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AND FISCAL POLICY STABILIZATION  
IN A MONETARY UNION**

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## ABSTRACT

### Mark-Up Fluctuations and Fiscal Policy Stabilization in a Monetary Union\*

We study optimal monetary and fiscal stabilization policy in a two-country monetary union in the presence of (inefficient) mark-up shocks, price rigidities and monopolistic competition. The underlying dynamic system contains two Phillips curves featuring public spending and mark-up shocks. We derive the second-order welfare loss approximation and characterize optimal monetary and fiscal policies under commitment and discretion. With symmetric rigidities, fiscal policy will not be employed in stabilizing union-level variables. Relative spending levels, however, are used to stabilize relative inflation rates and the terms of trade. Under commitment, both monetary policy and relative spending are inertial, while this is not the case under discretion. We conduct numerical analyses to assess the welfare gains from commitment and from having resource to fiscal stabilization. These gains are substantial. We conclude by investigating some simple monetary and fiscal policy rules. The former are based on the standard Taylor rule, while the fiscal rules link spending to output gaps. With mark-up shocks, the optimal fiscal rules are pro-cyclical. Finally, we find that welfare gains are obtained by making the rules inertial.

JEL Classification: E52, E61, E63 and F41

Keywords: commitment, discretion, mark-up shocks, monetary union, optimal monetary and fiscal policies and policy rules

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# 1 Introduction

It is frequently argued that a common monetary policy, such as the one for the Euro area, needs to be accompanied by fiscal stabilization policy at the national level so as to alleviate the consequences of non-synchronous business cycles. In this paper, we address this issue by analyzing monetary and fiscal stabilization policy in a micro-founded, two-country (“Home” and “Foreign”) model of a monetary union with monopolistic competition and sticky prices. The model extends our previous work, Beetsma and Jensen (2002), by introducing inefficient fluctuations in firms’ mark ups. These will be a source of inflation fluctuations that introduce trade-offs in monetary and fiscal policymaking that shed new light on the characteristics of optimal policies.<sup>1</sup> The dynamics of the model are described by log-linearized versions of the private agent’s optimal forward-looking decision rules, while our welfare criterion for policy evaluation is a quadratic approximation of the union-weighted average of the representative agents’ utility functions. Hence, our approach follows the recent methodology in monetary theory described in detail by Woodford (2003, Chapter 6).

We use the welfare criterion and the underlying dynamic macroeconomic model to analyze optimal monetary and fiscal policies under commitment and discretion. Since analyses of non-coordinated policies would fall beyond the scope of this paper, we assume that all policies are coordinated. Although this is not yet the case in the Euro area, one might expect enhanced policy coordination as European Monetary Union (EMU) moves along. Our results can, therefore, be read as a prescription of what policies might be followed, if Europe decides to move to a regime with enhanced fiscal policy coordination. Hence, our analysis is primarily normative.

For the case of symmetric cross-country nominal rigidities, we provide a full-fledged theoretical characterization of the optimal policies. In this case, we find that union-wide fiscal policy will not be employed in stabilizing union-level variables. The whole burden of stabilizing union-wide variables should fall on monetary policy. Hence, occasional calls for joint fiscal expansion in response to a world-wide recession are unwarranted in the context of this model. *Relative* government spending levels, however, are optimally used to stabilize inflation differentials as well as aggregate relative price misalignment (that is, terms-of-trade gaps).<sup>2</sup> Under commitment, both monetary policy and relative spending exhibit *inertia* implying that policymakers influence expectations about future aggregates in order to improve stabilization of current (forward-looking) variables. Such policy inertia,

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<sup>1</sup>Beetsma and Jensen (2002) introduce endogenous government spending into Benigno’s (2003) model of a monetary union. There we focus mainly on optimal policies in the face of productivity shocks and on the characterization of the circumstances under which the flexible price allocation is feasible. (In the presence of mark-up shocks, replication of the flex-price allocation will never be feasible.)

<sup>2</sup>A “gap” denotes the difference between the log-deviation of a variable from its inefficient steady state under sticky prices, and the log-deviation of a variable from the efficient steady state under flexible prices. From a stabilization point of view, closing a gap is therefore optimal *ceteris paribus*, whereas from a steady-state perspective, a positive gap may be desirable due to permanent distortions. This paper, however, focuses exclusively on optimal stabilization policy.

however, is time inconsistent and therefore absent under discretion. As far as monetary policy is concerned, this reflects earlier findings documented in, e.g., Clarida et al. (1999) and Woodford (1999a). Our analysis thus demonstrates that these results extend to fiscal policy as well.

To gauge the quantitative implications of our analysis, we perform a numerical assessment of the welfare gains from commitment of monetary as well as fiscal policy. We find that the gains from commitment — when only mark-up shocks are considered — are substantial: for the baseline configuration they correspond to a permanent change in private consumption of around 4-5%. Furthermore we find that given the ability to commit, the gains from using government spending as a stabilization instrument are substantial when the cross-country correlations of the mark-up shocks are not too high.<sup>3</sup> We should emphasize that our underlying micro-founded model exhibits Ricardian equivalence, so that variations in spending do not lead to costly movements in distortionary taxes (nevertheless, spending movements are costly because they lead to fluctuations in work effort and because they affect utility directly). Hence, our findings should be seen as a first step in the micro-founded analyses of how national fiscal stabilization policies may compensate for the loss of national monetary policy independence.

We conclude the numerical analysis by investigating some simple monetary and fiscal policy rules. The former are based on a standard Taylor rule defined over the union-wide inflation rate and output gap, while the fiscal rules link national spending gaps to national output gaps. We find that the relative performance (compared to the optimal solution) of the Taylor rule deteriorates when the correlation of the mark-up shocks increases. The reason is that the higher is the shock correlation, the more prevalent is the union-wide inflation-output gap stabilization trade-off. The Taylor rule, well suited in face of shocks creating no such trade-off in monetary policy, will then perform rather poorly.

Quite remarkably, the optimal fiscal rules are procyclical (the government spending gap is positively correlated with the output gap) rather than countercyclical. This finding reflects our exclusive focus on mark-up shocks, since productivity shocks call for countercyclical fiscal policies as we show in Beetsma and Jensen (2002). With a positive mark-up shock, both monetary and fiscal policy are contracted in order to weaken inflationary pressures. The monetary contraction reduces the consumption gap, so that both policy reactions contribute to a fall in the output gap. Hence, the optimal fiscal rule must be procyclical. The result thus highlights the general point that identification of the main sources of business cycle fluctuations is of crucial importance for proper policy conduct.

While optimal monetary policy has been extensively explored in micro-founded models with sticky prices (adhering to the methodology described by Woodford, 2003), less attention has been paid in such models to the role of fiscal policy, and its interaction with monetary policy. Closest in spirit to this paper is, as already mentioned, Beetsma

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<sup>3</sup>However, the losses from a failure to commit may outweigh the benefit from having recourse to fiscal stabilization.

and Jensen (2002) — cf. Footnote 1. Another related paper is Lombardo and Sutherland (2003), who study the benefits from monetary and/or fiscal coordination in a model that differs substantially from the current model. In particular, their setup is non-dynamic, but they consider second-order approximations of private agents’ decision schemes. Benigno and Woodford (2003) also analyze monetary and fiscal policy interactions in a micro-founded model with price stickiness. They include distortionary taxation in their model and they consider a closed economy. A separate strand of the literature uses the “Ramsey approach” to characterize monetary and fiscal policy interactions. Some articles in this line of the literature allow for some form of price stickiness. Examples are the closed-economy models developed by Schmitt-Grohé and Uribe (2001) and Correia et al. (2002). While the Ramsey approach relies to a lesser extent on approximations, it is primarily used to analyze public finance issues, rather than fiscal stabilization policy of the type we consider. Moreover, the approach generally assumes commitment, while explicit welfare comparisons of the type we provide here are uncommon in this approach.

