Monetary and Fiscal Policies Interactions in a Monetary Union with Country-size Asymmetry

by

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Abstract

Country-size asymmetry may crucially shape the monetary and fiscal policy interactions in a monetary union. Small and large countries cause different cross-border effects and may have different bargaining power in a stabilization policy game. Strategic interactions arising from different policy objectives and non-cooperative policies might play a significant role in the actual policymaking of a country-size asymmetric monetary union.

We analyze cooperative and non-cooperative optimizing stabilization policies in a micro-founded New-Keynesian two-country monetary union model, under two policy scenarios. One, where monetary and fiscal policy instruments exert their stabilization roles exclusively through the demand channel without any consequence on debt sustainability; other, where fiscal policy has both demand and supply-side effects but where lump-sum taxes are not enough to ensure fiscal policy solvency. We derive optimal strategic policy mix within an asymmetric country-size monetary union, and assess the effects of some institutional arrangements (cooperation, fiscal constraints, weight-conservative central bank) and of the level of public debt on the effectiveness of policy stabilization.

We found that country-size asymmetry within a monetary union qualifies meaningfully monetary and fiscal policy strategic interactions. A small country, suffering larger externality effects and benefiting less from a common monetary policy for stabilization purposes, has to optimally rely on a more active fiscal policy and, as expected, it experiences more welfare costs than a larger country. Furthermore, welfare evaluation of the alternative policy games shows that a large country achieves a better stabilization performance under fiscal leadership and that it may resist to a policy cooperation arrangement.We also found out that large and small debt levels condition the stabilization assignments of the different policy instruments. Moreover, in a large-debt monetary union, and focusing exclusively on stabilization costs, the large country may face incentives to raise public debt while the small country may prefer to be more disciplined. In a small-debt monetary union, reverse incentives can occur: a small country may face incentives to raise debt permanently.

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INTRODUCTION

Fiscal and monetary policy interactions are crucial in the current agenda of economic policy, both academically and institutionally, because of their relevance within the European Monetary Union (EMU) framework. In fact, there is a trade-off between the use of national fiscal policies to undertake the stabilization of idiosyncratic shocks and the credibility of the common monetary policy targeted at price stabilization. In this context, the implementation and the recent reform of the Stability and Growth Pact (SGP) as well as the need for closer policy cooperation are, thus, different tentative approaches to improve such trade-off in terms of welfare.[1] The debate on the need for closer policy cooperation is an active one, addressing both fiscal policy cooperation among the member states of the EMU (horizontal cooperation) and fiscal and monetary policy cooperation (vertical cooperation). Not only are the nature and the size of the cross-border repercussions of national fiscal policies and the spillovers between fiscal and monetary policies determinant in this dispute; the policy objectives of the monetary and fiscal authorities are determinant as well. These spillover effects have different expressions in small and large countries. Moreover, small and large countries in the EMU have asymmetrical bargaining power, as apparently embedded in the recent reform of the SGP.[2] Hence, small and large countries may experience different stabilization policy trade-offs and, in that case, they are expected to have different interests concerning institutional policy reforms.

Thus, the functioning of the EMU with country-size asymmetry motivates some challenging research issues on macroeconomic theory.

First, the analytical framework must be able to provide some insights on the distinction between macroeconomic policy conducting in a country-size homogeneous monetary union and, on the other hand, in an heterogeneous one.

[1] The Treaty establishing the European Union already provides a scope for fiscal policy coordination through a number of mechanisms such as the SGP itself or the Excessive Deficit Procedure, the Mutual Surveillance Procedure and the Broad Economic Policy Guidelines.

[2] According to Eichengreen (2005), the small and large countries had different points of view on the reform of the SGP. Reflecting the asymmetrical bargaining power of the two groups of countries, the agreement reached in March 2005 was closer to the point of view of the large countries.

Second, a related theoretical issue is the need to conveniently model the practice of stabilization policy conducting. One way to approximate positive policymaking through theoretical exercises is by deriving optimal policy games under divergent policy objectives of the different policymakers.[3] The key questions then are to assess what is the actual policy-mix, how far it is from the optimal solution and which country – small or large – loses more and would be more prone to enhance changes in the policy arrangements.

An expected gap between optimal and actual macroeconomic policies raises the issues of the desirability of closing policy cooperation and of the gains from imposing fiscal policy constraints. Thus, it is relevant to assess the relative incentives of the small and of the large countries to follow such policy arrangements.

Finally, all these questions may have different answers depending on the fiscal policy instruments available for stabilization purposes and on whether non-distortionary sources of government financing exist. When taxes do not fully adjust in order to guarantee fiscal policy solvency, there are additional sources of strategic interactions between fiscal and monetary authorities and the relative level of government indebtedness may impinge on the design of the optimal stabilization policies. Thus, the analysis of the monetary and fiscal policy interactions should encompass both fiscal policy regimes – balanced budget vs. debt financing policies.

A significant strand of academic literature on the interactions of fiscal and monetary policies within a monetary union has used static game-theoretic models.[4] Their main focus has been on the potential strategic nature of the interactions between the discretionary fiscal policies of multiple governments and the stabilization efforts of a common central bank. For instance, Beetsma and Bovenberg (1998) illustrate the argument that the exis-

[3] There are doubts in the literature on how to describe policymaking, especially, on what concerns fiscal policy and its interactions with monetary policy. For instance, Canzoneri et al (2003), arguing that the frequency of fiscal decision-making - determined by the political and budgetary processes - is hardly coincident with the business cycle frequency, propose thinking fiscal policy as one of the many sources of shocks to which the monetary authorities have to respond. Alternatively, other authors, like Colciago et al (2007), think fiscal policy by focusing on the functioning and design of the automatic stabilizers. Calmfors (2003) argue that automatic stabilizers could be destabilizing in the case of permanent supply shocks and that, in spite of the political-economy problems of fiscal policy, it may be a need for an active fiscal policy stabilization role. Empirical literature does not dismiss the existence of such a discretionary fiscal policy in the context of the EMU (see, Gali and Perotti, 2003).

[4] Beetsma and Debrun (2004) provide a thoroughly review of this literature.

tence of multiple fiscal authorities weakens the strategic position of each one of them vis-à-vis the common monetary authority (power effect) and conclude that strict fiscal policy cooperation (horizontal cooperation) is counterproductive. Catenaro and Tirelli (2000) relativize this conclusion by adding to the model cross-border repercussions of national fiscal policy (externalities effect), potentially conducing to free-riding problems, when each national fiscal authority fails to internalize the adverse consequences of its own policy on the other fiscal authorities. The relative strength of the two effects – power effect vs. externalities effect - determines whether fiscal policy cooperation is desirable. Uhlig (2003) provides another interesting illustration of the free-riding problem in the interplay between national fiscal authorities and the common central bank in a monetary union, to conclude for the need of strengthening the SGP. Dixit (2001) and Dixit and Lambertini (2001, 2003a) discuss the value of monetary commitment when fiscal policy is discretionary, the role played by the different timing structures of the policy game, and the importance of homogeneous policymakers' objectives for the macroeconomic outcomes in a monetary union.

The analysis of the strategic policy interactions using a static framework allows policy games to be solved analytically.[5] However, it has the important drawback of not conveniently incorporating expectations, which are now consensually seen to have important implications for current economic behaviour and policy design. This has encouraged the development of tractable dynamic general stochastic equilibrium models suitable for the analysis of fiscal and monetary policy in a monetary union. These models incorporate imperfect competition and nominal rigidities - in line with the ones recently developed and used for monetary policy analysis – and they usually represent a monetary union either as a continuum of small open economies or as a set of two large economies. Gali and Monacelli (2006) have been the first to develop an analytical framework describing a monetary union where countries are sufficiently small, having negligible effect on the others; instead, Beetsma and Jensen (2004, 2005) exemplify the two-country representation of a monetary union with endogenous fiscal policy. The latter has the advantage of

[5]Some authors like Beetsma and Bovenberg (1999), Beetsma and Uhlig (1999) or Chari and Kehoe (2004) introduce dynamics in a tractable way, through a two-period model where public debt is set strategically.

nesting the case of a monetary union with country-size asymmetry, where small countries co-inhabit with large countries that impose large externalities. An extensive branch of this literature has focused on the derivation of optimal fiscal and monetary policies from the perspective of the monetary union as a whole.[6] Few works have considered policymaking in non-cooperative policy regimes and even fewer have considered strategic policy interactions arising from the structure of the game played by the policymakers. In the context of a monetary union and using a dynamic framework, van Aarle et al (2002) and Beetsma and Jensen (2005), for instance, analyze the non-cooperative monetary and fiscal policies when policymakers set their instruments simultaneously in a Nash game, while Kirsanova et al (2005) examine the case of monetary leadership game. Non-cooperative policy games, where monetary and fiscal authorities - with different policy objectives - can set strategically their policies in order to influence the other policymaker's policy response, may provide a more realistic picture of how monetary and fiscal policy interact. This can be easily understood if we take the example of a large country in a monetary union that may benefit from setting its fiscal policy strategically in order to influence the common central bank to adopt a monetary policy biased towards the interests of the fiscal authority.

So far, little attention has been paid to the stabilization role of fiscal policy in dynamic general equilibrium multi-country models – the so-called new open economy macroeconomics (NEOM) models – not only because of the doubts on the usefulness of fiscal policy as a stabilization tool, but also because, in the words of Coutinho (2005, p. 809), "very little is still known about the stylized facts of the transmission of fiscal policy which would enable to choose alternative specifications."[7] Fiscal policy has begun to be revisited and incorporated in these models through balanced budget fiscal policies where government spending is the single fiscal policy instrument. More recently, there has been a concern to allow for a richer menu of fiscal policies by relaxing, for instance, the assumption of Ricardian equivalence or by using alternative fiscal policy instruments. For example, Leith

[6] See, among others, Beetsma and Jensen (2004, 2005), Ferrero (2007), Gali and Monacelli (2006) and Leith and Wren-Lewis (2007a).

[7] See, for instance, Coutinho (2005) and Lane and Ganelli (2002) for extensive surveys on fiscal policy in the NEOM models.

and Wren-Lewis (2007b) consider three alternative fiscal instruments and try to assess their relative effectiveness for stabilization purposes.

In the context of these challenging research issues raised by country-size asymmetry in a monetary union, our main objectives, through which we expect to contribute to the relevant literature, are the following: (i) to characterize optimizing stabilization policies in a monetary union when policymakers may act strategically; (ii) to assess whether institutional policy arrangements, such as policy cooperation, fiscal policy constraints or monetary policy delegation to a weight-conservative central bank, can improve the stabilization outcomes; (iii) to appraise how the level of government indebtedness constraints the effectiveness of policy stabilization. In particular, we intend to examine how country-size asymmetry shapes these outcomes and how it determines possible recommendations on monetary and fiscal policy arrangements to be applied, for instance, in the EMU context.

To address the above mentioned issues we begin by setting a baseline framework: a two-country micro-founded macroeconomic model for a closed monetary union with monopolistic competition and sticky prices, in line with the ones firstly developed by Benigno (2004) for monetary policy analysis, and extended by Beetsma and Jensen (2004, 2005) to include fiscal policy. The fiscal policy instrument is the welfare-improving public spending, fully financed by lump-sum taxes. Hence, the fiscal policy has no supply-side effects and the monetary policy does not interfere with the government sources of financing. Afterwards, we extend the model to include a more realistic fiscal policy setup, including additional sources of strategic interactions between the fiscal and the monetary authorities. Following the recent work of Leith and Wren-Lewis (2007a, 2007b), we allow the model to include two fiscal policy instruments yielding both demand and supply-side effects – respectively, home-biased government spending and distortionary taxes - but where lump-sum taxes are no longer enough to guarantee fiscal policy solvency.

The model also includes inflation persistence and enables capturing several differences in the structure of the two economies: namely, asymmetric degrees of nominal rigidity and inflation persistence and the existence of country-size asymmetry. The model also enables different levels of public debt for each country to be considered, which provides a relevant framework to analyse how long-term sustainability constrains the role of fiscal policy for short-run stabilization purposes.

Necessarily, we derive a welfare criterion to allow the derivation of optimal stabilization policies and the ranking of the alternative policy outcomes under different strategic set-ups. This relies on a quadratic approximation to the union-weighted average of the representative households' welfare where linear terms are removed through the use of a subsidy fully financed by lump-sum taxes, as in Rotemberg and Woodford (1998), for instance.[8] The characterization of optimal stabilization policies under non-cooperative and dynamic settings requires the model to be solved numerically using appropriate algorithms that reflect the various timing structures of the policy games: Nash, monetary leadership and fiscal leadership. We follow the methodology developed in the recent work of Kirsanova and co-authors (Blake and Kirsanova, 2006, for a closed-economy setup and Kirsanova et al., 2005, for an open-economy setup) to find the leadership discretionary equilibrium with dynamic rational expectations macroeconomic models.[9]

The plan of the thesis is as follows. In chapter 2 we present the setup for policy analysis. We first outline the model with and without binding budgetary solvency constraints; then, we derive a second-order approximation to union-wide welfare and present the alternative policy objectives; next, we present the methodology and the algorithms underlying the optimal policy solutions; finally, we present the calibration that allows the computation of numerical simulations. In chapter 3 we perform the policy analysis related to dynamic responses to exogenous disturbances under the several policy regimes and evaluate the respective welfare implications, under balanced budget fiscal policies. Chapter 4 performs equivalent policy analysis in the model with debt. Chapter 5 concludes and, in appendix, we derive some technical details and present figures and tables.

[8] Benigno and Woodford (2004, 2005, 2006), for a closed-economy, and Ferrero (2007), for a monetary union, present an alternative way to remove the linear terms of the social loss function, in the presence of a distorted steady-state. They focus on timeless optimal commitment policies and they need to compute second-order approximations to the structural equations of the model to get a purely quadratic loss. Schmitt-Grohé and Uribe (2004a,b), Correia et al (2003) and Lambertini (2006b) illustrate the so-called Ramsey approach, which configures an alternative to the joint design of optimal policies. Neither of these approaches is compatible with the study of the policy problem under discretion.

[9] Adam and Billi (2006), for a closed-economy setup, present an alternative computational method that delivers second-order accurate welfare expressions for economies with a distorted steady-state within the linear-quadratic approach.

1. The Setup for Policy Analysis

1.1 A baseline model for a monetary union

Currently, there is some consensus on the need of developing models with micro-foundations that allow more analytical rigor and a welfare criterion for policy evaluation. The objective is to evaluate and compare the equilibria resulting from alternative policies, from the point of view of the private-sector objectives that underlie the behavior assumed in the model for the effects of those policies. For that, the model's structural equations need to be derived from optimizing foundations. However, the answers one could obtain depend crucially upon the assumptions made about the structure of the economy. The assumptions on the nature of nominal rigidities, on the preferences and on the financial market structure are decisive to the welfare results.[10] Since the correct model specification remains controversial, the welfare criterion used to evaluate policy remains controversial as well. Policy recommendations derived from this research program must be highly qualified. In the open-economy context the controversy on the useful micro-founded work-horse model for macroeconomic analysis is exacerbated by the greater number of assumptions that have to be made relative to the closed-economy setup. There is a concern on converging to a "preferred" specification that should be supported by extensive empirical evidence. Typically, research on this topic is done by departing from a benchmark model and introduce some variants on it in order to evaluate the consistency of its predictions.[11]

The shortcomings just described seem to have stimulated to the work in the edification of a new paradigm for the analysis of macroeconomic interdependence that could offer a superior alternative to the Mundell-Fleming-Dornbusch model. In fact, recently, there has been an explosion of academic literature on the "new open economy macroeconomics".

[10] Cf., for instance, Woodford (2003) on the discussion of the derivation of a proper welfare criterion in a closed-economy setup and the suveys of Lane (2001) and Lane and Ganelli (2002) on the open-economy modelling.

[11] In the "new open economy macroeconomics" literature the model of Obstfeld and Rogoff (1995, 1996) is a natural benchmark model.

Since we want to focus on the policy interdependences within a monetary union, we will consider that the latter is a closed area. Hence, the models we are interested combine elements of the closed-economy literature and of the recent open-economy literature on exchange rate determination. However, we will follow recent literature on currency unions and we will minimize the incorporation of elements from the open-economy literature. For instance, in spite of the recognition that current account plays a relevant role in the transmission of disturbances, the major part of the models de-emphasise the importance of this channel by assuming complete financial markets and/or by assuming unitary intratemporal elasticity of substitution between domestic and foreign goods in consumption.[12] In fact, following Benigno (2004), Benigno and Benigno (2006) and Beetsma and Jensen (2004, 2005), the only element that we will incorporate in our model that makes it departing from the closed-economy setup is a cross-country consumption elasticity smaller than domestic elasticities of substitution.[13]

There is now a very recent literature that studies the interactions of monetary and fiscal policies within a micro-founded framework. Beetsma and Jensen (2004, 2005), Gali and Monacelli (2006), Kirsanova et al. (2005, 2006), Lambertini (2004, 2006b), Leith and Wren-Lewis (2007b), Canzoneri et al. (2005) and Ferrero (2007) represent this new branch of literature applied to a currency union's setup. While it is consensual to treat the interest rate as the monetary policy instrument, it is recognized that fiscal policy has many dimensions and that the several fiscal policy instruments have different effects. Even when one elects the public spending as the fiscal policy instrument, one gets different effects on the domestic economy when this is financed through lump sum taxes, distortionary taxes or public debt. The spillovers that these different sources of financing generate are also different. Hence, the fiscal and monetary policy interactions depend on the type of the fiscal policy implemented. Beetsma and Jensen (2004, 2005) and Gali and Monacelli (2006) assume that the fiscal policy instrument is public spending financed by lump sum taxes,

[12]Fabio Ghironi (2000) criticizes this modeling device of removing the problems caused by non-stationarity by shutting off an important channel of interdependences - the current account movements.

[13]Corsetti and Pesenti (2001) overstate this important source of inefficiency in the open-economy setting, the monopoly power of a country in its terms of trade.

Ferrero (2007) presents a model where fiscal policy is conducted through distortionary taxation and public debt and Leith and Wren-Lewis (2007b) consider three potential fiscal instruments - government spending, labour income taxes and revenue taxes.

We will consider two fiscal policy scenarios: one, where the fiscal policy instrument is home-biased government spending financed by lump-sum taxes; the other, where both government spending and distortionary sales taxes are fiscal policy instruments and lump-sum taxes are not enough to guarantee fiscal policy solvency. In the first scenario fiscal policy is balanced-budget and only has demand-side effects while, in the second scenario, fiscal policy has demand and supply-side effects but it is constrained by the need to verify the government's budget constraint.[14] We take, as a baseline model for the monetary union, a two-country model that closelly follows those of Beetsma and Jensen (2004, 2005) and extend them to allow for a more generic case of cross-country consumption elasticity and for inflation persistence.

Henceforth, we consider a monetary union with two countries, H(ome) and F(oreign), populated by a continuum of agents on the interval $[0, 1]$. The population on the segment $[0, n)$ belongs to country H, while agents on $[n, 1]$ live in country F. In each country there are two sectors - households and firms - and one fiscal authority.

1.1.1 Households

In period 0, the lifetime utility function of a representative Home-household is given by:

[14] In fact, we also have considered a fiscal policy scenario where government spending was the sole fiscal policy instrument with binding government budget constraints. However, we could not get stable discretionary solutions for usual levels of debt because we have imposed government intertemporal budget constraints at the national level and because government spending fluctuations are welfare-reducing. In a monetary union where the monetary policy instrument only can address aggregate union-wide effects, the short-run stabilization of country-specific variables conflicts with the satisfaction of the national government budget constraints and the system becomes instable. Hence, we had to use a model with two country specific fiscal policy instruments (the government spending and the tax rate) with one of them (the tax rate) having no direct effect on the social loss function. Notice that, in the open economy setup with optimal policies and debt constraints, most of the literature uses either the tax rate as the sole fiscal policy instrument (which does not affects directly welfare), as Ferrero (2007) does, or uses the tax rate and government spending as fiscal policy instruments, as Leith and Wren-Lewis (2007a, 2007b) do.

$$U_0^j = E_t \sum_{t=0}^{\infty} \beta^t \left[u\left(C_t^j, \overline{C}_t^H\right) + V\left(G_t^H\right) - v\left(L_t^j\right)\right] \tag{1}$$

where the index *j* denotes a variable that is specific to household *j* and the index *H* denotes a variable specific to the country H where *j* resides.

Each household delivers utility from consuming across baskets of home and foreign produced goods, from public good provision by the own-country government, while she receives disutility from labour effort . Here, L_t^j denotes hours of work type j that firm j will use as the unique input. There is a mass of one wage setting households working at each firm. We introduce the possibility of welfare being positely affected by domestic public spending. However, since we assume that it affects in a additive and separable way, the optimality conditions of the representative household are the same of the case where government spending is pure waste.[15]

To simplify the algebraic form of the results we will adopt the isoelastic functional forms:

$$u\left(C_t^j, \overline{C}_t^H\right) = \tfrac{\sigma}{\sigma-1}\left(C_t^j\right)^{\frac{\sigma-1}{\sigma}}\left(\overline{C}_t^H\right)^{\frac{1}{\sigma}}$$

$$V\left(G_t^H\right) = \delta\tfrac{\psi}{\psi-1}\left(G_t^H\right)^{\frac{\psi-1}{\psi}}$$

$$v\left(L_t^j\right) = \tfrac{d}{1+\eta}\left(L_t^j\right)^{1+\eta}$$

where $\overline{C}^H$ is a bounded exogenous disturbance[16] and C^j is a real consumption Dixit-Stiglitz index defined, as in Benigno and Benigno (2006) or Lombardo and Sutherland (2004), by

$$C^j \equiv \left[n^{\frac{1}{\rho}}\left(C_H^j\right)^{\frac{\rho-1}{\rho}} + (1-n)^{\frac{1}{\rho}}\left(C_F^j\right)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}} \tag{2}$$

[15]This is the case when $\delta = 0$. The parameter δ measures the relative importance of public versus private consumption for welfare. Ganelli (2003) stresses the relevance of incorporating government spending in the utility function in a non-separable fashion.

[16]We introduce a country specific demand shock by letting the marginal utility of consumption be stochastic.

and C_H^j and C_F^j are Dixit-Stiglitz indexes of consumption across the continuum of differentiated goods produced respectively in country H and F.

$$C_H^j = \left[\left(\tfrac{1}{n}\right)^{\frac{1}{\theta}} \int_0^n c^j(h)^{\frac{\theta-1}{\theta}} dh \right]^{\frac{\theta}{\theta-1}} ; \; C_F^j = \left[\left(\tfrac{1}{1-n}\right)^{\frac{1}{\theta}} \int_n^1 c^j(f)^{\frac{\theta-1}{\theta}} df \right]^{\frac{\theta}{\theta-1}} \tag{3}$$

The elasticity of substitution between the goods produced in each country (θ) may differ from the elasticity of substitution between home and foreign consumption baskets (ρ) [17]. It is assumed that countries H and F produce a continuum of goods in the segments $[0, n)$ and $[n, 1]$, respectively. There are no trade barriers and the two countries share the common currency and, in consequence, the price of each variety of good is the same across countries. Given these assumptions and the structure of preferences, purchasing power parity holds.

The implied overall consumption-based price index is[18]

$$P = \left[nP_H^{1-\rho} + (1-n) P_F^{1-\rho} \right]^{\frac{1}{1-\rho}} \tag{4}$$

while the country-specific price indexes P_H and P_F are given by

$$P_H = \left[\frac{1}{n} \int_0^n p(h)^{1-\theta} dh \right]^{\frac{1}{1-\theta}} ; \; P_F = \left[\frac{1}{1-n} \int_n^1 p(f)^{1-\theta} df \right]^{\frac{1}{1-\theta}} \tag{5}$$

where $p(h)$ is the price of good h produced in country H and $p(f)$ the price of a good produced in F. The terms of trade, T, is defined as the relative price of the Foreign bundle of goods in terms of the Home bundle of goods $(T \equiv P_F/P_H)$.

The problem of the representative household can be separated into an intertemporal and an intratemporal problem.

[17]This specification nests the specifications of Obstfeld and Rogoff (1995, 1996) for $\theta = \rho$, and Corsetti and Pesenti (2001) for $\rho = 1$.

[18]Formally, the consumption price index P solves the problem

$\underset{C_H, C_F}{min} \; Z = P_H C_H + P_F C_F$

s.t. $C \equiv \left[n^{\frac{1}{\rho}} (C_H)^{\frac{\rho-1}{\rho}} + (1-n)^{\frac{1}{\rho}} (C_F)^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}} = 1$

where the price index P_H (and P_F by symmetry) is obtained from

$\underset{c(h)}{min} \; P_H C_H = \int_0^n p(h) c(h) dh$

s.t. $C_H \equiv \left[\left(\frac{1}{n}\right)^{\frac{1}{\theta}} \int_0^n c(h)^{\frac{\theta-1}{\theta}} dh \right]^{\frac{\theta}{\theta-1}} = 1.$

In its intratemporal problem, she allocates a given level of expenditure across the differentiated goods so as to maximize its consumption index, C^j. In its intertemporal problem, she chooses the optimal paths of consumption, labour and bonds. The optimal consumption allocation across the differentiated goods[19] gives rise to j-individual demands for goods h and f

$$c^j(h) = \frac{1}{n}\left(\frac{p(h)}{P_H}\right)^{-\theta} C_H^j; c^j(f) = \frac{1}{1-n}\left(\frac{p(f)}{P_F}\right)^{-\theta} C_F^j \tag{6}$$

where

$$C_H^j = n\left(\frac{P_H}{P}\right)^{-\rho} C^j; C_F^j = (1-n)\left(\frac{P_F}{P}\right)^{-\rho} C^j \tag{7}$$

Furthermore, since we assume that each fiscal authority allocates government purchases only among the goods produced in the country of its sovereignity, the per capita public spending indexes, in countries H and F, are given by

$$G^H = \left[\frac{1}{n}\int_0^n g^H(h)^{\frac{\theta-1}{\theta}} dh\right]^{\frac{\theta}{\theta-1}}; G^F = \left[\frac{1}{1-n}\int_n^1 g^F(f)^{\frac{\theta-1}{\theta}} df\right]^{\frac{\theta}{\theta-1}} \tag{8}$$

Combining the previous expressions we obtain the total demands for goods h and f

$$y(h) = \left(\frac{p(h)}{P_H}\right)^{-\theta} Y^H; y(f) = \left(\frac{p(f)}{P_F}\right)^{-\theta} Y^F \tag{9}$$

where Y^H and Y^F are the national aggregate demands that can be expressed as functions of total consumption, relative prices and public spending as

$$Y^H = \left(\frac{P_H}{P}\right)^{-\rho} C^W + G^H \tag{10H}$$

$$Y^F = \left(\frac{P_F}{P}\right)^{-\rho} C^W + G^F \tag{10F}$$

[19] The optimal allocation across goods home produced goods is obtained by solving the two problems:
$\underset{C_H^j, C_F^j}{Max}\, C^j = \left[n^{\frac{1}{\rho}}\left(C_H^j\right)^{\frac{\rho-1}{\rho}} + (1-n)^{\frac{1}{\rho}}\left(C_F^j\right)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}$
s.t. $Z = P_H C_H^j + P_F C_F^j$
and
$\underset{c(h)}{Max} C_H^j = \left[\left(\frac{1}{n}\right)^{\frac{1}{\theta}} \int_0^n c^j(h)^{\frac{\theta-1}{\theta}} dh\right]^{\frac{\theta}{\theta-1}}$
s.t. $P_H C_H^j = \int_0^n p(h)\, c^j(h)\, dh$
The individual consumption for the f-good is obtained analogously.

where C^W is defined as $C^W \equiv \int_0^1 C^j dj$. Notice that each country's relative price is function of the terms-of-trade (T)

$$\left(\frac{P_H}{P}\right)^{\rho-1} = n + (1-n) T^{1-\rho} \; ; \; \left(\frac{P_F}{P}\right)^{\rho-1} = nT^{\rho-1} + (1-n) \tag{11}$$

so that changes in terms-of-trade imply a response in each country's aggregate demand that will be larger the smaller the size the country, that is, the large the degree of its openness.[20]

In each country, all households begin with the same amount of financial assets and own an equal share of all domestic firms. Further, we will assume that the representative Home household trades, with home and foreign households, a complete set of state-contingent one-period nominal bonds denominated in units of the monetary union currency. Hence, financial markets are complete both at domestic and international level. To insure her consumption pattern against random shocks at the time t, the Home household decides to spend $Q_{t,t+1}D^j_{t+1}$ in state-contingent one-period nominal bonds, where $Q_{t,t+1}$ is the price of a bond, at date t, paying one unity of currency in a particular state of the nature occurring in $t+1$ (s^{t+1}), and D^j_{t+1} is the number of these bonds purchased by the representative home household at date t.[21]

The flow budget constraint for the representative Home household is for each state s^t at date t, and for each date t

$$P_t C^j_t + \sum_{s^{t+1}} Q_{t,t+1} D^j_{t+1} \leq W_t(j) L^j_t + \int_0^n \Pi^j_t(z)\, dz - P_t T^H_t + D^j_t \tag{12}$$

where $W(j)$ is the nominal wage rate of labour of type j and, $\Pi^j(z)$, is the share of profits of domestic firm z going to household j in country H, while T^H is a lump sum tax levied by the domestic government on its citizens.

[20]For instance, if H is small relative to F ($n < 1-n$) an increase in the terms of trade leads to a reduction on the Home's relative price that is greater than the increase in the Foreign's relative price. In consequence, the H's aggregate demand increases by more than the F's aggregate demand decreases.

[21]We denote by $s^T = \{s_t, s_{t+1}, ..., s_T\}$ the history of events up to date T, where s_T is the state realization at time T. At each date T, the economy faces one of finitely many states $s_T = \{1, 2, ..., S_T\}$. The date T probability of observing history s^T is given by $\Pr ob\left(s^T\right)$ and, since the initial state s^t is given, $\Pr ob\left(s^t\right) = 1$. Notice that $s^T = \left(s^{T-1}, s_T\right)$.

In each period $t = 0, 1, ...$, the household chooses her period t allocation after the realization of the event s_T. She chooses the set of processes $\left\{C_t^j, L_t^j; D_{t+1}^j\right\}_{t=0}^{\infty}$, taking as given all the other processes and the initial wealth, so as to maximize the intertemporal utility function (1) subject to (12) .We can discribe the problem she faces, by the setting up the Lagrangian

$$MaxE_0 \sum_{t=0}^{\infty} \beta^t \left\{ u\left(C_t^j, \overline{C}_t^H\right) + V\left(G_t^H\right) - v\left(L_t^j\right) - \lambda_t \left[C_t^j + \right.\right.$$
$$\left.\left. + \frac{\sum_{s^{t+1}} Q_{t,t+1}}{P_t} D_{t+1}^j - \frac{W_t\left(j\right)}{P_t} L_t^j - \int_0^n \frac{\Pi_t^j\left(z\right)}{P_t} dz + T_t^H - \frac{D_t^j}{P_t} \right] \right\}$$

where λ_t is the lagrangian multiplier associated with the budget constraint (12) at time t.

For any given state of the world, the first-order conditions for period t are

$$u_c\left(C_t^j, \overline{C}_t^H\right) = \lambda_t \tag{13}$$

$$\lambda_t \frac{W_t\left(j\right)}{P_t} = \mu_{w,t}^H * v_L\left(L_t^j\right) \tag{14}$$

$$Q_{t,t+1} = \beta \frac{P_t}{P_{t+1}} \frac{\lambda_{t+1}}{\lambda_t} \tag{15}$$

where $\mu_{w,t}^H \geqslant 1$ is an exogenous Home-specific wage mark-up that is used as a device to introduce the possibility of "pure cost-push shocks" that affects the equilibrium price behaviour but does not change the efficient output, as in Benigno and Woodford (2003, 2005). In the labour markets wages are flexible and households may be monopolistic suppliers of labour $\left(\text{if } \mu_{w,t}^H > 1\right)$ while firms are wage-takers[22]. Notice that, equation (15) holds for each state at time t and for each state that may occur in $t+1$ (conditional on the state occurred in t).

We can use (15) to obtain the risk-free nominal interest rate. In fact, we can get a riskless one-period nominal bond from a portfolio of state-contingent one-period nominal bonds that pays off one unit of currency in each state of world with certainty. Equation (15) and no arbitrage imply that

[22]The derivation of this mark-up factor is available upon request.

$$\frac{1}{1+i_t} = E_t Q_{t,t+1} \tag{16}$$

Hence, by taking conditional expectations of equation (15) and combining with (16)we get the familiar Euler equation

$$u_c\left(C_t^j, \overline{C}_t^H\right) = \beta\left(1+i_t\right) E_t\left\{\left(\frac{P_t}{P_{t+1}}\right) u_c\left(C_{t+1}^j, \overline{C}_{t+1}^H\right)\right\} \tag{17}$$

Since the Foreign representative household solves a problem similar to that of the Home household, we can use expression (17) to write

$$\frac{E_t\left[u_c\left(C_{t+1}^H, \overline{C}_{t+1}^H\right)\right]}{E_t\left[u_c\left(C_{t+1}^F, \overline{C}_{t+1}^F\right)\right]} = \frac{u_c\left(C_t^H, \overline{C}_t^H\right)}{u_c\left(C_t^F, \overline{C}_t^F\right)}$$

where have substituted the upper index j of the representative household of each country by the corresponding index of the countries (H and F).

If we assume that the initial state-contingent distribution of nominal bonds is such that the life-time budget constraints of all households are identical, the risk-sharing condition implies that

$$u_c\left(C_t^H, \overline{C}_t^H\right) = u_c\left(C_t^F, \overline{C}_t^F\right) \tag{18}$$

The full caracterization of household's optimization requires that we add the transversality condition

$$\lim_{T\to\infty} E_t\left[Q_{t,T} D_T^j\right] = 0 \tag{19}$$

and specify that the budget constraint (12) must hold with equality at each date T.

1.1.2 Firms

We assume a common linear techonology for the production of all goods produced in each country, in which industry-specific labour is the unique variable input. There is a continuum of firms of measure n in country H and of measure $1-n$ in country F.

The differentiated consumption good $y(h)$, produced by firm h in country H, has the production function

$$y_t(h) = a_t^H L_t(h) \tag{20}$$

where a_t^H is an exogenous Home-specific technological shock common to all Home-firms, and $L_t(h)$ is the firm-specific labour input offered by a continuum of Home-households, indexed in the unit interval. Each of these households face the same first order conditions so, in a symmetric equilibrium, the same level of the work effort they choose to spend $\left(L_t^h\right)$ is equal to the aggregate labour input $(L_t(h))$. As we have already remarked, labour is immobile across countries and, it is possible to have monopolistic distortions in labour markets, if the wage-markup $\left(\mu_{w,t}^H\right)$, in equation (14) , takes a value greater than one.

