal policies that do not breach the 3% ceiling. This criticism is based on two arguments. The first is that the Pact does not envisage adequate incentives to the creation of surpluses during economic expansions (Bean 1998, CESifo 2002, Canzoneri and Diba 2001). One could argue that the risk of being forced to implement a procyclical policy in the face of a recession should induce governments to adopt symmetric fiscal policies. Unfortunately, adverse electoral incentives – one of the very rationales for the Pact – induce national governments to underestimate the future consequences of an asymmetric development of fiscal policy. In the present institutional set-up, the BEPGs should provide guidance to national fiscal policies within the limits imposed by the SGP. Von Hagen and Mundschenk (2001, p. 24) argue that the BEPGs enforcing mechanism relies only on moral suasion or reputation-damaging peer pressure. They also point out that the connection between the typical budgetary cycle and the discussion of national SCPs is at best feeble. As a result, countries like France and Germany have been able to undertake significant tax adjustments without mentioning them in their SCPs. The European Commission (2000) remarks that quite often the measures taken or planned within the SCPs are not thoroughly explained, preventing an effective process of peer review within Ecofin. The above arguments are confirmed by the actual behaviour of national fiscal policies between 1998 and 2000, when, despite the good growth record, the progress towards fiscal consolidation was very slow (CESifo 2002).

The second argument is that the SGP apparently ignores the fiscal distortions which may occur under a balanced budget rule. Excessive taxation may in fact arise as a consequence of time-inconsistent as well as beggar-thy-neighbour policies.[5] The issue of time inconsistency is described in Beetsma and Bovenberg (1998), whose results crucially depend on the order of moves by the wage setters, the national fiscal authorities and the ECB. In setting the tax rate, the fiscal authorities foresee that the ECB will accommodate a tax increase. However, they do not internalise the fact that, being completely anticipated, such a policy is ineffective. Another strand of literature (Levine and Pearlman 1998) highlights that unco-ordinated fiscal policies are systematically characterised by the incentive to relax the fiscal stance, in order to achieve an output expansion through the appreciation of the real exchange rate.[6] This result is typically obtained in a symmetric framework, but it is easily extended to the realistic case of asymmetries concerning national preferences and the economic structure of EMU members. The common theme to these two contributions is the implicit emphasis on the importance of commitment to announced tax/spending levels, which may well differ across EMU member states.

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[5] Successive interpretations of the Pact provided by the European Commission point at the excessive fiscal pressure within the Euro area, implicitly confirming the importance of the issue.

[6] This effect is normally described in models that assume a negative transmission of fiscal shocks to the foreign demand. *Catenaro* and *Tirelli* (2000) demonstrate that the same incentives exist in case of positive transmission if the fiscal authorities act as Stackelberg leaders vis-à-vis the ECB, and the latter controls the inflation rate.

The issue of how should national fiscal policies be implemented within the SGP limits has quickly turned into a unco-ordination versus co-ordination debate. In this regard, the main results emerged in the theoretical literature are easily summarised. Unco-ordinated and fully discretionary fiscal policies are undesirable, due to adverse “political” incentives, the missing internalisation of unfavourable effects on expectations, and spill-overs affecting the economies of member states. Fully discretionary and co-ordinated policies have ambiguous effects. On one hand, co-ordination worsens the time inconsistency of fiscal policy, strengthening the public expenditure bias (Beetsma and Bovenberg 1998). On the other hand, the argument in favour of co-ordination is twofold. First, co-ordination induces national fiscal authorities to internalise the transmission effects discussed in Levine and Pearlman (1998). Second, co-ordination of countercyclical fiscal policies is always desirable, provided that appropriate institutional design removes the expenditure bias. To this end, Catenaro and Tirelli (2000) propose the adoption of public spending targets.

Policy-oriented contributions have been characterised by opposing views. Those who favour unco-ordination claim that governments should run a cyclically-adjusted balanced budget (Alesina, Blanchard, Galì, Giavazzi and Uhlig 2001; CESifo 2002). In contrast with this approach, Von Hagen and Mundschenk (2001) argue that fiscal co-ordination is a necessary prerequisite to obtain EMU club-goods such as price stability. The authors criticise the present institutional set-up, where BEPGs must be unanimously approved by the European Council (Art. 99 of the Maastricht Treaty) but only a subset of EU members share EMU club-goods. The Commission (2001b) has explicitly recognised the need for stronger co-ordination within the Euro area, and has put forward a proposal. The latter is based on a stronger role for the Euro12-group, who should articulate the policy responses to specific shocks. On the other hand the Commission's proposal does not entail any enforcement mechanism and entirely relies on unanimous consensus within the Euro12-group to put pressure on “deviant” members.