The remainder of this paper is structured as follows. Section 2 briefly discusses the model and presents the equilibrium dynamics under sticky prices. Section 3 presents the micro-founded welfare loss approximation, while Section 4 provides a theoretical analysis of the optimal monetary and fiscal policies under commitment and discretion when nominal rigidities are equal across countries. A numerical assessment of the welfare gains from commitment and fiscal stabilization is provided in Section 5. Section 6 explores policy rules, while Section 7 concludes the paper. Technicalities and all derivations can be found in Appendices A-I, which are available upon request from the authors.

## 2 The model

As mentioned, the model extends Beetsma and Jensen (2002) by introducing inefficient fluctuations in firms’ mark ups.<sup>4</sup> To save space, we only present the dynamics of the associated log-linearized model, whose underlying details are described in Appendix A.

We consider a monetary union with two countries,  $H$ (ome) and  $F$ (oreign), which is inhabited by a continuum of agents on the interval  $[0, 1]$ . Agents on the segment  $[0, n)$  live in country  $H$ , while agents on  $[n, 1]$  live in country  $F$ . Each agent is a producer of a single imperfectly substitutable good that is perfectly tradable internationally. Hence, the price of each good is the same in both countries. All goods are aggregated into a Dixit-Stiglitz (1977) consumption index with elasticity of substitution between any pair of goods given by  $\sigma > 1$ . Preferences for private consumption are symmetric across all agents, so that purchasing power parity holds. The private consumption index enters

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<sup>4</sup>To provide a more formal rationalization for what earlier has been referred to as “cost-push” shocks (Clarida et al., 1999), others have also considered inefficient mark-up shocks within these types of models; see, e.g., Giannoni (2000) for a closed-economy analysis and Clarida et al. (2002) for a two-country model with time variation in workers’ monopoly power. In neither of these papers, endogenous fiscal policy is considered. Benigno and Benigno (2001) introduce inefficient inflation fluctuations by introducing a time-varying subsidy to firms.

additively separable into agents utility function (as do all its arguments; cf. below). In the approximated welfare measure discussed below,  $\rho > 0$  represents the coefficient of relative risk aversion associated with private consumption (and  $\rho^{-1}$  is the rate of intertemporal substitution). Following Benigno and Benigno (2001), we assume that financial markets are complete both at the domestic and at the international level. Combined with the assumption that each individual's initial holding of any type of asset is zero, we have that consumption levels are equal for all agents at all dates.

Agents also derive utility from public spending, which falls exclusively on own-country produced goods. Spending is financed by lump-sum taxes or deficits (Ricardian equivalence holds).<sup>5</sup> In the approximated welfare measure,  $\rho_g > 0$  represents agents' coefficient of relative risk aversion associated with government spending. Finally, agents experience disutility from work effort, whose efficiency is subject to a country-specific mean-zero productivity shock. The elasticity of disutility with respect to work effort is in the welfare approximation given by  $\eta > 1$  [corresponding to an implicit wage elasticity of work effort of  $1/(\eta - 1)$ ].

There is price rigidity of the Calvo (1983) type, so that in each period an individual producer in country  $i$  can adjust its price with a state-independent probability  $(1 - \alpha^i)$ . Finally, as mentioned above, by allowing for inefficient fluctuations in firms' mark ups, we introduce into our Beetsma and Jensen (2002) model a second type of supply shock.<sup>6</sup>

The log-linearized model is given by the following system (with subscript  $t$  denoting the time period):

$$\mathbf{E}_t \left( \widehat{C}_{t+1} - \widetilde{C}_{t+1} \right) = \left( \widehat{C}_t - \widetilde{C}_t \right) + \rho^{-1} \left[ \left( \widehat{R}_t - \widetilde{R}_t \right) - \mathbf{E}_t \left( \pi_{t+1}^W \right) \right], \quad (1)$$

$$\widehat{Y}_t^H = c_Y \left[ (1 - n) \widehat{T}_t + \widehat{C}_t \right] + (1 - c_Y) \widehat{G}_t^H, \quad (2)$$

$$\widehat{Y}_t^F = c_Y \left[ -n \widehat{T}_t + \widehat{C}_t \right] + (1 - c_Y) \widehat{G}_t^F, \quad (3)$$

$$\pi_t^H = \beta \mathbf{E}_t \pi_{t+1}^H + \kappa_T^H (1 - n) \left( \widehat{T}_t - \widetilde{T}_t \right) + \kappa_C^H \left( \widehat{C}_t - \widetilde{C}_t \right) + \kappa_G^H \left( \widehat{G}_t^H - \widetilde{G}_t^H \right) + u_t^H, \quad (4)$$

$$\pi_t^F = \beta \mathbf{E}_t \pi_{t+1}^F - \kappa_T^F n \left( \widehat{T}_t - \widetilde{T}_t \right) + \kappa_C^F \left( \widehat{C}_t - \widetilde{C}_t \right) + \kappa_G^F \left( \widehat{G}_t^F - \widetilde{G}_t^F \right) + u_t^F, \quad (5)$$

$$\widehat{T}_t - \widetilde{T}_t = \left( \widehat{T}_{t-1} - \widetilde{T}_{t-1} \right) + \pi_t^R - \left( \widetilde{T}_t - \widetilde{T}_{t-1} \right), \quad (6)$$

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<sup>5</sup>We assume that the governments meet their intertemporal budget constraint for all price paths; i.e., we consider only policies which are "Ricardian" in the sense of Woodford (1996).

<sup>6</sup>In Beetsma and Jensen (2002), we also consider demand shocks by letting the marginal utility of private consumption be stochastic. There, however, we show that such shocks do not affect any of the regime comparisons. This result also applies in the present context. Therefore, we choose to ignore demand shocks.

where  $0 < \beta < 1$  is the discount factor and  $\kappa_T^H$ ,  $\kappa_T^F$ ,  $\kappa_C^H$ ,  $\kappa_C^F$ ,  $\kappa_G^H$  and  $\kappa_G^F$  are positive functions of the structural parameters of the model (see the Appendix D). Variables with a hat denote a log-deviation from the zero-inflation inefficient steady state when prices are sticky and there are distortions from monopolistic competition. Variables with a tilde denote the log-deviation under flexible prices from the efficient zero-inflation steady state without distortions from monopolistic competition. Therefore, these variables are referred to as the *(stochastic) efficient rates*. The *efficient rates* only depend on the productivity shock and are thus zero in the absence of productivity shocks. For a generic variable  $X$ ,  $\widehat{X}_t - \widetilde{X}_t$  thus constitutes its gap; cf. Footnote 2. For a generic variable  $X$ , its *world* level is  $X^W \equiv nX^H + (1 - n)X^F$  and its *relative* level is  $X^R \equiv X^F - X^H$ . Further,  $C$ ,  $R$ ,  $T$ ,  $Y$ ,  $G$  and  $\pi$  denote per capita private consumption, the nominal interest rate (the monetary policy instrument), the terms of trade (defined as the price index of Foreign-produced goods,  $P^F$ , divided by that of Home-produced goods,  $P^H$ ), per capita output (GDP), per capita government spending and the inflation rate of locally-produced goods (the GDP deflator). Finally,  $E_t[\cdot]$  denotes the operator for (rational) expectations formed in period  $t$ . All variables are observable and thus the relevant period- $t$  information set includes the realizations of all variables dated  $t$  and earlier.