We admit the existence of persistence in inflation by assuming that a fraction of firms set prices by following a rule-of-thumb behaviour, while the other fraction follow an optimizing forward-looking behaviour. We follow Gali and Gertler (1999) and Amato and Laubach (2003), and assume that the fraction of firms that do not optimize ("rule-of-thumbers") set their prices taking into account the last-period behaviour of all firms. The structure of the price-setting behaviour is as following: i) as in Calvo's (1983) model, each period a fraction of firms have the opportunity to change their prices with a fixed probability $1-\alpha^i$, while the remaining firms maintain the prices they have charged before; ii) differently from Calvo's framework, a fraction $1-\lambda^i$ of firms that can reset their prices choose to not set their prices optimally and use a rule-of-thumb behaviour because of optimization costs. We allow for different α^i and λ^i across countries. Given these mechanisms, and realizing that, in equilibrium, each firm in a given country and a given period will set the same price when offered the chance to reset its price (optimally or not), the evolution of the price index P_H is defined the following law of motion

$$P_{H,t}^{1-\theta} = \alpha^H P_{H,t-1}^{1-\theta} + \left(1-\alpha^H\right) P_{H,t}^{*1-\theta} \tag{21}$$

where

$$P_{H,t}^{*1-\theta} = \lambda^H p_t^o(h)^{1-\theta} + \left(1-\lambda^H\right) p_{H,t}^{r1-\theta} \tag{22}$$

$p_t^o(h)$ is the price of an optimizing Home-firm, and $p_{H,t}^r$ is the price set by a "rule-of-thumber" firm. The latter is set according to

$$p_{H,t}^r = P_{H,t-1}^* \frac{P_{H,t-1}}{P_{H,t-2}} \tag{23}$$

where $P_{H,t}^*$ is the aggregate of the prices newly chosen in period t by both optimizing and rule-of-thumb firms. If firm h has the "chance" to reset its price in period t and adopts an optimizing behaviour, she chooses her price $(p_t^o(h))$ to maximize

$$E_t \left\{ \sum_{s=t}^{\infty} \left(\alpha^H\right)^{s-t} Q_{t,s} \left[\left(1\text{-}\tau_s^H\right) p_t^o(h)\, y_{t,s}(h) \text{-} W_s(h)\, L_s(h) \left(1\text{-}\zeta^H\right) \right] \right\}$$

where $y_{t,s}(h)$ is given by (9), assuming that $p_t^o(h)$ still applies at s, τ_s^H is a proportional tax rate on nominal income assumed to be a time-varying exogenous disturbance with the non-zero steady-state level $\overline{\tau}^H$, and ζ^H is an employment subsidy that can be used to eliminate inefficiencies associated with monopolistic competition and with distortionary taxation[23]. The first term represents sales revenues net of taxes, while the second term denotes total nominal cost in each period. In equilibrium, the stochastic discount factor $Q_{t,s}$ is given by

$$Q_{t,s} = \beta^{s-t} \frac{P_t}{P_s} \frac{u_c\left(C_s^H, \overline{C}_s^H\right)}{u_c\left(C_t^H, \overline{C}_t^H\right)}$$

After substituting the nominal wage rate and recasting the disutility of labour in terms of aggregate production and relative prices, we get the first-order condition for the optimizing wage-taker firm

$$\left(\frac{p_t^o(h)}{P_{H,t}}\right)^{1+\theta\eta} = \frac{\frac{\theta}{\theta-1} E_t \sum_{s=t}^{\infty} \left(\alpha^H\beta\right)^{s-t} \mu_{w,s}^H \left(1-\zeta^H\right) v_y\left(Y_s^H; a_s^H\right) \left(\frac{P_{H,s}}{P_{H,t}}\right)^{\theta(1+\eta)} Y_s^H}{E_t \sum_{s=t}^{\infty} \left(\alpha^H\beta\right)^{s-t} \left(1-\tau_s^H\right) u_c\left(C_s^H, \overline{C}_s^H\right) \left(\frac{P_{H,s}}{P_{H,t}}\right)^{\theta-1} \left(\frac{P_{H,s}}{P_s}\right) Y_s^H} \tag{24}$$

The numerator of this equation represents the present discounted value of the time-varying gross markup over all current and future marginal costs, while the denominator represents the present discounted value of all current and future marginal revenues net of

[23] Following Leith and Wren-Lewis (2007a, 2007b), we use this employment subsidy as a device to eliminate linear terms in the social welfare function without loosing the possibility of using the sales tax rates as fiscal policy instruments. This employment subsidy is financed using lump-sum taxes.

taxation. The gross markup is a combination of the constant price markup and the time-varying wage markup $\left(\frac{\theta}{\theta-1} * \mu_{w,s}^H\right)$.

1.1.3 Policymakers

The monetary policy instrument is the nominal interest rate i_t. We abstract from monetary frictions so that our model can be interpreted as cashless limiting model (as in Woodford, 2003). As a consequence, governments do not benefit from seigniorage revenues. Moreover, the presence of nominal rigidities ensures that monetary policy affects real activity.

Fiscal policy consists in public spending (G^i) and in an employment subsidy $\left(\zeta^i\right)$ financed by lump-sum (T^i) and distortionary (τ^i) taxes. The period budget constraint for the Home-fiscal authority is

$$nP_tT_t^H + \int_0^n \tau_t^H p_t\left(h\right) y_t\left(h\right) dh = nP_{H,t}G_t^H + \int_0^n \zeta^H W_t\left(h\right) L_t\left(h\right) dh \qquad (25)$$

We consider that lump-sum taxes fully adjust to balance the budget each period and Ricardian equivalence holds.

1.1.4 Equilibrium

Traditionally, the derivation of a micro-founded welfare criterion for policy evaluation requires the derivation of the efficient equilibrium and the definition of the variables in gaps. These are defined as the log-deviation of the actual variables from their efficient levels. With balanced budget fiscal policies, that equilibrium can be derived through two different but equivalent maximization programs. One, under a flexible-price setup, where monopolistic and tax distortions are removed through an employment or a production subsidy, and where fiscal authorities coordinate and choose government spending that maximizes the representative agent utility subject to the households and firms optimality conditions. The other way of getting the efficient equilibrium requires, previously, the resolution of the social planner's problem and, afterwards, the finding of a flexible-price equilibrium that supports the optimal allocation. This is obtained by setting a production or employment subsidy that, by removing distortions, allows the coincidence of the two equibriums. In addition, the fiscal authorities implement the government spending rules that follow from the social planner's solution. Beetsma and Jensen (2004, 2005) follow the first methodology, while Gali and Monacelli (2006) but also Leith and Wren-Lewis (2007a, 2007b) follow the second. We follow the latter methodology.

The social planner's problem and the efficient equilibrium The optimal allocation

for the monetary union as a whole, in any given period t, can be described as the solution to the following social planner's problem

$$\max_{\substack{C^H_{H,t},\, C^F_{H,t},\, C^H_{F,t},\\ C^F_{F,t},\, G^H_t,\, G^F_t}} \left\{ n\left[u\left(C^H_t, \overline{C}^H_t\right) + V\left(G^H_t\right) - v\left(L^H_t\right)\right] + (1-n)\left[u\left(C^F_t, \overline{C}^F_t\right) + V\left(G^F_t\right) - v\left(L^F_t\right)\right]\right\} \tag{26}$$

subject to the production technologies

$$Y^H_t = a^H_t L^H_t;\ Y^F_t = a^F_t L^F_t$$

the resource constraints

$$\begin{aligned} nY^H_t &= nC^H_{H,t} + (1-n)\, C^F_{H,t} + nG^H_t \\ (1-n)\, Y^F_t &= nC^H_{F,t} + (1-n)\, C^F_{F,t} + (1-n)\, G^F_t \end{aligned}$$

and the consumption price indexes

$$\begin{aligned} C^H_t &\equiv \left[n^{\frac{1}{\rho}} \left(C^H_{H,t}\right)^{\frac{\rho-1}{\rho}} + (1-n)^{\frac{1}{\rho}} \left(C^H_{F,t}\right)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}} \\ C^F_t &\equiv \left[n^{\frac{1}{\rho}} \left(C^F_{H,t}\right)^{\frac{\rho-1}{\rho}} + (1-n)^{\frac{1}{\rho}} \left(C^F_{F,t}\right)^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}} \end{aligned}$$

where it was already admitted that the social planner will choose to produce equal quantities of the different goods in each country. Moreover, the aggregation over all the agents (households, governments and central bank) cancels out the budget constraints so that the social planner's solution is not constrained by their verification.

This maximization program yields the following optimallity conditions

$$u_c\left(C_t^H,\overline{C}_t^H\right)n^{\frac{1}{\rho}}\left(\frac{C_{H,t}^H}{C_t^H}\right)^{-\frac{1}{\rho}} = v_y\left(Y_t^H;a_t^H\right) \quad (27)$$

$$u_c\left(C_t^H,\overline{C}_t^H\right)(1-n)^{\frac{1}{\rho}}\left(\frac{C_{F,t}^H}{C_t^H}\right)^{-\frac{1}{\rho}} = v_y\left(Y_t^F;a_t^F\right) \quad (28)$$

$$u_c\left(C_t^F,\overline{C}_t^F\right)n^{\frac{1}{\rho}}\left(\frac{C_{H,t}^F}{C_t^F}\right)^{-\frac{1}{\rho}} = v_y\left(Y_t^H;a_t^H\right) \quad (29)$$

$$u_c\left(C_t^F,\overline{C}_t^F\right)(1-n)^{\frac{1}{\rho}}\left(\frac{C_{F,t}^F}{C_t^F}\right)^{-\frac{1}{\rho}} = v_y\left(Y_t^F;a_t^F\right) \quad (30)$$

$$V_G\left(G_t^H\right) = v_y\left(Y_t^H,a_t^H\right) \quad (31)$$

$$V_G\left(G_t^F\right) = v_y\left(Y_t^F,a_t^F\right) \quad (32)$$

This means that the marginal loss of utility of producing an additional unit of the composite good at country $i = H, F$ - $v_y\left(Y_t^i;a_t^i\right)$ - must be equal, at the margin, to the utility gained from privately consuming it at H and F, as well as to the utility gained from its consumption by the domestic government.

From the four first optimally conditions we get that

$$u_c\left(C_t^H,\overline{C}_t^H\right) = u_c\left(C_t^F,\overline{C}_t^F\right) \quad (33)$$

$$\frac{C_{H,t}^H}{C_{F,t}^H} = \frac{C_{H,t}^F}{C_{F,t}^F} \text{ and } \frac{C_{F,t}^H}{C_{F,t}^F} = \frac{C_{H,t}^H}{C_{H,t}^F} = \frac{C_t^H}{C_t^F} \quad (34)$$

$$v_y\left(Y_t^F;a_t^F\right) = \left(\frac{n}{1-n}\right)^{-\frac{1}{\rho}}\left(\frac{C_{H,t}^H}{C_{F,t}^H}\right)^{\frac{1}{\rho}} v_y\left(Y_t^H;a_t^H\right) \quad (35)$$

In a symmetric efficient steady-state equilibrium, it follows that $\overline{Y}^H = \overline{Y}^F = \overline{Y}$; $\overline{C^H} = \overline{C^F} = \overline{C}$; $\overline{C_H^H} = \overline{C_H^F} = n\overline{C}$; $\overline{C_F^H} = \overline{C_F^F} = (1-n)\,\overline{C}$ and $\overline{G^H} = \overline{G^F} = \overline{G}$.

The complete solution for the efficient equilibrium is given by the following expressions

$$\widetilde{C}_t^w = \frac{1}{1+\eta\left[s_c\sigma+(1-s_c)\,\psi\right]}\left\{\left[1+(1-s_c)\,\psi\eta\right]\widehat{\overline{C}}_t^w + (1+\eta)\,\sigma\widehat{a}_t^w\right\} \quad (36)$$

$$\widetilde{G}_t^w = \frac{\psi}{1+\eta\left[s_c\sigma+(1-s_c)\psi\right]}\left[-\eta s_c\widehat{\overline{C}}_t^w+(1+\eta)\widehat{a}_t^w\right] \tag{37}$$

$$\widetilde{G}_t^F-\widetilde{G}_t^H = \frac{(1+\eta)\psi}{1+\eta\left[s_c\rho+(1-s_c)\psi\right]}\left(\widehat{a}_t^F-\widehat{a}_t^H\right) \tag{38}$$

$$\widetilde{C}_{H,t}^H-\widetilde{C}_{F,t}^H=\widetilde{C}_{H,t}^F-\widetilde{C}_{F,t}^F=-\frac{\rho(1+\eta)}{1+\eta\left[s_c\rho+(1-s_c)\psi\right]}\left(\widehat{a}_t^F-\widehat{a}_t^H\right) \tag{39}$$

where variables with a tilde denote the log-deviation of the efficient equilibrium from their steady-state levels. We use variables with a hat to denote the log-deviation of their actual values from their steady-state levels and, naturally, to the log-deviation of the exogenous disturbances from their deterministic values. Moreover, a generic "world variable", X^w, is defined as $X^w \equiv nX^H+(1-n)X^F$ and a "relative variable", X^R, is defined as $X^R \equiv X^F - X^H$.

When lump-sum taxes endogenously vary to ensure a balanced budget each period, this efficient allocation corresponds to decentralized flex-price equilibrium where monopolistic and tax distortions were removed through an employment or a production subsidy, and where the government spending follow the rules derived under the social planner's optimization. These government spending rules coincide with the ones obtained when fiscal authorities coordinate and choose G^H and G^F to maximize (**??**) in the flexible-price setup where distortions were removed.

The steady-state and the sticky prices equilibrium

Steady-state

To avoid the traditional inflationary bias problem due to an inefficiently low steady-state output level, we will assume the existence of an employment subsidy that removes average monopolistic and tax rate distortions.

In order to compute this employment subsidy, observe that the profit-maximizing Home firms, in a flexible-price setup, choose the same price $p_t(h)=P_{H,t}$ so that

$$u_c\left(C_t^H,\overline{C}_t^H\right)=\frac{\theta}{(\theta-1)\left(1-\tau_t^H\right)}\mu_{w,t}^H\left(1-\zeta^H\right)\left[n+(1-n)T_t^{1-\rho}\right]^{\frac{1}{1-\rho}}v_y\left(Y_t^H,a_t^H\right)$$

and, the Foreign counterpart of this price-setting behaviour is given by

$$u_c\left(C_t^F,\overline{C}_t^F\right)=\frac{\theta}{(\theta-1)\left(1-\tau_t^F\right)}\mu_{w,t}^F\left(1-\zeta^F\right)\left[nT_t^{\rho-1}+(1-n)\right]^{\frac{1}{1-\rho}}v_y\left(Y_t^F;a_t^F\right)$$

We allow the possibility of the two union monetary country members having different levels of steady-state sales tax rates. So, for getting symmetry in the steady-state levels of the output, consumption, government spending and prices, we need to impose that $\frac{\theta}{(\theta-1)\left(1-\overline{\tau}^H\right)}\overline{\mu}_w\left(1-\zeta^H\right)=\frac{\theta}{(\theta-1)\left(1-\overline{\tau}^F\right)}\overline{\mu}_w\left(1-\zeta^F\right)=\overline{\mu}$ where, as we have already remarked, the employment subsidy ζ^i is fully financed by lump sum taxes.

In this steady-state, we verify that

$$u_c\left(\overline{C},\overline{C}\right)=\overline{\mu}v_y\left(\overline{Y},\overline{a}\right)$$

and, if the employment subsidy ζ^i is set so that $\overline{\mu}=1$, one replicates the efficient steady-state output level. Hence, we assume that there is an employment subsidy in country $i=H,F$ that takes the value

$$\zeta^i=1-\frac{(\theta-1)\left(1-\overline{\tau}^i\right)}{\theta\overline{\mu}_w} \tag{40}$$

The steady-state nominal (an real) interest rate, obtained from (16), is $\overline{i}=1/\beta-1$.

Sticky prices equilibrium

We get the aggregate demand block system, from log-linearization of equations $(10H)$, $(10F)$, (17) and (18) around the efficient steady-state. The aggregate supply block follows from log-linear approximation of equations (21), (22) and (24) as well as from their Foreign counterparts.

The log-linearized model, with variables in gaps, is given by the following dynamic system:[24]

$$E_tc_{t+1}^w=c_t^w+\sigma\left(i_t-E_t\pi_{t+1}^w\right) \tag{41}$$

$$y_t^H=s_c\rho(1-n)q_t+(1-s_c)g_t^H+s_cc_t^w \tag{42H}$$

$$y_t^F=-s_c\rho nq_t+(1-s_c)g_t^F+s_cc_t^w \tag{42F}$$

[24]These log-linearizations are available upon request.

$$\pi_t^H = \gamma_b^H \pi_{t-1}^H + \gamma_f^H E_t \pi_{t+1}^H + k^H (1+s_c\rho\eta)(1\text{-}n)\, q_t + k^H \frac{1+s_c\sigma\eta}{\sigma} c_t^w + k^H (1\text{-}s_c)\,\eta g_t^H + k^H u_t^H \tag{43H}$$

$$\pi_t^F = \gamma_b^F \pi_{t-1}^F + \gamma_f^F E_t \pi_{t+1}^F \text{-} k^F (1+s_c\rho\eta)\, n q_t + k^F \frac{1+s_c\sigma\eta}{\sigma} c_t^w + k^F (1\text{-}s_c)\,\eta g_t^F + k^F u_t^F \tag{43F}$$

$$q_t = q_{t-1} + \pi_t^F - \pi_t^H - \left(\widetilde{T}_t - \widetilde{T}_{t-1}\right) \tag{44}$$

where k^H, k^F, γ_b^H, γ_f^H, γ_b^F and γ_f^F are defined as:

$$k^H \equiv \frac{\lambda^H\left(1\text{-}\alpha^H\right)\left(1\text{-}\alpha^H\beta\right)}{\left[\alpha^H + \left(1\text{-}\lambda^H\right)\left(1\text{-}\alpha^H + \alpha^H\beta\right)\right](1+\theta\eta)}; k^F \equiv \frac{\lambda^F\left(1\text{-}\alpha^F\right)\left(1\text{-}\alpha^F\beta\right)}{\left[\alpha^F + \left(1\text{-}\lambda^F\right)\left(1\text{-}\alpha^F + \alpha^F\beta\right)\right](1+\theta\eta)}$$

$$\gamma_b^H \equiv \frac{1\text{-}\lambda^H}{\alpha^H + \left(1\text{-}\lambda^H\right)\left(1\text{-}\alpha^H + \alpha^H\beta\right)}; \gamma_b^F \equiv \frac{1\text{-}\lambda^F}{\alpha^F + \left(1\text{-}\lambda^F\right)\left(1\text{-}\alpha^F + \alpha^F\beta\right)}$$

$$\gamma_f^H \equiv \frac{\alpha^H\beta}{\alpha^H + \left(1\text{-}\lambda^H\right)\left(1\text{-}\alpha^H + \alpha^H\beta\right)}; \gamma_f^F \equiv \frac{\alpha^F\beta}{\alpha^F + \left(1\text{-}\lambda^F\right)\left(1\text{-}\alpha^F + \alpha^F\beta\right)}$$

Variables in lower case letter are defined in gaps. For a generic variable X_t, its gap is given by $x_t = \widehat{X}_t - \widetilde{X}_t$, where $\widehat{X}_t$ denotes log-deviation from the zero-inflation efficient steady-state .We represent the terms-of-trade gap by $q_t \left(\equiv \widehat{T}_t - \widetilde{T}_t\right)$ where

$$\widetilde{T}_t = -\frac{1+\eta}{1+\eta\left[s_c\rho + (1-s_c)\psi\right]}\left(\widehat{a}_t^F - \widehat{a}_t^H\right) \tag{45}$$

The interest rate gap is $i_t \left(\equiv \widehat{i}_t - \widetilde{i}_t\right)$ with

$$\widetilde{i}_t = \frac{1}{\sigma} E_t\left[\left(\widetilde{C}_{t+1}^w - \widetilde{C}_t^w\right) - \left(\widehat{\overline{C}}_{t+1}^w - \widehat{\overline{C}}_t^w\right)\right] \tag{46}$$

Eq. (41) is the IS equation written in terms of the world consumption gap and the world nominal interest rate gap. Eqs. (43H) and (43F) are aggregate demand equations, where s_c is the steady-state consumption share of output. The absence of terms in demand shocks show that demand shocks alone have no impact in gap variables. Notice also that consumption is not affected by current income because it is purely forward looking. In consequence, public spending increases output but there is not a "Keynesian multiplier".[25]

[25] See Galí, López-Salido and Vallés (2007) for a closed-economy model that admit non-Ricardian

Eqs. (43H) and (43F) are hybrid open economy Phillips curves, which describe the aggregate supply (AS) in each of the monetary union's countries. Domestic inflation rate depends positively both on expected future domestic inflation, because optimizing producers know that they may be able of resetting their prices at next period; and on past domestic inflation, because of rule-of-thumber producers. This hybrid inflation-inertia Phillips curve formulation[26] collapses into the purely forward looking new Keynesian form, when $1 - \lambda^i \rightarrow 0$. Positive gaps on the terms-of-trade, consumption and public spending have inflationary consequences at Home, because they increase demand for Home produced goods, which leads to more work effort that raises marginal costs. Moreover, the positive gaps on the terms of trade and on the consumption exert an additional pressure on Home inflation, because they reduce the marginal utility of nominal income of Home's households. The term u_t^H, a rescaled mean-zero mark-up shock at Home, exerts a positive effect on inflation but does not imply any change in the socially optimal level of real output. It can be interpreted as a cost-push shock that precludes simultaneous stabilization of inflation, the private and public consumption gaps and the terms-of-trade gap.

Eq. (44) is the terms-of-trade gap's identity expressed through the inflation differential. To secure the validity of log linearization, all shocks are bounded exogenous disturbances of order $O\left(||\xi||\right)$.

The system (41)-(44) provides solutions for endogenous variables given the paths for policy instruments and the initial value of $\widehat{T}_{t-1}$.

1.2 Adding debt to the baseline model

In this section we are going to consider a fiscal policy scenario where both government spending and distortionary sales taxes are fiscal policy instruments and lump-sum

consumers triggering multiplier effects analogous to the ones found in traditional Keynesian model. Pescatori and Pisani (2006) develop a similar model for a monetary-union.

[26]Steinsson (2003) generalize the rule used by Gali and Gertler (1999) for the backward looking firms, in order to get the acceleration Phillips curve, when the fraction rule-of-thumber producers tends to one. With this extension, the output gap and its lag enter into the hybrid Phillips curve.

taxes are not enough to guarantee fiscal policy solvency. Hence, fiscal policy has demand and supply-side effects but it is constrained by the need to verify the government's budget constraint. Here, lump-sum taxes (T^i) only adjust to fully accomodate the employment subsidy (ζ^i) and the government intertemporal solvency condition is an additional binding constraint on the set of possible equilibrium paths of the endogenous variables.

The period budget constraints for the fiscal authorities of the Home and the Foreign countries can be written as

$$\begin{aligned} nB_t^H &= n\left(1+i_{t-1}\right)B_{t-1}^H+nP_{H,t}G_t^H+\int_0^n \zeta^H W_t^H L_t(h)\,dh - nP_tT_t^H - \int_0^n \tau_t^H p_t(h)\,y_t(h)\,dh \\ (1-n)\,B_t^F &= (1-n)\left(1+i_{t-1}\right)B_{t-1}^F+(1-n)\,P_{F,t}G_t^F+ \\ &\quad +\int_n^1 \zeta^F W_t^F L_t(f)\,df-(1-n)\,P_tT_t^F-\int_n^1 \tau_t^F p_t(f)\,y_t(f)\,df \end{aligned}$$

where B_t^H and B_t^F represent the per capita nominal government debt of country H and F. Using the demand expressions (9), the definition of the price indexes (5) and, the assumption that lump sum taxes just cover the employment subsidy, these period budget constraints can be rewitten, in per capita terms, as

$$B_t^H = \left(1+i_{t-1}\right)B_{t-1}^H + P_{H,t}G_t^H - \tau_t^H P_{H,t}Y_t^H \tag{47H}$$

$$B_t^F = \left(1+i_{t-1}\right)B_{t-1}^F + P_{F,t}G_t^F - \tau_t^F P_{F,t}Y_t^F \tag{47F}$$

With asset markets clearing only at the monetary union level, the only public sector intertemporal budget constraint is the union-wide constraint

$$\left[\left(1+i_{t-1}\right)nB_{t-1}^H+(1-n)\,B_{t-1}^F\right] = E_t\left\{\sum_{s=t}^{\infty} Q_{t,s}\left[n\tau_s^H P_{H,s}Y_s^H - nP_{H,s}G_s^H + (1-n)\,\tau_s^F P_{F,s}Y_s^F - (1-n)\,P_{F,s}G_s^F\right]\right\}$$

since the household's transversality condition does not impose a correspondent restriction on the national government's debt. The household's transversality condition only requires a restriction on the sum of the debt issued by the two governments.[27] However, there are arguments to impose the verification of this intertemporal budget constraint at the national levels. For instance, the equilibrium concept adopted by Ferrero (2007) and the existence of a symmetric steady state with a finite debt allows him to focus on the case where the

[27] This demonstration is available upon request.

public sector intertemporal budget constraint holds at the national level. In other hand, Leith and Wren-Lewis (2007b) appeal to the institutional EMU's arrangement to impose the verification of the intertemporal budget constraint at the national levels. Following these authors, we set

$$\begin{aligned} (1+i_{t-1})\, B_{t-1}^{H} &= E_t \left[\sum_{s=t}^{\infty} Q_{t,s} \left(\tau_s^H P_{H,s} Y_s^H \text{-} P_{H,s} G_s^H \right) \right] \\ (1+i_{t-1})\, B_{t-1}^{F} &= E_t \left[\sum_{s=t}^{\infty} Q_{t,s} \left(\tau_s^F P_{F,s} Y_s^F \text{-} P_{F,s} G_s^F \right) \right] \end{aligned}$$

that can be simplified to

$$b_t^H = (1+i_t) \left(b_{t-1}^H \frac{P_{t-1}}{P_t} + \frac{P_{H,t}}{P_t} G_t^H - \tau_t^H \frac{P_{H,t}}{P_t} Y_t^H \right) \tag{48H}$$

$$b_t^F = (1+i_t) \left(b_{t-1}^F \frac{P_{t-1}}{P_t} + \frac{P_{F,t}}{P_t} G_t^F - \tau_t^F \frac{P_{F,t}}{P_t} Y_t^F \right) \tag{48F}$$

since $E_t Q_{t,t+1} = \frac{1}{1+i_t}$ in equilibrium. Here, $b_t^i \equiv \frac{(1+i_t)B_t^i}{P_t}$ denotes, for $i = H, F$, the real value of debt at maturity in per capita terms. Log-linearizing $(48H)$ and $(48F)$ and re-writing variables in gaps

$$\widehat{b}_t^H = i_t + \frac{1}{\beta} \left\{ \widehat{b}_{t-1}^H \text{-} \pi_t + (1\text{-}n)(1\text{-}\beta)\, q_t + \frac{\overline{Y}}{\overline{b}^H} \left[(1\text{-}s_c)\, g_t^H \text{-} \overline{\tau}^H y_t^H \text{-} \overline{\tau}^H \tau_t^H \right] \right\} + \widehat{\varepsilon}_{b^H,t} \tag{49H}$$

$$\widehat{b}_t^F = i_t + \frac{1}{\beta} \left\{ \widehat{b}_{t-1}^F \text{-} \pi_t \text{-} n\,(1\text{-}\beta)\, q_t + \frac{\overline{Y}}{\overline{b}} \left[(1\text{-}s_c)\, g_t^F \text{-} \overline{\tau}^F y_t^F \text{-} \overline{\tau}^F \tau_t^F \right] \right\} + \widehat{\varepsilon}_{b^F,t} \tag{49F}$$

where $\widehat{\varepsilon}_{b^H,t}$ and $\widehat{\varepsilon}_{b^F,t}$ are composite shocks defined as

$$\begin{aligned} \widehat{\varepsilon}_{b^H,t} &= \widetilde{i}_t + \frac{1}{\beta} \left\{ (1\text{-}n)(1\text{-}\beta)\, \widetilde{T}_t + \frac{\overline{Y}}{\overline{b}} \left[(1\text{-}s_c)\, \widetilde{G}_t^H \text{-} \overline{\tau}^H \widetilde{Y}_t^H + \left(1\text{-}\overline{\tau}^H\right) \widehat{\mu}_{w,t}^H \right] \right\} \\ \widehat{\varepsilon}_{b^F,t} &= \widetilde{i}_t + \frac{1}{\beta} \left\{ -n\,(1\text{-}\beta)\, \widetilde{T}_t + \frac{\overline{Y}}{\overline{b}} \left[(1\text{-}s_c)\, \widetilde{G}_t^F \text{-} \overline{\tau}^F \widetilde{Y}_t^F + \left(1\text{-}\overline{\tau}^F\right) \widehat{\mu}_{w,t}^F \right] \right\} \end{aligned}$$

the steady-state tax rates required to support the exogenously given initial steady-state ratio of public debt-to-output are given by

$$\begin{aligned} \overline{\tau}^H &= (1-\beta) \frac{\overline{b}^H}{\overline{Y}} + (1-s_c) \\ \overline{\tau}^F &= (1-\beta) \frac{\overline{b}^F}{\overline{Y}} + (1-s_c) \end{aligned}$$

and the efficient levels of taxation $\widetilde{\tau}^H$ and $\widetilde{\tau}^F$ in the two countries are

$$\widetilde{\tau}^{H} = -\frac{1-\overline{\tau}^{H}}{\overline{\tau}^{H}}\widehat{\mu}_{w,t}^{H}$$
$$\widetilde{\tau}^{F} = -\frac{1-\overline{\tau}^{F}}{\overline{\tau}^{F}}\widehat{\mu}_{w,t}^{F}$$

the ones compatible with full stabilization of inflation, private and public consumption gaps and terms-of-trade gap so that the AS equations become

$$\pi_t^H = \gamma_b^H \pi_{t-1}^H + \gamma_f^H E_t \pi_{t+1}^H + k^H \left(1+s_c\rho\eta\right)\left(1\text{-}n\right) q_t + k^H \frac{1+s_c\sigma\eta}{\sigma} c_t^w + k^H \left(1\text{-}s_c\right)\eta g_t^H + k^H \frac{\overline{\tau}^H}{\left(1\text{-}\overline{\tau}^H\right)} \tau_t^H \tag{50H}$$

$$\pi_t^F = \gamma_b^F \pi_{t-1}^F + \gamma_f^F E_t \pi_{t+1}^F \text{-} k^F \left(1+s_c\rho\eta\right) n q_t + k^F \frac{1+s_c\sigma\eta}{\sigma} c_t^w + k^F \left(1\text{-}s_c\right)\eta g_t^F + k^F \frac{\overline{\tau}^F}{\left(1\text{-}\overline{\tau}^F\right)} \tau_t^F \tag{50F}$$

Equations 41, 42H, 42F, 44, 49H, 49F, 50H and 50F summarize the dynamic behaviour of the economies as observed by policymakers.

1.3 Policy objectives

Policymakers solve their optimization problems each period, given initial conditions and the rate of time preferences. The resulting optimal policy reactions lead to stochastic equilibria that should be compared across through an appropriate metric. The natural metric for welfare comparisons is a micro-founded social loss function. Benevolent authorities adopt the social loss function as the setup for policymaking. Hence, this welfare criterion enables us to derive optimal stabilization policies but also to evaluate alternative policies that are derived from other institutional setups.

1.3.1 Social loss function

In our framework, the natural welfare criterion is the discounted sum of the utility flows of the households belonging to the whole union and both monetary and fiscal policies are coordinated. The average utility flows is defined at each time t as

$$\begin{aligned} w_t &\equiv n w_t^H + (1-n) w_t^F \\ \text{with } w_t^H &= u\left(C_t^H, \overline{C}_t^H\right) + V\left(G_t^H\right) - \frac{1}{n}\int_0^n v\left(L_t^j\right) dj \\ \text{and } w_t^F &= u\left(C_t^F, \overline{C}_t^F\right) + V\left(G_t^F\right) - \frac{1}{1-n}\int_n^1 v\left(L_t^j\right) dj \end{aligned}$$

where it has been assumed that each country has a weight equal to its economic and population size. The welfare criterion for the whole union is then defined as

$$W = E_0 \left\{ \sum_{t=0}^{\infty} \beta^t w_t \right\}$$

Following Rotemberg and Woodford (1998, 1999), Woodford (2003), Benigno (2004), Amato and Laubach (2003), Steinsson (2003) and Beetsma and Jensen (2004, 2005), we compute a quadratic (second-order Taylor series) approximation of *W* around a deterministic steady-state where all the shocks are set to zero. Ignoring the terms independent of policy as well as terms of $\mathcal{O}\left(||\xi||^3\right)$ or higher order, our second-order approximation delivers a representation of the welfare function:[28]

$$W = -\Omega E_0 \left\{ \sum_{t=0}^{\infty} \beta^t L_t \right\}, \tag{51}$$

with

$$\begin{aligned} L_t = {} & \Lambda_c \left(c_t^w\right)^2 + \Lambda_g \left[n \left(g_t^H\right)^2 + (1\text{-}n)\left(g_t^F\right)^2 \right] + \Lambda_{gc}\left(c_t^w\right)\left[n\left(g_t^H\right) + (1\text{-}n)\left(g_t^F\right)\right] + \Lambda_T q_t^2 \\ & \text{-}\Lambda_{gT}\left(g_t^F\text{-}g_t^H\right) q_t + n\Lambda_\pi^H \left(\pi_t^H\right)^2 + (1\text{-}n)\Lambda_\pi^F\left(\pi_t^F\right)^2 + n\Lambda_{\Delta\pi}^H\left(\Delta\pi_t^H\right)^2 + (1\text{-}n)\Lambda_{\Delta\pi}^F\left(\Delta\pi_t^F\right)^2 \end{aligned} \tag{52}$$

[28]The derivation of the social loss function is available upon request.

and

$$\Lambda_c \equiv s_c\left(\frac{1}{\sigma}\text{+}s_c\eta\right), \quad \Lambda_g \equiv (1\text{-}s_c)\left(\frac{1}{\psi}\text{+}(1\text{-}s_c)\eta\right), \quad \Lambda_{gc} \equiv 2s_c\,(1\text{-}s_c)\,\eta,$$

$$\Lambda_T \equiv n\,(1\text{-}n)\,s_c\rho\,(1\text{+}s_c\rho\eta)\,, \quad \Lambda_{gT} \equiv 2n\,(1\text{-}n)\,s_c\,(1\text{-}s_c)\,\rho\eta, \quad \Lambda_\pi^H \equiv \frac{\theta\,(1\text{+}\theta\eta)\,\alpha^H}{(1\text{-}\alpha^H\beta)\,(1\text{-}\alpha^H)},$$

$$\Lambda_\pi^F \equiv \frac{\theta\,(1\text{+}\theta\eta)\,\alpha^F}{(1\text{-}\alpha^F\beta)\,(1\text{-}\alpha^F)}, \quad \Lambda_{\Delta\pi}^H \equiv \frac{1\text{-}\lambda^H}{\lambda^H\alpha^H}\Lambda_\pi^H, \quad \Lambda_{\Delta\pi}^F \equiv \frac{1\text{-}\lambda^F}{\lambda^F\alpha^F}\Lambda_\pi^F$$

Fluctuations of the consumption gap and in the public spending gaps imply welfare losses due to households' aversion towards consumption and public spending risk ($1/\sigma$ and $1/\psi$), as well as fluctuations in work effort (η). Home inflation is more costly the higher the degree of nominal rigidity $\left(\alpha^H\right)$, the higher the elasticity of substitution between Home-produced goods (θ) and the elasticity of disutility with respect to work effort (η). The welfare cost of inflation vanishes $\left(\Lambda_\pi^H\right)$ when prices are fully flexible $\left(\alpha^H = 0\right)$.

At the monetary union level, misallocation of goods also applies for deviations of the terms of trade from their efficient level. The costs of this distortion (Λ_T) increase with the elasticity of substitution between Home and Foreign produced goods (ρ), with the steady-state consumption share on output (s_c), with η and with the symmetry on countries' economic size. Following an asymmetric technologic shock, efficiency requires that relative prices should be moved in order to shift the burden of adjustment "equally" across the two countries (Benigno and López-Salido, 2006). This creates a trade-off for the monetary authority which is also concerned with stabilizing Home and Foreign producer inflation rates. This trade-off is further amplified by last terms in the loss function, which come from the presence of backward-looking firms in both countries. Policymakers should also be concerned with stabilizing the growth rate of Home and Foreign inflation rates, when past inflation is also important to explain inflation persistence. This trade-off, that the monetary authority faces, between stabilizing relative prices to their efficient levels and stabilizing inflation and the growth rate of inflation in both countries provides a rational for fiscal policy stabilization.

The cross term between the consumption gap and the weighted average government spending gap occurs because positive co-movements between these two variables cause undesirable fluctuations in world work effort, in addition to the effort fluctuations caused by each of these variables per se. There is also a negative cross-term between the terms of trade gap and the relative spending gap that is increasing (in absolute value) with η, ρ and decreasing with the asymmetry of countries' size. This negative co-movement arises because a positive terms of trade gap rises Home competitiveness, which, combined with a negative relative public spending gap (more public spending at Home than at Foreign) shift demand towards Home produced goods. As a consequence, work effort shifts from Foreign towards Home households (cf. Beetsma and Jensen 2004 and 2005, for these arguments).

1.3.2 Other policy objectives

When policymakers share the same objectives, the outcomes of the games played under the different discretionary policy regimes are the same. Dixit and Lambertini (2003a, 2003b) show, in a static setup, that when fiscal authorities and monetary authority agree on the ideal levels of country's output and common inflation rate, these will be obtained, regardless the structure of the game or the existence of any disagreement about the relative weights of the objectives. Considering a dynamic closed-economy model, Blake and Kirsanova (2006) and Kirsanova et al. (2006b) also show that discretionary outcomes do not depend on the structure of the game. Hence, it is useful for the analysis to set policymakers diverging in their policy objectives. There are many arguments sustaining this assumption. First of all, it is natural to admit that national fiscal authorities are mainly concern with their own citizens and so, the objective functions of benevolent non-cooperative fiscal authorities should reflect only the utility functions of their constituencies. The derivation of the appropriate utility-based loss functions for independent and non-cooperative fiscal authorities requires extra computations to avoid linear terms. Benigno and Benigno (2006) obtain loss functions, for cooperative and non-cooperative monetary policy regimes, that are identical on the forms but are different in the targets and the weights. Pragmatically, we approximate the national welfare criterions through welfare losses obtained from splitting the union-wide loss function. We let for future extension the derivations of the national welfare functions.