2. A Proposal

Our proposal rests on the view that significant externalities arise when national governments retain full discretion in the setting of tax/expenditures rates. Thus, there is a presumption that institutional arrangements which limit the discretionary power of national policymakers enhance efficiency. In particular, we claim that:

Proposition 1: In addition to deficit ceilings, the endorsement of national tax/expenditure targets, adequately supported by a system of checks and balances, will efficiently preserve the EMU-club good of price stability and induce the internalisation of traditional spill-over effects. Moreover, commitment to fiscal targets will prove consistent with more flexibility in the enforcement of deficit ceilings than is currently envisaged in the SGP.

Discussion: EU allocation of powers is based on the subsidiarity principle, according to which the powers of EU institutions should be limited to those tasks that cannot be adequately performed by its member states. Hence, we do not argue that some governing body should interfere with national sovereignty in fundamental decisions such as the choice of the welfare system by imposing, for instance, an identical tax level across EMU countries. Institutions should instead be designed to prevent the manipulation of fiscal stances aimed at achieving short-term macroeconomic effects.

The centrepiece of our proposal is the adoption of fiscal policy targets. Each government will be bound to announce a multi-year sequence of target levels for public spending, taxes and deficit that are mutually consistent. Such targets are a necessary requisite for policies precommitment, since they are used to ex-post assess the actual behaviour of the national governments. The flexible implementation of targets for expenditures, taxation and deficit combines a more effective control on the expansionary bias of national fiscal stances with the use of countercyclical policies. Several contributions have emphasised the importance of fiscal stabilisation policies. Some authors (Canzoneri and Diba 2001; CESifo 2002) propose that the focus of the Pact be shifted from actual to structural deficits. Others (Alesina, Blanchard, Galì, Giavazzi and Uhlig 2001) argue that, within the SGP limits, countries should commit to stabilise the budget over the cycle. Both suggestions are open to criticism. On one hand, although commitment to a balanced structural budget rule would provide the appropriate mix of fiscal discipline and flexibility, defining such a rule in practice may prove difficult because short run measures of the structural balance are subject to a tremendous uncertainty about the trend level of output.[7] On the other hand, the suggestion in Alesina, Blanchard, Galì, Giavazzi and Uhlig (2001) apparently ignores that SGP deficit ceilings would clearly become superfluous if countries were able to individually commit to a symmetric countercylical fiscal policy rule. Therefore, instead of defining a constitutional policy rule, we sketch a system of checks and balances, which should induce national governments to implement a countercyclical rule.

Expenditure/tax targets have received much less attention than deficit objectives in the EMU institutional set-up. In our view, both deficits and tax/expenditure targets are important in preserving EMU price stability and should thus be granted “equal treatment”. This requires that all targets are credible and hence governments be made accountable for them at the Union level. There must be absolute transparency over the management of fiscal policies. Finally, it is necessary to minimise the possibility that “political” conflicts over the consequences of governments' actions are disguised as “technical” controversies. To achieve these goals, we propose that: *i)* national targets be co-ordinated ex-ante and turned into binding announcements; *ii)* specific enforcement powers be assigned to EMU peers; *iii)* the surveillance procedure be strengthened.

Ex-ante targets coordination. Macro-economic efficiency may be attained only if each country internalises the consequences of its own choices on EMU conditions. This basic principle applies also to the definition of tax/expenditures targets. For example, the non-cooperative setting of taxation targets might gener-

[7] This is the reason why central banks never announce explicit output targets.

ate excessive inflationary pressures.[8] In our view, ex-ante co-ordination should also be concerned with the macroeconomic consequences of foreseeable structural reforms of the welfare state. It is well known that structural reforms affect the macroeconomic policy stance and typically require a prolonged adjustment period. Such effects cannot be ignored, because of externalities on other economies. Thus each country should retain the right to undertake structural reforms at its own choice, but the macroeconomic implications of transition periods should be matter for ex-ante policy co-ordination[9]. The Irish transition to a low-tax regime is a good case in point. Another good case in point is the hot and somewhat confused debate that followed the EC recommendations to the Irish government, showing that in this regard EMU policy co-ordination is still in a flux (Alesina, Blanchard, Galì, Giavazzi and Uhlig 2001).

Binding announcements. Targets credibility requires an institutional set-up such that announced objectives are not systematically disregarded. On the other hand, the flexible implementation of targets allows to stabilise the economy. The literature on the optimal trade-off between credibility and flexibility suggests that ex-post deviations of actual policies from announced targets should be made “costly” (Lohmann 1992). This is essentially the spirit of the SGP and we agree with it. Still, deviations from announced targets can be made costly without giving up flexibility. This is obtained designing a system of checks and balances among different institutional levels, whereby governments are induced to internalise the consequences of their own choices. We turn now to the main elements in such design.

Enforcement powers. A country willing to deviate from announced fiscal policy targets should submit a request to proceed to the Union members. The request will identify the underlying causes and the consequent domestic impact of the proposed change in policy. Moreover, it will spell out its consistency with the announced medium-term objectives.