Equation (1) is the consumption-Euler equation expressed in terms of the consumption gap and the world real interest rate gap. Equations (2) and (3) are the log-linearized versions of the expressions for Home and Foreign aggregate demand, where  $c_Y$  is the steady state consumption share. We observe that, even though an increase in public spending has a direct stimulating effect on output, there is no “Keynesian multiplier.” Consumption is purely forward looking and thus not directly affected by current income.

Equation (4) is a Home “Phillips curve” of the “New Keynesian” variety. Home inflation at  $t$  depends positively on expected future Home inflation, because producers know that they may not be able to reset their price at period  $t + 1$ .<sup>7</sup> Hence, to protect their expected discounted real income, producers take into account the expected future Home price level when setting the current price. A positive terms-of-trade gap shifts demand towards Home goods and reduces Home agents’ marginal utility of nominal income. Both effects induce increases in Home prices. Further, a positive consumption and government spending gap lead to inflation because they raise demand and thus production relative to the stochastic efficient output level. In consequence, the associated increase in real marginal costs puts upward pressure on prices. The term  $u_t^H$  is a rescaled mean-zero mark-up shock (see Appendix D) which exerts a direct pressure on Home inflation. Equation (5) is the Foreign counterpart to (4). For convenience, we assume that the variances of  $u_t^H$  and  $u_t^F$  are equal. The final equation, (6), is the definition of the terms of trade expressed through the inflation differential. For any of the shocks, we consider only bounded fluctuations of  $\mathcal{O}(\|\xi\|)$  or higher order, where  $\xi$  is the vector of all disturbances in the economies, so as

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<sup>7</sup>Remark that national inflation is understood to be producer-price inflation.

to secure the validity of the log linearization.

Summarizing, for given paths of the policy instruments  $\widehat{R}_t$ ,  $\widehat{G}_t^H$  and  $\widehat{G}_t^F$ , and for an initial  $\widehat{T}_{t-1}$ , the system (1)-(6) provides solutions for the endogenous variables  $\widehat{C}_t$ ,  $\widehat{Y}_t^H$ ,  $\widehat{Y}_t^F$ ,  $\pi_t^H$ ,  $\pi_t^F$  and  $\widehat{T}_t$ .

### 3 The loss function

As mentioned earlier, we examine the case where both monetary and fiscal policies are coordinated. Appendix E derives a welfare criterion based on (the negative of) a second-order Taylor approximation of the utilitarian welfare function given by an equally-weighted average of all individuals' utility functions. A simplified version of this loss function for the case without inefficient mark-up shocks is used in Beetsma and Jensen (2002). Ignoring an irrelevant proportionality factor as well as terms independent of policy or of  $\mathcal{O}(\|\xi\|^3)$  or higher order, the loss function is:

$$L = \sum_{t=0}^{\infty} \beta^t \mathbf{E}_0 [L_t], \quad (7)$$

$$\begin{aligned} L_t/\Lambda &= c_Y (\rho + \eta c_Y) \left( \widehat{C}_t - \widetilde{C}_t - c^* \right)^2 + n(1-n) c_Y (1 + \eta c_Y) \left( \widehat{T}_t - \widetilde{T}_t \right)^2 \\ &\quad + n(1-c_Y) [\rho_g + \eta(1-c_Y)] \left( \widehat{G}_t^H - \widetilde{G}_t^H \right)^2 \\ &\quad + (1-n)(1-c_Y) [\rho_g + \eta(1-c_Y)] \left( \widehat{G}_t^F - \widetilde{G}_t^F \right)^2 + \frac{n\sigma}{\kappa^H} (\pi_t^H)^2 + \frac{(1-n)\sigma}{\kappa^F} (\pi_t^F)^2 \\ &\quad + 2c_Y(1-c_Y)\eta \left( \widehat{C}_t - \widetilde{C}_t - c^* \right) \left( \widehat{G}_t^W - \widetilde{G}_t^W \right) \\ &\quad - 2n(1-n)c_Y(1-c_Y)\eta \left( \widehat{T}_t - \widetilde{T}_t \right) \left( \widehat{G}_t^R - \widetilde{G}_t^R \right), \end{aligned} \quad (8)$$

where  $\kappa^i > 0$ ,  $i = H, F$ , are functions of the underlying parameters (see Appendix D). Most notably,  $\kappa^i$  is decreasing in  $\alpha^i$ , i.e., the degree of nominal rigidity in country  $i$ . Moreover,  $\Lambda \equiv \sigma^{-1} [n/\kappa^H + (1-n)/\kappa^F]^{-1}$  and  $c^* \equiv -\ln(\overline{C}/C^*) > 0$ , which is of  $\mathcal{O}(\|\xi\|)$ . Here,  $\overline{C}$  is the steady state value of consumption under sticky prices and monopolistic distortions, while  $C^*$  is its steady-state value under flexible prices and no monopolistic distortions.

The loss function thus features quadratic terms in the national inflation rates and the terms of trade gap. Inflation at the national level induces dispersion in relative prices and thus differences in the production and consumption of goods that are valued identically in individuals' utility. Hence, as seen by (8), inflation is more costly the higher the degree of nominal rigidity — lower  $\kappa^i$  — and/or the higher the substitutability of goods, i.e., the higher is  $\sigma$ . The misallocation of goods applies at the international level for a non-zero terms-of-trade gap. The higher the consumption share of GDP, the more costly is this distortion (moreover, fluctuations in the terms-of-trade gap cause variations in output such that their costs are increasing in  $\eta$ ). Furthermore, fluctuations in the difference of the consumption gap from  $c^*$  and in the public spending gaps cause welfare losses due

to individuals' aversion towards consumption and public spending risk, as well as the associated losses from fluctuations in work effort [as is evident from (8), higher values of  $\rho$ ,  $\rho_g$  and  $\eta$  indeed increase the loss from such fluctuations]. A positive consumption gap is desirable, because monopolistic distortions cause average private consumption to be inefficiently low.