We should also take into attention other institutional arrangements that result in different objective functions for fiscal and monetary authorities. In the context of the EMU, it is natural to admit that the ECB is likely to be more conservative than the politicians who run the treasuries in the member countries, either by explicit mandate or by natural inclination. This hypothesis can easily be modeled by distorting the weights on the inflation and the output terms of the social loss function.[29]

Conversely, fiscal authorities are likely to be more concerned with output stabilization than inflation. Moreover, short-sighted politicians may discount more strongly the future than benevolent politicians. Calmfors (2003) states that there are strong arguments for a fiscal stabilization policy in the case of a country-specific recession but the arguments are less clear-cut in case of a country-specific boom. This could be a rationale for the consideration of asymmetric policy objectives, as Bennett and Loyaza (2005) have considered in a static game theoretic model. Following the same strategy of the weight-conservative hypothesis, we will consider that national fiscal authorities have symmetric preferences but they are biased towards the stabilization of domestic output-terms.

We focus on the cases of a weight-conservative central bank and of output-biased fiscal authorities, because they exemplify two different but concurrent argumentations on the policy stabilization debate. On the one hand, delegating monetary policy to a weight-conservative central bank is currently seen as a potential solution to reduce the time-inconsistency problems of policy stabilization. On the other hand, these time-inconsistency problems are seen to be aggravated by specific incentives of the fiscal authorities. The political economy literature highlights several motivations that potentially result in fiscal laxity and in wrong policy mix. Hence, whereas fiscal authorities, especially concerned with output variability, are expected to aggravate policy stabilization problems, delegating monetary policy to a central bank more averse than society to inflation variability is

[29] In addition, we could also consider that the ECB dislikes fluctuations in its instrument policy variable, that is, it has an interest rate smoothing objective. See for instance Buti et al. (2001) and Beetsma et al. (2001).

an institutional arrangement usually referred as a solution to mitigate such stabilization problems. The table below summarizes the policy scenarios we will analyze.

Benevolent Cooperative Policymakers
$L_t^{H,F}=L_t$ $L_t^{M}=L_t$
Benevolent non-Cooperative Policymakers
$L_t^{H}=\Lambda_c\left(c_t^{w}\right)^2+\Lambda_g\left(g_t^{H}\right)^2+\Lambda_{gc}c_t^{w}g_t^{H}+\Lambda_T q_t^2+\frac{1}{n}\Lambda_{gT}g_t^{H}q_t+\Lambda_\pi^{H}\left(\pi_t^{H}\right)^2+\Lambda_{\Delta\pi}^{H}\left(\Delta\pi_t^{H}\right)^2$ $L_t^{F}=\Lambda_c\left(c_t^{w}\right)^2+\Lambda_g\left(g_t^{F}\right)^2+\Lambda_{gc}c_t^{w}g_t^{F}+\Lambda_T q_t^2-\frac{1}{1-n}\Lambda_{gT}g_t^{F}q_t+\Lambda_\pi^{F}\left(\pi_t^{F}\right)^2+\Lambda_{\Delta\pi}^{F}\left(\Delta\pi_t^{F}\right)^2$ $L_t^{M}=L_t$
Conservative Central Bank
$L_t^{H};L_t^{F}$ $L_t^{M}=\left(1-\rho^{c}\right)\left\{\Lambda_c\left(c_t^{w}\right)^2+\Lambda_g\left[n\left(g_t^{H}\right)^2+\left(1-n\right)\left(g_t^{F}\right)^2\right]+\Lambda_{gc}c_t^{w}\left[n\left(g_t^{H}\right)+\left(1-n\right)\left(g_t^{F}\right)\right]+\Lambda_T q_t^2-\Lambda_{gT}\left(g_t^{F}-g_t^{H}\right)q_t\right\}$ $+\rho^{c}\left\{n\Lambda_\pi^{H}\left(\pi_t^{H}\right)^2+\left(1-n\right)\Lambda_\pi^{F}\left(\pi_t^{F}\right)^2+n\Lambda_{\Delta\pi}^{H}\left(\Delta\pi_t^{H}\right)^2+\left(1-n\right)\Lambda_{\Delta\pi}^{F}\left(\Delta\pi_t^{F}\right)^2\right\}$
Output-biased Fiscal Authorities
$L_t^{H}=\rho^{e}\left[\Lambda_c\left(c_t^{w}\right)^2+\Lambda_g\left(g_t^{H}\right)^2+\Lambda_{gc}c_t^{w}g_t^{H}+\Lambda_T q_t^2+\frac{1}{n}\Lambda_{gT}g_t^{H}q_t\right]+\left(1-\rho^{e}\right)\left[\Lambda_\pi^{H}\left(\pi_t^{H}\right)^2+\Lambda_{\Delta\pi}^{H}\left(\Delta\pi_t^{H}\right)^2\right]$ $L_t^{F}=\rho^{e}\left[\Lambda_c\left(c_t^{w}\right)^2+\Lambda_g\left(g_t^{F}\right)^2+\Lambda_{gc}c_t^{w}g_t^{F}+\Lambda_T q_t^2-\frac{1}{1-n}\Lambda_{gT}g_t^{F}q_t\right]+\left(1-\rho^{e}\right)\left[\Lambda_\pi^{F}\left(\pi_t^{F}\right)^2+\Lambda_{\Delta\pi}^{F}\left(\Delta\pi_t^{F}\right)^2\right]$ $L_t^{M}=L_t$

1.4 Policy Games

We assume that fiscal and monetary authorities set their policy instruments in order to minimize their loss functions, given the dynamic structure of the economies, and that they can engage themselves in various policy games. We will consider, as a benchmark case for policy analysis, that policymakers are benevolent and cooperate when they minimize their policy objectives under discretion. To assess the importance of the time-consistent problems on the policy stabilization performance, we also compute the optimal policy solution under commitment. These two optimizing problems will be solved by using the algorithms described recently by Soderlind (1999).

We also consider discretionary non-cooperative policy games and, depending on the time of events, we can obtain Nash or leadership equilibria. In these different setups, the timing of the events is as following: 1) the private sector forms expectations; 2) the shocks are realized; 3a) the central bank sets the interest rate in order to optimize its objectives; 3b) the fiscal authorities choose the fiscal policy instruments to optimize their objective functions. If 3a) and 3b) occurs simultaneously we get a Nash equilibrium; if 3a) occurs first and the central bank when chooses its policy is aware of the fiscal policy reaction we get a monetary leadership equilibrium; if the order of the occurrences is reversed, we have fiscal leadership equilibria. We will assume that the fiscal authorities act at the same time and play a Nash between them. To solve these dynamic policy games we use the methodology developed by Blake and Kirsanova (2006) for a closed-economy setup and by Kirsanova et al. (2005) for an open-economy model.

To illustrate the type of problems we are thinking on, we present next the case of a full non-cooperative discretionary with monetary leadership and fiscal authorities as followers playing a Nash between them.[30]

We have five strategic agents in the game. There are three explicit players, the monetary and the two fiscal authorities, and two implicit players, the private sector of both countries, that always act in last. In this type of game, the monetary authority moves first and sets the interest rate. Then the two fiscal authorities decide the levels of their policy instruments. Finally, the private sector in both countries reacts being the ultimate follower.

To solve this type of game, one inverts the order of playing and begins by solving the optimization of the last player ending up with the optimization of the leader (the first player). The private sector's optimization problem is already solved out - the system of the structural equations of the model - and can be represented by the system:

$$\begin{bmatrix} Y_{t+1} \\ X_{t+1} \end{bmatrix} = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix} \begin{bmatrix} Y_t \\ X_t \end{bmatrix} + \begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix} \begin{bmatrix} U_t^H \\ U_t^F \end{bmatrix} + \begin{bmatrix} D_1 \\ D_2 \end{bmatrix} U_t^M + \begin{bmatrix} \varepsilon_{t+1} \\ \mathbf{O} \end{bmatrix} \quad (53)$$

where Y_t are predetermined state variables and X_t are the effective instruments of private sectors, the non-predetermined or jump variables (consumption and the two inflation rates, in our model). The policy instruments are represented by U_t^H, U_t^F and U_t^M. U_t^H and U_t^F stand for the instruments of the followers which are, respectively, the Home and the Foreign fiscal authorities, while U_t^M represents the instrument of the leader, which is the

[30]We present in appendix a numerical algorithm for the solution of the discretionary monetary leadership regime.

monetary authority. ε_{t+1} is a vector of innovations to Y_t with covariance matrix Σ. This system describes the evolution of the economy as observed by policymakers.

In the discretionary case, the three policymakers reoptimize every period by taking the process by which private agents form their expectations as given - and where the expectations are consistent with actual policies (Söderlind 1999). The two Nash fiscal authorities minimize their loss functions treating the monetary policy instrument as parametric but incorporating the reaction functions of the private sectors. Assuming that the fiscal authority of the H country has the following objective function:

$$\frac{1}{2}E_0\sum_{t=0}^{\infty}\beta^t\left(G_t^{H\prime}Q^H G_t^H\right)=\frac{1}{2}E_0\sum_{t=0}^{\infty}\beta^t\left(Z_t'\mathcal{Q}^H Z_t+Z_t'\mathcal{P}^H U_t+U_t'\mathcal{P}^{H\prime}Z_t+U_t'\mathcal{R}^H U_t\right) \tag{54}$$

where G_t^H is the target variables for the H fiscal authority while Q^H is the corresponding matrix of weights. The target variables can be rewritten in terms of the predetermined and non-predetermined state variables collected on vector Z_t, in terms of the policy instruments (U_t) and in terms of combinations of these two variables. Being a follower, the H fiscal authority observes monetary authorty's actions and reacts to them. In a linear-quadratic setup, the optimal solution belongs to the class of linear feedback rules of the form:

$$U_t^H=-F^H Y_t-L^H U_t^M \tag{55}$$

where F^H denotes feedback coeficcients on the predetermined state variables and L^H is the leadership parameter. The other fiscal authority solves a similar problem and get:

$$U_t^F=-F^F Y_t-L^F U_t^M \tag{56}$$

Being in a Nash game, the two fiscal authorities do not respond to each other's actions.

The monetary leadership authority takes into account these fiscal policy reaction functions as well as the private sector's optimal conditions, when solves its optimization problem. Thus, the leader can manipulate the follower by changing its policy instrument. The monetary leadership reaction function takes the form of:

$$U_t^M = -F^M Y_t \tag{57}$$

1.5 Calibration

Our baseline calibration was chosen taking as reference Beetsma and Jensen (2004, 2005), Benigno and Benigno (2006), Benigno (2004), Benigno and López-Salido (2006) and Ferrero (2007).

As it is common in the literature, we assume that each period corresponds to a one quarter of a year. The one period discount factor of the private sector and policy makers β is set to 0.99, which implies a four percent annual basis steady-state interest rate.

The parameter θ, the elasticity of substitution between goods produced in the same country, is set such that the price mark-up is equal to 10%. We thus set θ equal to 11, which is a high value than the one found in the literature where distortions come only from monopolistic competition in the goods market[31]. The elasticity of substitution between Home and the Foreign produced goods ρ is set to 4.5, as in Benigno and Benigno (2006). These authors remark that, when this intratemporal elasticity is higher than the intertemporal elasticity of substitution in consumption (σ), the home and the foreign goods are substitutes in the utility. We follow Beetsma and Jensen (2004, 2005) and set the coefficient of the intertemporal elasticity of substitution in consumption σ at 0.4, which implies a coefficient of risk aversion for private consumption equal to 2.5. This is also the value we adopt for the coefficient of risk aversion for public spending $(1/\psi = 2.5)$. The steady-state value of consumption over output $\left(s_c{=}\overline{C}/\overline{Y}\right)$ is set at 0.75 in our baseline calibration.

Following Benigno and Benigno (2006) and Ferrero (2007), the inverse of the Frisch elasticity of labour supply to real wage, η, is assumed to be 0.47.[32] Our benchmark calibration intends to reflect a perfectly symmetric setup from which we can diverge and

[31] See Ferrero (2007) on this.

[32] Beetsma and Jensen (2004, 2005) emphasize the dilemma of choosing reasonable values for this parameter and for the mark-up and getting realistic magnitudes on the inflation response to changes in real variables. They set $\eta = 0.3$ and $\eta = 10$ on their papers of 2005 and 2004, respectively.

assess how asymmetries affect the results. Hence, we begin by assuming that the two economies in the monetary union have an equal size $(n = 0.5)$, have identical degrees of nominal rigidities $\left(\alpha^H = \alpha^F\right)$ and share the same proportion of rule-of-thumbers firms (1-λ^H=1-λ^F). We select a value for α equal to 0.75, in order to get an average length of price contracts equal to one year. Afterwards, we will allow this parameter to diverge across countries and we will get countries with different degrees of nominal rigidities. This is an important issue for a common monetary policy, as Benigno (2004) and Aoki (2001) have noticed.

Many empirical studies agree in concluding that the empirical Phillips curve has a significant backward-looking component. However, the empirical estimates vary widely across them. Some of them find a predominant forward-looking component while, in others, the backward-looking component prevails[33]. Since there is less consensus and the evidence is less clear cut, we will follow Kirsanova et al. (2005) and calibrate to 0.5 the fraction of firms acting as backward looking price setters $(1 - \lambda^i)$, but we will take particular attention to the results under other calibrations of this parameter. Notice that, with $1 - \lambda^i = 0$, the domestic "hybrid" curves of Phillips collapse to the pure forward-looking case. Finally, we assume that the log-linear deviations of average and relative shocks to consumption and productivity follow an uncorrelated AR(1) process with common persistence of 0.85, while the wage mark-up shocks are i.i.d., and the standard deviation of the innovations are equal to 0.01.

We also try to assess an EMU scenario, taking as reference the five large countries of the euro area - Germany, Italy, France, Spain and Netherlands -, which account for about 85 per cent of the total GDP in 2005. There are various criterions we can follow to collect these economies in two groups – one to represent country H and other to symbolise country F.

Some authors like Benigno (2004) and Benigno and López-Salido (2006) highlight the importance, for the design of the optimal monetary policy, of having a currency union with structural heterogeneity in the degrees of nominal rigidity and of inflation persis-

[33] See for instance Gali and Gertler (1999) and Benigno and López-Salido (2006) for the prevalence of the forward-looking specification and Mehra (2004) for a backward-looking extreme case.

tence, when there is an endogenous non-distortionary fiscal policy instrument that ensures the verification of the government budget constraint for any given level of public debt and all the other policy instruments are exogenous. In both cases, the terms-of-trade is not insulated from monetary policy and this policy should be conducted to mitigate the distortions in the relative price mechanism. While Benigno concludes that monetary policy should follow an inflation targeting rule which puts higher weight in the inflation rate of the country with higher degree of nominal rigidity, Benigno and López-Salido conclude similarly for the country with higher degree of inflation persistence. Andrea Ferrero (2007) demonstrates that, when all fiscal policy instruments are exogenous, monetary policy can not prevent explosive debts in a monetary union with symmetric nominal rigidities whereas, in some cases, it can ensure debt sustainability when there are differentiated degrees of nominal rigidity across countries. Actually, Ferrero characterizes the optimal targeting rules for a monetary union calibrated to have asymmetric rigidities and where distortionary taxation and government debt are endogenously determined. In a diverse fiscal regime, where home-biased government spending is the stabilization fiscal policy instrument and lump-sum taxes automatically adjust to satisfy the budget constraint, Beetsma and Jensen (2004, 2005) also integrate the existence of asymmetric rigidities in their analysis of the optimal joint conduct of fiscal and monetary policy stabilization in a two-country monetary union. They show that, with symmetric rigidities, fiscal policy should not be employed in stabilizing union-level variables and monetary policy does not stabilize relative variables but, with asymmetric rigidities, both policies should be concerned with the stabilization of relative and aggregate variables.

Hence, it is evident that the asymmetry on price rigidity and on inflation persistence it is important for the design of the optimal stabilization policies in a monetary union. However, Leith and Wren-Lewis (2007a) have shown that the optimal discretionary stabilization policy plan depends crucially on the level of the debt-output ratio. The relative efficiency of the monetary and fiscal policy instruments to accomplish the short-run and the long-run stabilization assignments depends on the size of the debt stock: the tax rate reveals to increase its short-run stabilization performance with the raise of the debt-output ratio at the same time as it becomes less effective on the satisfaction of the government budget constraint. Despite the numerical constraints of the Maastricht Treaty prescribing, namely, that public debt should not exceed 60 per cent of GDP, it is a fact that some countries in the euro area exceed largely this limit and that there is high heterogeneity concerning this fiscal policy indicator.

Therefore, given the importance of public debt to the monetary and fiscal policy interactions, we choose to calibrate a two-country EMU scenario using as criterion the magnitude of the debt to GDP ratio. Taking as reference the five large countries of the euro area we consider a high debt country (H) and a low debt country (F). The prototypical H country represents Germany, France and Italy and its yearly steady-state debt-output ratio is calibrated to 80%, which corresponds to the weighted average of the debt-output ratios of these countries, in the period 2002-2005. Country F matches the average debt ratio of Spain and Netherlands in the referred period (roughly 50%)[34]. Moreover, taking weighted averages of the estimations of the degree of price stickiness and of inflation persistence for these countries provided by Benigno and López-Salido (2006), we get the calibration for these structural parameters in the two prototype countries. Country H has a high degree of nominal rigidity ($\alpha^H = 0.76$) and a relatively small degree of inflation persistence (the fraction of rule-of-thumb firms represents 26% of the total, $\omega^H = 0.26$). Country F represents a backward-looking country ($\omega^F = 0.56$) having a relatively low degree of price stickiness ($\alpha^F = 0.72$). Finally, our choice of the two EMU representative countries[35] also pins down the parameterization of the relative size of country H to $n^H = 0.8$. The stochastic processes are restricted to be the same in the two countries and the first-order autoregressive coefficients and the variances of the shocks are calibrated taking the posterior median estimates reported in Smets and Wouters (2003). Table D.1 reports the calibrated values for the remaining parameters of the model and the implied steady-state magnitudes for the baseline and the EMU scenarios.

[34]Sources: ECB Monthly Bulletin - Euro Area Staitistcs Online - and Satitistics Pocket Book Online, March 2007.

[35]Benigno and López-Salido (2006) and Ferrero (2007) present an alternative EMU representation. They use, as criterion, the degree of nominal rigidity (and the degree of inflation persistence) to get two homogeneous groups of countries. In spite of the use of a different criterion, we end up by getting two countries with different degrees of price stickiness and inflation persistence. Our country H includes Germany and it is correctly parameterized to be a more forward-looking country with relatively low price flexibility.

2. Policy Analysis in a Model with Balanced-budget Fiscal Policies

In EMU, where monetary policy is centralized, fiscal policy emerges as the lone flexible instrument available for individual countries to stabilize country-specific shocks. However, there is still much to learn on how fiscal policy is transmitted and what would the better specification of fiscal policy be, given its multidimensionality. There are still many doubts about the usefulness of fiscal policy as a stabilization tool for reasons related to political and budgetary processes.

In what follows, we will try to get some insights on the fiscal policy stabilization gains in a monetary union, when each government uses, as fiscal policy instrument, a balanced budget change on home-biased and useful government spending. Here, fiscal policy has no supply-side effects, monetary policy does not interfere with the government financing sources and, thus, the sources of strategic interactions between fiscal and monetary authorities are minimal. The fiscal and the monetary policy instruments exert both their stabilization effects on the economy through the demand channel but with differentiated impacts on country-specific and union-wide variables. We intend to assess how fiscal and monetary policies interact in macroeconomic stabilization of a country-size asymmetric monetary union, where policymakers lack credible commitment tools and where policy-making "reality" is approximated by means of optimizing discretionary fiscal and monetary policy games. Most of the recent literature that uses dynamic settings for policy stabilization analysis restrains the discretionary policy games to the Nash policy game case. But, the current policy debate seems to assume that the central bank moves first and that the fiscal authorities follow and, thus, the policy stabilization game is a monetary leadership game. However, some authors, like Beetsma and Bovemberg (1998), have argued that, as it takes a long time to change fiscal policy instruments whereas monetary policy can be adjusted more quickly, the policy game played by monetary and fiscal authorities is a fiscal leadership game. Kirsanova et al. (2005) argue that, in a monetary union, fiscal authorities cannot act as Stackelberg leaders unless they coordinate themselves. We think that we can envisage fiscal authorities having a first move advantage relative to the monetary authority while playing a Nash amongst them, if they set their policies non-cooperatively. To gain intuition on the type of dynamic strategic policy interactions that the different order of playing creates, we will consider all policy games.

Discretionary policies are appealing in order to represent policymaking because they are time-consistent. However, they are not a first-best and, so, even when policymakers are benevolent, there can be welfare gains from promoting institutional changes.

Moreover, some authors like Lambertini and Rovelli (2004) sustain that it is reasonable to be apprehensive on the possibility of the balanced budget policies undermining the stance of monetary policy in the pursuit of price stability. Even if fiscal discipline is not a problem in this setup, inflation pressures attached to expansionary fiscal policies of fully tax-financed acting on the demand-side may occur. This argument focuses on the existence of diverging fiscal and monetary policy objectives and on the possible destabilizing role of a disciplined fiscal policy, regarding price stability.

In line with these arguments, we intend to assess the potential benefits of some traditional institutional arrangements in the literature, such as: the imposition of fiscal policy constraints; the promotion of horizontal (among fiscal authorities) and vertical (among monetary and fiscal authorities) policy cooperation; and the delegation of the monetary policy to a weight-conservative central bank. Our main objective is to reevaluate these issues in a monetary union where small and large countries coexist.

In the next section, we will characterize optimal policies under benevolent policy policymakers. We will analyze the dynamic response of the relevant endogenous variables to some exemplificative shocks and, we will quantitatively complement this analysis with the computation of welfare losses. Next, we will extend the analysis to some non-benevolent scenarios, where fiscal and monetary authorities have distorted policy objectives. Finally, we will perform some sensitivity analysis seeking to address some specific additional questions.

2.1 Benevolent policy authorities

We start by assuming that all policymakers are benevolent and share the same policy objective function: the union-wide social loss function. Under a common loss function, the strategic interactions between the different policymakers are null and, thus, the equilibrium is the same no matter what the discretionary policy games are. In this context, we can legitimately set the discretionary cooperative regime as the benchmark for policy analysis. Secondly, we will assume that policymakers remain benevolent but are biased towards their own constituencies. Hence, we consider fiscal authorities to be domestically-oriented, whereas the central bank remains union-wide oriented. This is a slightly more realistic setup, for instance, in regard of the EMU functioning, and enables the discussion of the gains from fiscal policy coordination and the assessment on which countries (large or small) gain more from it.

In what follows, we first consider the optimal policy responses to symmetric shocks, which are usually seen as an exclusive task for monetary policy. We conclude that, in the cooperative regime, symmetric shocks do not create any policy trade-off to fiscal policy. However, in the non-cooperative settings, both monetary and fiscal policymakers face incentives to react to this type of shocks and, thus, there is also a case for a meaningful analysis of the fiscal and monetary policy interactions.

The rationale for the use of the fiscal policy as a stabilization tool is mainly found in the need to stabilize the effects of country-specific shocks. Moreover, since their impact on the union-wide variables depends on the relative size of the country hit by the shock, we expect country-size asymmetry to be an important variable in the policy interaction outcomes and in the distribution of the stabilization burden of these shocks across countries. Hence, we will proceed with the policy analysis of the asymmetric shocks and, finally, we will evaluate the welfare implications of the alternative policies.

2.1.1 Adjustments to shocks within a monetary union of equal-size countries

Benchmark scenario: discretionary coordinated policies

Symmetric shocks

In the present model, where lump-sum taxes are endogenously adjusted to ensure intertemporal government solvency together with full efficiency, the budgetary consequences of the monetary policy have no impact on welfare. Consequently, the central bank can freely react to symmetric shocks without constraining the use of fiscal policy instruments. Here, where, the sole fiscal policy instrument, it is home-biased and useful government spending, there are welfare costs of making it diverge from its efficient level. Moreover, both policy instruments exert their effects on the macroeconomic variables through the demand channel, even though their impacts on the diverse welfare-related variables do not have the same magnitude. Hence, it is natural to expect that, in a full cooperative and benevolent regime, there is no place for the use of government spending gaps to stabilize symmetric shocks.

In fact, given the existence of enough lump-sum taxes, neither the symmetric demand shock nor the symmetric productivity shock creates any policy trade-off. Government expenditures and the interest rate are optimally set at their efficient levels and they fully stabilize the effects of these shocks. On the other hand, cost-push shocks do not affect the efficient flexible-price equilibrium. However, perfectly positively correlated cost-push shocks raise inflation in both countries and, since there are nominal rigidities, there are inefficient fluctuations across goods that are identically valued on individuals' utilities. The inflation-output dilemma vivifies but it only applies to the use of the monetary policy instrument. Effectively, to lessen the misallocation of goods it is optimal to increase the interest rate and set the H and F government spending at their efficient zero levels. The raise of the interest rate decreases the consumption gap and, consequently, lowers the inflation rate in both countries. In our model specification, where government spending has a crowding-out effect on consumption, it would be possible, by reducing government spending, to attenuate the monetary policy effects on the consumption gap without penalizing inflation. However, since the benefits from decreasing the aggregate public spending gap, in terms of a lower fluctuation in the consumption gap, are overwhelmed by the costs of having positive co-movements between the two variables[36] and of having government spending variability, fiscal policy does not share the stabilization burden of these shocks with monetary policy. These results can be demonstrated, by observation of the feedback coefficients of the optimal discretionary policy rules displayed in Table D.2. It is interesting to observe that other authors, such as Blake and Kirsanova (Oct. 2006), obtain a different fiscal policy response to a cost-push shock in a closed economy framework. There, the government spending rises in response to a cost-push shock and displays a traditional counter-cyclical trajectory, because the AS equation and the social loss have terms which depend on past inflation and also on past output.[37]

Asymmetric shocks

Demand-side asymmetric shocks are irrelevant for policy stabilization in our model, because financial markets are complete. Due to perfect risk sharing, any idiosyncratic demand shock alters the marginal utilities of consumption by the same amount in both countries. Thus, the effect on the terms-of-trade is null, because the work effort changes by the same magnitude in the two countries.

A negative productivity shock at the Home country (H) lowers output and increases the price level at H but, given price stickiness, there is a positive terms-of-trade gap and also a positive output gap in H. The positive terms-of-trade gap shifts the demand from Foreign produced goods to Home produced goods, lowering inflation rate and the output gap in the Foreign country (F). Under symmetric nominal rigidities, the monetary policy can not affect cross-country inflation differentials and, thus, domestic fiscal policies are needed to mitigate the welfare consequences of the misallocation of goods, at the monetary union level. Hence, to alleviate these external distortions, the government spending gap has to increase at F and to decrease at H. The world government spending and the interest rate gaps stay at the respective zero steady-state levels, since the union-wide variables are not affected by the shock. Figure 1 displays the impulse responses to

[36]A positive co-movement between the consumption gap and the aggregate government spending gap is welfare-reducing, because it causes undesirable fluctuations in the work effort.

[37]This follows from the adoption of Steinsson's (2003) specification of the rule-of-thumb firms' behaviour. In our model, we have followed Galí and Gertler (1999) and Amato and Laubach (2003) on this and, thus, no output persistence occurs.

a one-standard negative productivity shock at H, under the baseline parameters, except for the elimination of any shock persistence. The dynamics are, as expected, very similar to the ones presented by Beetsma and Jensen (2005), apart from those in the inflation rates, which, exhibit a smoother trajectory due to the existence of inflation persistence in our model. Figure 1 confirms their findings on the counter-cyclical conduct of the fiscal policy instruments in response to a country-specific productivity shock.

Different from productivity shocks, cost-push shocks, exemplified by mark-up shocks, affect both relative and union-wide aggregate variables and, thus, call for the use of both monetary and fiscal policy instruments in the stabilization process.

A cost-push shock at H raises its GDP inflation rate and depresses the terms-of-trade gap. Under full flexible-price adjustments, the negative terms-of-trade gap would efficiently shift demand from H to F goods. However, under nominal rigidities, this shift is inefficient and it becomes optimal to stabilize relative inflation and the terms-of-trade gap through appropriate domestic fiscal policies. The government spending gap should decrease at H and increase at F. However, it is not optimal to raise the relative government spending gap ($g^R = g^F - g^H$) in order to close the terms-of-trade gap, even if we had considered government spending as pure waste, because it gives rise to inefficient fluctuations in the work effort. Moreover, since the raise on the inflation rate at H boosts the aggregate inflation by less than perfectly positively correlated shocks, the interest rate also increases to a lesser extent. Figure 2 depicts the dynamics of the principal endogenous variables in response to a one percent shock in the wage mark-up. It clearly shows a pro-cyclical behaviour of the H government spending gap, contrasting with the response to a negative productivity shock.

Furthermore, one can also verify that, after the first period, once expectations about inflation are incorporated in the price setting, both fiscal policy instruments shift in opposite directions: the government spending gap becomes positive at H and negative at F.

Finally, it is important to state, once again, that all these experiments are in accordance with the analytical findings of Beetsma and Jensen (2004, 2005) and that, as expected, fiscal policy specializes in the stabilization of the relative variables while the monetary policy stabilizes the union-wide aggregate variables.

Other policy solutions

Commitment

Cost-push shocks and productivity shocks lead to time-inconsistency problems with very different magnitudes. Consequently, the divergences between the optimal policy solutions, under commitment and under discretion, largely depend on the type of shock hitting the economies. This can be easily understood by recalling that only fiscal policy suffers from a commitment problem in response to a country-specific productivity shock, given the inexistence of trade-offs for the monetary policy while both monetary and fiscal policies experience time inconsistency in response to a cost-push shock, except when the latter is of symmetric nature.

In fact, the main difference between commitment and the discretionary responses to an idiosyncratic negative productivity shock is on the conduct of the relative government spending gap. After the first period, it converges to steady-state by positive values, under commitment whereas, under discretion, it converges to the steady-state level, from negative values. The welfare superiority of the commitment solution is revealed, essentially, in the positive permanent co-movement between the terms-of-trade gap and the relative government spending gap.

The dynamics of the endogenous variables, under commitment and under discretion, after a country-specific mark-up shock, display larger discrepancies. These are especially evident on the trajectories of the policy instruments. The latter are less actively used under commitment and display a smoother path, in relation to the discretionary outcome. The other macroeconomic variables also exhibit less short-run volatility under commitment.[38]

Hence, one can conclude that, relative to commitment, the optimal discretionary cooperative policy manifests a stabilization bias that is apparent in the larger fluctuations of the macroeconomic variables. Since we have removed all the permanent distortions of the model, the traditional equilibrium bias of the discretionary equilibrium is inexistent.

[38]Only the foreign inflation rate depicts large variance under the commitment solution. See Figures 3 and 4.

Discretionary non-coordinated policies

In what follows, we focus on the policy analysis of the non-cooperative setups where fiscal authorities are exclusively motivated by the well-being of their own constituencies. A simple comparison of the policy feedback coefficients in Tables D.2 and D.3, allows us to immediately conclude that, and differently from the full cooperative regime, the aggregate government spending gap (g^w) is actively used in the stabilization of symmetric and asymmetric cost-push shocks. In fact, there is now a race between the monetary and the aggregate fiscal policies in the stabilization of the aggregate effects of cost-push shocks: aggregate fiscal policy becomes expansionist, while monetary policy remains restrictive. However, in general, we also observe that the H and the F government spending gaps are both less actively used, in response to these shocks and, so, the relative government spending gaps suffer small changes.

To get the intuition of these results, it is important to note that, for instance, the H government spending gap falls in response to a domestic cost-push shock and this attenuates the H inflation rate but also the negative terms-of-trade gap and the impact on the F inflation rate. The H government does not internalize this positive effect on country F and, thus, uses its policy instrument less actively than it would do in a cooperative setup. In F, the government spending gap has to rise to mitigate the deflationary consequences arising from the restrictive monetary policy. This policy instrument ends up being more actively used at F than at H, because there is a negative co-movement between the consumption and the F government spending gaps that enhance welfare at F, while the reverse occurs at country H. This asymmetric effect justifies a positive reaction of the aggregate government spending gap to a country-specific cost-push shock and, consequently, to a symmetric cost-push shock.

In the non-cooperative regimes, the order of moves is also a source of strategic interactions between the fiscal and the monetary policymakers. In the fiscal leadership regime, H government, anticipating the fact that the monetary authority will raise the interest rate in response to a cost-push shock in H - to fight against excessive inflation - will adopt a less restrictive fiscal policy than in other policy regimes. The domestically-oriented benevolent F government will also behave less actively. Expecting an increase in the interest rate that will negatively impact its GDP inflation rate, the F government will moderately raise government spending to help terms-of-trade stabilization. In sum, the H government, suffering direct inflationary pressures, will be better off if the monetary authority conducts a more restrictive policy and, hence, moderates its restrictive policy. The F government will be worse off if the central bank fights more aggressively the cost-push shock at H and, thus, performs a less extreme expansionary policy. Hence, the fiscal policy response to an idiosyncratic cost-push shock is more moderated when the fiscal authorities lead than when they follow the monetary authority or than when all the policymakers move simultaneously. Conversely, the monetary policy has to be slightly more restrictive in the fiscal leadership regime than in other non-cooperative regimes. Logically, this also applies to a symmetric cost-push shock.

In regards to the responses to a country-specific negative productivity shock, H and F fiscal policies, generate negative spillover effects that are not internalized by domestically-oriented fiscal authorities. Both authorities conduct more active fiscal policies in the Nash and in the monetary leadership regimes. This does not apply in the fiscal leadership regime, because each authority ignores that the other fiscal authority will set a symmetric policy, that prevents aggregate policy trade-offs, but it perceives that the union-wide benevolent central bank will overreact to any excessive fiscal policy response. Hence, both governments moderate their responses to the shock.

In sum, the nature of the spillover effects of the fiscal policy responses to the different shocks determine that: i) the relative government spending gap reacts to a lesser extent to a country-specific cost-push shock and more to a productivity shock[39], than in the cooperative setup; ii) the aggregate fiscal policy reacts counter-cyclically to union-wide variables; iii) the fiscal leadership regime substantially moderates the responses of the government spending gaps to the shocks; iv) with the exception of the fiscal policy instruments, the dynamics of the other endogenous variables exhibit considerable similitude across the different policy regimes.

[39]Except under the fiscal leadership regime.

Fiscal policy rules

The time-inconsistency problems of fiscal policy (addressed above) may outweigh the gains from using fiscal policy as a stabilization tool and, thus, it can be welfare-enhancing to restrain its use. In particular and in an extreme scenario, it could be desirable, under discretion, to exclusively provide the optimal provision of public goods (i.e., to set the government spending gap at zero) every period. Call this passive fiscal policy rule. It becomes apparent, from the inspection of Figures 5 and 6 in the appendix that, constraining fiscal policy, does not substantially affect the dynamics of the non-policy instrument variables, in face of a negative and country-specific supply shock. Thus, the eventual gains of letting fiscal policy unconstrained would be due to cross-terms on the social loss function reflecting undesirable fluctuations in the work effort, at the union-level and across countries, and arising from co-movements among variables. In particular, in relation to the negative productivity shock at H (Figure 6), we verify that, under the benchmark solution, there is a positive co-movement between the relative government spending gap and the terms-of-trade gap which is absent under the passive fiscal policy rule. Recalling the social loss function (see eq. 51 in Chap. 1), we observe that this positive co-movement is welfare-increasing and may overwhelm the costs of large variability on the government spending gaps that occur under the benchmark solution.

Considering now the example of a positive mark-up shock at H, the benchmark solution (discretionary cooperation) generates a negative co-movement between the relative government spending gap and the terms-of-trade gap that causes an inefficient fluctuation of the work effort across countries (see Figure 5). Moreover, it was shown above that, in response to this type of shock, the fiscal policy instrument is more actively used under discretion than under commitment. Hence, potential welfare gains can accrue from constraining the fiscal policy response to this type of shock, in the absence of credible commitment.