We propose that enforcement powers on specific intra-EMU matters, currently entrusted to Ecofin, be handed over to the Euro12-group.[10] The Euro12-group will then be called upon to express a binding opinion about (proposed) devia-

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[8] This conclusion can be intuitively demonstrated, by comparing the behaviour of a country maintaining monetary sovereignty with that of a member of the Union. The first, in selecting the taxation target, will take into account the impact of a distortionary taxes on output, and therefore on the consequent inflationary pressures. The second will ignore the symmetric behaviour of the other members of the Union and will underestimate the inflationary impact of its own choices. As a result, the non-coordinated setting of the taxation targets in the Union will lead to excessive levels of fiscal pressure. The same conclusion is drawn by taking into consideration the possibility of increasing production through appreciation of the real exchange that could be attained with a unilateral increase in the public spending level.

[9] This issue was implicitly acknowledged in the Lisbon meeting of the European Council, when it was agreed that countries should present a yearly report discussing the interactions between the domestic macroeconomic policy stance and the structural policies.

[10] Our proposal is akin to the one put forward in *Von Hagen* and *Mundschenk* (2001), who argue that coordination powers should be handed over to an Economic Policy Council: “With an appropriate institutional design, such a council would enhance policy coordination by developing judgements about policy trade-offs and the distribution of adjustment costs.” (*Von Hagen* and *Mundschenk* 2001, p. 23).

tions from announced targets. Such opinion will be based on EMU-wide macroeconomic implications of the new policy course. As the Irish case clearly shows, countries are unlikely to implement symmetric policies along the cycle, (e.g.: they may not reduce taxation during a boom). The Euro12-group should monitor countries for their compliance with the announced targets in good as well as bad times. Finally, should a country disregard the Euro12-group opinion, it would be subject to pecuniary sanctions.[11]

Since each decision is likely to have significant and asymmetric effects on the welfare of each member country, hegemonic coalitions might bias Euro12-group decisions in favour of specific national interests. It is therefore important to regulate the Euro12-group discretionary power. Hence we propose that any decision should respect an equal treatment principle, i.e. countries experiencing similar cyclical conditions should be allowed a symmetric adjustment of their fiscal stance if they wish so. Decisions should be based on publicly disclosed motivations concerning the Union-wide effects of national policies and should take into account the ECB's opinion[12] about the inflationary consequences of the policy change. Finally, the European Commission – whose objective function reflects the interests of the Union as such – should be appointed as agenda setter for the Euro12-group meetings.[13]

Improved commitment to a broader set of targets allows to introduce new provisions concerning deviations from deficit targets. The crux of the matter obviously is represented by requests to deviate from the 3% ceiling set in the SGP. In our view, a country (a group of countries) should be allowed to increase its deficit beyond the ceiling if: *i)* this is consistent with a balanced budget in the medium term; *ii)* the remaining Euro12-group members agree to implement policies such that the Union-wide deficit does not exceed the 3% limit. This rests on the important argument that EMU price stability depends on the global fiscal stance (Von Hagen and Mundshenk 2001; Casella 1999). Thus, if current rules allow for a global deficit close to 3% there is no need to sanction countries that breach the SGP rule provided that EMU peers agree to co-ordinate the global EMU stance within the SGP limit. As for decisions entailing a breach of the 3% deficit rule at the Union level, Onorante (2002) shows that empowering the ECB with the right to choose the excess deficit would entirely remove any spending bias and leave room for enough fiscal flexibility. This solution may in fact be unfeasible, as it would cause undue political pressures on the ECB. Bearing in mind that the enforcement of the SGP ultimately rests in the sole hands of national governments, i.e. to the extent that transparency sufficiently raises the

[11] In contrast with the current arrangement (*Artis* and *Winkler* 1998; *Casella* 1999), the implementation of sanctions should be devoid of any discretion.

[12] At the present, the ECB plays a role in the policy coordination process via the Economic and Financial Committee (EFC). The latter consists of representatives of national administrations and central banks, of the European Commission and the ECB itself. The EFC has an advisory and preparatory role for the European Council meetings. Our proposal strengthens the ECB role in the policymaking process, extending the accountability mechanism and favouring co-ordination between monetary and fiscal policy.

[13] At present, the Euro12-group meetings are chaired by one of the finance ministers of EMU members. We agree with the European Commission's request (2001b) of granting it the right to advance economic policy measures and to participate into setting the agenda for the European Council meetings.

costs of running time-inconsistent fiscal policies, a viable alternative is to require that the Euro12-group and the ECB issue a public statement arguing the case for their preferred policy stance, leaving the final decision to a qualified majority within the Euro12-group.

Surveillance procedure. The Amsterdam Treaty assigns the European Commission the task of monitoring economic developments and policies in member states. Given our emphasis on a broader set of policy targets, the Commission surveillance tasks should be extended accordingly. As mentioned above, the effectiveness of the surveillance procedure is currently impaired by the widespread timing mismatch between the writing of SCPs and the national budget cycle. The European Commission (2001a) itself has recently put forward some practical suggestions aimed at improving EU budgetary surveillance. Three are noteworthy: *i*) partners must be "pre-informed" in case of important policy measures; *ii*) the information content of the SCPs must be improved and standardised across countries[14]; *iii*) the SCPs must be submitted to the competent authorities in autumn each year. We favour the outright adoption of such proposals.