Except for the quadratic terms in the public spending gaps, the terms just described also feature in Benigno's (2003) welfare criterion. However, their coefficients are different because  $c_Y < 1$ .<sup>8</sup> More importantly though, the format of the loss function also differs from that of Benigno (2003) by the presence of the cross terms in the last two lines of (8). The intuition for the first of these terms is that positive co-movements between the consumption gap and the world government spending gap cause undesirable fluctuations in world work effort, in addition to the effort fluctuations caused by fluctuations in consumption and government spending per se. The second term arises from the undesirable fluctuations in effort caused by a negative co-movement between the terms-of-trade gap and the relative government spending gap. In particular, a positive terms-of-trade gap provides the Home country with a competitive advantage, which, combined with a negative spending gap (thereby implying relatively more Home than Foreign spending), inefficiently shifts work effort from Foreign towards Home residents.<sup>9</sup>

## 4 Optimal stabilization policies

This section analyses optimal stabilization policies in the benchmark case with symmetric nominal rigidities captured by  $\alpha^H = \alpha^F$ . We start by exploring optimal monetary and fiscal policies under commitment and discretion. In this case fiscal policy is referred to as *unconstrained*. That is, the policymakers manipulate  $\widehat{G}_t^H - \widetilde{G}_t^H$  and  $\widehat{G}_t^F - \widetilde{G}_t^F$  (in conjunction with the nominal interest rate) in order to optimally stabilize the economy. We also investigate the situation where fiscal policy is *constrained*, meaning that the policymaker sets  $\widehat{G}_t^H = \widetilde{G}_t^H$  and  $\widehat{G}_t^F = \widetilde{G}_t^F$  under all circumstances. The only remaining instrument for macroeconomic stabilization will then be the nominal interest rate. There are several reasons why it is interesting to consider constrained fiscal policies. First, many economists are sceptical about the potential contribution that fiscal policy can make to macroeconomic stabilization. Hence, a comparison of the losses under constrained versus unconstrained fiscal policies may provide us with an indication of the usefulness of government spending stabilization policies. Second, it may give an indication of the potential losses that arise from imposing fiscal constraints that implicitly may hamper

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<sup>8</sup>One should thus note that, as the coefficients of the loss function depend on  $c_Y$ , so does the consumption-inflation trade-off, which is important for monetary policymaking; cf. Section 4.

<sup>9</sup>From this description of the loss function, it should be clear that although we consider a situation where governments finance spending by lump-sum taxation, fiscal stabilization policy cannot be a "free lunch." Even when spending fluctuations have no direct welfare cost (i.e., when  $\rho_g = 0$ ), they are welfare costly because they give rise to fluctuations in work effort.

fiscal stabilization.<sup>10</sup>

Here, and in the sequel, we focus exclusively on macroeconomic stabilization in response to shocks and not on the gains from solving or counteracting credibility problems of the conventional Barro and Gordon (1983) inflation bias type, which would otherwise arise as  $c^* > 0$ . With symmetric rigidities, we can write the loss function as (see Appendix F):

$$L = -(\Omega/\kappa) c^* \left( \pi_0^W - \sum_{t=0}^{\infty} \beta^t \mathbf{E}_0 u_t^W \right) + \sum_{t=0}^{\infty} \beta^t \mathbf{E}_0 [L_t^S], \quad (9)$$

plus a term which is independent of policy, where the expression for  $L_t^S$  is given by the right-hand side of (8) multiplied by  $\Lambda$  and with  $c^*$  set at zero. Hence, by (9), the optimal policy responses to shocks are found by minimizing  $\sum_{t=0}^{\infty} \beta^t \mathbf{E}_0 [L_t^S]$ , subject to the relevant constraints given by the model.

We can further rewrite:

$$L_t^S = L_t^W + n(1-n) L_t^R, \quad (10)$$

where

$$L_t^W = \lambda_C^W (\widehat{C}_t - \widetilde{C}_t)^2 + \lambda_G^W (\widehat{G}_t^W - \widetilde{G}_t^W)^2 + (\pi_t^W)^2 + 2\lambda_{CG}^W (\widehat{C}_t - \widetilde{C}_t) (\widehat{G}_t^W - \widetilde{G}_t^W), \quad (11)$$

which contains world variables only, and

$$L_t^R = \lambda_T^R (\widehat{T}_t - \widetilde{T}_t)^2 + (\pi_t^R)^2 + \lambda_G^R (\widehat{G}_t^R - \widetilde{G}_t^R)^2 - 2\lambda_{TG}^R (\widehat{T}_t - \widetilde{T}_t) (\widehat{G}_t^R - \widetilde{G}_t^R), \quad (12)$$

which contains relative variables only (including the terms of trade). Here,  $\lambda_C^W$ ,  $\lambda_G^W$ ,  $\lambda_{CG}^W$ ,  $\lambda_T^R$ ,  $\lambda_G^R$  and  $\lambda_{TG}^R$  are all positive and functions of the structural parameters (see Appendix F). This way of decomposing  $L_t^S$  will prove useful in the sequel.

## 4.1 The role of the shock correlation

Before delving into the characterization of the optimal policies, we explore the role of the correlation of the mark-up shocks when rigidities are equal. By adding, respectively subtracting, the two Phillips curves (4) and (5), under this assumption, we obtain:

$$\pi_t^W = \beta \mathbf{E}_t \pi_{t+1}^W + \kappa_C (\widehat{C}_t - \widetilde{C}_t) + \kappa_G (\widehat{G}_t^W - \widetilde{G}_t^W) + u_t^W, \quad (13)$$

$$\pi_t^R = \beta \mathbf{E}_t \pi_{t+1}^R - \kappa_T (\widehat{T}_t - \widetilde{T}_t) + \kappa_G (\widehat{G}_t^R - \widetilde{G}_t^R) + u_t^R, \quad (14)$$

where  $\kappa_C \equiv \kappa_C^H = \kappa_C^F$ ,  $\kappa_G \equiv \kappa_G^H = \kappa_G^F$  and  $\kappa_T \equiv \kappa_T^H = \kappa_T^F$ . The latter expression can also be written as:

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<sup>10</sup>An example of a fiscal rule that potentially hampers fiscal stabilization through spending policies is Europe's Stability and Growth Pact (SGP). Especially when the structural deficit is high, there is little room for fiscal stabilization, a situation that in this respect corresponds to our case of constrained fiscal policy (in the absence of productivity shocks). To allow for sufficient room for (automatic) fiscal stabilization, the SGP therefore aims at structural balance or surplus.

$$\widehat{T}_t - \widehat{T}_{t-1} = \beta \mathbb{E}_t \left( \widehat{T}_{t+1} - \widehat{T}_t \right) - \kappa_T \left( \widehat{T}_t - \widetilde{T}_t \right) + \kappa_G \left( \widehat{G}_t^R - \widetilde{G}_t^R \right) + u_t^R. \quad (15)$$

Using (13) and (15) [combined with (1)], we have

**Proposition 1** *Assume that mark-up shocks are the only source of shocks and assume equal rigidities,  $\alpha^H = \alpha^F$ . (a) When  $u_t^H$  and  $u_t^F$  are perfectly negatively correlated and country sizes are equal (so that  $u_t^W = 0$ ), monetary policy trade-offs and aggregate fiscal policy trade-offs vanish. That is, it is optimal to commit to closing the consumption gap ( $\widehat{C}_t = \widetilde{C}_t$ ) and setting  $\widehat{G}_t^W = \widetilde{G}_t^W$  at all times. (b) When  $u_t^H$  and  $u_t^F$  are perfectly positively correlated, relative fiscal policy trade-offs disappear.*

With mark-up shocks only, all natural levels of variables in the model become zero. Then, with perfectly negatively correlated mark-up shocks and equally-large countries, uncertainty at the aggregate level disappears. Therefore, all aggregate policy trade-offs disappear, while the stabilization burden on relative fiscal policy trade-offs  $\widehat{G}_t^R - \widetilde{G}_t^R$  is at its maximum, because the variance of  $u_t^R$  attains its maximum value. Hence, there is no role for monetary policy in economic stabilization.<sup>11</sup> By contrast, when the mark-up shocks are perfectly positively correlated, the stabilization burden on the aggregate policy instruments is at its largest, as the variance of  $u_t^W$  reaches its maximum. Hence, there is an important role for monetary policy in macroeconomic stabilization.