2.1.2 Insights for a monetary union with country-size asymmetry

Under the full cooperative regime, the government spending gap of the small country has to be more actively used to stabilize a country-specific shock, than the fiscal policy tool of the large country (cf. feedback coefficients in Table D.2 for $n = 0.8$ vs. $n = 0.5$). To understand this result, it is important to note that the marginal costs and the inflation rates for smaller and more open economies are affected to a greater extent by changes in relative prices which transmit to the per capita output gaps. Hence, for instance, a productivity shock in one of the two countries has a direct impact on the terms-of-trade gap, which, in turn, affects mostly the domestic variables of the small country. Consequently, the home-biased government spending gap has to be used more actively by the small country to alleviate such asymmetric effect of the shock. Moreover, relative to the large country, the variance of the welfare-related variables of the small country is less weighted in the loss function, also explaining its larger business cycle fluctuations.

Likewise, an idiosyncratic mark-up shock in a big country benefits further from the policy stabilization contribution of the monetary policy instrument and, again, requires a relatively larger intervention of the fiscal policy instrument of the small country. Once more, this is easily explained by the large intrinsic externality of that shock but also by the different weights received by the country-specific variables in the social loss function. If it is the small country to be hit by such shock, the domestic fiscal policy instrument has to be more intensively used while the other policy instruments play a small stabilization role than what they would have played in a symmetric monetary union. Thus, the fiscal policy stabilization costs are not equally shared by the two countries, since the smaller country has to respond more strongly to a disturbance either at home and overseas than the big country has.

In terms of non-cooperative regimes and from the observation of the optimal feedback coefficients reported in Tables D.2 and D.3, we conclude that the Nash and the monetary leadership regimes accentuate the asymmetry on the fiscal policies of the two countries. The small country performs an even more active fiscal policy, except when it responds to a domestic cost-push shock, while the large country conducts a slightly less active policy. Effectively, in comparison with the cooperative regime, one observes that, as in a symmetric monetary union, the relative government spending gap responds less to a cost-push shock. However, this response is relatively weaker if the shock hits the small country. Similarly, the aggregate government spending gap becomes expansionist but to a lesser extent when the shock occurs in the small country.

The fiscal leadership regime moderates the fiscal policy responses to the shocks but this moderation is stronger for the fiscal policy of the large country. Under this policy regime, the government of the large country, anticipating that the monetary authority will be more reactive to its domestic cost-push shock, faces an incentive to adopt a looser policy[40], transferring the stabilization costs to the central bank. This incentive results in a counter-cyclical policy. In this policy regime, the asymmetry between the fiscal policies of the two different size countries is the largest.

We can then systematize our main findings in the global implications of the countries size asymmetry.

First, our experiments show that policy stabilization favors the large country in detriment of the small country. This can be easily exemplified by observing the impulse responses to a one-percent relative productivity shock in Figure 7: the specific variables of the large country (H-variables) depict lower short-run volatility than those for the small country (F-variables).

Second, country-size asymmetry leads to fiscal policy asymmetry, amplified in the non-cooperative settings. However, the main differences occur in the dynamics of the policy variables and thus, it is natural to expect that the small country will benefit from being in a cooperative regime.

Finally, we verify that the large country profits from being in a fiscal leadership regime, while the small country looses the most in this non-cooperative regime.

[40]Expecting a restrictive monetary policy that creates a negative consumption gap, the fiscal authority of the large country chooses to increase the government spending gap, therefore benefiting from a negative co-movement between the two variables.

2.1.3 Welfare analysis

From the analysis of the optimal policy responses to shocks, it became clear that, in general, fiscal and monetary policies accomplish different stabilization tasks – fiscal policy focus on the stabilization of relative variables, while monetary policy performs the stabilization of aggregate variables - and that productivity and mark-up shocks create different policy trade-offs and call for different stabilization policies. It is apparent that the mark-up shocks generate more relevant policy trade-offs and, therefore, it would be expected that these would imply larger welfare stabilization costs. In fact, there are other factors that determine the welfare costs of the shocks. For instance, the way the mark-up shock is normalized and the calibration one takes for its persistence and variance, reveal to be essential for the differences found in the stabilization costs of the two supply shocks. With our benchmark parameterization, the welfare effects of the productivity shocks, under the different policy regimes, clearly dominate the welfare consequences of the mark-up shocks (cf. results in Table D.8). Hence, we should be cautious on the welfare evaluation of the various policy regimes and take into consideration the possible divergent evaluations when considering the analysis of the two shocks separately.

There are basically three questions that are relevant to address under the present setup. First, we want to know if there are gains from constraining fiscal policy, given the existence of time-inconsistency problems and also fiscal authorities that may have policy objectives diverging from the objectives of the union-wide representative household. Second, we try to reappraise the debate on the need for policy cooperation - an active one in the EMU context - within a dynamic framework. In this context we compare the cooperative solution with an extensive set of non-cooperative policy solutions. We start by assessing whether gains accrue from enhancing cooperation even when the fiscal authorities are domestically-benevolent. Third, it is important to perceive, given the inexistence of macroeconomic policy coordination in current EMU, which non-cooperative policy regimes beneficiate more the union-wide stabilization performance and how the stabilization costs are split between the small and large countries.

The existence of a micro-founded welfare criterion enables the evaluation and the ranking of the different policy stabilization outcomes and allows addressing the above-mentioned questions. Tables D.6 and D.8 report the union-wide welfare losses under the several optimal policy regimes (and with the benchmark parameter calibration) in a monetary union exclusively hit by idiosyncratic shocks; Table D.7 evaluates the welfare losses of each country using, as an approximation to the correct welfare criterion[41], the welfare losses obtained from splitting the union-wide loss function.

By examining Table D.6, we conclude that constraining fiscal authorities with a passive fiscal policy rule delivers an inferior welfare outcome. However, a closer look at the welfare losses reported in Table D.8, shows that this conclusion is not extensive to the stabilization performance of both supply shocks. As noticed above, the stabilization of mark-up shocks creates more time-inconsistency problems than that of the productivity shocks. Accordingly, it would be reasonable to expect worse discretionary stabilization of mark-up shocks and, thus, constraining fiscal policy may enhance welfare. In fact, results show that a rule setting is welfare-improving if the economies are exclusively hit by idiosyncratic mark-up shocks[42] but, is welfare-reducing, if the productivity shocks prevail. The discrepancies of the welfare losses under the two shocks are related to the assumption of the persistence of the shocks and to the relative size of the mark-up shock.[43] They are crucial for the welfare outcomes we get when the economies are hit by all the shocks. Restraining fiscal policy is welfare reducing, under the latter hypothesis, because of the excessive importance productivity shocks have on business cycle fluctuations.

Our experiments also suggest that there are welfare gains from promoting policy cooperation and that it is the small country that gains relatively more from adopting this

[41]Benigno and Benigno (2006) derive, instead, the quadratic utility-based objective functions for each country in order to analyze the case of non-coordinated monetary policies. This requires second-order approximations of the structural equations of the model and it is algebraically cumbersome.

[42]This replicates the findings of Beetsma and Jensen (2004). The authors argue that this result is due to the trade-off between the distortions associated with discretionary (relative) fiscal policy and discretionary (aggregate) monetary policy. Thus, the elimination of the former distortion reveals to be welfare enhancing.

[43]Here, this shock is calibrated as a one percent innovation in the mark-up, which represents a 0.0042% shock in the GDP inflation rate. Beetsma and Jensen (2004), for instance, normalize this shock to be a 1% shock in the inflation rate and they get much more welfare losses. However, this normalization also exacerbates the welfare importance of this shock. Few cost-push shocks in real world have this impact, especially in the presence of nominal rigidities. Notice that a 1% shock in the relative productivity shock has a direct impact on the terms-of-trade gap of 0.5582%, under our benchmark calibration.

institutional arrangement.[44] In fact, the large country has more to gain from being in a fiscal leadership policy regime than in a full cooperative policy regime (cf. Table D.7) and so the enforceability of macroeconomic policy cooperation in a monetary union may be hardly attained within asymmetric-size countries.

Moreover, the welfare ranking of the three non-cooperatives scenarios shows that, from the whole union point of view, the monetary leadership and the Nash policy regimes are preferable to fiscal leadership. However, from the inspection of Table D.8, we conclude that this outcome arises from the relative large welfare effects of the productivity shocks. The mark-up shock is better stabilized under a fiscal leadership regime. Leading fiscal authorities mitigate time-inconsistency problems of the monetary policy; conversely, productivity shocks only cause time-inconsistency problems to fiscal policy and a leading monetary authority is more successful in alleviating this distortion. Thus, the welfare inferiority of the fiscal leadership regime arises because, in our baseline calibration of the stochastic process, cost-push shocks are exemplified by i.i.d. mark-up shocks with rather negligent welfare impact.

We also observe that the large country is always better-off than the small country and prefers to be in a fiscal leadership policy regime, where it beneficiates from its large strategic power vis-à-vis the other policymakers. Diversely, the small country has lower welfare stabilization costs under monetary leadership (cf. Table D.7).

2.2 Non-benevolent scenarios

We now propose to analyze the policy interactions that arise when fiscal and monetary authorities have distorted policy objectives.

A first scenario that we can motivate within such analysis is the one assuming an inflation averse central bank. Delegating the monetary policy to a central bank that is

[44]Under the cooperative regime, the small F-country focus on maximizing home welfare and on stabilizing shocks hitting the large economy. Simultaneously, the large country imposes higher spillover effects on the small country. Thus, while policy cooperation is not crucial for the large economy, it could make be good for the small country. Our simulations confirm this expectation. The small country, facing larger externalities, is better off if the large country internalizes them; conversely, and the large country hasn't got much to gain when the small internalizes its smaller spillovers.

biased towards the control of inflation variability is usually a referred setup to reduce the inflation bias arising from the discretionary monetary policy. A central bank more inflation averse than society as whole, as Rogoff (1985) originally proposed, was shown to provide welfare gains in a dynamic setup, even when the distortions that incentive an inflation bias are fully eliminated (cf., Clarida et al. 1999). However, as Luisa Lambertini (2006) remarked, the time-inconsistency problem of the monetary policy is not the sole problem when there is also endogenous fiscal policy. A conservative central bank creates a divergence between fiscal and monetary policy objectives and that may be a source of sub-optimal outcomes. Thus, there is no a priori conclusion favouring, unambiguously, the delegation of monetary policy to an inflation averse central banker.

To illustrate this scenario, we follow Blake and Kirsanova's (2006) example, by considering that the inflation welfare-related terms of the monetary policy objective function receive higher weighs than they receive in the union-wide welfare function.

A second example fitting a non-benevolent scenario can be motivated by conflicting interests between national fiscal policies and common monetary policy concerning the stabilization of the output terms. For instance, one of the fears underlying the fiscal architecture of the EMU is the possibility of the fiscal policy stance to undermine monetary policy in the pursuit of price stability. This hypothesis can be described by assuming that governments are less worried with inflation variability than society is or, alternatively, by postulating that they are more dissatisfied with the fluctuation of the macroeconomic real variables. Once more we follow Blake and Kirsanova (2006): the demand-terms on the benevolent fiscal authorities' loss functions are attached with an additional weight.

We begin by characterizing the optimal discretionary equilibrium under the weight-conservative central bank hypothesis and, afterwards, we go through the analysis of the policy interactions when governments are particularly concerned with output fluctuations. Of course, the effects of imposing fiscal policy constraints will be assessed. Our focus is on the existence of countries' size asymmetry in the EMU and how this affects the strategic policy interactions and the outcomes.

2.2.1 Adjustments to shocks

Conservative central bank and benevolent domestically-oriented governments First, it is important to note that a sufficiently high degree of weight-conservatism ($\rho^c > 0.7$) changes the qualitative response of fiscal policy to a domestic positive mark-up shock: this response becomes expansionary and counter-cyclical.[45] Furthermore, the monetary policy responds more aggressively to this type of shocks and a wrong policy mix is manifested. Figure 8 compares the impulse responses to a unit innovation in the mark-up at H, under the benevolent and the conservative Nash policy regime. It appears that the domestic (H) and consumption based inflation rates exhibit less variability under weight-conservatism but the F inflation rate displays larger fluctuation. In the first period, both government spending gaps are positive under the weight-conservatism case but, their expansionary effects, are not enough to fully counteract the monetary policy overreaction and, thus, the output gaps decrease more than under the benevolent setup. In fact, the conflicting objectives between fiscal and monetary authorities accentuate policy reactions: a more restrictive monetary policy and a more expansionist aggregate fiscal policy (g^w). Additionally, this conflict moderates the relative fiscal policy (g^R) response to the mark-up shocks and, thus, worsens the stabilization of relative variables (cf. Tables D.3 and D.4).

The central bank's high aversion to inflation variability has no significant impact on the fiscal policy response to productivity shocks, because, under symmetric nominal rigidities, productivity shocks do not cause any trade-off for monetary policy. This is particularly evident in the fiscal leadership outcome, where the fiscal authorities anticipate that the monetary authority will not react to a productivity shock (cf. feedback coefficients on this shock, under benevolent and conservative fiscal leadership, in Tables D.3 and D.4).

The playing order takes special relevance in the policy response to mark-up shocks, where policy trade-offs are extended to fiscal and monetary policies. In the fiscal leadership policy game, the fiscal authorities, aware that the conservative central bank will overreact to an inflationary fiscal policy, will be more moderated in the conducting of fis-

[45] See feedback coefficients in Table D.4, for a degree of weight-conservatism of 0.75.

cal policies. In the monetary leadership regime, the conservative central bank anticipates that the fiscal authorities will react to its excessive concern towards inflation variability through an expansionary aggregate fiscal policy. Consequently, the central bank will engage in a more moderated restrictive policy than it would do in the Nash policy regime (cf. Table D.4). In spite of these divergences in policy responses under the different policy regimes, the dynamics of the other endogenous variables do not present substantial differences.

Finally, country-size asymmetry interacts meaningfully with the weight-conservative delegating arrangement in the stabilization of mark-up shocks. In face of idiosyncratic mark-up shocks, while the fiscal policy response of the large country is expansionary and counter-cyclical, in the small country, the domestic fiscal policy remains, as in the benevolent scenarios, restrictive and pro-cyclical (cf. Table D.4). It appears that, the government of the large country faces additional incentives to counteract the central bank's excessive concern with inflation fluctuation. Conversely, the government of the small country (F) perceives that both the effects of country-F idiosyncratic shocks and of its fiscal policy reaction have lower impact on the design of optimal monetary policy. Consequently, the fiscal authority of the small country ends up conducting fiscal policy in similar way as with a benevolent central bank.[46]

Output-biased fiscal authorities and benevolent central bank If fiscal authorities are less averse to inflation variability than society is, they will have incentives to promote a more expansionist fiscal policy than if they were benevolent. Similarly to the previous case, the fiscal policy response to a domestic mark-up shock turns to be expansionary and counter-cyclical, in contrast with the domestic fiscal policy response in the benevolent scenarios. Observing, for instance, the optimal policy responses to an idiosyncratic positive mark-up shock when all the policymakers play Nash, we verify that aggregate fiscal policy (g^w) expands further and this generates a more aggressive monetary policy contraction (cf. Tables D.3 and D.5). In addition, the relative government spending gap, re-

[46]See Figures 9 and 10 for the impulse responses to a mark-up shock hitting, respectively, the large and the small country, comparing the benevolent with the weight-conservative central bank Nash game.

sponsible for the stabilization of relative variables, experiences a smaller variation in this non-benevolent scenario than in the correspondent benevolent policy regime. Figures 11 and 12 in appendix depict the dynamics of endogenous variables in response to a positive mark-up shock at H, under Nash with and without benevolent governments and under all the policy regimes with output-biased fiscal authorities, respectively. The figures suggest that the main consequences of the distorted objectives are on the dynamics of the government spending gaps. Under the fiscal leadership regime the fiscal authorities, taking into account the subsequent reaction of the monetary authority, expand slightly less than in the monetary leadership or the Nash regimes. Thus, the high aversion to the variability of output-related terms ends up by being reflected, more intensively, in the lower variability of the fiscal policy instruments.

2.2.2 Welfare analysis

To complement, quantitatively, the description of the dynamic response to shocks of the previous section, we compute the welfare losses reported in Tables D.6-D.8.

The computation of the welfare costs under the different policy regimes, when the monetary policy is delegated to a conservative central bank, confirms that this institutional arrangement is harmful for welfare. Additionally, and as expected, we also confirm that this inferior outcome is mainly imputed to the worse stabilization of the mark-up shocks, in particular, the Nash regime, where policy responses to these shocks become more extreme, yields the more damaging outcome (cf. Table D.8). Despite the worst performance of the Nash policy regime in the stabilization of the mark-up shocks for the weight-conservative central bank case, the welfare ranking of the policy regimes does not show substantial differences. The fiscal leadership policy regime still performs the worst stabilization performance while the monetary leadership delivers the lowest welfare stabilization costs (cf. Table D.6).

Moreover, the costs of delegating the monetary policy to a conservative central bank do not spread symmetrically across the monetary union, if countries are of different size. Comparing the welfare losses under the benevolent and the conservative cases for the large and the small country (Table D.7), it is easy to verify that the small country is the most harmed by this institutional arrangement.

Fiscal authorities with distorted policy objectives also augment the welfare cost of macroeconomic policy stabilization in relation to the benevolent setups. The race between fiscal and monetary authorities affects the stabilization performance of the two supply shocks but, such larger stabilization costs, do not equally spread over the various policy regimes nor across different size countries (see Tables D.6-D.8). Welfare impacts are lower under the fiscal leadership regime, where fiscal policy is more moderated. In fact, accentuating the preferences of the fiscal authorities over output stabilization may overturn the welfare ranking of the policy regimes. In non-reported simulations, we found that, when fiscal authorities do not care at all with inflation variability, fiscal leadership gives the better policy solution among the non-cooperative regimes. Moreover, under an asymmetric country-size monetary union, the large stabilization burden of this hypothesis falls mainly on the small country.

Finally, constraining fiscal authorities to pursue passive fiscal policy rules does not improve welfare, even when policymakers have distorted policy objectives (cf. Table D.6).

In sum, our non-benevolent exercises suggest that distorted policy objectives raise the conflict between fiscal and monetary authorities and aggravate welfare; small countries have more to loose with those scenarios than large countries; and, that it may be better, in the lack of alternative, to give a first move advantage to the policymakers with distorted objectives.

2.3 Sensitivity analysis

In this section we intend to provide some sensitivity analysis regarding the parameters of the model and of the policy objectives seeking to address a set of additional questions.

First, we intend to reformulate and reassess the question of the desirability of policy cooperation in the context of "non-benevolent" policy objectives. In order to do that, we take an extreme case of policy specification: the monetary authority faces a pure inflation target while governments are totally biased towards actively reducing the output-related terms variability.

Next, we assess if structural reforms, for instance, leading to a reduction of the degree of nominal rigidity can improve welfare and, in particular, conclude which type of country (large or small) is more acute to the need for reforms. This requires performing welfare analysis under different degrees of nominal rigidity. Finally, some authors like Kirsanova and co-authors, stress the importance of inflation persistence on the welfare gains attached to fiscal policy stabilization. They found that gains increase with inflation persistence, in a model with both inflation and output persistence. We want to address the importance of inflation persistence in our model, where output persistence is ruled out; we also want to assess how the macroeconomic stabilization performance is affected by the existence of asymmetric inflation persistence across countries.

2.3.1 Reappraising the gains of policy cooperation

We found that, when policymakers agree on policy objectives and are motivated by the well-being of the monetary union as a whole, monetary and fiscal policies specialize in different stabilization tasks: monetary policy stabilizes the aggregate effects of the shocks while fiscal policy performs the stabilization of their relative effects. It was shown that, in general, it is better to have a stabilization policy conduced by these optimizing policymakers (benevolent cooperative setup) than to allow fiscal authorities to guide their fiscal policies by the exclusive interests of their own citizens (non-cooperative setups). We observed that, under our baseline calibration, there are welfare gains from enhancing policy cooperation from all point of views, in spite of the existent time-consistency problems. However, in the case of a monetary union with different size countries, the large country may have no incentives to cooperate.

We propose to reappraise the gains of macroeconomic policy cooperation in a "non-benevolent" setup. Following Lambertini and Rovelli's (2004) exercise in a static framework, we assume that the central bank, in line with the institutional EMU arrangement, is assigned to, exclusively, stabilize inflation (a case of extreme weight-conservatism) and that fiscal authorities are only concerned with the stabilization of domestic output terms (a case of extreme output-bias). The relevant question to be answered is on the optimality of this a priori task-specialization between fiscal and monetary policies. We want to assess if, in this context, there could be gains from enforcing a cooperative arrangement between fiscal authorities or if it would be better to induce all the policymakers to cooperate. The eventual welfare gains have to be evaluated from each policymaker's point of view and that of the whole union to appraise the feasibility of the cooperative solutions. In particular, we will compare the welfare costs under a full non-cooperative setup with the welfare costs arising under fiscal policy cooperation and full cooperation under the monetary union social loss. These welfare costs are computed on the basis of the welfare criterion of each authority and of the social welfare measure.

We find that, when policymakers have clearly different stabilization assignments in the context of a monetary union: 1) horizontal and full cooperative stabilization policy arrangements are hardly implemented if there are no appropriate enforcement devices; 2) the extreme conservative central bank prefers fiscal authorities cooperating in minimizing the social loss function (horizontal cooperation) but national governments will face incentives to deviate from this conduct; 3) national fiscal authorities face incentives to ensure a full cooperative regime but the central bank has more to gain from non-cooperating; 4) from the point of view of a representative household of the monetary union, it is better to have some cooperative arrangement and full cooperation is better than horizontal policy cooperation (see Table D.9). These experiments also show that the fiscal leadership regime is welfare superior to the other policy regimes.

The same qualitative results apply to the case of country-size asymmetry and are extensive to an EMU scenario calibration of the model (cf. Table D.10), where the major differences from the baseline parameterization with country-size asymmetry are the existence of asymmetries on nominal rigidity and on inflation persistence.[47] The main qualitative difference, relative to baseline calibration, is on the ranking of the various policy regimes from the viewpoint of the central bank. In the EMU scenario, the extremely conservative central bank would prefer to be in a monetary leadership policy regime while, under the benchmark scenario, it would be indifferent among the diverse policy regimes. In any circumstances, the national fiscal authorities and the representative household would be better-off under fiscal leadership.

In sum, our results suggest that there are no welfare gains from assigning policymakers with different stabilization objectives. It would be better to induce their agreement on social policy objectives and the specialization of the policy instruments on different stabilization tasks would emerge. If divergent policy objectives are already in place, it is difficult to implement the welfare-improving cooperative solutions, because either the national fiscal authorities or the central bank will prefer not to cooperate.

2.3.2 Nominal rigidity and inflation persistence

Our modelling deliberately includes a production subsidy to eliminate steady-state deadweight losses resulting from imperfect competition and distortionary taxation. However, these sources of inefficiency, as well as price stickiness, remain important to the analysis of the business cycle and to the welfare costs. It is well-known that a first best equilibrium is obtained when all distortions are eliminated but it is not obvious how welfare behaves when one reduces, or removes, some of them.

In concrete, we wonder if structural reforms that consubstantiate, for instance, in a reduction of the degree of nominal rigidity reduce the welfare costs of the policy stabilization. In particular, we will try to assess which type of country has more to benefit from raising nominal flexibility.

There are basically two ways through which, decreasing the degree of price stickiness, can affect welfare in our model. First, by reducing the inefficient dispersion of

[47] Differently from baseline calibration, the shocks under the EMU scenario display larger and differentiated variances.

output across firms, it decreases the weight attached to inflation volatility in the welfare function. Hence, there is a direct effect reducing welfare and changing the trade-off between inflation and output stabilization.

Second, it indirectly affects welfare by changing the relative volatility of the various welfare-related variables. From the observation of the AS equations, we conclude that, when the degree of nominal rigidity diminishes (α^H and α^F), the H and the F inflation rates respond more to mark-up shocks and to the other welfare-related variables (private and public consumption gaps and terms-of-trade gap). Simultaneously, the governments spending gaps and the interest rate gap have large effects on the inflation rates and small effects on the output gaps. Thus, relative to inflation terms, the indirect and the direct effects on welfare to decrease the degree of nominal rigidity seem to go in opposite directions. Moreover, we should expect a different behaviour of the stabilization performance of mark-up and productivity shocks, when one raises the degree of nominal flexibility. The intuition follows from the different impact of the two shocks on the efficient outputs and, consequently, in the output gaps. In contrast with the productivity shock, the mark-up shock should cause large output gap fluctuation when prices become more flexible. The combination of all these effects may generate non-linearities that explain why welfare can not behave monotonically with the decrease of the degree of nominal rigidity.

When the reduction of the degree of nominal rigidity occurs only in one of the countries, the monetary policy becomes apt to influence and control the terms-of-trade gap variability. Since the variability of this policy instrument has no direct welfare costs, idiosyncratic shocks can be stabilized at a lower cost. Hence, there can be lower welfare costs for the monetary union, when there is high price flexibility in only one of the countries.

Welfare losses computations, under cooperative and non-cooperative benevolent scenarios, for different degrees of nominal rigidities are reported in Tables D.11-D.14. They confirm that the stabilization costs of the two supply shocks evolve differently with the degree of nominal flexibility ($1 - \alpha$). Raising the degree of nominal flexibility symmetrically in both countries increases the welfare stabilization costs of the mark-up shocks and, for high enough degrees of price flexibility, decreases the stabilization costs of the productivity shocks (Table D.13). In fact, similarly to the findings of Lombardo (2002), we find a non-monotonic relationship between the welfare stabilization costs of productivity shocks and nominal rigidity: the latter decreases welfare up to a point where more rigidity becomes welfare-improving.[48] The small and more open economy, being the more affected by the larger fluctuation of relative prices, loses with a larger price flexibility, while the large economy benefits (Tables D.12 and D.14).

Our results suggest that, while focusing exclusively on the welfare consequences of stabilization policies, structural reforms that reduce symmetrically nominal rigidity across countries of a monetary union are likely to have a negative effect on welfare. In our dynamic model, sticky-prices distortion acquires a second-best quality when coupled with internal and external monopolistic distortions (monopolistic supply in production and monopoly power of a country in trade).[49] Our results also suggest that in a country-size asymmetric monetary union, these reforms could be welcomed by the large economies but would face the contest of the small economies.

Under country-size symmetry, allowing asymmetry on price stickiness, that is, decreasing the degree of nominal rigidity in only one of the countries is welfare enhancing for the union and for the country that remains with more nominal rigidity. The country that carried out structural reform and raises its price flexibility only gains when this flexibility becomes high enough (cf. Tables D.11 and D.12).[50][51] Hence, in a monetary union where the effects of the productivity shocks dominate, it could be good to accomplish an asymmetric structural reform but this could hardly be fulfilled, given the probable resistance of the country that is the object of the reform.

Decreasing the degree of nominal rigidity in the small country raises welfare from the viewpoint of a representative household of the monetary union and of the large country; the small country only gains with the "reform" if this substantially reduces the degree of

[48] See Lombardo (2002, p.30) for a rationale of this result.

[49] See Lombardo (2006) for similar argument on the degree of monopolistic distortion.

[50] From inspection of Table D.14, one concludes that the specific calibration of the productivity shocks relative to the mark-up shocks is crucial to explain those results. The welfare stabilization costs of the mark-up shocks always increase with the symmetric or asymmetric raise of the degree of price flexibility.

[51] The elimination of the sticky-price distortion only outweighs the other (monopolistic) distortions when it is high enough.

nominal rigidity. The large country faces no incentive to implement a structural reform that raises domestic price flexibility.

In order to match the short-run dynamics exhibited by inflation we considered, in the model, the existence of rule-of-thumb price-setters. This generates inflation persistence affecting both the AS and the welfare equations. In general, it conduces to smooth paths in inflation but also in the policy instruments. Blake and Kirsanova (2006) and Walsh (2003), in different settings, study how inflation persistence affects the ranking of policy rules. In experiments not reported here we did not find any significant change on the policy ranking. Table D.15, for some representative values of inflation persistence $(1 - \lambda)$ and the benchmark policy regime, suggests that decreasing symmetrically across countries the degree of inflation persistence (increase of λ) is welfare improving. However, as in the case of nominal rigidity, the two supply shocks display divergent stabilization performance with the change on the degree of inflation persistence. The stabilization of the productivity shock is enhanced with smaller inflation persistence while that of the mark-up shock is worse. In general, countries would not face any incentive for, individually, accomplishing some type of reform that reduces their inflation persistence. Our results suggest that a small country may configure an exception and may benefit from lower domestic inflation persistence.

3. Policy Analysis in a Model with Debt

Beforehand, we performed the policy analysis in an environment where the sole fiscal policy instrument was public spending and where the lump-sum taxes were adjusted to ensure the satisfaction of the contemporaneous (and, thus, inter-temporal) government budget constraints. The monetary and the fiscal policy instruments exerted both their stabilization effects on the economy through the demand channel without any consequences for debt sustainability. In the benevolent cooperative scenario, the home- biased and useful government spending substitutes the use of the monetary policy that, in a monetary union, is unable to address the effects of idiosyncratic shocks. In accordance with the results obtained by Beetsma and Jensen (2004, 2005), we have concluded that optimal fiscal policy specializes in stabilizing relative variables while optimal monetary policy concentrates on the stabilization of the union-wide variables.

In a more realistic setting, where fiscal policy makes use of home-biased government spending but also of distortionary taxes, and where lump-sum taxes are not enough to guarantee fiscal policy solvency, there are additional sources of strategic interactions between the fiscal and the monetary authorities that, naturally, have important consequences for the design of the optimal stabilization policies. Now, monetary policy impinges on government budget constraints affecting the costs of the debt service, the real burden of public debt and the tax basis income. Moreover, although we have eliminated the long-run distortionary effects of the tax rate through a production subsidy that ensures an efficient steady-state outcome, the use of the tax rate as a fiscal policy instrument introduces short-run distortions that may be welcomed in order to counteract other distortions. From the AS equations, we observe that the inflationary effect of a cost-push shock is parallel to the one produced by a change in the tax rate. Therefore, this fiscal policy instrument can be successfully used to offset the impact of this shock.

However, if, on the one hand, stabilization gains arise from having another fiscal policy instrument, on the other hand, we have to be cautions with potential losses arising from the possible conflict between the short-run macroeconomic stabilization task and the long-run debt stabilization task, which occurs due to the insufficient adjustment of lump-sum taxes. Furthermore, the relative efficiency of the monetary and the fiscal policy instruments to control public debt depends on the size of the debt stock. The larger the steady-state debt-output ratio is, the greater the efficacy of monetary policy to stabilize debt through its accrued impact on the debt-service costs. Hence, the optimal discretionary stabilization policy plan and the role played by the fiscal and monetary policies also depend on the debt-stock level. To appreciate the intuition of the discretionary policy outcomes, it is important to understand the nature of the time-inconsistency problems underlying pre-commitment policies. As Leith and Wren-Lewis (2007a) have demonstrated in a closed-economy setup, policymakers face the temptation, given the expectations, to use their policy instruments to change the ultimate debt burden they need to service. This temptation is eliminated if the debt-output ratio returns to its pre-shock steady-sate. Hence, in the discretionary solutions the policy instruments are changed to accomplish short-run macroeconomic stabilization but also debt stabilization and, since they perform differently these stabilization tasks when debts are small and large, the optimal policy plans will reflect a specialization of the policy instruments according to the debt levels.

As it will become evident subsequently, this specialization is not evident under optimal committed policies, where public debt does not return to its pre-shock level and displays random walk behaviour.[52] The optimal commitment policy plans ensure lower short-run variability but a permanent disequilibrium in the debt-output ratio and in some welfare-related variables. Conversely, the optimal discretionary policy plans produce higher short-run volatility but long-term equilibriums.

These results suggest that the problems with time-consistent policies may reside in their excessive concern with debt stabilization and, consequently, that it may be welfare-reducing to impose fiscal policy constraints aiming at a strict stabilization of the debt-output ratio. Effectively, our experiments confirm that constant-debt fiscal policy rules lead to worse welfare outcomes than the ones obtained under unconstrained discretionary policies, both with benevolent and non-benevolent policymakers.

[52]This result is consistent with the ones found by Benigno and Woodford (2003), Schmitt-Grohe and Uribe (2004), Leith and Wren-Lewis (2007a, 2007b) and Kirsanova and Wren-Lewis (2006).

Other institutional arrangements such as policy cooperation and the delegation of monetary policy to a conservative central bank could mitigate the time-consistency problems and improve welfare. We will scrutinize the welfare consequences of these solutions in a high-debt and in a low-debt monetary union where the member-countries have either symmetric or asymmetric size. Furthermore, we will appraise how fiscal authorities that are less averse to inflation variability than society affect the stabilization outcome.

Finally, in the next section, we will characterize and evaluate optimal policies under benevolent policy scenarios. Next, we will perform policy analysis under non-benevolent policy scenarios and we conclude with a sensitivity analysis in an attempt to address some specific additional questions.

3.1 Benevolent policy authorities

3.1.1 Adjustments to shocks under country-size symmetry

In what follows, we begin with analyzing stabilization properties associated to the optimal discretionary cooperative regime. This involves the dynamic responses of the relevant endogenous variables to three symmetric exogenous pure white-noise shocks in order to sharpen the perception about the adjustment mechanisms involved.[53] Subsequently, we compare these outcomes with the ones obtained under the first best policies, the non-cooperative discretionary policies and the monetary discretionary policy with a constant-debt fiscal policy rule.

We have checked, by examining eigenvalues, that the solutions are saddle-path stable for large debt stocks. However, for small debt-output ratios, the number of eigenvalues inside the unit circle are larger than the number of pre-determined variables. This is usually seen as a case of model indeterminacy but, Blake and Kirsanova (2007) argue that

[53] We follow Benigno and López-Salido (2006), Ferrero (2007) and Beetsma and Jensen (2005), among others, that also perform the dynamic analysis by setting the autocorrelation coefficient of the shocks to zero.

the time-consistency property of the discretionary equilibria rules out this indeterminacy. Nevertheless, these authors also demonstrate that isolated discretionary multiple equilibria are likely to occur. We also have checked this possibility, by initializing the algorithms with different matrices, and we did not find evidence of this hypothesis for our debt calibrations.

Benchmark scenario: discretionary coordinated policies Without accommodative lump-sum taxes, both symmetric and asymmetric shocks have budgetary consequences and require policy responses of the monetary and fiscal policy instruments. In spite of the inexistence of any debt target in the social loss function, the optimal policy plan under discretion reveals to be consistent with debt stabilization. Given expectations, the policymakers face the temptation to use policy instruments, in the first period, to mitigate permanent debt effects. This provides an effective stabilization of the steady-state debt-output ratio at its initial value, under discretion. This excessive optimal policy response to debt disequilibria magnifies the differences relative to our previous setup, where there were enough lump-sum taxes to satisfy government budget constraints.

Under balanced budget fiscal policies, symmetric productivity and demand shocks did not create any policy trade-off and, under optimal policies, all the variables could remain at their efficient levels. Additionally, a symmetric mark-up shock – implying the usual consumption-inflation dilemma - required, in the previous setup, the sole response of monetary policy to achieve the optimal disequilibrium combination. Under binding budget constraints, optimal policy responses to symmetric shocks require the use of both monetary and fiscal policy instruments.

Naturally, in the context of a monetary union, the rationale for the use of the fiscal policy as a stabilization tool is mainly found in the need for stabilizing the effects of country-specific shocks, given the inability of the common monetary policy to fully stabilize this type of shocks. The differences concerning optimal policy responses to symmetric and asymmetric shocks were particularly evident in the previous model (Chap. 3), with optimal fiscal policy specializing in the stabilization of the relative effects of the shocks and with monetary policy concentrating on their aggregate effects. In the present setup, optimal fiscal policy also has to stabilize aggregate variables. Moreover, the steady-state debt-output ratio reveals to be crucial for the policy instruments specialization amongst the short-run macroeconomic stabilization and the long-run debt stabilization assignments.

Symmetric shocks

Demand shocks

A positive aggregate consumption shock increases the natural interest rate and decreases the efficient provision of public goods.[54] If monetary policy could adjust the interest rate in accordance with the natural interest rate and if the fiscal policy could enforce the same with government spending, this would have been enough to completely circumvent the effects of the shock. However, without lump-sum taxes automatically adjusting to ensure government's solvency, this policy would have had impact on public debt. Depending on the initial steady-state debt-output ratio, this impact can be positive or negative. For small debt stocks, the raise of the debt service costs is relatively small compared to the decrease of public spending and the debt is reduced. The reverse can occur for large debt stocks. Under optimal discretionary policies and binding solvency constraints, the policy response to a demand shock becomes more moderated because of the additional constraint to stabilize debt.