III. The Monetary Institutions

The following discussion focuses on two key aspects of EMU arrangements concerning the monetary policy. The first is the ECB status as a goal-independent Central Bank; the second is the composition of the ECB governing bodies, where national interests are directly and explicitly represented. We will argue that in principle such a combination of goal independence and national representation can adversely affect EMU monetary policies, and probably lies at the heart of the serious difficulties the ECB met in establishing a reputation *vis-à-vis* the financial markets.

1. A Critical Assessment

The Maastricht Treaty assigns to the ECB price stability as its primary objective. Without prejudice to the primary objective, the ECB is committed also to support the general economic policies of the Community and to promote the smooth operations of the payment system. The assignment of lexicographic preferences to the ECB can be interpreted as a device to enhance efficiency, transparency and accountability in the conduct of monetary policy. However, the ECB statute and the Bank's interpretation of it have been subject to sharp criticisms, well summarised in Tabellini (1999). First, being goal-independent rather than instrument-independent, the ECB enjoys excessive discretion. Second, the endorsement of a monetary policy strategy based on the two pillars of consumer price inflation and M3 growth may seriously hamper the effective accountability of the Bank's actions. Third, the ECB has *de facto* shown little transparency, re-

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[14] This requires the adoption of standardised statistical procedures across countries and, more important, the elaboration of appropriate Union-wide indicators (*European Commission* 2001a).

leasing information useful to justify ex-post its operations, but of little avail in assessing ex-ante how it intends to achieve its objectives.[15] To improve transparency, the publication of the minutes of the Board meeting has been often invoked (among others, see Begg, De Grauwe, Giavazzi, Uhlig, and Wyplosz 1999; Eijffinger 2001). However, no decision has been taken in this direction, causing also negative judgements by renowned Central Bank watchers (ABN AMRO 2001).[16]

The large degree of independence enjoyed by the ECB Governing Council is acceptable in principle. In fact, goal-independent central banks – notably the Fed and in the past the Bundesbank – indeed retain a substantial degree of discretion. In particular, the Fed has often surprised markets (Mishkin and Posen 1997), and the Bundesbank has repeatedly accommodated substantial deviations of the money supply from the announced objectives (Issing 1997). There is a fundamental difference, however, between pre-EMU Bundesbank and the Fed on one hand and the ECB on the other. In fact, EMU political fragmentation impairs an ex-post assessment of the ECB actions. To the contrary, in the US controlling powers are firmly in the hands of the central bank political principal (Chang 2001), so as they were in Germany before EMU (Lohmann 1997). Therefore the current ECB institutional set-up does not fit well with the global architecture of EMU macroeconomic institutions, simply because there is a striking imbalance between its degree of goal independence and the strength of ex-post control. Furthermore, such imbalance leaves room for a potentially excessive influence of national interests within the ECB Governing Council. This may happen as a consequence of the peculiar arrangements characterising the ESCB, where the NCBs constituting the ESCB are nation-based institutions and their Governors' votes in the ECB Governing Council may exert a distorting influence.[17] In case of serious cyclical asymmetries across EMU countries, such an influence may take place either through prevailing coalitions of national interests or through paralysing conflicts.[18] Both cases would be highly detrimental to the credibility of the ECB as a European institution (Baldwin, Berglöf, Giavazzi, and Widgrén 2000).

EMU monetary policy has been subject to several criticisms. According to Galì (2001), it is simply difficult to interpret it in relation to the ECB self-declared objectives. The uncertain and ambiguous conduct of monetary policy is seen as the consequence of internal conflicts. Market analysts seem convinced that decision-making within the Governing Council is unlikely to rely on unanimous

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[15] This criticism is partly attenuated by the recent decision to publish the forecasts.

[16] The words of *Baldwin*, *Berglöf*, *Giavazzi* and *Widgrén* (2000, p. 40) well represent dissatisfaction with this state of affairs: "The detailed study of EMU reform [concerning the ECB statute] is difficult at this point because we do not know how the system works now….".

[17] *Thomas Mayer*, an economist at Goldman Sachs in Frankfurt, stresses this point by observing that Mr. Greenspan is a "strong leader who has managed to steer markets' expectations skilfully. Mr. Duisenberg is more of a "moderator" of the ECB's 18-strong governing council…" (The Economist 2001a).