## 4.2 Optimal policies under commitment

Appendix G sets up the relevant Lagrangian (see also, e.g., Woodford, 1999a) and manipulates the first-order conditions to yield the following system of equations for  $t \geq 1$ :

$$\widehat{G}_t^W = \widetilde{G}_t^W, \quad (16)$$

$$\pi_t^W = -\frac{c_Y}{\sigma} \left[ \left( \widehat{C}_t - \widetilde{C}_t \right) - \left( \widehat{C}_{t-1} - \widetilde{C}_{t-1} \right) \right], \quad (17)$$

$$\pi_t^R \left( 1 - \frac{c_Y}{\sigma} \right) + \gamma_1 \left[ \left( \widehat{G}_t^R - \widetilde{G}_t^R \right) - \left( \widehat{G}_{t-1}^R - \widetilde{G}_{t-1}^R \right) \right] + \frac{c_Y}{\sigma} \left( \widetilde{T}_t - \widetilde{T}_{t-1} \right) = \phi_{3,t}, \quad (18)$$

$$\phi_{3,t} = -\gamma_2 \sum_{i=0}^{\infty} \beta^i \left( \widehat{G}_{t+i}^R - \widetilde{G}_{t+i}^R \right), \quad (19)$$

where  $\phi_{3,t}$  is the Lagrange multiplier associated with (6), and  $\gamma_1 > 0$  and  $\gamma_2 > 0$  are functions of the structural parameters (see Appendix G). Together with (4)-(6), the system (16)-(19) determines the optimal evolution of  $\left( \widehat{C}_t - \widetilde{C}_t \right)$ ,  $\pi_t^H$ ,  $\pi_t^F$ ,  $\widehat{G}_t^H - \widetilde{G}_t^H$ ,  $\widehat{G}_t^F - \widetilde{G}_t^F$ ,  $\widehat{T}_t - \widetilde{T}_t$  and  $\phi_{3,t}$  with commitment under the “timeless principle”; cf. Woodford, 1999b (see also McCallum and Nelson, 2000, for further discussion). That is, the Lagrange multipliers

<sup>11</sup>This provides a micro-founded analogy to the “do nothing” result for monetary policy obtained by Lane (2000) in a Mundell-Fleming type model of a monetary union, when demand shocks are perfectly negatively correlated.

are not set at zero at  $t - 1$ , which would render the solution dependent upon the particular date the commitment plan is implemented.

The above results lead us to the following proposition:

**Proposition 2** *With equal rigidities, the optimal plan under commitment involves (a) constraining world government spending to its efficient flex-price level and (b) allowing both monetary and relative fiscal policies to be inertial.*

While it is often thought that union-wide developments should be addressed by both monetary and aggregate fiscal policies, part (a) of Proposition 2 reveals that aggregate fiscal policy has no role in dealing with union-wide developments. This result arises due to the presence of the cross term between the consumption and world spending gap in the micro-founded loss function. In the absence of this term, the optimal setting of the instruments would induce a positive co-movement between the consumption and world spending gap. However, the benefits of sharing the stabilization burden between monetary policy and aggregate public spending are offset by the losses caused by the induced undesirable fluctuations in world work effort due to the positive co-movement of the consumption and world spending gaps. As a result, the authority sets aggregate spending at its efficient level, thereby eliminating these losses, but also eliminating the role of fiscal policy in providing macroeconomic stabilization at the union level. While these losses could also have been eliminated by setting consumption at its efficient level, it is optimal instead to have public spending attain its efficient level, because in this way the authority avoids the suboptimally low production of public goods associated with the monopolistic competition. Hence, only monetary policy is used to deal with union-wide developments. We observe that this result holds irrespective of the correlation of the mark-up shocks.

The role of credibility is important both in monetary policy and in relative fiscal policies. By committing to an inertial monetary stabilization policy, the central bank influences future expectations in such a way that the inflation-consumption trade-off becomes more favorable [note that the lagged consumption gap features in (17), and that the equation indeed has the format of a targeting rule under commitment as seen in closed-economy models; see, e.g., Clarida et al., 1999]. In effect, the world inflation rate is stabilized better when world mark-up shocks hit. A, say, positive realization is met by a (commitment to a) prolonged contraction, which dampens expectations of future inflation and, therefore, also current inflation. Note how the use of a micro-founded loss function clarifies what determines the inflation-consumption trade-off relevant for monetary policy conduct. From (17) one observes that the trade-off only depends on  $c_Y$  and  $\sigma$ . An increase in the former raises the relative importance of stable consumption, while a rise in the latter increases the importance of stable inflation. The reason is that the more substitutable are goods, the larger is the output dispersion across producers for given inflation.<sup>12</sup> A higher

<sup>12</sup>In a monetary union model with monetary policy only, Lombardo (2003) associates a high value of

degree of nominal rigidity, as measured by a higher  $\alpha$ , plays *no* role. It reduces  $\kappa_C$ , and thus the marginal cost of changing the consumption gap in terms of inflation; at the same time, however, it increases the welfare loss coefficient of inflation relative to consumption by the same amount.

Note the analogy of optimal fiscal policy inertia to the inertia in monetary policy. A, say, positive realization of relative inflation is met by a prolonged relative fiscal contraction [note that the lagged relative spending gap features in (18)]. The commitment of authorities to further contract dampens expectations of future relative inflation, thereby stabilizing current relative inflation and the current terms-of-trade gap – see (14) or, alternatively, (15). Observe also that, with identical rigidities, only relative public spending affects relative inflation or the terms of trade.

### 4.3 Optimal policies under discretion

By virtue of the fact that (10) is separated into a “world part”  $L_t^W$  and a “relative part”  $L_t^R$ , plus the fact that the two Phillips curves have been recombined accordingly as (13) and (14), we can split the problem into a “world problem” and a “relative problem”. The former reduces to a sequence of static optimization problems where  $L_t^W$  is minimized over the consumption gap and the world government spending gap, subject to (13) and taking  $E_t \pi_{t+1}^W$  as given, as neither of the two variables in period  $t$  has any dynamic implications. The necessary and sufficient first-order conditions imply for world government spending (see Appendix H) that

$$\widehat{G}_t^W - \widetilde{G}_t^W = 0,$$

leaving it to monetary policy to strike the balance between inflation and consumption volatility according to

$$\pi_t^W = -\frac{c_Y}{\sigma} (\widehat{C}_t - \widetilde{C}_t), \quad (20)$$

which resembles the standard non-inertial targeting rule under discretion for a closed economy; see, e.g., Clarida et al. (1999). World government spending is thus the same under discretion and commitment, whereas monetary policy conduct differs, due to credibility problems to the extent that there are shocks to  $\pi_t^W$ . This is the case as long as  $u_t^H$  and  $u_t^F$  are not perfectly negatively correlated.