Therefore, for small steady-state debt-output ratios, the interest rate gap decreases (current interest rate raises by less than its efficient natural level), the government spending gap increases and the tax rate gap decreases in all countries. The decrease in the tax rates has positive effects in the aggregate supply so that inflation falls and the output gap rises. The overall policy response is expansionist and pro-cyclical. Conversely, for large debt stocks, the interest rate gap decreases further and fiscal policy becomes contractionary and counter-cyclical: the government spending gaps diminish and the tax rate gaps increase (see Tables D.16 and D.17 and Figure 13). In this case, one observes an output gap and inflation co-movement in line with the ones that are usually expected, af-

[54]This can be easily confirmed by looking to equations 37 and 46 in Chapter 1, above.

ter a demand side shock: both individual countries and union-wide output gaps and GDP inflation rates increase.

Productivity shocks

A negative productivity shock in both countries lowers output and increases the price level but, due to the existence of nominal rigidities, it gives rise to positive output gaps in the two economies. Under a balanced budget, all policy instruments would optimally be set at their efficient levels and the shock would be fully stabilized. However, without adequate lump-sum taxes, there are also negative budgetary consequences requiring different policy responses under small and large steady-state debt ratios.

For small debt stocks, the government spending gaps fall and the tax rates increase in order to stabilize the debt. But, since the raise of distortionary taxation impacts positively on the marginal costs, there will be additional inflationary pressures that the monetary authority will try to overcome through a restrictive policy. The increase in the interest rate will moderately raise the debt service cost, given the low debt stocks. For large debt stocks, the monetary policy may have important fiscal consequences. In this case, the stabilization of the public debts is done through the combination of a less contractionary fiscal policy and an expansionary monetary policy. Consequently, and in accordance with the results reported by Leith and Wren-Lewis (2007a,b), the output and consumption gaps display negative co-movements with inflation under small debt stocks, and exhibit positive co-movements under large debt stocks (cf. Figure 14).

Mark-up shocks

In a model with automatically adjusting lump-sum taxes, a mark-up shock hitting a country would be eliminated through the use of the domestic tax rate without welfare costs. The use of government spending or the interest rate to stabilize the shock would not be necessary. When it is possible to use the tax rate, without any restrictions, to respond to a mark-up shock, the trade-off between inflation and output is absent.

With binding government solvency constraints, the tax rate can not be freely used to respond to a mark-up shock because a decrease in the tax rate increases the government debt. Hence, we expect the tax rate gap to increase with a domestic mark-up shock, as the tax rate decreases less than the respective optimal level (i.e., the level that fully eliminates the mark-up shock). As a consequence, beyond the debt effect, there are also inflation and output effects and there is an active role for other policy instruments.

For small debt stocks, the effectiveness of the fiscal policy instruments in order to stabilize the debt is larger than for large debt stocks, while the reverse occurs with the monetary policy instrument. On the one hand, fiscal policy is more restrictive in reaction to a shock with negative consequences for government budgets, when it is constrained by small levels of public debt than when it is constrained by large debt stocks. On the other hand, monetary policy moves from an anti-inflationary to a fiscal accommodative conduct when the debt stocks are large enough. Hence, while for small debt stocks the initial raise of the interest rate and the cut of the government spending gaps amplify the negative output effect of the shock, for sufficiently large debt stocks, the drop of the interest rate boosts consumption enough to neutralize the fall in government spending gaps and so, the individual country and the aggregate output gaps increase. To alleviate the accrued inflationary pressures in the latter case, the tax rates have to follow the path of their efficient levels more closely. Consequently, the increase of the tax rate gaps is smaller when debt stocks are larger (see Figure 15 and Tables D.16 and D.17).

In sum, the relative dimension of government indebtedness crucially shapes the policy responses to shocks, under discretion. In particular, optimal fiscal policy responds actively to symmetric shocks and this response, depending on the size of the debt stocks, may be pro or counter-cyclical. Fiscal policy instruments are used pro-cyclically, when debts are small, and counter-cyclically, when debts are large.

Asymmetric shocks

Demand-side asymmetric shocks are irrelevant for policy stabilization in our model, given our assumption of financial market completeness at the international level. Thus, we focus solely on productivity and mark-up shocks.

Productivity shock

A negative productivity shock at H gives rise to a positive terms-of-trade gap that inefficiently shifts demand from F goods towards H goods. This has a lowering effect on the inflation rate and on the output gap at F. Furthermore, there are also different budgetary consequences for the two countries: negative for H and positive for F.[55]

Optimal discretionary policy in the cooperative regime requires a fall in the government spending gap at H and a rise at F (a positive relative government spending gap), to alleviate the H inflation and the F deflation arising from the positive terms-of-trade gap. This is complemented with a raise in aggregate and relative tax rates and in the interest rate gap, when the debt stocks are small enough. The raise of the tax rates helps to stabilize debts while the increase in the interest rate gap forbids accrued inflationary pressures. Furthermore, the relative tax rate rise also helps the stabilization of relative inflation.

However, with sufficiently large debt-output ratios, the policy roles to prevent excessive inflation and to stabilize debt are inverted. As before, monetary policy, through a fall in the interest rate gap, works to reduce the debt service costs and, the tax rate at H decreases, to mitigate the inflationary consequences. The optimal monetary policy response to this shock becomes expansionary while the aggregate fiscal policy remains contractionary, since the aggregate government spending decreases and the aggregate tax rate increases. It is worth noting that the optimal response of the tax rates may be overturned, if the steady-state debt-output ratios are too high. The response to a negative productivity shock at H may require a decrease in both tax rates and so the aggregate tax rate decreases, if its inflationary consequences become too sharp.

Mark-up shock

A mark-up shock at H raises the domestic production inflation rate and decreases the terms-of-trade gap. This puts inflationary pressures on the F country. Because tax rates can be used as stabilization tools, it is optimal to decrease them to compensate the augmented mark-up distortions. However, since this has also negative budgetary consequences, the domestic tax rate gap increases, nevertheless, this change will be smaller, when the interest rate gap helps the stabilization of the debt stock. In effect, in response to mark-up shock at H, the aggregate tax rate gap increases by a lesser amount when the debt stocks are large than when they are small.[56] Moreover, the interest rate gap increases

[55] At H, the output, and not the output gap, deceases and, thus, the tax receipts diminish. At F, the output (and the output gap) increases generating a budgetary surplus.

[56] Actually, one observes that the F tax rate gap has to fall, when debts are large, to counteract the

when debts are small, to mitigate the inflationary pressures, and falls when debts are large, to lessen the debt consequences, while aggregate government spending gap drops, in both cases. Relative government spending increases to stabilize inflation differentials. Additionally, if we disregard the tax rate gaps and focus on the actual tax rates, we verify that the relative tax rate raises and facilitates the stabilization of relative inflation.

Depending on the debt-output ratio level, the optimal government spending gap may be pro-cyclical or counter-cyclical. Small debts retain the pro-cyclicality property of the previous setup, while large debts call for a counter-cyclical government spending rule.

Other policy solutions

Commitment

In order to appraise the main differences between the optimal stabilization policies under discretion and commitment, we consider the examples of a symmetric and an asymmetric negative productivity shock. When comparing the responses to these shocks under commitment (Figures 18 and 19) and under discretion (Figures 14 and 16), it is clear that the welfare-related variables display a lot less volatility under commitment. In contrast, the values of government debt at maturity (b) are permanently affected while under optimal discretionary policy debt changes are only temporary. The existence of a unit root in public debts that makes them permanently jump to higher permanent levels, under commitment, also characterizes the other fiscal policy variables and the output gaps. Thus, commitment apparently leads to less short-run macroeconomic volatility but to large long-run variability compared with discretion. Moreover, despite the steady-state debt-output ratio, the monetary policy instrument, in the first period, slightly accommodates the negative budgetary consequences of the shocks and boosts inflation while, in subsequent periods, returns to its pre-shock level.

In the first period, there is the temptation, given inflation expectations, to exploit the AS equations and generate an extra source of debt financing – unexpected inflation – that reduces the need to adjust the other instruments. This allows the fiscal policy

excessive inflationary pressures resulting from the decrease in the interest rate gap.

instruments to accomplish a better stabilization of the welfare-related variables, in the first period. Beyond the first period, inflation expectations can no more be exploited under the commitment solution, and the fiscal policy instruments have to be adjusted to sustain the new steady-state debt stocks. The temptation to use the policy instruments, in the first period, to reduce the debt-disequilibrium and to mitigate the costs of supporting the new debt levels is eliminated, in subsequent periods, only if the debt-output ratios return to their pre-shock levels. Hence, time-consistent discretionary solutions eliminate the unit root result and are extremely sensitive to the levels of the steady-state debt-output ratios (see Leith and Wren-Lewis, Feb. 2007, for a more complete analysis on this).

Looking at the short-run properties of the optimal policy plans under commitment and under discretion, we conclude that balanced budget policies present larger similitude with the former than with the latter.

Discretionary non-coordinated policies

Assuming that fiscal authorities are biased towards the satisfaction of their own citizens' well-being and, thus, do not cooperate while optimally choosing their own policies, the possibility of different optimal discretionary responses, correspondent to different policy games, are introduced.

From the comparison of the feedback coefficients on the shocks of the monetary policy instrument in Tables D.18 and D.19 with their corresponding counterparts in Table D.16, we conclude that, for small steady-state debt-output ratios, the monetary policy response to the various shocks, under the non-cooperative regimes and, in particular, the Nash regime, is qualitatively the same as the one observed in the cooperative regime but it is, globally, less active (less restrictive). In contrast, when all the countries in a monetary union have large debt stocks, monetary policy accommodates the negative debt consequences of the negative supply shocks and of the positive demand shock more and, thus, becomes more expansionary. This contributes to the differences observed in the variability of the consumption gap and in the variance of the inflation rates in the Nash and the cooperative policy regimes. When debts are small, the consumption gap is better stabilized while the inflation rates are worse stabilized under the non-cooperative Nash game than under the full cooperative regime; the reverse occurs for large debt stocks (see Figures 20, 21, 22 and 23, for a symmetric and an asymmetric negative productivity shock cases under both policy regimes and small and large debts). We should also remark that the fluctuations of the real value of debt at maturity are larger (smaller) when debts are small (large). Obviously, these results are mainly explained by the conducting policy of H and F fiscal authorities. To exemplify these adjustments, we pursue with the analysis of the reaction to a negative and non-persistent productivity shock at H, under the non-cooperative setup.

With large debt stocks, a negative productivity shock at H leads to a decrease in the domestic tax rate and government spending gaps to control the inflationary impulse. The decrease in the tax rate exacerbates the terms-of-trade gap deviation and the impact on F, while the converse occurs with the movement of the government spending gap. Hence, the domestic non-cooperative government makes less active use of the government spending gap and more active use of the tax rate gap. This aggravates the budget consequences and so, there has to be a stronger fall in the interest rate gap to pursue debt stabilization. Since the fiscal policy instruments of the F government inflict symmetric externalities, the tax rate gap raises with more moderation and the government spending gaps increases to a greater extent, at F.

Low debt stocks and non-cooperative regimes require, instead, more moderate responses from the monetary policy and the domestic fiscal policy instruments, but a more active response from the F fiscal authority. Basically, this difference in the feedback coefficients of the H and F fiscal instruments is explained by the non-internalization of the positive (negative) spillover effect of the fiscal policy at H (F) in the inflation rate at F (H).[57] While the fiscal policy at H attenuates the change in the terms-of-trade gap and, thus, diminishes the externalities of the shock, the fiscal policy at F accentuates it, aggravating the inflationary pressures at H. Domestically-oriented fiscal authorities ignore the outside effects and use their policy instruments more moderately when they impose positive externalities (H) and more vigorously when these inflict negative externalities (F).

[57]Notice that the tax rate gaps raises in both countries, for low debt countries.

This reasoning also explains the policy responses to symmetric shocks. Under small debt stocks, the benevolent, but purely domestically-oriented fiscal authorities, ignore the positive spillover effect of the fiscal policy and set their policy instruments sub-optimally (see Figure 20). Under large debt stocks, both fiscal authorities face incentives to use their tax rates more heavily (because of their non-internalized negative spillover effects) while the reduction in the government spending gaps, causing positive spillover effects, is less accentuated. The tax rates' behaviour in the non-cooperative setting increases debts and, thus, the monetary policy has to be looser (see Figure 21).

In this context, the playing order has an important role on the strategic policy interactions and deserves some reflection. We will perform the analysis of the leadership regimes by comparison with the Nash regime, where it is assumed that the policymakers act simultaneously. We focus on the responses to symmetric shocks.

When fiscal authorities are Stackelberg leaders relative to the monetary authority, they anticipate that the latter is more concerned with union-wide variables than with domestic variables. The fiscal authorities, biased towards maximizing domestic welfare, try to overcome this by performing more active policies than under Nash. In particular, in response to a negative productivity shock, they would raise the tax rates more when debts are small, while the central bank raises the interest rate gap, and reduces the tax rates when debts are large, while the central bank decreases the interest rate gap.

Under a monetary leadership regime, the central bank understands that the fiscal authorities are biased towards the performance of the domestic welfare-related variables. The monetary authority perceives that governments conduce less active polices, when debts are small, and decrease the tax rates further, when debts are large, than they would if their preferences were in accordance with enhancing the union-wide welfare. Hence, the monetary authority should perform a more active stabilization policy when debts are small and a less active policy when debts are large.

In spite of these specificities of the policy interactions under the various non-cooperative regimes, the policy reaction functions and the impulse responses are not substantially different. In general, when debts are small, the impact on consumption and government spending gaps is quantitatively smaller under the non-cooperative regimes than under the full cooperation regime. When debts are large, the latter performs a slightly better stabilization of the consumption gap but the inflation rates and the public spending gaps display larger volatility.

Fiscal policy rules

In order to discuss the stabilization consequences of imposing constraints on fiscal policy, we consider a constant debt rule for the government spending gap. In practice, this rule implies that a positive enough real surplus must be created every period to cover the net interest rate spending on outstanding real debt. In addition, we assume that the tax rates are set at their efficient levels so that the tax rate gaps are zero.[58] From the observation of the impulse responses to the several shocks, it is easy to conclude that such policy rule, combined with an optimal discretionary monetary policy, delivers much more short-run volatility (Figures 24 and 25 exemplify these findings). The feedback coefficients of the interest rate gap on negative supply and positive demand shocks are negative, and broadly independent of the steady-state debt-output ratios (see Table D.16 and D.17). This is explained by the negative impact on inflations and output gaps when government spending gaps adjust to maintain debt. This negative impact has to be alleviated through an expansionary monetary policy.

3.1.2 Insights for a monetary union with country-size asymmetry

Symmetric shocks We would expect the policy responses to symmetric shocks to be the same in a full symmetric setup and in a setup where the exclusive source of asymmetry is the relative size of the union-country members. Effectively, while the cooperative

[58]We have also considered the case of the tax rate adjustment to maintain constant debt while government spending is set at its efficient level. Naturally, this hypothesis imposes lower welfare costs, because the tax rate does not directly affects welfare. However, one may think that this hypothesis is more difficult to implement namely for political economy reasons thus implying a greater volatility in the tax rates. Nevertheless, if we took away the assumption of removing the long-run distortions through an employment subsidy, this debt constant rule would possibly have larger welfare effects.

solutions are in accordance with this conjecture, under non-cooperative nationally-biased fiscal authorities, this does not hold.

Country-size asymmetry does not affect the policy reactions in the cooperative regime: the large and the small country equally share the stabilization burden of the symmetric shocks. However, under the non-cooperative scenarios and large debt stocks, it is the small country that undertakes the more active fiscal policy stabilization role while the reverse occurs for small debt stocks (cf. Tables D.20, D.21, D.22 and D.23). Hence, in the non-cooperative setups, aggregate (gw and tw) and the relative (gr and tr) fiscal policies are both used to stabilize symmetric shocks.

Once more, we make use of a symmetric negative productivity shock as a meaningful example to get the intuition of this result.

When a symmetric negative productivity shock hits a large country and debt stocks are small, the domestic government spending gap falls and there is a raise in the domestic tax rate that attenuates the spillover effects of the shock by reducing the terms-of-trade gap variability (Table D.22). This positive externality of the fiscal policy is ignored under a non-cooperative setup and, thus, the fiscal authority uses its instrument less actively. If the two countries are of equal size, both take the same measures with equal intensity. A large country imposes larger externalities but the weight attributed to the small country in the social loss is in accordance with its relative size, that is, a small weight. When the fiscal authority of the large country is only concerned with the welfare of its citizens, it looks for the large part of the social loss. Hence, it will make use of its fiscal instruments less actively but to a minor degree than the fiscal authority of the small country would do. For this reason, the large country performs a more active fiscal policy in comparison to the small country.

If the spillover effects of the fiscal policy are negative, as it happens with large debt stocks, both fiscal authorities would be more active than in the cooperative setup as to the use of the tax rate. But, the fiscal authority of the large country will face a relatively smaller incentive for more active fiscal policies. Hence, larger volatility in fiscal policy instruments is expected in small countries.

Asymmetric shocks Under the full cooperative regime, the optimal policy response to a negative supply shock that hits the large (H) country requires a more active use of the monetary policy instrument and of the fiscal policy instruments of the small (F) country. Marginal costs and inflation rates for smaller and more open economies are more influenced by a change in the relative prices and, thus, F fiscal policy instruments have to be more actively used to counteract the effects of an idiosyncratic shock in the large country; the larger spillover effects of the domestic (H) fiscal policy instruments are not enough to compensate for cross-border effects of the shocks.

The optimal use of the fiscal policy instruments of the large country depends on the relative size of the debt stocks. In a low debt environment, the larger increase of the interest rate gap relative to the adjustment when the countries are of equal size has sharp negative budget consequences requiring a stronger increase in the domestic tax rate gap. In a high debt environment, the interest rate gap falls more to help the stabilization of the debt while the domestic fiscal policy instruments, now attached to the stabilization of the short-run effects of the shock, suffer a more moderated variation.

When an idiosyncratic shock hits a small country, one observes that the feedback coefficients on this shock of the monetary policy and of the foreign fiscal policy instruments are lower than under the symmetric monetary union. Again, we would expect a larger usage of the policy instruments by the F country. Effectively, one verifies that in a low debt union environment, the fiscal policy instruments of the small country are less actively used in response to a mark-up shock.[59] In all other cases, the fiscal policy instruments of the small country display a large active stabilization role.

From the comparison of the fiscal and monetary policy feedback coefficients under the full cooperative regime with the non-cooperative Nash regime, we can conclude that the changes on the parameters are similar to the ones observed in the low-debt country-size symmetry case (Tables D.20 and D.22). For instance, under the Nash regime, the optimal monetary and domestic fiscal policy responses to a negative supply shock hitting the large country are less active whereas, by contrast, the small country has to perform

[59] It is important to remark that the small feedback coefficient of the tax rate gap in this shock means a stronger adjustment in the tax rate.

a more active stabilization policy. By analyzing Figure 28 and 29, it is apparent that, in a low-debt environment, the Nash allows for a better stabilization of the output gaps and worsens the stabilization of the inflation rates, when compared to cooperation.

However, when departing from full cooperation, for large debt stocks, the feedback coefficients of the policy instruments do not move in line with what was observed for the symmetric union (Tables D.21 and D.23). In particular, and differently from what occurs in the symmetric setup, the interest rate gap decreases a reduced amount whereas the tax rates decrease by more in the Nash regime than under full cooperation, in response to a mark-up shock in the large country. Consequently, and regarding Figure 26, the welfare-related variables display less volatility in the non-cooperative regime, while the government debt of the large country exhibits higher variability. We should remark as well that the monetary policy in the Nash non-cooperative regime is also globally looser than under full cooperation, in response to negative supply shock hitting the small country, and that the domestic F government spending gap and the domestic F tax rate experience larger fluctuations (cf. Tables D.21 and D.23 and Figure 27).[60] In practice, and as cooperation is concerned, optimal policy under Nash enhances stabilization when the shocks hit the large country and worsens stabilization if the shocks mainly hit the small country.

Country-size asymmetry may take especial relevance in policy interactions and in the respective stabilization outcome, when policymakers face divergent policy objectives and can benefit from having a first-move advantage. Particularly, we expect the fiscal leadership regime to benefit the large country more, which would successfully impose the fulfillment of its own policy objectives to the central bank and also to the other country. The small country, having lower strategic power, would benefit more with a monetary leadership regime with a central bank serving its policy on the union-wide interests. For the union as a whole it is not clear which regime would perform a better stabilization outcome, given the benevolent policy objectives.

[60]When there is a positive mark-up shock, the efficient tax rate decreases to eliminate the mark-up distortion. If the actual tax rate does not go alongside its efficient level, the tax rate gap increases. This raise is larger, the smaller the decrease of the tax rate is. In the present case, the positive feedback coefficient of the F tax rate gap on the F mark-up shock is smaller under Nash than under full cooperation. Thus, the tax rate has decreased by more under the Nash regime.

In fact, our experiments do not display significant differences among the various non-cooperative regimes. The divergence between the fiscal and the monetary leadership policy regimes, under countries size-asymmetry, is apparent on the monetary policy response to a mark-up shock hitting the small or the large country. For instance, in a high-debt environment, the interest rate gap more accommodates the budgetary consequences of a positive mark-up shock that hits a large country under fiscal leadership than under monetary leadership. Diversely, the monetary policy responds more to a mark-up shock in the small country, under the monetary leadership than under the fiscal leadership policy regime.[61]

Finally, it is worth noting that, for any of the debt levels, when fiscal authorities are constrained by constant-debt rules, the interest rate gap decreases when the countries are hit by negative asymmetric supply shocks. This reduction is naturally more intense the larger the country hit by the shock. It is obvious from the inspection of the impulse-responses that, so seriously constraining fiscal policy, gives rise to larger short-run fluctuations.

3.1.3 Welfare analysis

There are many factors that globally affect the performance of the stabilization policies. In particular, the relative size of the government debt stocks, the type and frequency of shocks in the monetary union, the existence of country-size asymmetry and, obviously, the structure of the optimizing policy games played by the policymakers. Some of these dimensions were not considered in our previous model or took less relevance there. For instance, in that model, the fiscal policy instrument was reduced to the government spending gap fully accommodated by sufficient lump-sum taxes; thus, fiscal solvency constraint was not binding. Hence, the stabilization of the long-run effects of the shocks over the

[61] This different behaviour can be easily confirmed by looking at the feedback coefficient in these shocks in Table D.22. Under fiscal leadership, the interest rate gap decreases 0.2294 in response to a mark-up shock hitting the large country (H) and falls 0.1957 under the monetary leadership. The optimal feedback coefficients on the mark-up shock of the small country are naturally small under both policy regimes but, the interest rate gap decreases by 0.1582 when the central bank leads and decreases slightly less (0.1547) when the fiscal authorities lead the monetary authority.

debt was not a problem as it is the case with the current setup. It has also been showed that time-inconsistency problems are much more important in the debt model and, thus, the optimal benevolent cooperative plan under commitment diverges substantially from the corresponding discretionary policy plan. This raises some relevant questions that can be addressed even in benevolent policy setups.

First, since time-inconsistency problems are magnified by the budgetary consequences of the monetary policy, we speculate on the desirability of constraining fiscal policy to the exclusive control of the real value of debt.[62] Following Ferrero (2007), we tackle this issue by evaluating the welfare consequences when imposing a rigid fiscal policy rule: the government spending gap is adjusted to ensure, in each period, a constant real value of the debt, while the tax rate is set equal to its efficient value.[63] This reflects a more rigid interpretation of the fiscal policy rules embedded in the Maastricht Treaty and in the Stability and Growth Pact, but it conveniently illustrates the potential costs of an excessive concern with debt stabilization.

A second pertinent question to be addressed relies on the desirability to enhance macroeconomic policy coordination. In the context of the EMU, this issue has two dimensions: horizontal policy coordination (coordination among the fiscal authorities of the union country-members) and vertical coordination (coordination among the fiscal and the monetary authorities). The arguments favouring these institutional arrangements fall on the existence of spillovers between the fiscal and the monetary policies and on the free-riding problem.[64] Some of the coordination sceptics emphasise the extra time-inconsistency problems which arise from the larger strategic-power of coordinated fiscal authorities with different preferences as to those of the central bank.[65] Others extend their

[62]Political economy literature adds arguments on the specificity of the fiscal policy process that rationalize the imposition of balanced budget rules.

[63]This implies, in practice, that the tax rate fully stabilizes a mark-up shock. Setting the tax rate equal to its steady-state value does not change, qualitatively, the results we obtained.

[64]See Uhlig (2003) for an example of a static model on this free-riding problem.

[65]See Beetsma and Bovenberg (1998) on this argument and Catenaro and Tirelli (2000) and Pina (1999) on the discussion of its generality.

scepticism to the benefits of monetary and fiscal policy coordination.[66] Effectively, the debate on the gains of macroeconomic policy coordination is still active.

Within our current setup, the sources of strategic interactions between the various policymakers are scarce because they are benevolent and policy objectives only diverge because governments are domestically-oriented. Here, fiscal policy cooperation also corresponds to full policy cooperation, given the coincidence of the monetary and fiscal policy objectives. Moreover, through a production subsidy we eliminate the steady-sate sources of suboptimal policy outcomes associated to discretionary policies, such as "inflation bias", but the time-inconsistency problems associated to stabilization policies still remain. In practice, providing full policy cooperation when policymakers decide sequentially may, or may not, reinforce their incentives to exploit predetermined inflation expectations. The argument follows the same of the Rogoff (1985) when recast in a dynamic setting: making policymakers diverge from socially desirable objectives may approximate the discretionary stabilization solution to the optimal commitment outcome. Hence, it is relevant to appraise if there are gains when enhancing policy cooperation, when policymakers determine their policies period-by-period in an optimizing manner.

Finally, the movement order in optimizing fiscal and monetary policy games is critical on the strategic policy interactions and the stabilization outcomes, when there are diverging policy objectives.[67] This takes especial relevance when the two countries have different relative sizes and the stabilizations costs are unequally spread over them.

The existence of a micro-founded welfare criterion allows for the evaluation and the ranking of the different policy stabilization outcomes and to address the above-mentioned questions, using the benchmark parameter combination. Tables D.32 and D.34 report the union-wide welfare losses under the various optimal policy regimes, in a monetary union exclusively hit by idiosyncratic shocks and by symmetric shocks, respectively; Tables

[66]See Beetsma and Debrun (2004) for an extensive overview of a recent research on the interactions between fiscal and monetary policy in the EMU.

[67]In static frameworks, Dixit and Lambertini (2000 and 2001) and Lambertini (2006) found that the Nash equilibrium is more extreme and worse than the leadership equilibria. In dynamic settings, Kirsanova et al (2005) found that the Nash equilibrium results in large welfare losses while Blake and Kirsanova (2006) verified that, in most cases, the Nash gives more active policy reactions and better social outcomes than the leadership policy games.

D.33 and D.35 show the welfare losses for each country using, as an approximation to the correct welfare criterion,[68] the welfare losses obtained from the split-off the union-wide loss function. This intends to capture the traditional argument for the use of the fiscal policy as a stabilization tool when the monetary policy is unable to undertake the stabilization of country-specific shocks. However, in our current model and differently from the previous no-debt model, the stabilization of the symmetric shocks also requires the use of fiscal policies, even under full cooperation. Notwithstanding, the policy trade-offs and the strategic interactions among fiscal and monetary policymakers are less important for the stabilization of symmetric shocks and, as expected, a monetary union where symmetric shocks prevail, benefits from a larger welfare than a monetary union where asymmetric shocks dominate. Our experiments confirm this result (cf. Tables D.32 and D.34) and they also allow us to conclude that:

- Welfare losses are larger under discretion and in a monetary union with equal-sized countries.[69] The representative household of the large country is clearly beneficiated, compared to that of the small country, with the policy stabilization of idiosyncratic shocks.
- Constraining fiscal authorities, in order to follow constant-debt policy rules, has a substantial negative impact on stabilization performance, independently of the steady-state debt-output ratios. This follows from the excessive response of the government spending gaps to debt deviations. This extreme variability is a direct source of welfare costs but also an indirect one, by raising the variance of the other welfare-related variables. Furthermore, when comparing the welfare losses under these fiscal policy constraints with the ones obtained under the more favorable policy regime for each country, we verify that the big country looses less than the small country, when debts are small, but it loses relatively more, when debts are large.
- Relative to non-cooperative setups, discretionary policy cooperation worsens the union-

[68] Benigno and Benigno (2006) derive the quadratic utility-based objective functions for each country, to analyze the case of non-coordinated monetary policies. This requires second-order approximations of the structural equations of the model and it is algebraically cumbersome.

[69] Equal-size countries in a monetary union lead, in practice, to more asymmetry on shocks at the union level than in the case where country-size differs. Hence, stabilization is expected to be more difficult to perform in a monetary union with equal size countries.

wide welfare in a small-debt monetary union and, is welfare-enhancing in a large-debt monetary union (Table D.32, cfr. Lcoop with LML through LNash). Hence, divergent policy objectives may mitigate the time-inconsistency problems, when debts are small and, raise them, when debts are large.[70] When countries are of different size, the co-operative solution is preferred by the small country, but only in a large debt environment. The large country prefers not to cooperate (Table D.33).

- Among the non-cooperative regimes, and from the whole union standpoint, the monetary leadership policy regime performs better stabilization of the shocks, while the fiscal leadership depicts the worse stabilization performance (Table D.32). The large country, whose government benefits from having a large strategic power vis-à-vis the other policymakers, is better-off under fiscal leadership or Nash (respectively, for large and small debt-stocks), while the small country clearly benefits from being in the monetary leadership regime.

In sum, from our numerical analysis it is apparent that: there are welfare costs from constraining fiscal policy to strictly stabilize the debt-output ratio; full policy cooperation is only welfare-enhancing in a large-debt monetary union but this regime would be difficult to implement because the large country prefers to be in non-cooperative regimes; among the non-cooperative regimes, the monetary leadership results in smaller union-wide welfare losses and it reveals to be the best solution for the small country.

3.2 Non-benevolent scenarios

In the following section, we will analyze the policy interactions that arise when the fiscal and the monetary authorities have distorted policy objectives. We focus on the cases of a weight-conservative central bank and of output-biased fiscal authorities, because they

[70] Large debts accentuate the dilemma between short-run and long-run stabilization missions and, at the same time, change the relative stabilization roles of the fiscal and the monetary policy instruments. Allowing policymakers to deviate from the social welfare objective aggravates the outcomes when debts are large, because the monetary policy becomes looser. Small debt stocks keep monetary policy consigned to the stabilization of the short-run effects of the shocks. In this case, benevolent non-cooperative regimes moderate the monetary and the aggregate fiscal policy responses to the shocks, reducing the variance of the welfare-related variables and, thus, increasing welfare.

exemplify two different but concurrent argumentations on the policy stabilization debate. On the one hand, delegating monetary policy to a weight-conservative central bank is currently seen as a potential solution to reduce the time-inconsistency problems of policy stabilization. On the other hand, these time-inconsistency problems are seen to be aggravated by specific incentives of the fiscal authorities. The political economy literature highlights several motivations that potentially result in fiscal laxity and in wrong policy mix. Hence, whereas fiscal authorities especially concerned with output variability are expected to aggravate policy stabilization problems, delegating monetary policy to a central bank more averse than society to inflation variability is an institutional arrangement usually referred to as a solution to mitigate such stabilization problems.

In this context, we begin to appraise how the weight-conservative hypothesis shapes the policy responses to the shocks under monetary and fiscal leadership policy regimes[71] and, then, follow with the case of fiscal authorities biased towards output gap stabilization.

3.2.1 Adjustments to shocks

Conservative central bank and benevolent domestically-oriented governments Our experiments show that delegating monetary policy to a conservative central bank magnifies its response to shocks, particularly under monetary leadership. The benevolent, domestically-oriented, fiscal authorities try to compensate this overreaction by conducting less restrictive fiscal policies. In fact, on impact[72] and in relation to the benevolent scenario, the fiscal authorities decrease by less the government spending gaps and, depending on the debt-stock levels, decrease by more or raise by less the tax rates in response to shocks that have domestic inflationary consequences.[73]

[71]For a more straightforward analysis, we focus on the fiscal leadership and the monetary leadership regimes, the two regimes that exhibit more extreme welfare outcomes under the benevolent setups.

[72]We focus the analysis on the first-period policy interactions to shocks.

[73]Cf. the coefficients of the policy reaction functions under monetary and fiscal leadership in Tables D.24 and D.25 with the corresponding coefficients in Tables D.18 and D.19 for the same policy games but benevolent policymakers.

From the inspection of the impulse responses to symmetric and asymmetric shocks, one verifies that the variables maintain, in general, the same trajectories of the benevolent setups, but the weight-conservative hypothesis increases the volatility of the consumption gap while it decreases the variance of the inflation rates and that of the government spending gaps. It is also important to remark that this institutional arrangement provokes larger variability on the real value of debts at maturity (see Figure 30 and 31 for symmetric shocks and 32 and 33 for asymmetric shocks, under benevolent and weight-conservative monetary leadership).

In fact, these overall results have slightly different expressions when the monetary authority plays first relative to both fiscal authorities and when it behaves as a follower. In the fiscal leadership policy game, the fiscal authorities, anticipating that the monetary authority will fight more aggressively the inflationary stress than they judge as desirable, follow even less restrictive fiscal policies than in the corresponding benevolent case. When the conservative central bank policy leads the fiscal authorities, the former knows that the latter policymakers are not sufficiently concerned with inflation variability. As expected, the central bank will raise by more the interest rate gap in response to shocks that have inflationary consequences, but only when debts are small. However, in a high-debt monetary union, the central bank decreases the interest rate gap in response to a shock that has negative budgetary consequences, while governments have to reduce the government spending gaps and the tax rates to provide short-run stabilization. However, the benevolent fiscal authorities ponder inflation variability less than the monetary authority does. To force fiscal authorities to adopt policies more in accordance to its preferences, the monetary authority ends up decreasing the interest rate gap more than it would do in the benevolent setup. In practice, as to the fiscal leadership regime, the monetary leadership regime exacerbates the response of the interest rate gap to shocks but this conducting policy only improves inflation stabilization for large debts (see Figures 34 and 35).

Output-biased fiscal authorities and benevolent central bank We follow Blake and Kirsanova (Oct. 2006) by considering a specification that is equivalent to the one used for the weight-conservative scenario: we assume that the fiscal authorities penalize the variability of the welfare demand-related terms relatively more than society does.

Fiscal authorities that penalize inflation variability less than the central bank and society do, bring in another source of strategic interactions between the fiscal and the monetary policymakers that, in the present model, tightens the monetary policy response to shocks and reduces the use of government spending with direct welfare effects. In fact, the qualitative changes on the policy responses to the shocks are very similar to the ones observed under the weight-conservative scenario: i) depending on the magnitude of the debt-output ratios, the interest rate gap raises by more or decreases by less in response to shocks that have inflationary effects, relative to the benevolent setups; ii) similarly, government spending gaps are used less actively but, in general, a domestic negative supply shock requires a more intensive use of the domestic tax rate gap.

In spite of these qualitative similarities, the stabilization properties of this scenario are significantly different from those of the weight-conservative case. The dynamics of the welfare-related variables confirm that, in comparison to the corresponding benevolent regimes, the inflation rates display more volatility, particularly when debts are large, while the output gaps and the government spending gaps exhibit smaller variances. Moreover, our simulations do not corroborate the conclusion of larger fluctuations on the real value of the debts at the maturity, when governments are less prone than the benevolent central bank to enhance inflation stabilization. In fact, and in terms of the benevolent setups, debts also return to their pre-shock steady-state values and depict small fluctuations in a number of situations. Figures 36-39 illustrate these findings, for a symmetric, negative and non-persistent productivity shock case.

The playing order in the two leadership regimes shapes the strategic interactions between the fiscal and the monetary policymakers making inflation relatively better stabilized, under the monetary leadership regime, while the fiscal leadership regime ensures a better stabilization of the consumption and the output gaps.

Anticipating that the fiscal authorities will perform output-biased stabilization policies, the benevolent central bank uses its policy instrument more actively to create some extra recession, when debts are small, or to generate extra budgetary revenue that liberates tax rates to outweigh the inflationary effects and, simultaneously, to mitigate recession, under large debts. By their side, the non-benevolent fiscal authorities desire to reduce by less the government spending gaps than in the benevolent setup and so, they have to raise by more the tax rate gaps or to decrease them by less, to mitigate the budgetary consequences. They are aware that, when debts are small, for instance, the monetary authority will raise the interest rate gap in response to negative supply shocks. To circumvent the recessionary effect of this monetary policy reaction, the fiscal authorities choose to raise the tax rate gaps moderately. In general, the monetary leadership regime reaches a better stabilization performance of the inflation rates than the fiscal leadership regime while, the latter, performs a better stabilization of the consumption and the output gaps (see Figures 40 and 41).