[18] According to *Eichengreen* (1991), the Fed faced troubles of this sort in the years before the '29 crisis because of an institutional framework very similar (i.e. biased towards an excessive influence of national interests) to the present ECB.

consensus, as the ECB insists to be the case (The Economist 1999, 2000). To the contrary, the Council appears – plausibly – characterised by contrasting views among its members, due to the structural and cyclical divergences affecting member states. To see that, recall the ECB's official position on the divergence of regional inflation rates. The ECB (1999) insists that monetary policy in the Eurosystem must be oriented to price stability for the Euro area as a whole, and that possible phenomena of persistent divergence in the growth rates of prices require structural policies. Favero, Freixas, Persson and Wyplosz (2000a, p. 3 and p. 44) have criticised this claim: higher inflation in a region might be accompanied by localised real expansions that – without proper stabilising actions – can favour a "boom and bust" development of asset prices, with possible negative repercussions over systemic financial stability. Consequently, neglect for the interregional inflation differentials is interpreted as the attempt to prevent potential conflicts within the Governing Council. In the present institutional setup, such an attempt may be regarded as second-best policy to preserve the ECB reputation as a European institution, but it is likely to generate inefficiencies in the conduct of monetary policy.

2. Independence, Transparency and Accountability for the ECB

The aim of our proposed reform is twofold. We suggest measures to increase transparency and ex-post accountability in the ECB decision-making procedures. At the same time, we propose to strengthen the ECB insulation from political influences that do not manifest themselves in the classical forms of appointment power and ex-post policy assessment. To this end, we identify institutional arrangements such that the ECB governing bodies are made largely immune from nationalistic influences, and NCBs simply act as ECB "local" branches, providing "privileged" information about the actual state of EMU regions.

New Jurisdictions for the NCBs. To prevent the over-representation of national interests within the ECB Governing Council, the NCBs should be turned into regional banks as in the Federal Reserve system, and should be fewer in number than EMU members.[19] This implies that the jurisdictions of the reformed NCBs should no longer coincide with national borders. Instead they should be redefined so as to reduce structural asymmetries among them[20], limiting the risk of a structural polarisation of the votes within the Governing Council. Moreover, in light of the foreseeable EMU enlargement, re-design of jurisdictions could prevent the dominance of small countries feared in Baldwin, Berglöf, Giavazzi and Widgrén (2000).

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[19] In view of the enlargement, *Baldwin*, *Berglöf*, *Giavazzi* and *Widgrén* (2000) suggest either weighting NCBs' voting rights by the country GDP shares or assigning monetary policy to the Executive Board only. In the following we comment on both these proposals.

[20] See *Graboyes* (1990) for a similar view. It is interesting to observe that the federation of the local central banks in the US Federal System was preceded by a redefinition of jurisdictions which cut across state borders and local economies, so as to limit the risk that representatives on the Fed Board could be captured by specific economic interests.

Our proposal is likely to raise two objections. The first concerns the organisation of banking policy. In fact, in many countries NCBs have traditionally played quite an important role for prudential supervision. By statute, the ECB is supposed just to co-ordinate national banking policies and the Maastricht Treaty is ambiguous about the allocation of powers. Perhaps not surprisingly, the NCBs Governors opted to retain their powers. However, the ever growing integration of European financial markets calls instead for the centralisation of banking policies (Prati and Schinasi, 1997; Begg, De Grauwe, Giavazzi, Uhlig, and Wyplosz 1999; Lossani, Natale and Tirelli 1999; Von Hagen and Mundschenk 2001, Uhlig 2002). Our proposal is likely to meet the stiff opposition of those who fear the complete integration of national financial markets and see the survival of national regulators as a prerequisite for the protection of national champions in the banking sector.[21] In our view, this strengthens the case for a re-design of NCBs jurisdictions. The second objection concerns the legal status of the regional banks. At the present, the NCBs are the shareholders of the ECB. Each national bank contributes to the capital of the ECB in proportion to national GDP. Seigniorage revenues are apportioned by a system of weighted votes assigned to the NCBs Governors only. This should change, with all proprietary rights shifted to EMU national governments. As for seigniorage, its distribution is a matter for governments to discuss and should be assigned to the Euro12-group.

A new appointment mechanism for NCBs Governors. Following the re-design of jurisdictions, NCBs turn into regional banks. Thus their Governors should be selected according to a competence principle. The appointment power should be entrusted to the ECB Governing Council.[22]

A rotation rule for the NCBs Governors right to vote. At the present, coalitions forged by converging national interests can command a majority of votes in the Governing Council. To remedy it, Baldwin, Berglöf, Giavazzi, and Widgrén (2000) recommend assigning monetary policy decisions to the Executive Board exclusively.[23] Such proposal postulates that Executive Board members represent Union-wide rather than national interests. Given the current selection procedures this may well not be the case.[24] Moreover, assigning monetary policy to a body whose members are entirely appointed by elected governments may trigger electoral cycles in monetary policy. Following the Federal Reserve example, we would retain a role for the Governors of the newly designed NCBs. Being non-political appointees, they should counteract the effects of shifting po-

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[21] In this regard a good example is provided by the Bank of Italy, who retains the power to discipline competition in banking sector.

[22] In steady state, the ECB Governing Council will be composed by the Executive Board members and by the Governors of the new regional banks. One could imagine several transition rules consistent with the steady state.