The “relative problem” involves the choice of  $(\widehat{G}_t^R - \widetilde{G}_t^R)$  and requires dynamic programming with  $\widehat{T}_{t-1} - \widetilde{T}_{t-1}$  as the state variable. We use dynamic programming because  $(\widehat{G}_t^R - \widetilde{G}_t^R)$  affects  $\pi_t^R$ , and thus  $(\widehat{T}_t - \widetilde{T}_t)$ , with direct loss implications through the next period’s terms of trade [by the dynamics of (6)]. To solve the model (see Appendix H), one conjectures that  $\pi_t^R$  is a linear function of the state variable  $(\widehat{T}_{t-1} - \widetilde{T}_{t-1})$  with coefficient  $-b_1$  and of all the shocks. Combining the conjecture with (14) and (6), one obtains expressions for  $\pi_t^R$  and  $\widehat{T}_t - \widetilde{T}_t$  that are the constraints on the optimization problem. The

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$\sigma$  with a high degree of competition, and argues that the common policy should put relatively larger emphasis on inflation stability in the more competitive country.

first-order conditions of the problem can be combined to yield:

$$\begin{aligned}
& -c_Y (1 + b_1\beta) \left( \widehat{T}_t - \widetilde{T}_t \right) + (\mu [1 + b_1\beta + \kappa_T] - c_Y \kappa_G) \left( \widehat{G}_t^R - \widetilde{G}_t^R \right) + \sigma \pi_t^R \\
& + \beta \left[ c_Y \mathbb{E}_t \left( \widehat{T}_{t+1} - \widetilde{T}_{t+1} \right) - \mu \mathbb{E}_t \left( \widehat{G}_{t+1}^R - \widetilde{G}_{t+1}^R \right) - \sigma \mathbb{E}_t \pi_{t+1}^R \right] = 0,
\end{aligned} \tag{21}$$

where  $\mu > 0$  is a function of the structural parameters. Although (21) is a rather involved expression, the crucial difference with the corresponding relationship (18) under commitment is that  $\left( \widehat{G}_{t-1}^R - \widetilde{G}_{t-1}^R \right)$  is *absent* from (21). In other words, the history dependence that characterizes the optimal relative government spending policies under commitment is absent under discretionary policymaking.

We summarize the results for optimal policies under discretion in the following proposition:

**Proposition 3** *Consider discretionary optimal policymaking. With equal rigidities, the optimal monetary and relative fiscal policies are non-inertial. Further, the optimal aggregate fiscal policy is not used for stabilization as it equals its flex-price efficient level.*

#### 4.4 Constrained fiscal policies

Below we will assess the welfare gains from fiscal stabilization policy. Having theoretically analyzed the case of unconstrained fiscal policies, it is useful to consider also the situation in which fiscal policies are constrained. The optimal monetary policy under commitment in this case again implies (17) and is thus inertial. Appendix I derives the explicit solution when all shocks are  $AR(1)$ -processes. The solution consists of an independent system at the world level in  $\widehat{C}_t - \widetilde{C}_t$  and  $\pi_t^W$ , which are both a function of the one-period lagged consumption gap and the markup shocks, and an independent system in the relative variables  $\widehat{T}_t$  and  $\pi_t^R$ , which are both a function of  $\widehat{T}_{t-1}$  and all the shocks.

As in the case with unconstrained fiscal policy, the optimal discretionary monetary policy implies (20). The outcomes for world consumption and world inflation can now be written as linear functions of the current shocks  $u_t^H$  and  $u_t^F$  only, while the solutions for the terms of trade and relative inflation are the same as under commitment. This follows from the fact that with equal rigidities, monetary policy cannot affect the terms of trade; cf. Benigno (2003). In contrast to the commitment solution,  $\pi_t^W$  and  $\left( \widehat{C}_t - \widetilde{C}_t \right)$  thus no longer depend on the lagged consumption gap, which reflects the absence of inertia in optimal monetary policy under discretion.

## 5 Numerical results

Our choice of the benchmark parameter combination is largely based on Benigno (2003). Each period corresponds to a quarter of a year. Benigno calibrates his model to the EMU situation and divides the area into two groups. Both groups have a weight of approximately 50% in Euro-area GDP, so that in all our numerical computations we will set  $n = 0.5$ .

We set  $\beta = 0.99$ , which implies a steady-state real rate of return of 1% on a quarterly basis. Further, we set  $\sigma = 7.66$ , implying a steady-state mark up of prices over marginal costs of 15%. The benchmark values for  $\alpha^H$  and  $\alpha^F$  are selected so as to produce an average duration of a price contract of 1 year, so that  $\alpha^H = \alpha^F = 0.75$ . We assume a coefficient of relative risk aversion for both private consumption and public spending of 2.5, in line with empirical findings (for example, see Beetsma and Schotman, 2001, and the references therein). Further, we set  $\eta = 10$  implying an elasticity of labor supply of around 0.1. Finally, based on 0.6 and 0.2 being reasonable approximations for the private and government consumption shares of output in reality, we assume that  $c_Y = 0.75$ , so that private consumption is three times as large as government spending in the steady state.

The final step involves the choices about the shocks. While Beetsma and Jensen (2002) extensively analyze the welfare gains from commitment and fiscal stabilization under productivity shocks, in the ensuing numerical analysis we focus on mark-up shocks. Therefore, our numerical analysis sets the productivity shocks to zero. We follow McCallum and Nelson (2000) in setting the standard deviation of the mark-up shocks at 0.5%, leading to realistic standard deviations of inflation at the yearly level. Finally, we assume that the mark-up shocks are white noise.

In the ensuing numerical runs, we focus exclusively on differences in stabilization performance, and we therefore set  $c^* = 0$  throughout.

## 5.1 Equal rigidities

We now want to quantify both the gains from policy commitment and the gains from having recourse to unconstrained fiscal stabilization policies. To ease comparisons, we express losses relative to those for commitment with unconstrained fiscal stabilization in terms of a loss-equivalent permanent percentage consumption shortfall  $c^p$  from the efficient flex-price consumption level. Concretely,  $c^p$  is computed from the following expression:

$$\frac{c_Y (\rho + \eta c_Y)}{1 - \beta} \left( \frac{c^p}{100} \right)^2 = L^i - L^{cu},$$

where  $L^{cu}$  is the loss under commitment with unconstrained fiscal policy and  $L^i$  is the loss under some alternative.

Table 1 provides, for different assumptions about the cross-country correlations of the mark-up shocks, the welfare losses under the four possible optimal policy arrangements: (1) commitment and unconstrained fiscal policy, (2) discretion and unconstrained fiscal policy, (3) commitment and constrained fiscal policy and (4) discretion and constrained fiscal policy. The outcomes are computed for our benchmark parameter combination. Comparing commitment and discretion with unconstrained fiscal policy, we see that there are substantial gains from commitment, ranging to a maximum of almost 6.5% permanent consumption change. The gains are increasing in the correlation of the national mark-up shocks. This is not surprising as the variance of the world mark-up shock increases

with this correlation. While commitment problems in relative fiscal policy are absent when the mark up shocks are perfectly positively correlated ( $u_t^R = 0$ , so that it is always optimal to set  $\widehat{G}_t^R = \widetilde{G}_t^R$ ), commitment problems in monetary policy are at their maximum (commitment problems in aggregate fiscal policy are always absent when rigidities are equal — recall that it is then optimal to set  $\widehat{G}_t^W = \widetilde{G}_t^W$ ).