3.2.2 Welfare analysis

The question of whether monetary conservatism improves welfare has been frequently addressed in the literature. Originally, this solution was proposed by Rogoff (1985) to overcome the monetary commitment problem originating from an excessive output target. Clarida et al (1999) recast Rogoff's rationale for a conservative central banker in a context where the commitment problem follows exclusively from the forward-looking nature of inflation. The welfare gains from this institutional arrangement were uncontroversial in the context of monetary policy models but it became doubtful in models that integrate monetary and fiscal policies. A fiscal authority, acting strategically, may prevent the conservative central bank to achieve a lower inflation and may lead to a wrong policy-mix. Dixit and Lambertini (2001, 2003a, 2003b), in the context of static models, highlight the problems arising from making fiscal and monetary authorities diverge in their policy objectives. Within dynamic closed-economy settings, Adam and Billi (2006) found that monetary conservatism improves the conduct of stabilization policy but Blake and Kirsanova (Oct. 2006) only get this outcome when they introduce inflation persistence into their model.

Our experiments suggest that the desirability of monetary conservatism depends on the type of strategic policy interactions that can be developed in the economy and, so, is highly model and parameter dependent. This can be easily verified by taking the example of our small-debt monetary union representation, when countries have equal and unequal sizes and shocks are country-specific. Looking at the welfare losses reported in the 2nd half of Tables D.32 and D.33 for the small-debt case, we verify that making the central bank more averse to inflation than society has positive welfare consequences, when countries have equal size (4.75 vs. 4.79), but it may aggravate the welfare stabilization costs, when countries have different relative dimensions (3.26 vs. 3.25). A more attentive examination of the distribution of the welfare losses among the two countries allows for the perception of how country-size asymmetry shapes the strategic policy interactions and impinges these outcomes. Under fiscal leadership, the government of the large country anticipates the reaction of the conservative central bank and it is aware of its greater influence. It ends up conducting a less active fiscal policy and this benefits the stabilization of its welfare-related variables, diminishing the perceived costs of macroeconomic stabilization. Diversely, the welfare-related variables of the small country are worse stabilized and, in spite of its small weight on the union-wide loss function, this inferior stabilization performance overturns the stabilization gains obtained by the large country and welfare decreases at the union-wide level. Under monetary leadership, the central bank anticipates that the fiscal authority of the large country may react aggressively and with more success to its anti-inflationary policy. Instead of moderating its policy, the conservative central bank ends up conducting a more reactive policy to the shocks hitting the large country. This raises the welfare costs in the large country and makes welfare decrease in the whole union, despite the welfare gains of the small country.

In a large-debt monetary union and from the union-wide perspective, there are welfare costs from raising the central bank aversion to inflation in the monetary leadership policy regime but, there are welfare gains as well, if the fiscal authorities have a first-move advantage. The divergent outcomes relative to the small-debt case follow from the change of the policy instruments stabilization assignments. In a large-debt scenario, we should conclude that there is no need to set the central bank more averse to inflation when it leads but, it may be desirable to do that, if it follows fiscal authorities.

In what concerns output-biased governments, in general, welfare worsens compared to the benevolent solutions (cf. Tables D.32 and D.34). Notwithstanding, the citizens of the large and the small countries could be better-off with the distorted policy objectives of their governments, under certain circumstances: the representative household of the large country seems to be slightly better, if its government is a Stackelberg leader and cares less inflation variability than society in small-debt monetary union; the representative household of the small country would prefer to get a government with this characteristic in office, if a benevolent common central bank is a Stackelberg leader in a large-debt monetary union (cf. Tables D.33 and D.35).

3.3 Sensitivity analysis

3.3.1 Stabilization outcomes in a monetary union with divergent debt-to-output ratios

In Chapter 3, the fiscal policy dimension of the stabilization problem was mainly analyzed within an environment where government spending was the fiscal policy instrument and where there were enough lump sum taxes to satisfy the government budget constraint. Recently, there is a growing branch of literature that recognizes the inexistence of these non-distortionary sources of government receipts and looks for the fiscal policy stabilization dimension when the intertemporal government solvency constraint is binding. Here, public debt and, specially, its steady-state debt-output ratio play a crucial role on the fiscal and monetary policy interactions. There is a natural concern that large debts may impair the stabilization performance of the policies and, correlatively, that it may be optimal to impose limits on government indebtedness.

Our experiments showed that, under commitment, the optimal stabilization policies were not substantially affected by the levels of the pre-shock debt-output ratios but, the discretionary policies were very sensitive to the public debt ratios. In accordance with the analytical findings of Leith and Wren-Lewis (2007a), our results revealed the existence of a threshold on those ratios that shifts the stabilization assignments of the various policy instruments. It became clear that, for large enough debts, the monetary policy instrument accommodates the budgetary consequences of the shocks, while the tax rates gain efficiency in the control of their inflationary consequences. Under our model parameterization that threshold occurs for a very low debt-output ratio (19%) and, given the EMU evidence on this, it may be arguable that we should only focus the analysis on high debt-output ratios. However, if the existence of balanced budget fiscal policies is improbable, because it requires the full availability of lump sum taxes, we may also claim that, for the unreality of the inexistence of non-distortionary receipts, which accommodate, at least in part, the budgetary consequences of the shocks. If this is the case, one can envisage the qualitative results of a low debt scenario as a proxy of this policy setup. This is an additional reason to assess the stabilization performance of the policies under both high and low debt-output ratios.

In a structurally symmetric monetary union, perfectly positively correlated shocks only have welfare consequences because they have budgetary consequences that do not allow the policy instruments to be set at their efficient levels. The impact of the shocks on debt depends on their persistence and on the pre-shock debt-output ratio. Under our calibration, we verify that, in general, the budgetary consequences of the symmetric shocks decrease with the size of the steady-state debt-output ratio (Table D.36). Moreover, as we have already noticed, with the raise of the debt-output ratio, the policy instruments change their ability to counteract the effects of the shocks on debt and on the welfare-related variables: both fiscal policy instruments turn out to be less effective in controlling debt and the tax rate becomes more efficient to control the inflation rate; in contrast, the interest rate has a large impact on the debt service costs. Therefore, we observe that raising the steady-state debt-output ratios symmetrically in both countries may have positive or negative welfare effects, under the various discretionary policy regimes, depending on the size of the debt-output ratio. If this ratio is sufficiently small, raising it is welfare-reducing because, in spite of the small impact of the shocks, the fiscal policy instruments that specialize in the debt stabilization also become less effective in performing their task. For adequately high debt-output ratios, when the policy instruments changes their stabilization assignments, there are welfare gains attached to large debt stocks, once the tax rate became more apt to stabilize the inflation rate. Nevertheless, we also verify that welfare losses are small in a low-debt monetary union than in a high-debt union. That is, in an environment that replicates a closed economy scenario, and focusing exclusively on the stabilization costs, we conclude for the rationale of imposing limits on debts that do not allow their long-run values to surpass a given threshold level at which the policy instruments change their stabilization assignments and that may justify an augmented government conduct of indebtedness. In fact, when debts are high, a country that unilaterally increases its debt stock sees its welfare losses being reduced as well as the welfare losses of the whole union, in spite of the negative effect on the wellbeing of the "well-behaved" country. There will be stabilization gains for all the countries, if the "well-behaved" government raises its debt too. Opposite effects take place, when debts are small enough.

In a monetary union, where idiosyncratic shocks prevail and, therefore, the welfare consequences of the shocks do not result exclusively from their budgetary effects, there are amplified policy stabilization conflicts, particularly when there are divergent policy objectives. From examining the welfare losses reported in Table D.37, we conclude that the discretionary, benevolent and full cooperative regime replicates the qualitative outcomes of the previous setups but, naturally, with high welfare costs. However, for discretionary, non-cooperative policy regimes,[74] raising the steady-state debt-output ratio symmetrically across countries is welfare-reducing. In addition, in a high-debt monetary union, a country that unilaterally raises its debt stock ameliorates its welfare, but it deteriorates welfare from the perspective of the other country and of the whole union. The latter country will gain, and will improve the union's welfare as well, if it follows that debt deviating behavior and lets its indebtedness attain a higher level. Since in EMU there is no policy cooperation, one finds accrued arguments for the imposition of debt limits that

[74] The fiscal leadership regimes replicate the qualitative results of the monetary leadership regimes.

push the steady-state debt-output ratios to levels that are consistent with our low debt scenarios.

The consideration of a monetary union, where small and large countries coexist, places additional concerns on the stabilization performance of the policies and the possibility of small countries to benefit from a free-riding behavior that conduces to a large indebtedness. In fact, we observe that, from the whole union's point of view, the stabilization performance is better under an unequal sized monetary union, for the reason that this implies, in practice, having more symmetric shocks. In contrast, the shocks that hit the small country are even more idiosyncratic and so, this country is naturally worse-off than the large country.

Differently from the case where the union's members have the same size, one verifies that, raising symmetrically the steady-state debt-output ratio in both countries when debts are high deteriorates the well-being of the small country while benefiting the large one (see Table D.38).[75] Hence, we can find here a rationale for the small countries to be more enthusiastic about fiscal policy constraints that lead to a reduction of the public debt in the monetary union. This argument is reinforced, when we look at the small-debt scenarios and verify that the small country is better-off there than in the high-debt scenarios. Moreover, we also verify that, when both countries are fulfilling the same (high) target for the annual steady-state debt-output ratio, say 60%, the small country faces no motivation to raise its debt beyond that limit, except when there is a benevolent cooperative and discretionary policy regime. On the other hand, the large country does not envisage an incentive to raise its debt only in a monetary leadership with a weight-conservative central bank. If the government of the large country adopts a looser conduct, the union-wide welfare augments but the small country does not gain from having a government that follows the loose behavior of a large country and raises permanently its indebtedness.

Hence, by focusing exclusively on the welfare consequences of the stabilization policies under various high debt-output ratios, we do not find a motivation to be especially concerned with a potential free-riding behavior of the small countries that raises their public indebtedness. In fact, they are more interested in being disciplined as well as enforcing

[75] Except in a monetary leadership regime with a weight-conservative central bank.

fiscal discipline for whole the union. The large country faces accrued incentives to be fiscally undisciplined and this may explain the fact that, in current EMU, large countries tend to have larger debts than the smaller ones.

However, we have to temperate these settlements when we focus on the low-debt monetary union scenarios. Here, the large country and the union-wide are manifestly worse-off when the pre-shock debt ratios increase symmetrically or when the large economy raises its debt ratio unilaterally. Thus, by only looking for the stabilization motives, this country would not face any incentive to be fiscally undisciplined and to accumulate debt permanently. Notwithstanding, a deviating debt behavior of the government of the small country would be welcomed from the viewpoint of the representative household of the monetary union. In general, the small country gains with this conduct and the large country does not face an incentive to follow it. Hence, according to our experiments, an unequal-sized monetary union would tend to accumulate public debt differentially. Under low-debt scenarios, the small countries would register large public indebtedness while, under high-debt scenarios, it would be the large countries to get large debt-output ratios. This debt asymmetry would be beneficial for the monetary union welfare.

3.3.2 Nominal rigidities

A structural reform that reduces the degree of nominal rigidity impinges directly on welfare, because it reduces the penalization of inflation variability, however, it also indirectly affects welfare by its impact on the volatility of the welfare-related variables.[76] In general, the combination of these two effects leads to a non-monotonic relationship between the degree of nominal rigidity and the welfare stabilization costs, as it was shown in Chapter 2 and confirmed, for instance, by Lombardo (2002).

In the present fiscal policy setup, the change on the degree of nominal rigidity has, in addition, non negligible budgetary consequences and it may have consequences on the relative contribution of the different policy instruments for debt stabilization. Thus, there are additional effects that condition the optimal policy plans and their stabilization per-

[76] See Chapter 2.

formance. In effect, Leith and Wren-Lewis (2007a), in a closed-economy setup, showed that the contribution to debt stabilization of the fiscal policy instruments is only significant for low levels of steady-state debt. Moreover, they found that the tax rates are more relevant for high-nominal rigidity while government spending contributes relatively more to debt stabilization for low-nominal rigidity. For high levels of debt-output ratios, debt stabilization mainly relies on the monetary policy and, as long as prices become more flexible, the monetary policy's ability to change the real interest rate is reduced and there is added reliance on inflation surprise to return debt to its pre-shock steady-state level. Notwithstanding, the need to reduce debt service costs may increase because, with large price flexibility, the decline of the real interest rate has a small positive effect on the output and, consequently, on tax revenues.

In sum, the arguments above do not provide clear cut conclusions on the welfare consequences of raising the degree of price flexibility. Moreover, the degree of nominal rigidity crucially affects the monetary and fiscal policy interactions, under binding budgetary constraints. Thus, in the present setting, the welfare consequences of instituting reforms that decrease the degree of nominal rigidity are even less clear cut.

In effect, by focusing on the cooperative policy outcomes we find that, similarly to our previous findings, the reduction of the degree of nominal rigidity causes non-monotonic effects on welfare (Tables D.39 and D.40). Despite the steady-state debt-output ratios, raising symmetrically price flexibility in the monetary union only reduces the union-wide welfare stabilization costs for a high enough degree of nominal flexibility $(1-\alpha)$ .The small and more open economy loses with high price flexibility whilst, the large country, in general, benefits (cf. Table D.42). This suggests a potential conflict of interests between small and large countries in a monetary union: large countries may desire structural reforms that raise price flexibility in all the union but, small countries, could resist them. Moreover, the large countries would only face incentives to perform these types of reforms unilaterally, if debt-stocks were low enough and the degree of nominal flexibility became sufficiently high. Otherwise, they would prefer having high nominal rigidity and this also would be beneficial from a union-wide perspective (cf. Tables D.41 and D.42).

In a symmetric country-size monetary union, consenting to asymmetric nominal rigidities is beneficial for the country that maintains more nominal rigidity, because it benefits from a larger monetary policy response, when debts are small and the monetary policy instrument performs the traditional short-run stabilization task, and it profits from a small reaction of the interest rate, when debts are large and the monetary policy instrument specializes in debt-stabilization.[77] The whole union and the country with high price flexibility only gain when this is sufficiently high.

Non-cooperative policy regimes lead to strategic interactions between fiscal and monetary authorities. Different degrees of nominal rigidity may diversely shape these strategic interactions and, consequently, the welfare ranking of the diverse policy regimes may suffer alterations. We did not find evidence of this possibility in our previous policy setup, as the welfare ranking of the various benevolent policy regimes remained unchanged. In the present fiscal policy setup, there are non-trivial interactions between fiscal and monetary decisions and, the steady-state debt-output ratio and the degree of nominal rigidity are both decisive for those policy interactions. In fact, we have obtained results that seem to confirm the importance of the degree of price flexibility, on this fiscal policy context, for the monetary and fiscal strategic interactions. The welfare ranking of the diverse policy games revealed to be sensitive to the degree of price stickiness.

3.3.3 Tentative assessment of the EMU case

In order to assess how country-size asymmetry impinged on the monetary and fiscal policy interactions in a monetary union, we have calibrated our model disregarding all its other sources of potential asymmetry. In the two previous sections we have separately considered the possibility of having asymmetric debts and asymmetric degrees of nominal rigidity. The current EMU assembles a number of these asymmetries: large and small

[77] The feedback coefficients on the shocks hitting the country with high nominal rigidity are large, for small debts, and small, for high debt-stocks. This is analogous to the findings of Benigno (2004) and Beetsma and Jensen (2004, 2005), among others. It is optimal to direct monetary policy at trying to keep more stable inflation in the country with high nominal rigidity. In our setting, this implies a more restrictive monetary policy response to shocks hitting the country with more nominal rigidity, when debts are small, and a less expansionary response, when debts are large. These results are available upon request.

countries; low and high debt countries; more and less flexible-price economies, *inter alia*. To get an idea of how this would affect the stabilization outcomes, under the various policy regimes, we calibrate our model to replicate some of the features of the current EMU. Tables D.43-D.45 provide the welfare losses under various policy regimes. From its examination it is apparent that under an EMU scenario and benevolent policymakers that re-optimize every period, there are union-wide welfare gains from being in a monetary leadership regime. The large and more indebted economies of the EMU would prefer to be under a fiscal leadership regime while the small and more disciplined countries would be better-off under a Nash. Full policy cooperation would deliver a worse outcome and no country would face any incentive to promote this institutional arrangement (Table D.43 and D.44).[78]

Furthermore, delegating monetary policy to a conservative central bank deteriorates welfare, except in fiscal leadership. Therefore, there are no gains from radicalizing the preferences of the central bank towards the combat of inflation variability, when the central bank has a first move advantage but, it can be beneficial to do that, when fiscal authorities lead. If governments are more adverse to output variability than society, the stabilization outcome worsens at both the union-wide and individual country levels. Notwithstanding, it is preferable to have a monetary leadership regime. In sum, and in accordance with our previous results, there are welfare gains from having benevolent policymakers with a first moving advantage (Table D.43 and D.44).

Finally, if the central bank, in line with the institutional EMU arrangement, is exclusively assigned to stabilize inflation (a case of extreme weight-conservatism) and if fiscal authorities are only concerned with the stabilization of domestic output terms (a case of extreme output-bias), the welfare stabilization costs are extreme (Table D.45, LMLw and LFLw). In this context, there would be substantial welfare gains from both the monetary union and the central bank perspectives, if the national fiscal authorities cooperate in minimizing the union-wide loss function. However, national fiscal authorities would face incentives to deviate from this cooperative solution because they would be better-off un-

[78]Our experiments showed that, for this model calibration, policy cooperation only would be beneficial for the union-wide, if there were symmetry on government indebtedness in the monetary union.

der non-cooperation.[79] Full policy cooperation would deliver an even better stabilization outcome but, it could be difficult to implement, especially when the fiscal stance ignores the monetary policy inflation goal.

[79] For instance, from the H fiscal authority perspective, the stabilization welfare costs increase from 47.55, under non-cooperation, to 156.51, under horizontal policy cooperation.

CONCLUDING REMARKS

This work explored the interactions between monetary and fiscal stabilization policies in a micro-founded macroeconomic dynamic model for a monetary union with country-size asymmetry.

Our objectives, as spelled out in the introduction were to derive the optimal strategic policy mix within an asymmetric country-size monetary union, and assess the effects of some institutional arrangements (cooperation, fiscal constraints, the promotion of a weight-conservative central bank) and of the level of government indebtness on the effectiveness of policy stabilization. Two scenarios were set up in order to accomplish this exercise: the former, where monetary and fiscal policy instruments exert their stabilization roles exclusively through the demand channel and without any consequence on debt sustainability; the latter, where fiscal policy has both demand and supply-side effects but where lump-sum taxes are not enough to ensure fiscal policy solvency. Using a second-order approximation to the union-wide (social) welfare, optimal policy reaction functions under diverse policy regimes were computed and evaluated according to the stabilization performance. We have also investigated whether the social welfare under discretionary policy could be improved through some institutional arrangements, such as policy cooperation, the delegation of monetary policy to a conservative central bank, and the implementation of some structural reforms. We have found out that the results of these analysis change qualitatively with the degree of country-size symmetry, and with both cross-country average and dispersion of debt-to-output levels.

In regard to the optimal time-consistent stabilization policy mix in a monetary union, our results show that the outcomes are highly sensitive to the available fiscal policy instruments as well as to the existence of non-distortionary government sources of financing. Furthermore, with divergent policy objectives, strategic interactions arising from the time structure of the policy games, played by the national fiscal authorities and by the common central bank, affect significantly the stabilization outcomes.

In a monetary union where heterogeneity derives exclusively from exogenous shocks and balanced budget fiscal policies are enforced, optimal discretionary cooperative policies lead to a clear specialization of the policy instruments for different stabilization tasks: while monetary policy stabilizes union-wide aggregate variables, fiscal policy is concerned with the stabilization of country-specific variables. Conversely, when policy instruments are constrained by the need to ensure debt stabilization, fiscal policy responds to both types of variables and, depending on the level of government indebtedness, a different specialization of the policy instruments emerges. In a large-debt monetary union, the monetary policy instrument specializes on debt stabilization and the fiscal policy instruments focus on short-run macroeconomic stabilization; in a small-debt monetary union, the reverse occurs. As a consequence, the dynamics of endogenous variables are very different when the economies are hit by negative supply shocks: inflation and output gap co-move positively in a large-debt monetary union while, in a small-debt monetary union, they co-move negatively. These different dynamics express the importance of time-inconsistency problems when the debt accumulation process constrains policymaking. Thus, and in the context of perfect coordination between policy authorities, if large debts prevail in a monetary union (like the EMU), it seems to enclose a meaningful risk for the monetary policy to shift away from the traditional price stabilization objective.

Compared with discretionary outcomes, optimal policy mix under commitment induces a unit root in all real variables and yields a better short-run stabilization performance at the expenses of a permanent adjustment in the government debt, irrespective of the initial debt-to-output ratio. In contrast, under optimal discretionary policies, all endogenous variables (inclusive the debt-to-output ratio) return to their pre-shock levels, but there are larger short-run fluctuations. Unlike commitment, the trajectories for the endogenous variables depend on the initial level of government indebtedness. Hence, it may be misleading to use the simplifying assumption of balanced budget fiscal policies in the analysis of the monetary and fiscal policy interactions under discretion.

Considering divergent policy objectives – domestically-oriented fiscal authorities and a benevolent union-oriented central bank –, non-cooperative policies lead to strategic interactions among policymakers that produce a worse stabilization performance; however, when debts are small enough, these strategic interactions apparently mitigate time-inconsistency problems and improve welfare. If non-cooperation prevails (strategic policymaking), welfare stabilization costs are minimized under the monetary leadership regime, where the benevolent central bank, anticipating the policy conducting of the national fiscal authorities, sets its policy to manipulate that of the latter.

The results, in the case of country-size asymmetry within a monetary union, meaningfully qualify the statements made throughout. A small country, suffering larger externality effects and benefiting less from a common monetary policy for stabilization purposes, has to optimally rely on a more active fiscal policy and, as expected, it experiences more welfare costs than a larger country.[80] Our experiments also suggest that country-size asymmetry, and consequently, asymmetric bargaining power, is a relevant variable in determining the optimal strategic policy mix. The welfare evaluation of the alternative policy games show that: i) the large country achieves, in general, a better stabilization performance under fiscal leadership because it can exploit, on its own benefit, its large strategic power vis-à-vis the common central bank; ii) conversely, the small country benefits more from a benevolent monetary leadership regime; iii) moreover, even when cooperation[81] yields a superior outcome for the monetary union as a whole – the cases of balanced-budget fiscal policies or of a large-debt monetary union –, it proves difficult to implement such a policy arrangement, because the large country faces incentives to deviate.

We have also accessed on how the delegation of the monetary policy to a conservative central bank could improve the outcome of strategic games when the cooperative outcome proved to be optimal – the cases of balanced-budget fiscal policies or of a large-debt monetary union –. With symmetric-size countries, this solution increases the potential conflicts between fiscal and monetary authorities and, thus, it deteriorates welfare. However, in a small-debt monetary union, where policy cooperation would deliver a worse stabilization outcome, there are welfare gains from accentuating the preferences of the central bank for fighting inflation variability.[82] Additional strategic elements arising from

[80] In spite of using a different framework, these results are in accordance with the findings of Canzoneri et al. (2005).

[81] Recall that the central bank's policy objective is union-wide social loss. In this case, fiscal policy cooperation is equivalent to full cooperation.

[82] Adam and Billi (2006), for a closed-economy setup with balanced budget policies, found welfare gains from delegating monetary policy to a conservative central bank. Blake and Kirsanova (2006), for a closed-economy setup with a fiscal solvency constraint imposed on a small-debt economy, also found this hypothesis to be welfare enhancing, but conditioned on the existence of inflation persistence.

different size countries in a monetary union, may overturn some of these conclusions, especially when monetary and fiscal interactions are amplified by the existence of binding budgetary solvency constraints. We found out that when the central bank leads, there are no advantages from delegating the monetary policy to a conservative central bank, but when the large country fiscal authority leads, this arrangement may be welfare improving.[83] These results add to the rationale for a conservative ECB, given that the larger countries in the EMU may, by taking advantage of their relative size, behave strategically and, thus, deteriorate the union-wide welfare.

If we take policymakers to exhibit extreme preferences (exclusively) over inflation variability (central bank) and over the stabilization of domestic output (national fiscal authorities), the welfare stabilization costs would also be extremely high. In this case, the central bank and the monetary union would prefer to get fiscal authorities cooperating and internalizing the average monetary union inflation goal, while national governments would face incentives to deviate from the cooperative solution.

Largely motivated by the recent efforts of fiscal consolidation within the EMU countries, as well as by the debate on the need for the implementation of structural reforms, we have tentatively assessed, in the context of our model and regarding only to the policy stabilization performance, the incentives for reforms aiming at reducing the degree of nominal rigidity or that decrease the long-run debt-to-output ratio. Hence we focus on the impacts of such reforms exclusively on the welfare costs attached to stabilization policies, and not on their full structural impacts in the economy.

Reducing nominal rigidity symmetrically across the monetary union is likely to raise the costs of stabilization policies, unless this reduction acquires a significant expression. In general, smaller, and so more open, economies lose with this reform, whilst larger countries benefit from it. Focusing exclusively on stabilization costs, this suggests a potential conflict of interests between small and large countries in a monetary union: large countries may desire structural reforms to raise price flexibility across the union, but small countries may resist to them. An asymmetric reform improves the effectiveness of the monetary policy instrument to deal with asymmetric shocks, but it could be difficult to

[83] This is the case in a large-debt monetary union.

implement, given the negative welfare stabilization effect on the country enhancing the reform.

In what regards the effects of the debt levels, it is apparent from our results that, in general, low welfare stabilization costs occur with low debt-to-output ratios. Moreover, under a large-debt monetary union and discretionary non-cooperative policy regimes, raising the steady-state debt-output ratio symmetrically is welfare-reducing. However, each country would face an incentive to unilaterally raise its public indebtedness and, additionally, the other country would follow this behavior. As a consequence, debt would rise in the whole monetary union and this would prove welfare decreasing for all. Thus, these are accrued arguments to impose debt limits that push the steady-state debt-output ratios to levels consistent with low-debt scenarios, when these incentives are absent. Our results also suggest that, in a country-size symmetric monetary union, there is rationale for homogenizing the public debt ratios across countries.

Diversely, an unequal-sized monetary union would tend to accumulate public debt differently. Under low-debt scenarios, the small countries would register large public indebtedness, while under high-debt scenarios the large countries would have larger debt-to-output ratios. This debt asymmetry favours stabilization policies outcomes for the whole monetary union. In addition, we can infer from our results that the small countries may be more enthusiastic towards fiscal reforms aimed at reducing public debt in a high-debt monetary union.

From this sensitivity analysis to debt-level asymmetry, we can infer on both normative and positive sides of the policy-making in the EMU. i) On the normative side, the results imply that low-debt levels are a desirable environment, even if we account only for welfare stabilization costs. At the same time, our results also highlight that an homogenized-debt target may not be a wise feature to impose in an EMU where countries are not size-symmetric. ii) On the positive side, our results also seem to confirm the EMU current stance regarding long-term fiscal sustainability: in the EMU, where non-homogeneous public indebtedness prevails and average public debt can be considered as large, small countries tend to have small debt-to-output ratios while the large ones are, in general, characterized by large debt-to-output ratios.

Although we have contributed to the relevant literature by incorporating strategic policymaking in a dynamic open-economy framework with size-asymmetric countries, there is still substantial controversy in regard to model specification and to the main features it should include to mimic the reality of a multi-country world. Some of them, such as the government spending effect on private consumption, are common to closed-economy models. In our model fiscal policy causes a crowding-out effect on consumption which seems to be in conflict with empirical evidence.[84] This seems to be an important issue that deserves further research, as it should affect policy interactions and the design of the optimal stabilization policies. Notice that, for instance, in line with the findings of Beetsma and Jensen (2004), we found out that a mark-up shock called for a pro-cyclical balanced-budget policy. However, if an increase on government spending raises private consumption, the optimal fiscal policy response to a cost-push shock could act counter-cyclically, amplifying the potential stabilization conflict with the central bank. Another promising extension to more realistically model fiscal policy is to consider implementation lags. This may reduce the gains from fiscal policy stabilization but Leith and Wren-Lewis (2007b) still found non-trivial benefits from using fiscal policy in this case.

There are other extensions, specific to open-economy models, that are more probably worth following in order to capture a clearer picture of the current EMU context for stabilization policy conducting. One of them is to consider incompleteness on international financial markets that introduce current-account as a channel of interdependencies[85], determining an additional role for fiscal stabilization policies – the stabilization of asymmetric demand-side shocks. Other extension stems from the need to represent more realistically a monetary union composed by many small countries and few large ones. A two-country model, as we have used as a good starting point for representing a monetary union with country-size asymmetry, can be improved by describing part of the union as a continuum of small open economies, as Gali and Monacelli (2006) do for the whole monetary union.

[84]See Gali et al. (2007) for recent evidence and for the development of a closed-economy model that allows for a positive effect of government spending on consumption. Pescatori and Pisani (2006) extend this framework to a two-region monetary union.

[85]See Ghironi (2006) for a recent model with incomplete markets.

In the EMU, the majority of the country-members are small comparing to the union as a whole, and so, taken in isolation, their policy decisions have very little impact.

Relying on political economy literature, future work should also develop a more accurate specification of domestic-specific fiscal policy objectives, namely by endogenizing influential interests on the decision-making process.

Finally, and following the example of Fragetta and Kirsanova (2007) for the UK, Sweden and the US, our plan to future use of the model includes an empirical examination of monetary and fiscal interactions in large and small EMU countries, in order to retrieve some information on policy objectives and to identify the implicit policy regime.

Appendix A.0. Monetary leadership and Nash between the fiscal authorities

This appendix summarizes the iterative dynamic programming algorithm for the discretionary monetary leadership case when fiscal authorities play a Nash between them. This is an extension of the algorithms developed by Oudiz and Sachs (1985) and Backus and Driffill (1986) and popularized by Söderlind (1999). It closely follows the one developed by Kirsanova et al. (2005).

There are five strategic agents in the game: three explicit players - the monetary and the two fiscal authorities - and two implicit players - the private sector of both countries - that always act in last. In this type of game, the monetary authority moves first and sets the interest rate. Then the two fiscal authorities decide the levels of their fiscal policy instruments. Finally, the private sector in both countries reacts being the ultimate follower.

To solve this type of game, one inverts the order of playing and begins by solving the optimization of the last player, ending up with the optimization of the leader (the first player). The private sector's optimization problem is already solved out - the system of equations of sections $(1.1$ and $1.2)$ in Chap. 1 - and can be represented by the following system, written in a state space form:

$$\widetilde{A}_0 \begin{bmatrix} I_{n_1} & \mathbf{O}_{n_1xn_2} \\ \mathbf{O}_{n_2xn_1} & H_{n_2xn_2} \end{bmatrix} \begin{bmatrix} Y_{t+1} \\ E_t X_{t+1} \end{bmatrix} = \widetilde{A} \begin{bmatrix} Y_t \\ X_t \end{bmatrix} + \widetilde{B} \begin{bmatrix} U_t^H \\ U_t^F \end{bmatrix} + \widetilde{D} U_t^M + \widetilde{C} \widetilde{\varepsilon}_{t+1} \quad (58)$$

where Y_t is an n_1-vector of predetermined state variables, Y_0 is given, and X_t are the effective instruments of the private sector, an n_2-vector of non-predetermined or forward-looking variables ($n = n_1 + n_2$). The policy instruments are represented by U_t^H, U_t^F and U_t^M. U_t^H and U_t^F stand for the instruments of the followers which are, respectively, the Home and the Foreign fiscal authorities, while U_t^M represents the instrument of the leader, which is the monetary authority. ε_{t+1} is an n_ε-vector of exogenous zero-mean iid shocks with an identity covariance matrix. Premultiplying (58) by $\widetilde{A}_0^{-1}$ we get

$$\begin{bmatrix} Y_{t+1} \\ HE_t X_{t+1} \end{bmatrix} = A \begin{bmatrix} Y_t \\ X_t \end{bmatrix} + B \begin{bmatrix} U_t^H \\ U_t^F \end{bmatrix} + DU_t^M + C\varepsilon_{t+1} \quad (59)$$

where $A = \widetilde{A}_0^{-1}\widetilde{A}$, $B = \widetilde{A}_0^{-1}\widetilde{B}$, $D = \widetilde{A}_0^{-1}\widetilde{D}$ and $C = \widetilde{A}_0^{-1}\widetilde{C}$. The covariance matrice of the shocks to Y_{t+1} is CC' and matrices A, B, C, and D are partionated comformably with Y_t and X_t as

$$\begin{aligned} A &\equiv \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix}; \; B \equiv \begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix} \\ D &\equiv \begin{bmatrix} D_1 \\ D_2 \end{bmatrix}; \; C \equiv \begin{bmatrix} C_1 \\ \mathbf{O} \end{bmatrix} \end{aligned}$$

A common special case is when $H \equiv I$, but in general this matrix need not to be invertible. This system describes the evolution of the economy as observed by policymakers.

A.1. The followers' optimization problem

In the discretionary case, the three policymakers reoptimize every period by taking the process by which private agents form their expectations as given - and where the expectations are consistent with actual policies (Söderlind 1999). The two Nash fiscal authorities minimize their loss functions treating the monetary policy instrument as parametric but incorporating the reaction functions of the private sectors. Assuming that the fiscal authority of the Home country has the following objective function:

$$\frac{1}{2}E_0 \sum_{t=0}^{\infty} \beta^t \left(G_t^{H\prime} Q^H G_t^H \right) = \frac{1}{2}E_0 \sum_{t=0}^{\infty} \beta^t \left(Z_t' \mathcal{Q}^H Z_t + Z_t' \mathcal{P}^H U_t + U_t' \mathcal{P}^{H\prime} Z_t + U_t' \mathcal{R}^H U_t \right) \tag{60}$$

where $G_t^{H\prime}$ is the target variables for the Home fiscal authority while Q^H is the corresponding matrix of weights. The target variables can be rewritten in terms of the predetermined and non-predetermined state variables collected on vector Z_t, in terms of the policy instruments (U_t) and in terms of combinations of these two variables.

The fiscal authority in H optimizes every period, taking into account that she will be able to reoptimize next period. The model is linear-quadratic, thus the solution in $t+1$ gives a period return which is quadratic in the state variables, $W_{t+1}^H \equiv Y_{t+1}' S_H^{t+1} Y_{t+1} +$

w_{t+1}^H, where S_H^{t+1} is a positive semidefinite matrix and w_{t+1}^H is a scalar independent of Y_{t+1}. Moreover, the forward looking variables must be linear functions of the state variables, $X_{t+1} = -N_{t+1}Y_{t+1}$. Hence, the value function of the fiscal authority of H in t will then satisfy the Bellman equation:

$$W_t^H = \min_{U_t^H} \frac{1}{2}\left[\left(Z_t'\mathcal{Q}^H Z_t + Z_t'\mathcal{P}^H U_t + U_t'\mathcal{P}^{H\prime} Z_t + U_t'\mathcal{R}^H U_t\right) + \beta E_t\left(W_{t+1}^H\right)\right] \tag{61}$$

$$s.t.\ E_t X_{t+1} = -N_{t+1}E_t Y_{t+1},\ W_{t+1}^H \equiv Y_{t+1}' S_H^{t+1} Y_{t+1} + w_{t+1}^H, \text{ eq. } (59) \text{ and } Y_t \text{ given.}$$

Rewriting the system by using $E_t X_{t+1} = -N_{t+1}E_t Y_{t+1}$

Using the expression above to substitute into the upper block of (59), we get

$$E_t X_{t+1} = -N_{t+1}\left[A_{11}Y_t + A_{12}X_t + B_{11}U_t^H + B_{12}U_t^F + D_1 U_t^M\right]$$

while the lower block of (59) is

$$HE_t X_{t+1} = A_{21}Y_t + A_{22}X_t + B_{21}U_t^H + B_{22}U_t^F + D_2 U_t^M$$

Multiplying the former equation by H, setting the result equal to the latter equation and solving for X_t we obtain

$$\begin{aligned} X_t \;=\; & -\underbrace{\left(A_{22}+HN_{t+1}A_{12}\right)^{-1}\left(A_{21}+HN_{t+1}A_{11}\right)}_{J_t}Y_t - \underbrace{\left(A_{22}+HN_{t+1}A_{12}\right)^{-1}\left(B_{21}+HN_{t+1}B_{11}\right)}_{K_t^H}U_t^H \\ & -\underbrace{\left(A_{22}+HN_{t+1}A_{12}\right)^{-1}\left(B_{22}+HN_{t+1}B_{12}\right)}_{K_t^F}U_t^F - \underbrace{\left(A_{22}+HN_{t+1}A_{12}\right)^{-1}\left(D_2+HN_{t+1}D_1\right)}_{K_t^M}U_t^M \end{aligned}$$

$$X_t = -J_t Y_t - K_t^H U_t^H - K_t^F U_t^F - K_t^M U_t^M \tag{62}$$

where J_t is n_2xn_1, K_t^H is n_2xk_H, K_t^F is n_2xk_F and K_t^M is n_2xk_M (k_H and k_F stand respectively for the number of fiscal policy instruments of H and F, while k_M stands for the number of monetary policy instruments)[86].