[23] *Baldwin*, *Berglöf*, *Giavazzi* and *Widgrén* (2000) contemplate also maintaining the present arrangement while weighting the NCBs' Governors vote by their country GDP share. Unfortunately, the weighting cannot prevent a nationalistic bias in policy making. Consider an asymmetric shock which leaves Union-wide output unchanged but adversely affects the largest economies in the Union. If the latter contribute for more than half of the Union GDP, expansionary policies would be adopted, absent any need for them at the Union level.

[24] In support of this view, one has just to mention the controversy over the appointment of Duisenberg as ECB President.

litical majorities in the Union and thus in the composition of the Executive Board, to prevent a nationalistic bias in monetary policy, However, given their presumably large number relative to the "political" appointees, we favour the adoption of a rotation-voting rule for the NCBs Governors.[25]

A staggering of appointments. At present, Executive Board members are assigned staggered, even if non-renewable, terms. Instead, a NCBs Governor's term of office has a minimum length of five years and is renewable. It follows that members of the Governing Council change in an un-coordinated fashion and some of them do not leave at all.[26] In line with established theoretical results (Waller and Walsh 1996), we favour the adoption of a proper staggering of appointments for Executive Board members as well as for NCBs Governors.

A re-design of information flows. Successful monetary policy depends on timely and accurate information about the working of an economy. At the present, the Governing Council relies on NCBs' informational inputs in making policy decisions.[27] National interests would loose importance within a reformed ECB. However, one cannot rule out the case where some local interests might affect policy decisions. Even in the US Federal System FOMC members receive information processed only by the Board of Governors staff (Cecchetti 2001). One might argue that, as long as NCBs can provided better or cheaper information than the ECB staff, there is a cost in curbing local influences. However, whether or not such cost is large, is an open question. Thus, following Cecchetti (2001), we advocate for the ECB more centralisation of information gathering and processing than there is at the present.

Procedures for ensuring the ex-post accountability of the ECB. The ECB's "two-pillar strategy" assigns a prominent role to money growth targets as the first pillar. This strategy has been widely criticised, either because it is of no practical relevance, or because it might generate confusion and ambiguity. We take the view that the ECB should discard the two-pillar strategy in favour of inflation targeting. Following a contractualist approach (Walsh 1995, Persson and Tabellini 1993, Svensson 1997), we suggest that inflation targeting be supported by institutional arrangements designed to increase the Bank accountability. Given the relative weakness of the ECB political principals, the endorsement of an inflation target should *per se* strengthen ex-post control and help to anchor monetary policy to EMU-wide objectives. Holding the ECB accountable by means of an inflation target requires that some key issues be settled: *i*) Should the ECB autonomously select the target, or should it be agreed upon, and with whom? *ii*) To whom should the ECB account for the actual implementation of monetary policy?

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[25] Rotation will naturally have to be implemented at least by the time the new accession countries will enter EMU. The Nice Treaty (2000) simplified the procedure for changing the voting system for the ECB governing bodies.

[26] One of these is the Governor of the Bank of Italy, whose term length depends on his/her retiring age.

[27] *Cecchetti* (2001) argues that ECB economic forecasts are based on information explicitly provided by NCBs.

We propose the following:

i. By statute the ECB pursues price stability. We suggest that the ECB retains the task of defining the medium-term inflation target consistent with price stability.[28]

ii. As in Tabellini (1999), a political principal should be charged with the power of assessing the consistency between: *a)* announced policies and the ECB constitutional mandate; *b)* announced policies and their actual implementation. Following a conflict with the ECB, the political principal is allowed to adopt a sanctioning procedure. The latter may take the form of public and motivated censorship of the ECB policies or (possibly) the imposition of fines on the Bank. If the political constituencies of the European Union and of the EMU coincided, the European Parliament would be the natural ECB principal. However, only a subset of EU countries share the EMU club-good of price stability. Thus we propose that the Euro-12 group takes up the job. Should EU and EMU eventually overlap, this choice should obviously be reversed.

IV. Conclusions

Our proposal for a revision of EMU institutions leaves two issues open:

- Do the elements constituting our scheme need a simultaneous implementation or is it possible to proceed to a “piece-wise” implementation?
- Would the proposed reform require a formal revision of existing treaties?

As regards the first issue, the adoption of fiscal targets obviously requires the contemporaneous design of checks and balances necessary to ensure both credibility and flexibility in their implementation. For what concerns ECB reform, stripping down the NCBs of their national character, albeit highly desirable, may prove too difficult in the short term. In any case, the adoption of an explicit inflation targeting regime coupled with stronger ex-post accountability would be a first necessary step to curb national influences.

As regards the second issue, it is a delicate matter to establish how much of our proposal can be implemented within the framework provided by the existing treaties, perhaps exploiting the procedure of enhanced co-operation. This would be the case for the new arrangements concerning the adoption of fiscal targets.