Next, comparing the gains from not constraining fiscal policy under commitment, we see that these gains fall when the correlation of the mark-up shocks rises. In the limit, when the correlation is perfect, the gains from fiscal stabilization are zero. This is not surprising as the authority optimally sets  $\widehat{G}_t^W = \widetilde{G}_t^W$ , while  $u_t^R = 0$  with perfectly correlated shocks. Therefore, in the absence of productivity shocks, the authority sets  $\widehat{G}_t^R = \widetilde{G}_t^R$ , as (14) makes clear. When the shock correlation is low, say zero, the gains from fiscal stabilization are substantial (amounting to approximately a 3% consumption change). The result that a fall in the correlation of the mark-up shocks raises the gain from fiscal stabilization contrasts with the finding by Beetsma and Jensen (2002) that a reduction in the correlation of the productivity shocks fails to make fiscal stabilization relatively more desirable. The explanation for this contrast is that it is *only* the *relative* productivity shock (and not both countries' productivity shocks separately) that affects the system (1)-(6). This relative productivity shock (which enters the system via the natural terms of trade) effectively acts as a *common* shock to both countries. Hence, the reduction in macroeconomic variability provided by national fiscal stabilization policies remains proportional when the shock correlation changes. This is in sharp contrast with the case of mark-up shocks, which enter the Home and Foreign Phillips curves separately.

Finally, it is worthwhile to notice from Table 1 that under discretion the losses are *lower* when fiscal policy is constrained, than when fiscal policy is unconstrained. This reveals the trade-off between two distortions. By constraining fiscal stabilization policy, one also eliminates the distortion associated with discretion in (relative) fiscal policy. Indeed, one observes that the difference in  $c^p$  for the two cases becomes smaller when the shock correlation increases. In the limit, when the shock correlation is perfect, the difference vanishes completely: relative fiscal policy would not be used for stabilization in any case and, thereby, losses from not being able to commit relative fiscal policies would also disappear.

## 5.2 Different rigidities

With productivity shocks only, Beetsma and Jensen (2002) showed that if price rigidities disappear in one of the countries, then all gaps can be closed and national inflation rates can be held at zero, so that the welfare loss falls to zero. This is no longer the case under mark-up shocks. If  $\alpha^F \rightarrow 0$ , the coefficients  $\kappa_T^F$ ,  $\kappa_C^F$  and  $\kappa_G^F$  become infinitely large and (5) is rewritten as  $\widehat{T}_t - \widetilde{T}_t = \nu_1 (\widehat{C}_t - \widetilde{C}_t) + \nu_2 (\widehat{G}_t^F - \widetilde{G}_t^F)$ , where  $\nu_1$  and  $\nu_2$  are functions

of the structural parameters. Substituting this into (4) yields:

$$\begin{aligned}\pi_t^H &= \beta \mathbf{E}_t \pi_{t+1}^H + [\kappa_C^H + \nu_1 \kappa_T^H (1-n)] (\widehat{C}_t - \widetilde{C}_t) \\ &\quad + \kappa_G^H (\widehat{G}_t^H - \widetilde{G}_t^H) + \nu_2 \kappa_T^H (1-n) (\widehat{G}_t^F - \widetilde{G}_t^F) + u_t^H.\end{aligned}$$

Clearly, in the absence of mark-up shocks, all gaps can be closed, thereby also forcing national inflation rates to be zero, so that  $L_t^S = 0$ . This is no longer the case, however, in the presence of mark-up shocks.

Table 2 reports welfare losses for varying degrees of rigidity in Foreign, while maintaining  $\alpha^H = 0.75$  and holding the other parameters at their benchmark values. Throughout, the correlation of the mark-up shocks is zero. The numerical results indeed show that if  $\alpha^F$  becomes very small, the welfare loss does not fall to zero (observe that numerical results cannot be obtained in the limit when  $\alpha^F = 0$ , because the coefficients in the Foreign Phillips curve become infinitely large). We see that the gains from commitment and from unconstrained fiscal policy remain large, irrespective of the asymmetry in rigidity.

## 6 Simple policy rules

In this section, we consider simple monetary and fiscal policy rules as an alternative to the optimal policies studied above. Both monetary policy and (relative) fiscal policy may benefit from being conducted by a rule, because both policies are plagued by potential credibility problems. To stay in line with the literature, we consider following monetary and fiscal policy rules:

$$\widehat{R}_t - \widetilde{R}_t = b_R (\widehat{R}_{t-1} - \widetilde{R}_{t-1}) + b_\pi \pi_t^W + b_Y (\widehat{Y}_t^W - \widetilde{Y}_t^W), \quad (22)$$

$$\widehat{G}_t^H - \widetilde{G}_t^H = g_{GH} (\widehat{G}_{t-1}^H - \widetilde{G}_{t-1}^H) - g_{YH} (\widehat{Y}_t^H - \widetilde{Y}_t^H), \quad (23)$$

$$\widehat{G}_t^F - \widetilde{G}_t^F = g_{GF} (\widehat{G}_{t-1}^F - \widetilde{G}_{t-1}^F) - g_{YF} (\widehat{Y}_t^F - \widetilde{Y}_t^F). \quad (24)$$

The case of  $(b_R, b_\pi, b_Y) = (0, 1.5, 0.5)$  corresponds to a standard Taylor rule for monetary policy. If  $g_{YH} > 0$  and  $g_{YF} > 0$ , then fiscal policies are countercyclical, because a higher output gap leads to a contraction of fiscal policy.<sup>13</sup> The preceding results suggest that there may be gains from persistence in both monetary and fiscal policies. For this reason, the rules (22)-(24) also allow for the possibility that the policy instruments depend on their own lag.

Table 3 reports, for the benchmark parameter combination, the losses when fiscal policy is constrained ( $g_{GH} = g_{GF} = g_{YH} = g_{YF} = 0$ ). With perfectly negatively correlated mark-up shocks, world variables are completely stable and monetary policy does not need to respond to any shocks. Indeed the loss in this case coincides with the loss under optimal monetary policy combined with constrained fiscal policy, as reported in Table 1. As the

<sup>13</sup>We refer to fiscal policy as procyclical when the public spending *gap* is positively correlated with the output *gap*.

correlation of the shocks increases, the performance of the Taylor rule relative to the optimal monetary cum constrained fiscal policy deteriorates (compare Tables 1 and 3). The variance of the world level shock increases and the optimal monetary policy becomes relatively better equipped to handle this shock. The final column in Table 3 shows that making the current interest rate dependent on last period's interest rate reduces losses substantially. Observe that the optimal coefficient is larger than one, thus making the amended Taylor rule “super-inertial,” as is also found to be optimal in a closed-economy, monetary policy context by Rotemberg and Woodford (1997).