[86] It is assumed that $A_{22} + HN_{t+1}A_{12}$ is invertible.

The evolution of Y_t

Use (62) in the first n_1 equations in the system(59) to get the reduced form evolution of the predetermined variables

$$\begin{aligned} Y_{t+1} &= \underbrace{[A_{11} - A_{12}J_t]}_{O_{Y_t}} Y_t + \underbrace{[B_{11} - A_{12}K_t^H]}_{O_{H_t}} U_t^H \\ &\quad + \underbrace{[B_{12} - A_{12}K_t^F]}_{O_{F_t}} U_t^F + \underbrace{[D_1 - B_{12}L_t^F]}_{O_{M_t}} U_t^M + C_1\varepsilon_{t+1} \end{aligned}$$

$$Y_{t+1} = O_{Y_t}Y_t + O_{H_t}U_t^H + O_{F_t}U_t^F + O_{M_t}U_t^M + C_1\varepsilon_{t+1} \quad (63)$$

Being a follower, the Home fiscal authority observes monetary authority's actions and reacts to them. In a linear-quadratic setup, the optimal solution belongs to the class of linear feedback rules of the form:

$$U_t^H = -F_t^H Y_t - L_t^H U_t^M \quad (64)$$

where F_t^H denotes feedback coeficcients on the predetermined state variables and L_t^H is the leadership parameter. The other fiscal authority solves a similar problem and get:

$$U_t^F = -F_t^F Y_t - L_t^F U_t^M \quad (65)$$

Being in a Nash game, the two fiscal authorities do not respond to each other's actions.

The monetary leadership authority takes into account these fiscal policy reaction functions as well as the private sector's optimal conditions, when solves its optimization problem. Thus, the leader can manipulate the follower by changing its policy instrument. The monetary leadership reaction function takes the form of:

$$U_t^M = -F_t^M Y_t \quad (66)$$

Reformulated optimization problem

Therefore we can substitute eqs. (62) and (63) into (61) to obtain an equivalent minimization problem[87]:

$$
\begin{aligned}
2\widetilde{W}_t^H \equiv \min_{U_t^H} \Big\{ & Y_t' \left[Q_H^S + \beta O_{Y_t}' S_H^{t+1} O_{Y_t}\right] Y_t + U_t^{H'} \left[\mathcal{U}_H^{S,H'} + \beta O_{H_t}' S_H^{t+1} O_{Y_t}\right] Y_t \\
& + Y_t' \left[\mathcal{U}_H^{S,H} + \beta O_{Y_t}' S_H^{t+1} O_{H_t}\right] U_t^H + U_t^{F'} \left[\mathcal{U}_F^{S,H'} + \beta O_{F_t}' S_H^{t+1} O_{Y_t}\right] Y_t \\
& + Y_t' \left[\mathcal{U}_F^{S,H} + \beta O_{Y_t}' S_H^{t+1} O_{F_t}\right] U_t^F + U_t^{M'} \left[\mathcal{U}_M^{S,H'} + \beta O_{M_t}' S_H^{t+1} O_{Y_t}\right] Y_t \\
& + Y_t' \left[\mathcal{U}_M^{S,H} + \beta O_{Y_t}' S_H^{t+1} O_{M_t}\right] U_t^M + U_t^{H'} \left[\mathcal{R}_H^{S,H} + \beta O_{H_t}' S_H^{t+1} O_{H_t}\right] U_t^H \\
& + U_t^{F'} \left[\mathcal{R}_F^{S,H} + \beta O_{F_t}' S_H^{t+1} O_{F_t}\right] U_t^F + U_t^{M'} \left[\mathcal{R}_M^{S,H} + \beta O_{M_t}' S_H^{t+1} O_{M_t}\right] U_t^M \\
& + U_t^{H'} \left[\mathcal{P}_{HF}^{S,H} + \beta O_{H_t}' S_H^{t+1} O_{F_t}\right] U_t^F + U_t^{F'} \left[\mathcal{P}_{HF}^{S,H'} + \beta O_{F_t}' S_H^{t+1} O_{H_t}\right] U_t^H \\
& + U_t^{H'} \left[\mathcal{P}_{HM}^{S,H} + \beta O_{H_t}' S_H^{t+1} O_{M_t}\right] U_t^M + U_t^{M'} \left[\mathcal{P}_{HM}^{S,H'} + \beta O_{M_t}' S_H^{t+1} O_{H_t}\right] U_t^H
\end{aligned}
$$

$$
+U_t^{F'} \left[\mathcal{P}_{FM}^{S,H} + \beta O_{F_t}' S_H^{t+1} O_{M_t}\right] U_t^M + U_t^{M'} \left[\mathcal{P}_{FM}^{S,H'} + \beta O_{M_t}' S_H^{t+1} O_{F_t}\right] U_t^F \Big\} \tag{67}
$$

where

$$
\begin{aligned}
Q_H^S &= \mathcal{Q}_{11}^H - J_t' \mathcal{Q}_{21}^H - \mathcal{Q}_{12}^H J_t + J_t' \mathcal{Q}_{22}^H J_t \\
\mathcal{U}_H^{S,H} &= J_t' \mathcal{Q}_{22}^H K_t^H - \mathcal{Q}_{12}^H K_t^H + \mathcal{P}_{12}^H - J_t' \mathcal{P}_{22}^H \\
\mathcal{U}_F^{S,H} &= J_t' \mathcal{Q}_{22}^H K_t^F - \mathcal{Q}_{12}^H K_t^F + \mathcal{P}_{13}^H - J_t' \mathcal{P}_{23}^H \\
\mathcal{U}_M^{S,H} &= J_t' \mathcal{Q}_{22}^H K_t^M - \mathcal{Q}_{12}^H K_t^M + \mathcal{P}_{11}^H - J_t' \mathcal{P}_{21}^H \\
\mathcal{R}_H^{S,H} &= K_t^{H\prime} \mathcal{Q}_{22}^H K_t^H - K_t^{H\prime} \mathcal{P}_{22}^H - \mathcal{P}_{22}^{H\prime} K_t^H + \mathcal{R}_{22}^H \\
\mathcal{R}_F^{S,H} &= K_t^{F\prime} \mathcal{Q}_{22}^H K_t^F - K_t^{F\prime} \mathcal{P}_{23}^H - \mathcal{P}_{23}^{H\prime} K_t^F + \mathcal{R}_{33}^H \\
\mathcal{R}_M^{S,H} &= K_t^{M\prime} \mathcal{Q}_{22}^H K_t^M - K_t^{M\prime} \mathcal{P}_{21}^H - \mathcal{P}_{21}^{H\prime} K_t^M + \mathcal{R}_{11}^H \\
\mathcal{P}_{HF}^{S,H} &= K_t^{H\prime} \mathcal{Q}_{22}^H K_t^F - K_t^{H\prime} \mathcal{P}_{23}^H - \mathcal{P}_{22}^{H\prime} K_t^F + \mathcal{R}_{23}^H \\
\mathcal{P}_{HM}^{S,H} &= K_t^{H\prime} \mathcal{Q}_{22}^H K_t^M - K_t^{H\prime} \mathcal{P}_{21}^H - \mathcal{P}_{22}^{H\prime} K_t^M + \mathcal{R}_{21}^H \\
\mathcal{P}_{FM}^{S,H} &= K_t^{F\prime} \mathcal{Q}_{22}^H K_t^M - K_t^{F\prime} \mathcal{P}_{21}^H - \mathcal{P}_{23}^{H\prime} K_t^M + \mathcal{R}_{31}^H
\end{aligned}
$$

[87]We have make use of the fact that w_{t+1}^H is independent of Y_{t+1} and $E_t \varepsilon_{t+1} = 0$.

Hence, the problem faced by the Home fiscal authority has been transformed to a standard linear-quadratic regulator problem without forward looking variables but with time varying parameters. The first-order condition is

$$\begin{aligned}0 &= \left[\mathcal{U}_H^{S,H'} + \beta O'_{H_t} S_H^{t+1} O_{Y_t}\right] Y_t + \left[\mathcal{R}_H^{S,H} + \beta O'_{H_t} S_H^{t+1} O_{H_t}\right] U_t^H \\ &\quad + \left[\mathcal{P}_{HF}^{S,H} + \beta O'_{H_t} S_H^{t+1} O_{F_t}\right] U_t^F + \left[\mathcal{P}_{HM}^{S,H} + \beta O'_{H_t} S_H^{t+1} O_{M_t}\right] U_t^M\end{aligned}$$

Since $U_t^H = -F_t^H Y_t - L_t^H U_t^M$ and $U_t^F = -F_t^F Y_t - L_t^F U_t^M$, the first-order condition can be solved for the feedback coefficients of the reaction function of the Home fiscal authority:

$$F_t^H \equiv \left[\mathcal{R}_H^{S,H} + \beta O'_{H_t} S_H^{t+1} O_{H_t}\right]^{-1} \left\{ \begin{array}{l} \left[\mathcal{U}_H^{S,H'} + \beta O'_{H_t} S_H^{t+1} O_{Y_t}\right] \\ - \left[\mathcal{P}_{HF}^{S,H} + \beta O'_{H_t} S_H^{t+1} O_{F_t}\right] F_t^F \end{array} \right. \tag{68}$$

$$L_t^H \equiv \left[\mathcal{R}_H^{S,H} + \beta O'_{H_t} S_H^{t+1} O_{H_t}\right]^{-1} \left\{ \begin{array}{l} \left[\mathcal{P}_{HM}^{S,H} + \beta O'_{H_t} S_H^{t+1} O_{M_t}\right] \\ - \left[\mathcal{P}_{HF}^{S,H} + \beta O'_{H_t} S_H^{t+1} O_{F_t}\right] L_t^F \end{array} \right. \tag{69}$$

Finding the recursive equation for S_H^t

Substituting the decision rules (64) , (65) and (66) into (67) we obtain the recursive equations for

$$S_H^t \equiv T_{0,t}^H + \beta T_t^{H\prime} S_H^{t+1} T_t^H \tag{70}$$

$$\begin{aligned}T_{0,t}^H &= Q_H^S - \mathcal{U}_H^{S,H}\left(F_t^H - L_t^H F_t^M\right) - \left(F_t^H - L_t^H F_t^M\right)' \mathcal{U}_H^{S,H'} - \mathcal{U}_F^{S,H}\left(F_t^F - L_t^F F_t^M\right) \\ &\quad - \left(F_t^F - L_t^F F_t^M\right)' \mathcal{U}_F^{S,H'} - \mathcal{U}_M^{S,H} F_t^M - F_t^{M\prime} \mathcal{U}_M^{S,H'} + \left(F_t^H - L_t^H F_t^M\right)' \mathcal{R}_H^{S,H}\left(F_t^H - L_t^H F_t^M\right) \\ &\quad + \left(F_t^F - L_t^F F_t^M\right)' \mathcal{R}_F^{S,H}\left(F_t^F - L_t^F F_t^M\right) + F_t^{M\prime} \mathcal{R}_M^{S,H} F_t^M \\ &\quad + \left(F_t^H - L_t^H F_t^M\right)' \mathcal{P}_{HF}^{S,H}\left(F_t^F - L_t^F F_t^M\right) + \left(F_t^F - L_t^F F_t^M\right)' \mathcal{P}_{HF}^{S,H'}\left(F_t^H - L_t^H F_t^M\right) \\ &\quad + \left(F_t^H - L_t^H F_t^M\right)' \mathcal{P}_{HM}^{S,H} F_t^M + F_t^{M\prime} \mathcal{P}_{HM}^{S,H'}\left(F_t^H - L_t^H F_t^M\right) \\ &\quad + \left(F_t^F - L_t^F F_t^M\right)' \mathcal{P}_{FM}^{S,H} F_t^M + F_t^{M\prime} \mathcal{P}_{FM}^{S,H'}\left(F_t^F - L_t^F F_t^M\right)\end{aligned}$$

and

$$T_t^H = O_{Y_t} - O_{H_t}\left(F_t^H - L_t^H F_t^M\right) - O_{F_t}\left(F_t^F - L_t^F F_t^M\right) - O_{M_t} F_t^M$$

Similar formulae can be derived for country F.

A.2. The leader's optimization problem

This part of the problem is the standard optimization problem when the system under control evolves as

$$\begin{bmatrix} Y_{t+1} \\ HE_t X_{t+1} \end{bmatrix} = \begin{bmatrix} A11\text{-}B11F_t^H\text{-}B12F_t^F & A12 \\ A21\text{-}B21F_t^H\text{-}B22F_t^F & A22 \end{bmatrix} \begin{bmatrix} Y_t \\ X_t \end{bmatrix} + \begin{bmatrix} D11\text{-}B11L_t^H\text{-}B12L_t^F \\ D21\text{-}B21L_t^H\text{-}B22L_t^F \end{bmatrix} U_t^M + C\varepsilon_{t+1} \tag{71}$$

The monetary authority loss function is

$$\frac{1}{2} E_0 \sum_{t=0}^{\infty} \beta^t \left(G_t^{M\prime} \mathbf{Q}^M G_t^M \right)$$

But, since the leadership integrates the followers' reaction functions - $U_t^H = -F_t^H Y_t - L_t^H U_t^M$ and $U_t^F = -F_t^F Y_t - L_t^F U_t^M$ - into its optimization problem, the leadership's loss function as to be rewritten in terms of the relevant variables for the leadership authority. Since

$$\begin{bmatrix} Y_t \\ X_t \\ U_t^M \\ U_t^H \\ U_t^F \end{bmatrix} = \underbrace{\begin{bmatrix} I & 0 & 0 \\ 0 & I & 0 \\ 0 & 0 & I \\ -F_t^H & 0 & -L_t^H \\ -F_t^F & 0 & -L_t^F \end{bmatrix}}_{\mathcal{C}} \begin{bmatrix} Y_t \\ X_t \\ U_t^M \end{bmatrix}$$

we can set $G_t^{M\prime} \mathbf{Q}^M G_t^M = \begin{bmatrix} Y_t' & X_t' & U_t^{M\prime} \end{bmatrix} \widetilde{\mathcal{K}}^M \begin{bmatrix} Y_t \\ X_t \\ U_t^M \end{bmatrix}$ where $\widetilde{\mathcal{K}}^M = \mathcal{C}' \underbrace{C^{M\prime} \mathbf{Q}^M C^M}_{\mathcal{K}^M} \mathcal{C}$ and $\widetilde{\mathcal{K}}^M$ have to partioned comformally with $\begin{pmatrix} Y_t' & X_t' & U_t^{M\prime} \end{pmatrix}'$.

A.3. The iterative procedure

We start with initial approximation for the monetary policy rule, $F^M_{(0)}$, symmetric positive definite matrices (usually, identity matrices), $S^{(0)}_H$ and $S^{(0)}_F$, some (e.g. a matrix of zeros) $N_{(0)}$ and solve the follower's problem, using Eq. $(68-70)$ for country H and equivalent equations for country F. We get $F^H_{(0)}$ and $L^H_{(0)}$, as well as $F^F_{(0)}$ and $L^F_{(0)}$ and updated matrices $S^{(1)}_H$ and $S^{(1)}_F$. We then take into account the policy reaction functions of fiscal authorities and compute new matrices in Eq. (71), updated target variable $\left(G^M_t = C^M \mathcal{C} \begin{pmatrix} Y'_t & X'_t & U^{M\prime}_t \end{pmatrix}'\right)$ and solve the problem for the monetary authority. This will give us the monetary policy reaction function, $F^M_{(1)}$, and updated matrices $N_{(1)}$ and $S^{(1)}_M$. Then, we again solve the problem for the fiscal authorities to update $S^{(2)}_H$ and $S^{(2)}_F$ and $F^H_{(1)}$, $L^H_{(1)}$, $F^F_{(1)}$ and $L^F_{(1)}$ and so on. The fixed point is found when the policy rules and the matrices converge towards constants for a given level of tolerance.

Blake and Kirsanova (2007) have examined the existence of multiple discretionary equilibria in dynamic linear quadratic rational expectations models. They have concluded that linear quadratic discretionary problems can only have isolated stable equilibria. Even when the number of stable eigenvalues exceed the number of pre-determined variables in the model, there is no indeterminacy because the time-consistency property of the discretionary equilibria rules out that possibility. However, there could be multiple but isolated discretionary equilibria. To check this hypothesis (only when the number of explosive eigenvalues is smaller than the number of non-predetermined variables) it is necessary to initialize the algorithm with different matrices and see if the solutions obtained are or not distinct.

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FIGURES

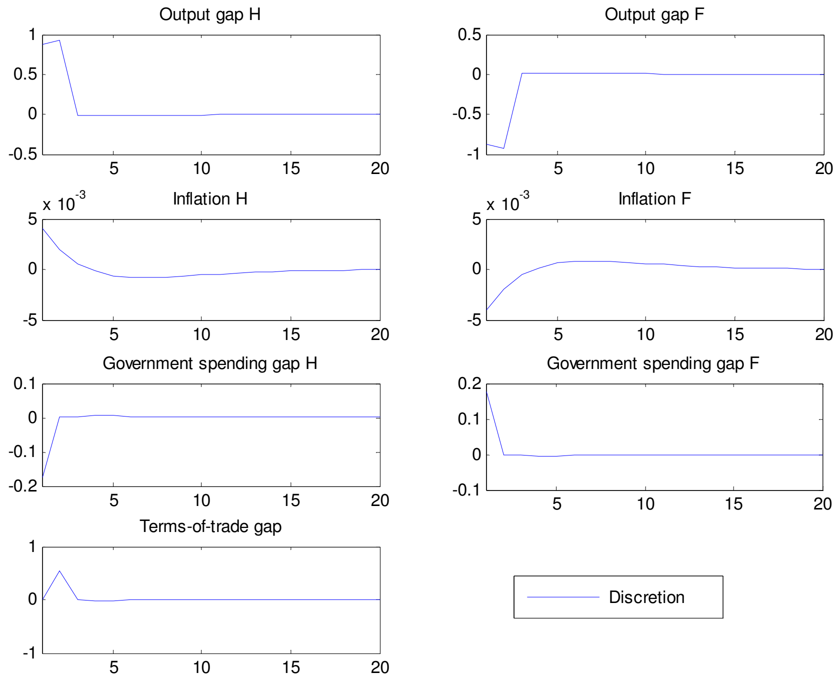

Figure 1: Percentage response to a 1% negative productivity shock at H - cooperation

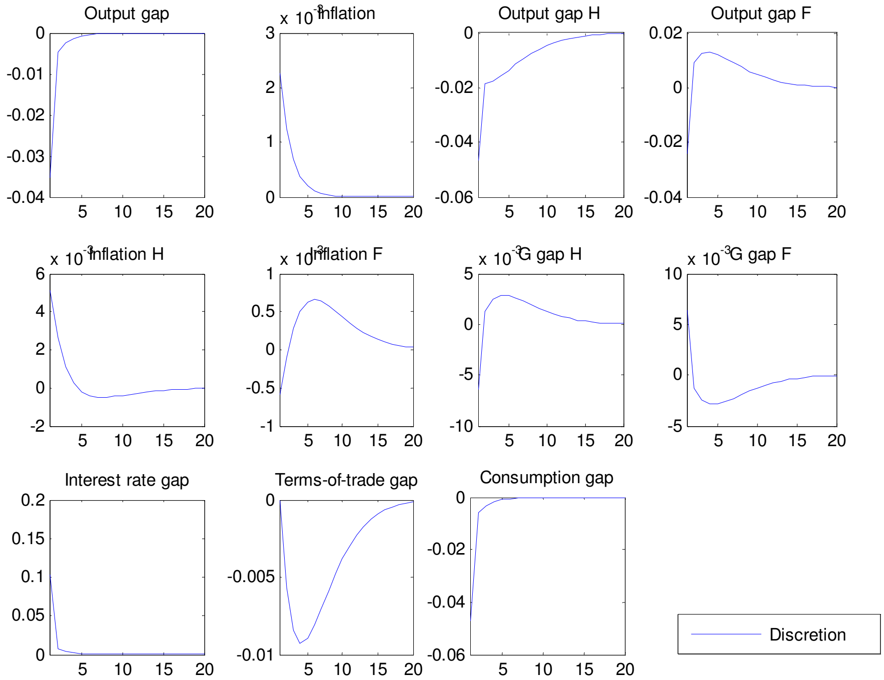

Figure 2: Percentage response to a 1% positive mark-up shock at H - cooperation

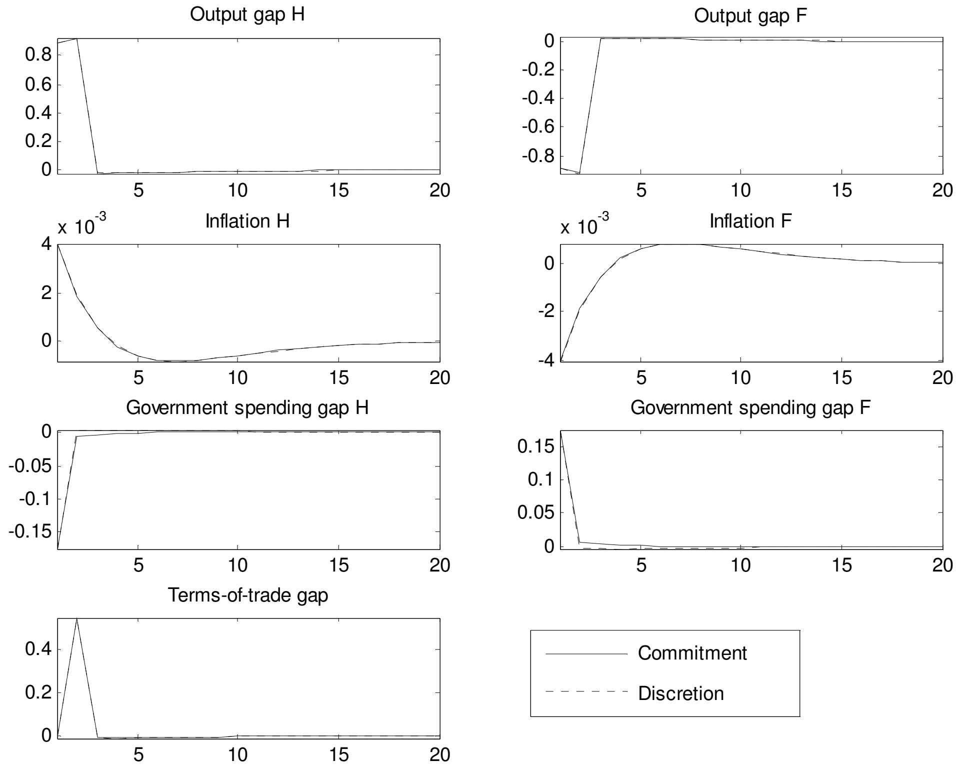

Figure 3: Percentage response to a 1% negative productivity shock at country H - commitment vs. discretion

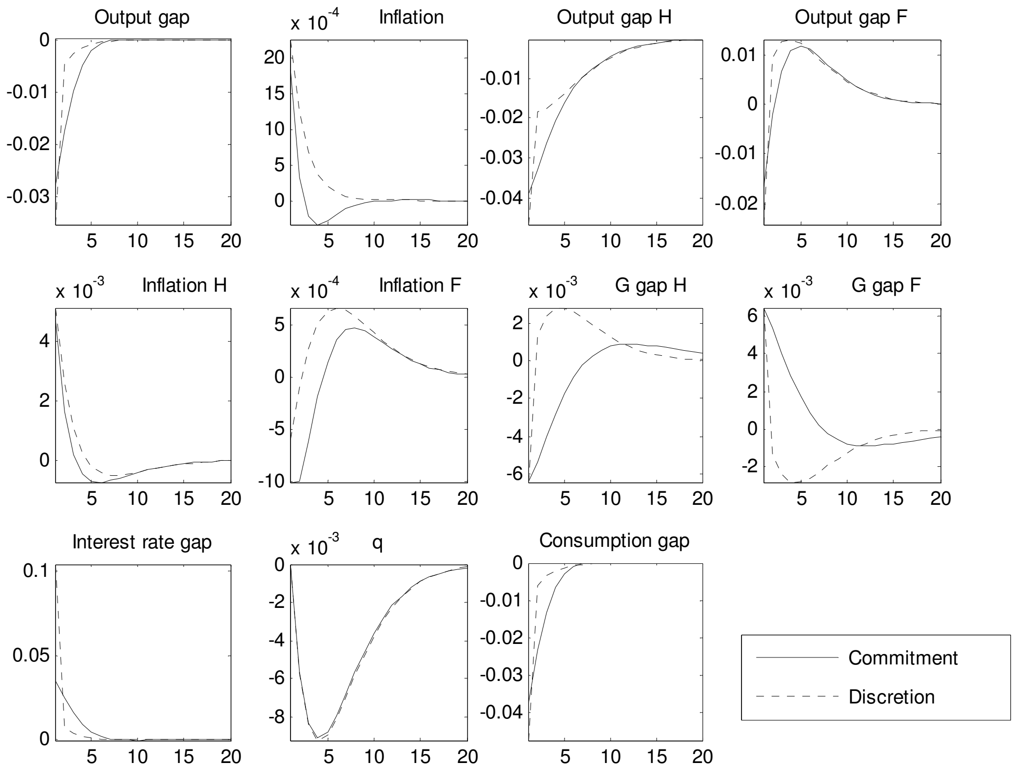

Figure 4: Percentage response to a 1% positive mark-up shock at country H - commitment vs. discretion

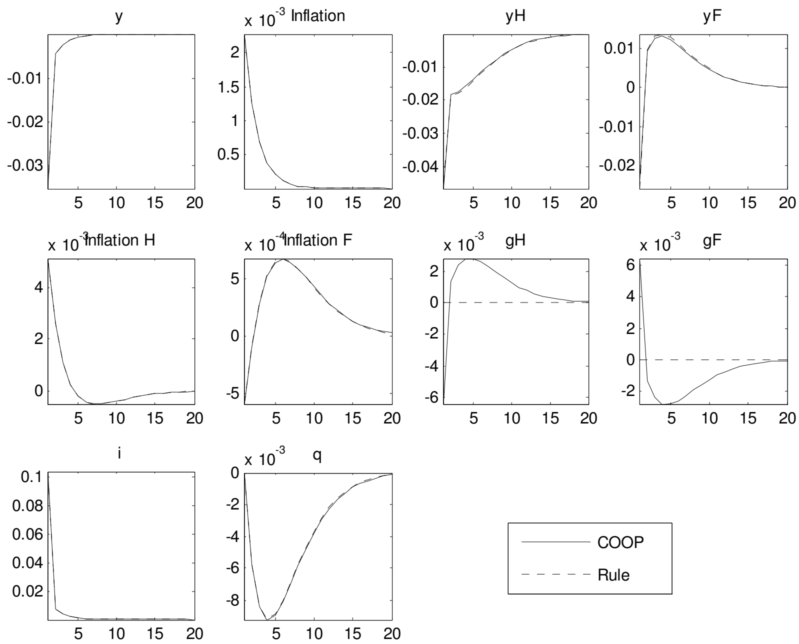

Figure 5: Percentage response to a 1% positive mark-up shock at H - cooperation vs. rule

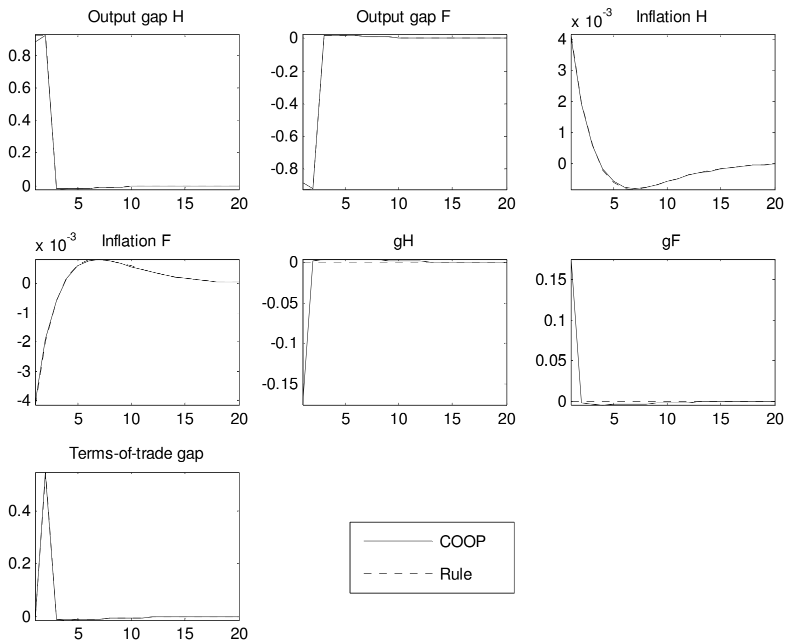

Figure 6: Percentage response to a 1% negative productivity shock at H - cooperation vs. rule

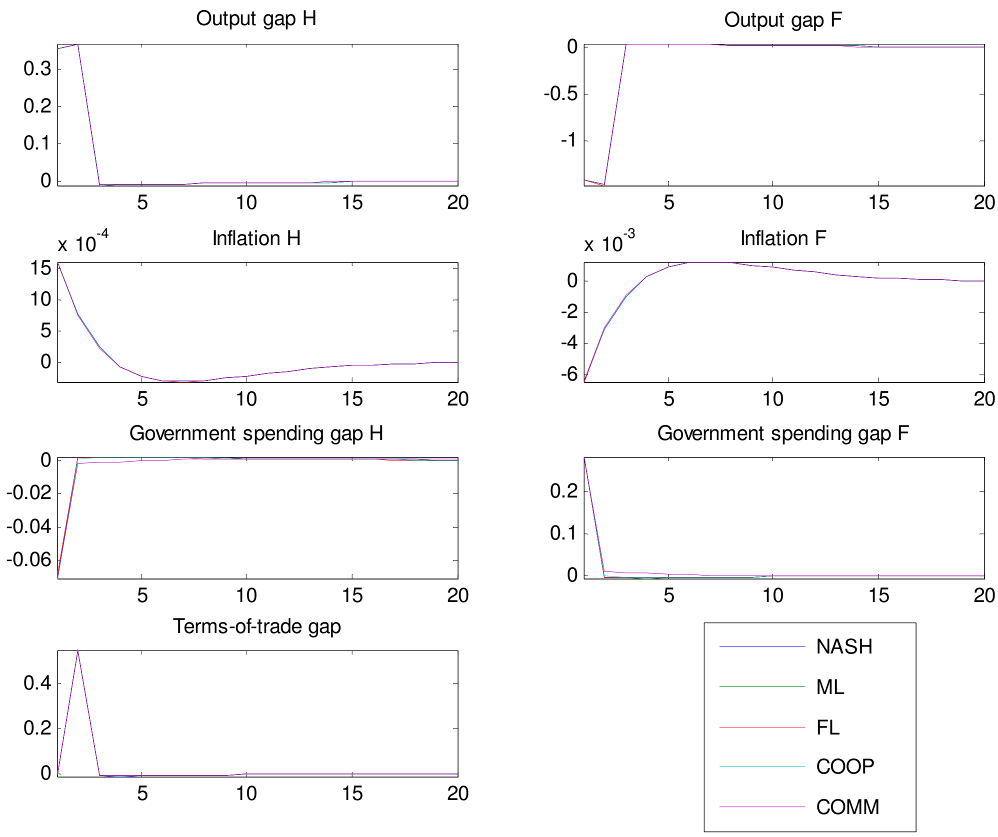

Figure 7: Percentage response to a 1% negative productivity shock at a large country H - all policy regimes

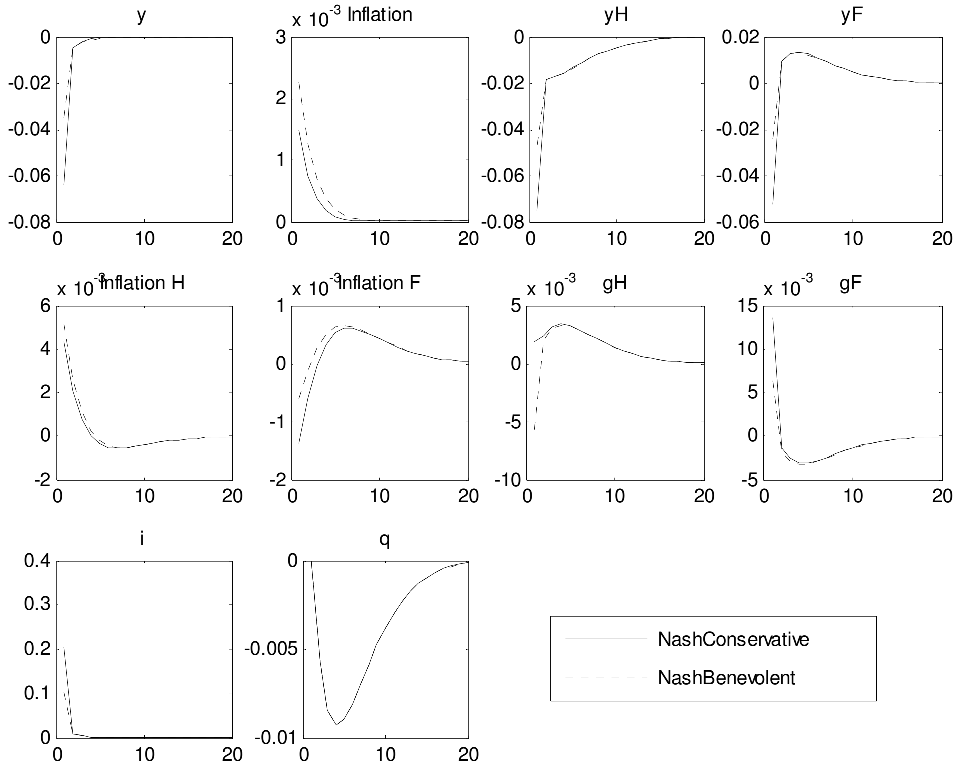

Figure 8: Percentage response to a 1% positive mark-up shock at H - benevolent Nash vs. conservative Nash

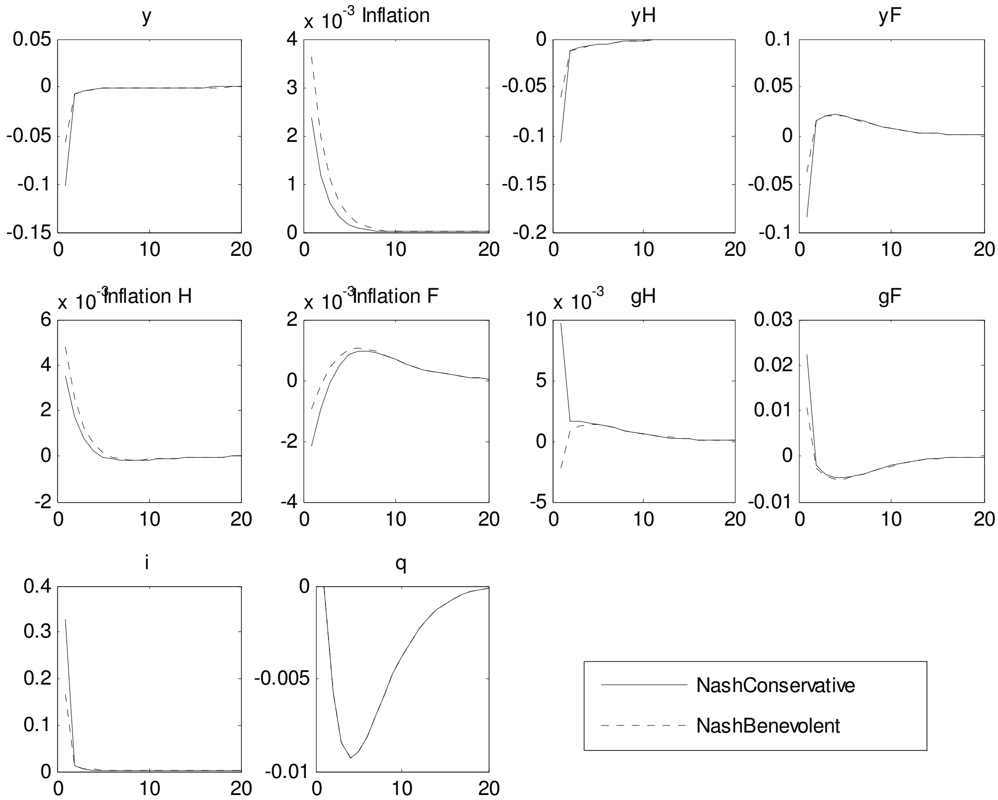

Figure 9: Percentage response to a 1% positive mark-up shock at the large country H - benevolent Nash vs. conservative Nash