[28] *Baldwin*, *Berglöf*, *Giavazzi*, and *Widgrén* (2000) suggest that Ecofin be entrusted with the power of setting the inflation target. This proposal closely resembles institutional arrangements in the UK, where the government sets the year-to-year target in the budget law. We disagree with them for two reasons. First, by including non-EMU countries Ecofin cannot be an appropriate political principal for the ECB. Second, this approach leaves room for the manipulation of the target for short–term purposes. In fact, the credibility of their proposal would ultimately rest on the political costs of unexpectedly raising the target. In our proposal, separation of powers supplements the transparency inherent to an inflation targeting regime.

To the contrary, the new clauses regulating budget deficits and the new arrangements proposed for the ECB would certainly require a formal revision of the Maastricht Treaty. In any event, our proposal is meant as a sketch rather than a detailed blueprint for institutional reforms. The investigation of this issue is left for future research.

Summary

Building on widespread criticisms of current EMU institutional arrangements, we sketch a reform proposal for EMU macroeconomic institutions. We advocate the adoption of targets for both monetary and fiscal policies, to be integrated by a system of checks and balances. As for fiscal policy, expenditures, taxation and deficit targets will strengthen the governments commitment and, at the same time, facilitate "well-behaved" stabilisation policies. Turning to monetary policy, inflation targeting, alongside with the assignment of ex-post assessing powers to the Euro12-group and an internal reform of the ECB, will limit undue nationalistic influences within the ECB governing bodies.

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Reply to the Comment Currency in Circulation, The Cash Changeover and the Euro-Dollar Exchange Rate

by Franz Seitz and Ulrich Bindseil to CESifo Working Paper 493, May 2001, Why Has the Euro Been Falling?

By *Hans-Werner Sinn* and *Frank Westermann*

The paper by Seitz and Bindseil is a comment on our CESifo Working Paper (see above) on the determinants of the euro exchange rate. We welcome the publication of this comment in the ifo Studien as a matter of principle in a truly academic debate, but we do not believe that the authors have made a relevant contribution. We answer points made by the authors (in italics) one by one.

1. *The liquidity management of the Eurosystem fully neutralises any reduction of the banknotes in circulation (with regard to interest rates) by simply reducing the funds provided to banks through open market operations.*

The liquidity management we called "passive intervention". Passive intervention is the reason why the stock of money balances shrinks after a reduction in demand. Indeed, passive intervention fully neutralises all effects on interest rates, as we explained in detail, and yet there are clear cut exchange rate effects.[1] Pointing to a behaviour of the ECB which we explicitly assumed and

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[1] Passive intervention that stabilises the interest rate cannot fully neutralise the effects on the exchange rate if the short-term debt instruments with which the Fed and the ECB carry out their interventions (collateralised loans, treasury bills etc.) are not perfect substitutes. *Seitz* and *Bindseil* mention in passing (section III) that the neutralisation of interest effects would imply a neutralisation of exchange rates effects, too, but they give no argument whatsoever why that should be true. By contrast, in our paper, it is demonstrated formally why an imperfect substitutability of the debt instruments that US and European central banks use for passive intervention precludes a neutralisation of the exchange rate. We show that the mechanism is the same as the one which implies the effectiveness of sterilised interventions in the foreign exchange market. As we do not want to counter an argument that has not been made we refer the reader to our paper.

modeled, and using a language that sounds like a counter argument, but isn't, is mere rhetoric.

2. *A change in the currency stock does not precede or "Granger cause" changes in the exchange rate.*

Of course, the decline in the stock of money balances does not precede or "Granger cause" the devaluation of the euro. According to our theory, the decline results from the described passive intervention of the ECB, i.e. from an implicit counter reaction attempting to compensate for the demand shock which caused the devaluation. Thus, if anything, a variation in the exchange rate should Granger cause the variation in the stock of money balances. Showing that the reverse causality does not prevail is, once again, a semantic exercise phrased in a way that suggests a contradiction with our findings, but it is not a counter argument.

Moreover, it is well known that applying the concept of Granger causality to a pair of financial time series and its fundamentals will produce meaningless results, as one of them is forward looking. This is a well-known textbook fallacy.[2]

3. Until mid 2001, when the euro was particularly weak, the increase in total euro area reserve requirements overcompensated the decline in the stock of currency in circulation. The portfolio effect should therefore have worked in the opposite direction, implying a revaluation of the euro.

This statement is empirically misleading and theoretically false. The reserve requirements in the euro-system grew from the beginning of 1999 (January) to the middle of 2001 (July) by 25.7 bn. euro. By contrast, the downward deviation of the currency in circulation from its trend, which had begun in 1997, was already about 36 bn. euro in July 2001. Until the end of 2002 (December), the reserve requirements had risen by 27.4 billion euros, while the stock of currency in circulation was down by 120 billion euro (about 25%) against the trend.