Table 4 combines a Taylor rule for monetary policy with fiscal policy rules of the type (23)-(24). Quite remarkably, the optimal fiscal rules are *procyclical*, rather than counter-cyclical as is often thought to be optimal. The explanation of this rather counterintuitive finding lies in the source of the shock. A, say, positive mark-up shock gives rise to inflationary pressures that, because of the convexity of the loss function, should be mitigated by contracting both monetary and fiscal policy [(4) and (5) show that the public spending gap affects inflation directly]. Hence, both policy reactions contribute to a fall in the output gap, thus calling for procyclical fiscal rules.<sup>14</sup>

The procyclicality of the optimal fiscal rules is in contrast to what common wisdom prescribes and also to what Beetsma and Jensen (2002) find in the case of productivity shocks instead of mark-up shocks. With productivity shocks, it is optimal to employ countercyclical fiscal rules. In contrast to mark-up shocks, productivity shocks do not affect inflation directly, but only via the gaps of the variables that enter (4) and (5). Using (2) and (3) and their flex-price counterparts, one can express the Phillips curves as functions of the terms-of-trade gap and the national output and spending gaps. A countercyclical fiscal rule stabilizes the output gap, thereby stabilizing fluctuations in real marginal cost that produce movements in inflation. These findings point to the more general conclusion that proper policy conduct requires identification of the main sources of business cycle fluctuations.

Table 4 shows that welfare losses can be reduced by employing a rule in which the current public spending gap also depends on the gap in the previous period. The reductions in the losses are rather modest, though.

## 7 Conclusion

This paper has explored the interactions between monetary and fiscal policies in a fully micro-founded model of a monetary union. Here we have mainly focused on macroeconomic stabilization in the presence of inefficient mark-up shocks. Our analysis was based

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<sup>14</sup>The numerical results for the corresponding optimal policies discussed above indeed show a high positive correlation between the national output and spending gaps, except when  $\rho_u = 1$ . In that case, the optimal spending gaps are zero (cf. Proposition 1). However, because the Taylor rule does not reproduce the optimal monetary policy, also in this case it is optimal to employ a procyclical fiscal rule, as Table 4 shows.

on a second-order welfare loss approximation that features quadratic deviations of consumption, the two spending levels and the terms of trade from their efficient flex-price levels. The loss function also features quadratic terms in the national inflation rates and cross terms in world government spending and consumption spending and in relative government spending and the terms of trade.

A number of basic results have been derived that may be helpful in understanding monetary-fiscal interactions. When rigidities between countries are equal, we find that aggregate fiscal policy is not used for stabilization and that the whole burden of aggregate stabilization falls on monetary policy. By contrast, the whole burden of stabilizing relative variables falls on relative spending gaps. Under commitment, both monetary and relative fiscal policy are inertial, while neither of the two is inertial under discretion. In our numerical analyses we found that the gains from commitment and fiscal stabilization (under commitment) can be substantial when expressed in terms of permanent consumption gains.

We have also explored simple monetary and fiscal policy rules. The relative performance (compared to the optimal solution) of a standard Taylor rule deteriorates when the correlation of the mark-up shocks increases. With mark-up shocks, the optimal fiscal rules are procyclical, rather than countercyclical, as in the case of productivity shocks. Further, and in line with the results for optimal policies under commitment, welfare gains can be reaped by including lagged values of the instruments in both the monetary and fiscal rules.

As micro-founded analyses of monetary-fiscal policy interactions in multi-country models are still in their infancy, a wide-ranging set of extensions could be worthwhile to pursue. Here, we mention only two of them. One is to relax the assumption that policies are coordinated and, thus, to allow for explicit strategic interactions between national fiscal policies. This would in principle enable one to make a thorough micro-founded analysis of the welfare gains from fiscal policy coordination in a monetary union. This is of particular relevance for the Euro area, where the issue of fiscal coordination remains high on the policymakers' agenda. Another extension would abolish the assumption of internationally complete markets. When centralized to a sufficient extent, fiscal policies could then be employed to provide for the sharing of country-specific risks. Hence, one would expect the gains from fiscal stabilization to increase when international asset markets are incomplete.

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# Tables

Table 1: Numerical comparison of optimal policies.

	CU	DU		CC		DC	
$\rho_u$	loss	loss	$c^p$	loss	$c^p$	loss	$c^p$
-1	19.97	22.01	4.34	21.80	4.11	21.80	4.11
-0.5	19.47	22.12	4.95	20.84	3.56	21.97	4.80
0	18.97	22.23	5.49	19.88	2.90	22.13	5.40
0.5	18.47	22.35	5.99	18.92	2.04	22.30	5.95
1	17.97	22.46	6.44	17.97	0	22.46	6.44

Legend:  $\rho_u$  is the correlation coefficient of  $u_t^H$  and  $u_t^F$ ; loss = computed loss multiplied by 10,000; CU = commitment, unconstrained fiscal policy; DU = discretion, unconstrained fiscal policy; CC = commitment, constrained fiscal policy; DC = discretion, constrained fiscal policy.

Table 2: Asymmetric rigidities ( $\rho_u = 0$ ,  $\alpha^H = 0.75$ ).

	CU	DU		CC		DC	
$\alpha^F$	loss	loss	$c^p$	loss	$c^p$	loss	$c^p$
0.001	18.31	22.65	4.47	18.33	0.30	22.65	4.47
0.25	18.62	21.95	3.99	19.72	2.30	21.98	4.01
0.50	18.14	21.42	4.21	19.30	2.50	21.44	4.22
0.75	18.97	22.23	5.49	19.88	2.90	22.13	5.40

Legend: see Table 1.

Table 3: Standard and modified Taylor rule for monetary policy ( $b_\pi = 1.5$ ,  $b_Y = 0.5$ ).

$\rho_u$	$b_R$	loss	$c^p$	$b_R^{opt}$	loss	$c^p$
-1	0	21.80	4.11	NE	21.80	4.11
-0.5	0	22.53	5.32	2.7	21.34	4.16
0	0	23.26	6.29	2.7	20.89	4.21
0.5	0	23.99	7.14	2.7	20.43	4.25
1	0	24.72	7.89	2.7	19.98	4.31

Note: Fiscal policy is constrained (all coefficients in (23) and (24) are set to zero);  $b_R^{opt}$  = optimal value of  $b_R$ ; NE = non-existent (all values of  $b_R$  give the same outcome).

Table 4: Fiscal policy rules.

	$g_G = 0$			$g_G=0.1$			$g_G=0.5$		
$\rho_u$	$g_Y^{opt}$	loss	$c^p$	$g_Y^{opt}$	loss	$c^p$	$g_Y^{opt}$	loss	$c^p$
-1	-0.7	21.55	3.82	-3.0	20.08	1.01	-1.2	20.94	2.99
-0.5	-0.7	22.33	5.14	-3.0	21.14	3.93	-1.2	21.86	4.70
0	-0.7	23.12	6.19	-3.0	22.21	5.47	-1.2	22.77	5.92
0.5	-0.7	23.90	7.08	-3.1	23.26	6.65	-1.2	23.68	6.94
1	-0.7	24.69	7.88	-3.2	24.26	7.62	-1.2	24.59	7.82

Note: Fiscal policy is conducted according to (23) and (24), where we assume that  $g_{GH} = g_{GF} \equiv g_G$  and  $g_{YH} = g_{YF} \equiv g_Y$ ; monetary policy is set according the standard Taylor rule ( $b_R = 0$ ,  $b_\pi = 1.5$ ,  $b_Y = 0.5$ );  $g_Y^{opt}$  = optimal value of  $g_Y$ .