More importantly, an increase in reserve requirements cannot be netted out with a decline in currency in circulation because it has no exchange rate effect. Under the new ECB rules, reserve requirements are interest bearing assets. Thus an increase of these requirements does not imply a reduction in the stock of short term interest bearing assets which could have compensated for the increase of such assets in the international portfolio that resulted from the ECB's passive interventions following the negative money demand shock in eastern

[2] Suppose we test for Granger causality between share prices and dividends, we might find that the share prices Granger cause dividends due to the forward looking nature of the variable. The true causality is, of course, the other way around. Similarly, a variation in the exchange rate could be caused by a correctly expected money supply shock although it takes place before this movement. Furthermore, the causality can go both ways and the granger causality should thus be implemented as a two sided test. The relative money stocks Granger-causing the exchange rate would be consistent with our model as argued above.

Europe and that implied that these interventions could only mitigate, but not prevent a devaluation.

4. *In daily data, there is a negative correlation between the stock of European currency in circulation and the value of the euro.*

The negative correlation is an artifact. First, one wonders why the authors limit their observations to the period January 1999 to December 2001. This is strange, given that they possess the data for the full time series from 1993 onwards and given that the co-movements between the exchange value of the deutschmark and the stock of deutschmarks in circulation on which our paper focuses concerns the years before and after the Dublin Summit of 1996, i.e. the period where increasing amounts of deutschmarks were absorbed in, and repelled from, eastern Europe and other parts of the world.

Second, even for the limited time period chosen, the correlation does have the right sign if a serious mistake in the authors' calculation is corrected. The authors correlate the trend in the *level* of the European stock of money balances with the exchange rate between the dollar and the euro. This makes little sense since they forget about the US stock of money balances. Suppose *all* advanced economies have positive time trends in the levels of their currencies and the exchange rates between them have (positive or negative) time trends, too. In this case the test of Seitz and Bindseil will confirm that the currency is positively correlated with the exchange rate in 50% of the cases and negative in the other 50%, but both findings would be meaningless.

To correct for this mistake we measured the correlation of the exchange value of the euro with the *ratio* of the German and US stocks of currency in circulation. This correlation turned out positive regardless of the frequency (quarterly, weekly or daily), the type of filtering (ARIMA, HP-Filter, or no filter)[3], or the choice of time period after 1990 (including the pre-euro DM period, or not).[4] In particular, it turned out positive if the same data and the same time period were used as in the comment by Seitz and Bindseil.

[3] When looking at the *ratio*s, the correlation is 0.65 (Weekly 1-1-1999 to 12-31-2001) and 0.43 (daily 1-1-1999 to 9-12-2000), using the preferred filter of *Seitz* and *Bindseil*. This also holds for most of the subperiods (0.97, 0.37, -0.75, 0.13, 0.95 in weekly and 0.61, 0.48, -0.89, 0.43 for daily data). The only exception is a few months around the date 1-1-2000, as there was a larger year Y2K effect in the US. We thank the authors for supplying us with the daily and weekly data.

[4] The positive correlation we reported refers to 11 years of quarterly data from 1990:1 to 2000:4. Our findings have been confirmed in monthly data for a wider range of currencies and longer time periods by (*Breedon* and *Fornasari*, CESifo Forum, Fall 2001).

5. *A good exchange rate model is one that includes the risk premium in the forex markets measured by the difference between the consensus exchange rate forecast and the forward rate.*

We do not share this view either, because it confuses explanatory and dependent variables. Any meaningful theory of the exchange rate has to explain variations in the exchange rate, given the expected future spot rate, because these variations reflect fundamentals. In other words, it is necessary to explain the *change* of the exchange rate from one point in time to another or, which is equivalent when the interest rates are given, the *difference* between the future expected spot rate and the forward rate. The authors regard the difference between a consensus forecast of the expected future spot rate and the forward rate as an *explanatory* variable in their estimation equation for the exchange rate rather than the *dependant* variable that needs to be explained. They therefore effectively explain the exchange rate with the difference between an exogenous variable and itself. This must indeed yield truly wonderful and significant results, but again there is very little to be learned from such an exercise.

We find it remarkable that the multiple regression Seitz and Bindseil use for this type of "explanatory" variable does, in fact, yield the positive regression coefficient between cash and currency value that we claim and they deny (see figure 5). Unlike the correlation coefficients reported in table 3, here they indeed regress the exchange rate to the ratio of German and US currency stocks. The authors downplay this contradiction to their earlier empirical conclusions by arguing that the coefficient is not statistically significant. This is true, but trivial, given that the estimation was limited to a maximum of 30 data points and explains the exchange rate with itself.[5]

We conclude that most of the points Seitz and Bindseil make are irrelevant and that their econometric apparatus is fundamentally flawed. Their comment gave us the opportunity to document that the positive correlation between the currency in circulation and the exchange value of this currency is robust in high frequency data, although our model was aimed to explain only longer-term fluctuations.

Concerning the validity of our theory we finally wish to point to the strong increase of the euro and the stock of euro currency in circulation that happened after the physical currency conversion in February 2002. This was exactly what we had predicted.

[5] The model has seven variables and is estimated with only two and a half years of monthly data. This is an obvious case of a small sample bias. As can be seen in figure 5, the standard errors decrease as the sample size increases. The estimation starts with only seven data points on the left-hand side of the diagram and has thirty data points on the right-hand side.

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