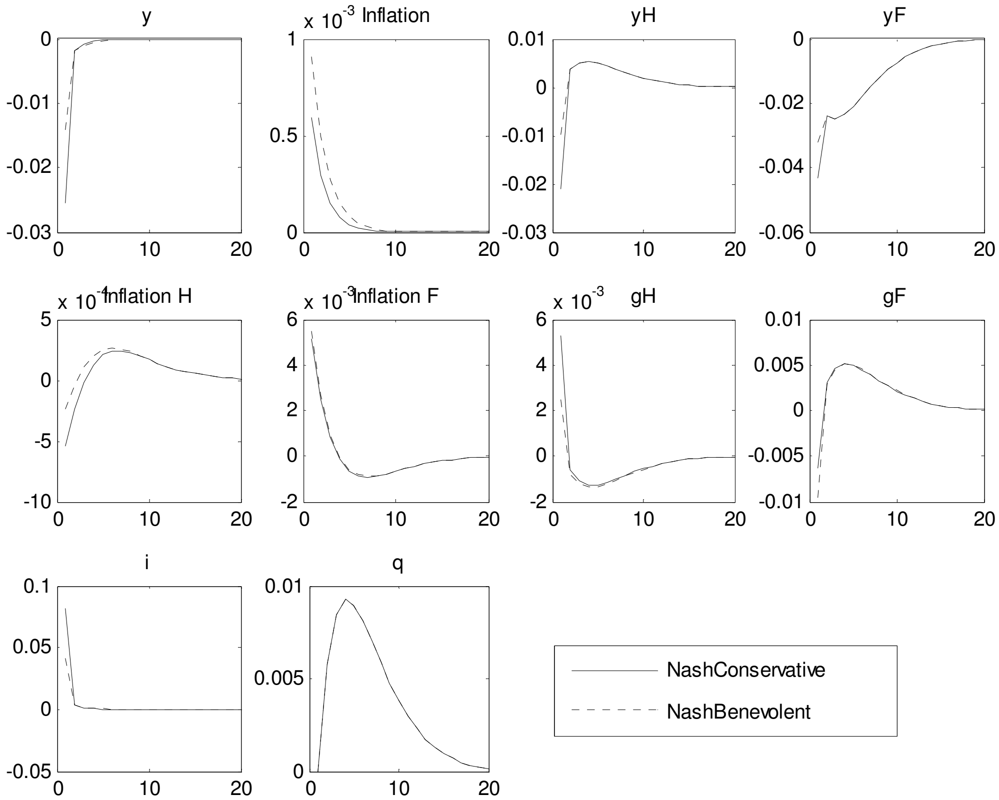

Figure 10: Percentage response to a 1% positive mark-up shock at the small country F - benevolent Nash vs. conservative Nash

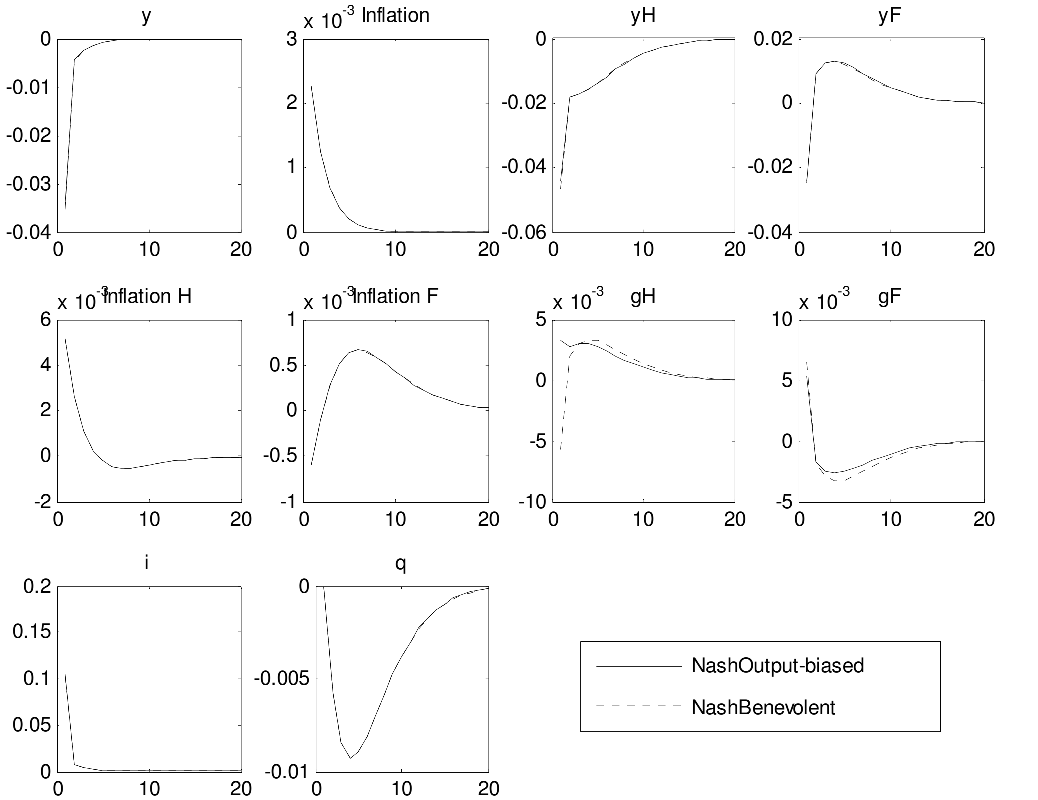

Figure 11: Percentage response to a 1% positive mark-up shock at country H - benevolent Nash vs. output-biased FAs Nash

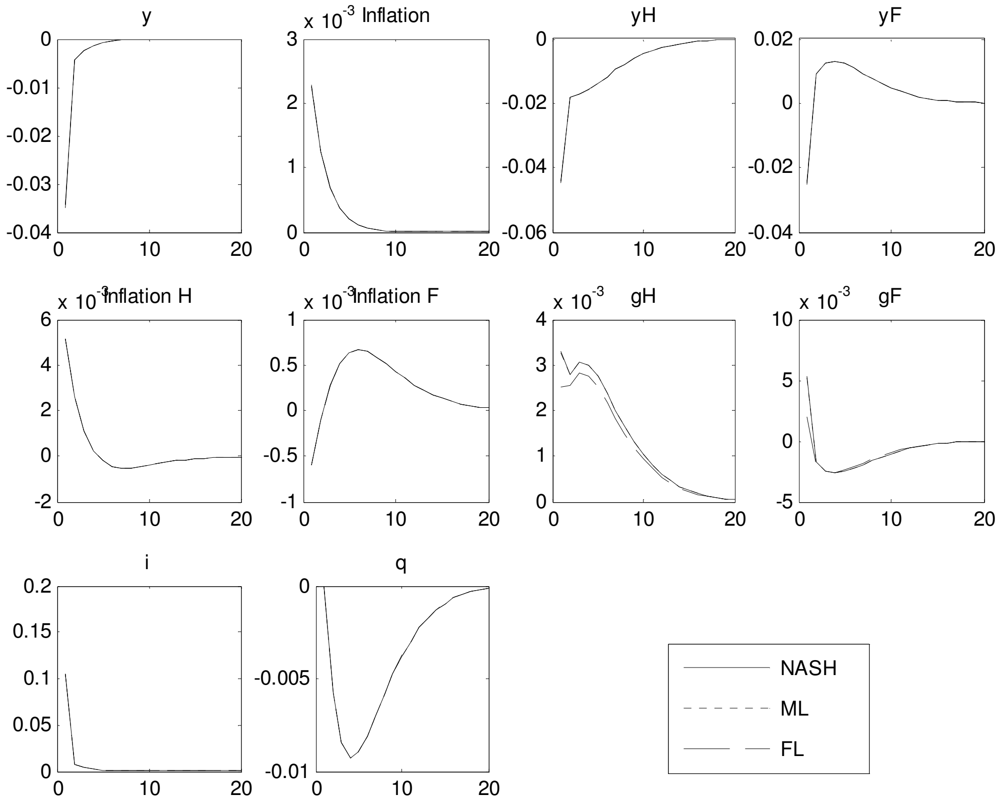

Figure 12: Percentage response to a 1% positive mark-up shock at H - output-biased FAs (Nash, ML, FL)

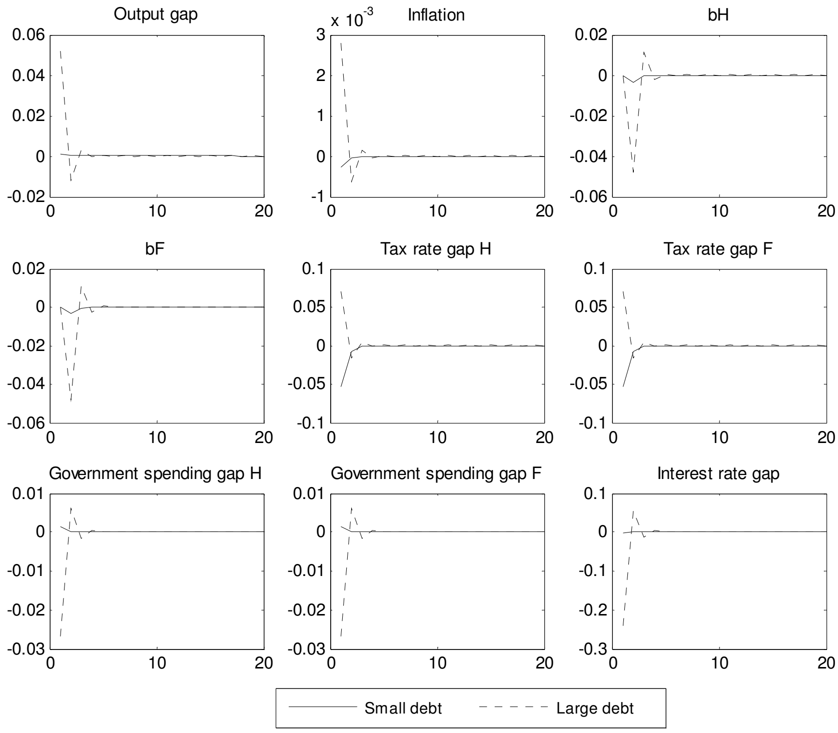

Figure 13: Percentage response to a 1% innovation in consumption preference ($\overline{c}_t^w$)

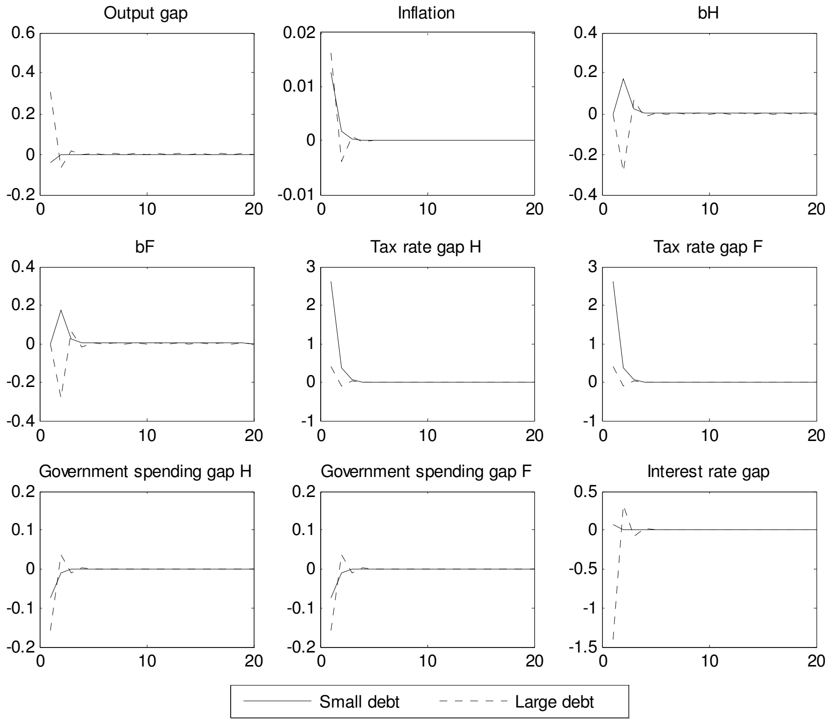

Figure 14: Percentage response to a 1% symmetric negative productivity shock

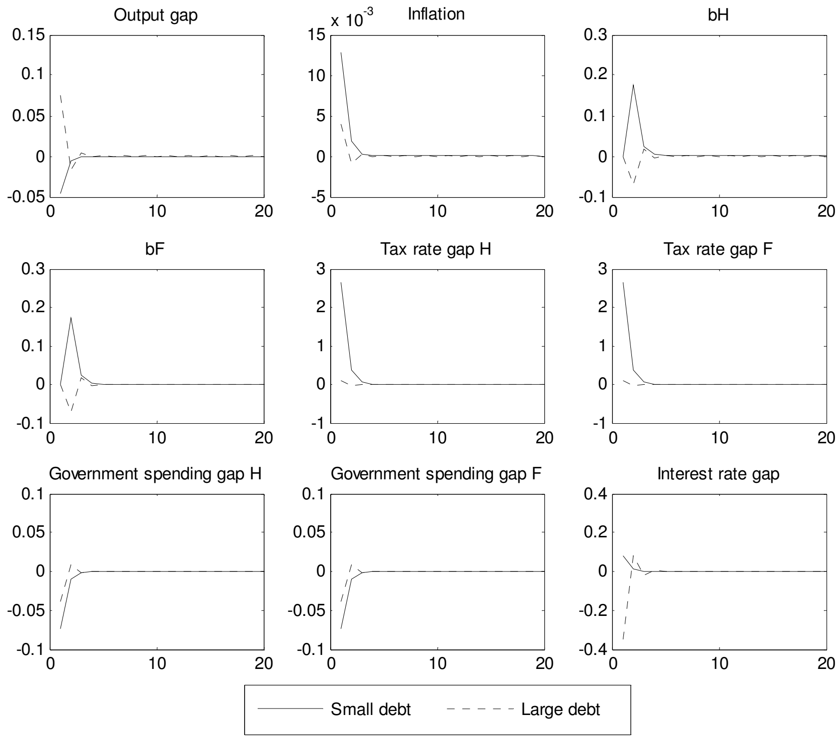

Figure 15: Percentage response to a 1% symmetric mark-up shock

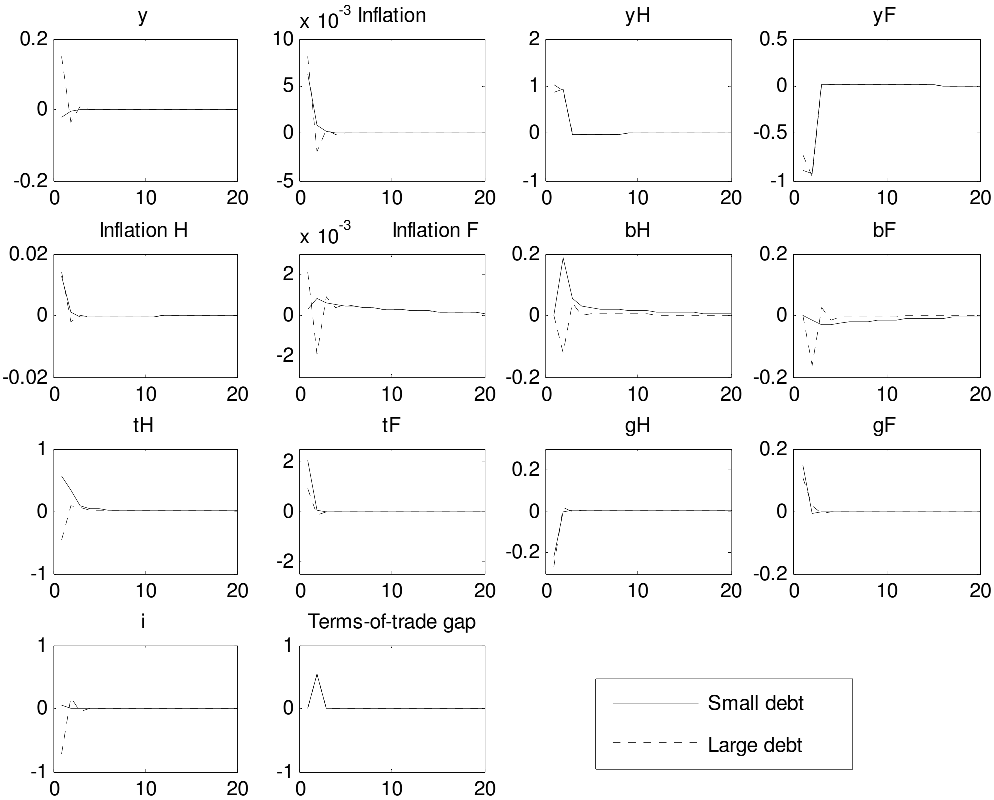

Figure 16: Percentage response to a 1% a negative productivity shock at H

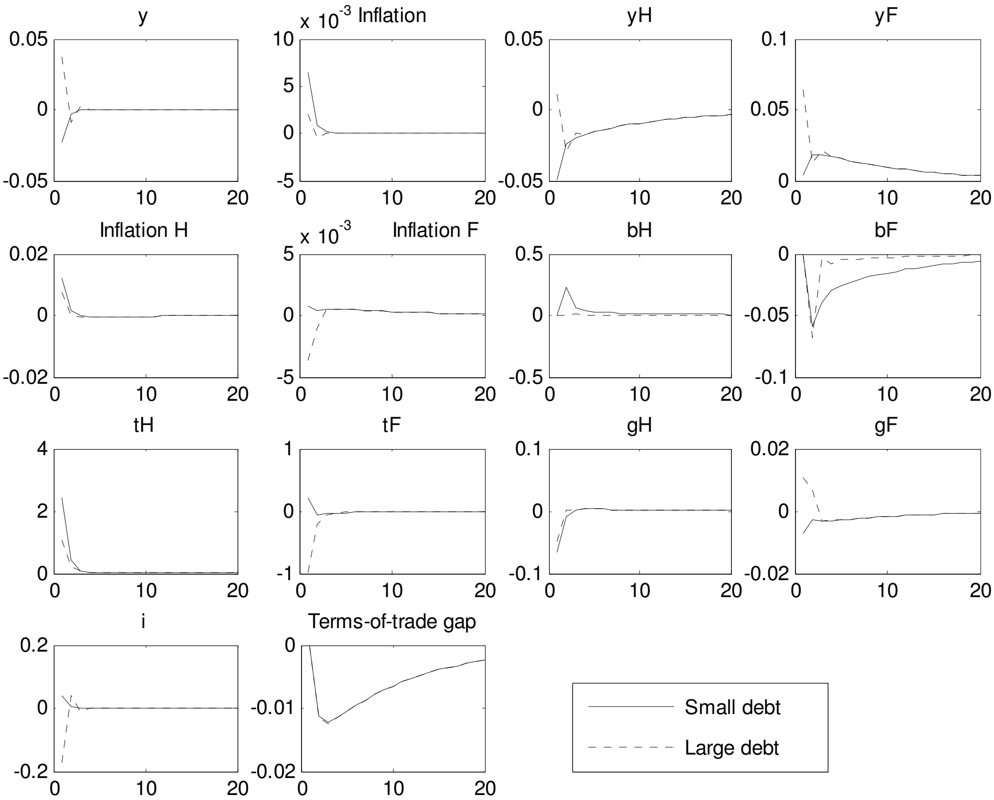

Figure 17: Percentage response to a 1% a mark-up shock at H

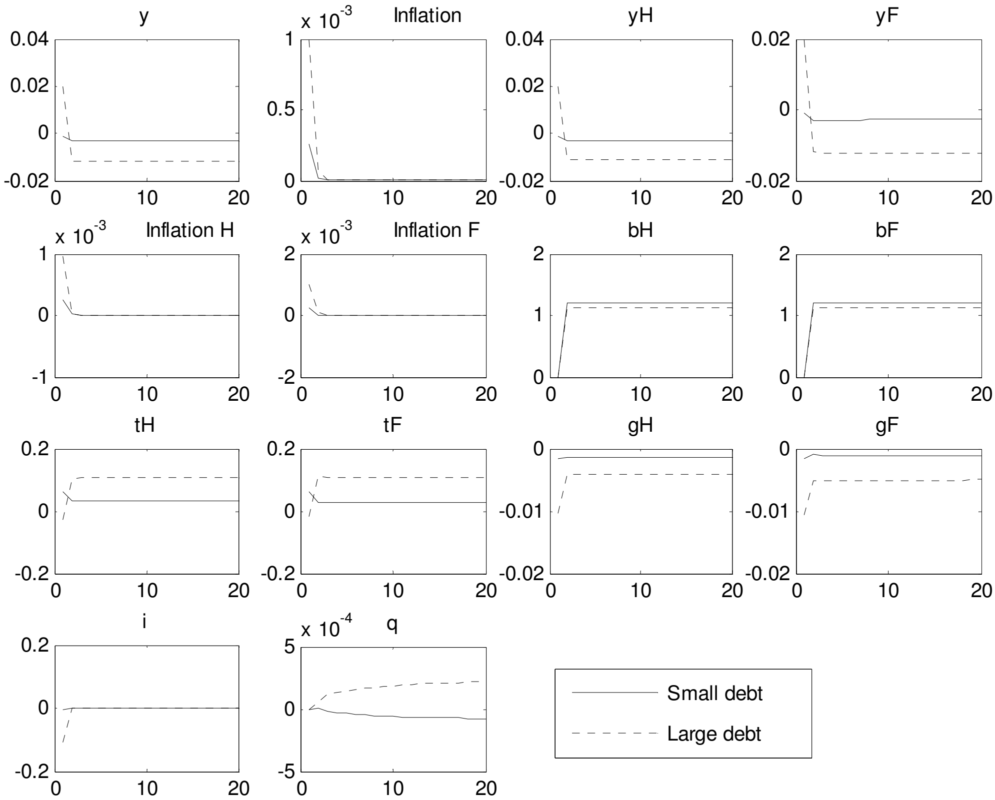

Figure 18: Percentage response to a 1% a symmetric negative productivity shock under commitment

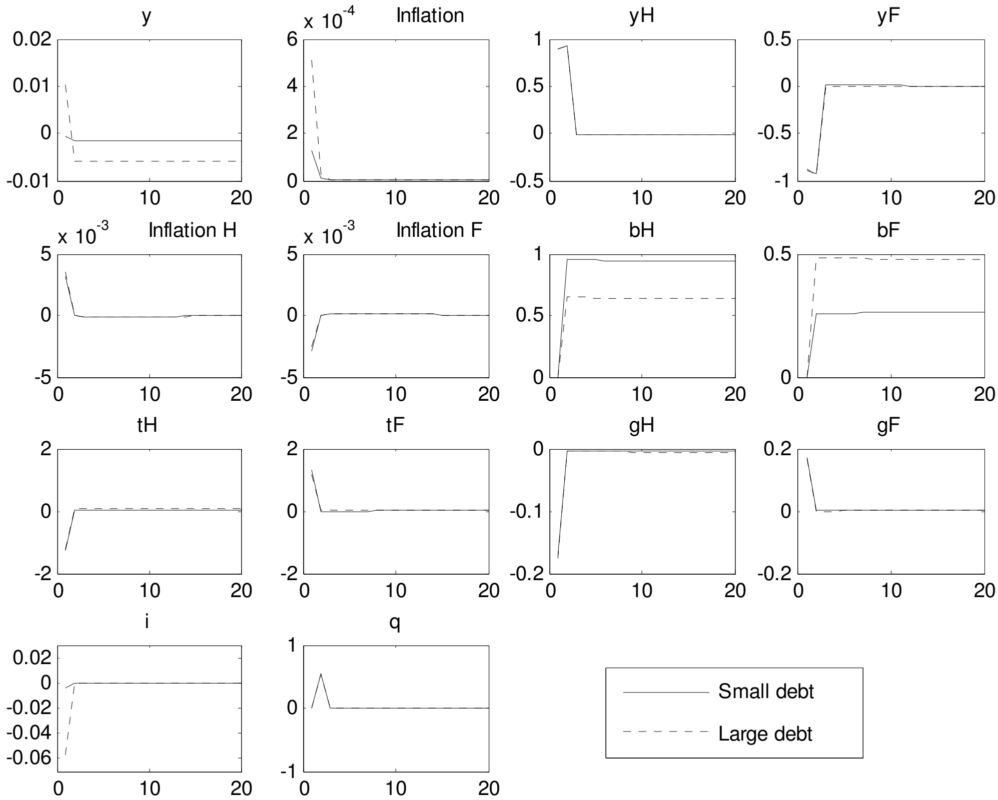

Figure 19: Percentage response to a 1% a negative productivity shock at H under commitment

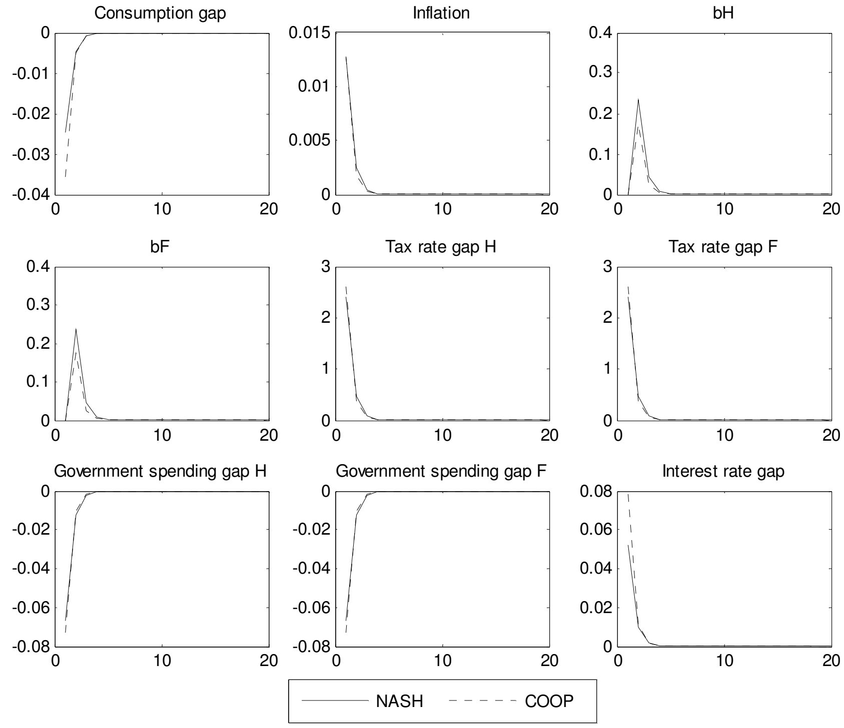

Figure 20: Percentage response to a 1% a symmetric negative productivity shock under small debts

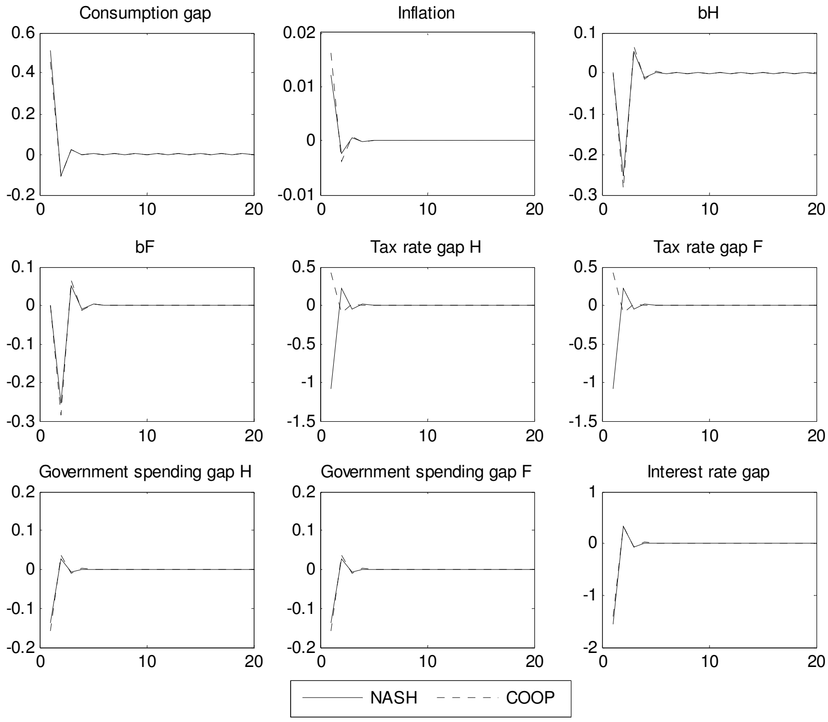

Figure 21: Percentage response to a 1% a symmetric negative productivity shock under large debts

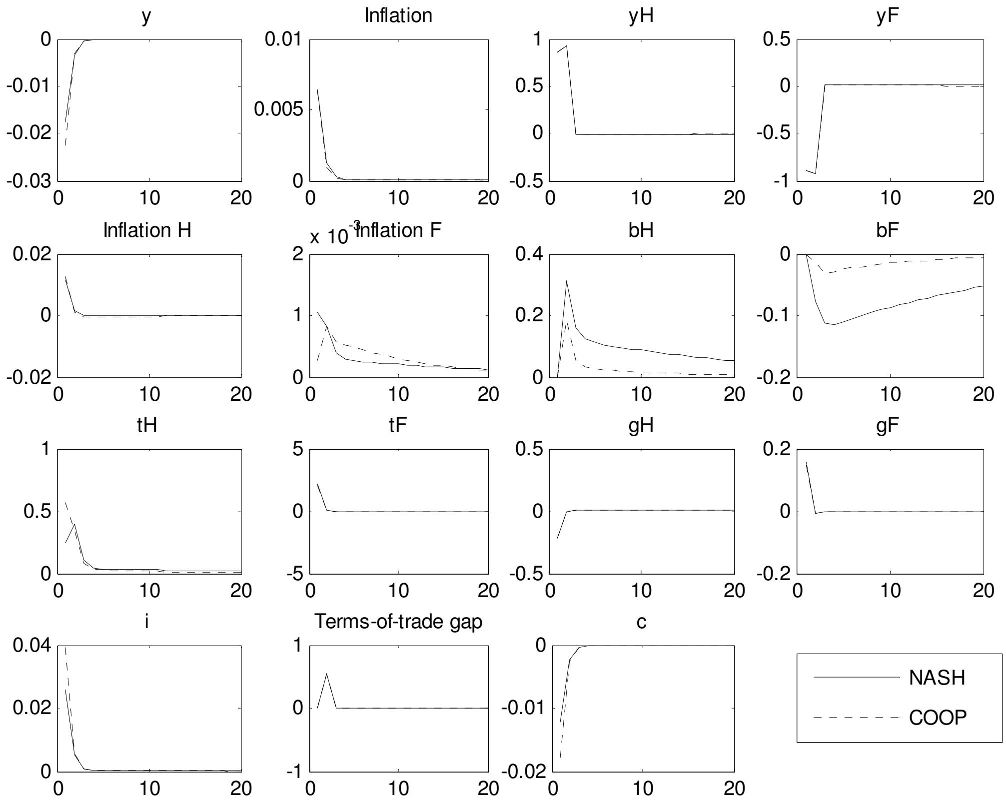

Figure 22: Percentage response to a 1% a negative productivity shock at H under small debts

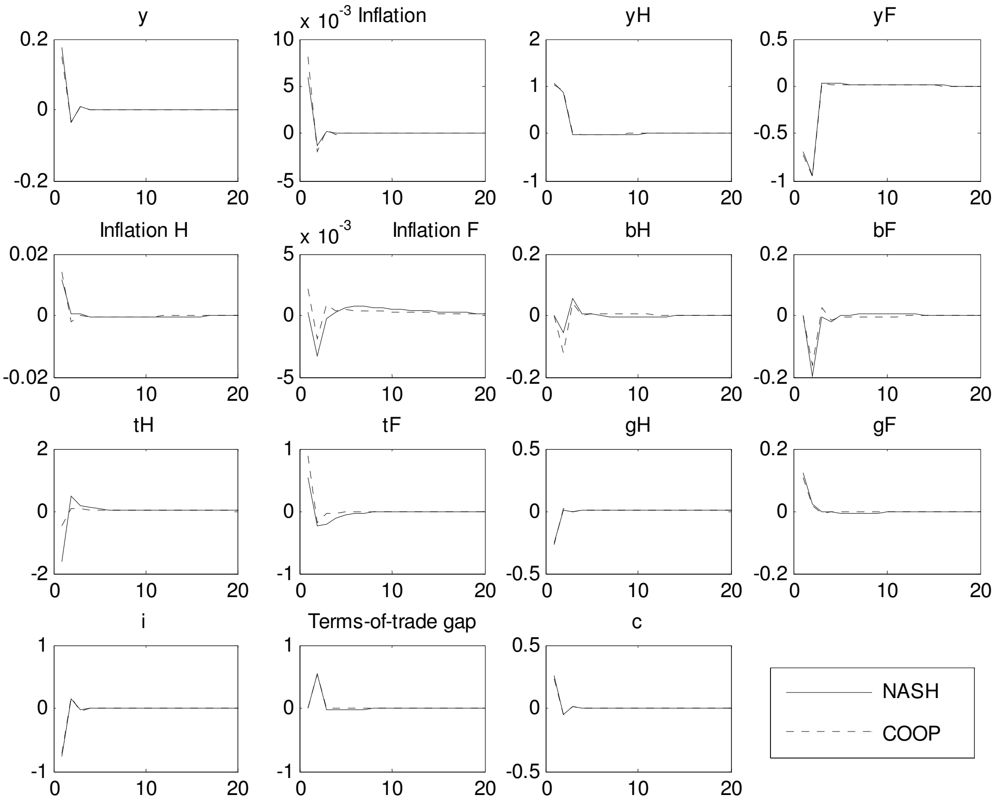

Figure 23: Percentage response to a 1% a negative productivity shock at H under large debts

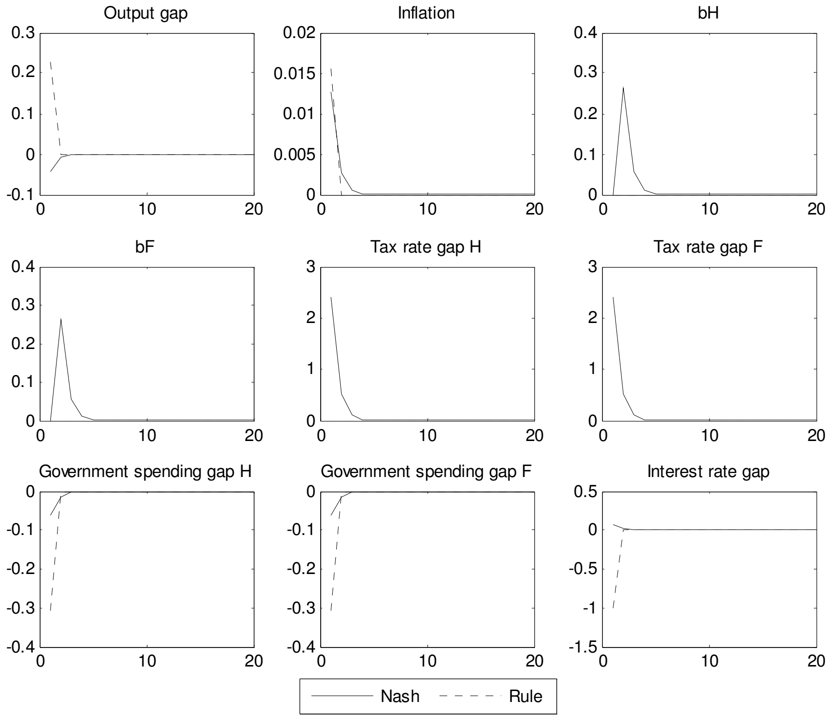

Figure 24: Percentage response to a 1% a symmetric negative productivity shock under small debts

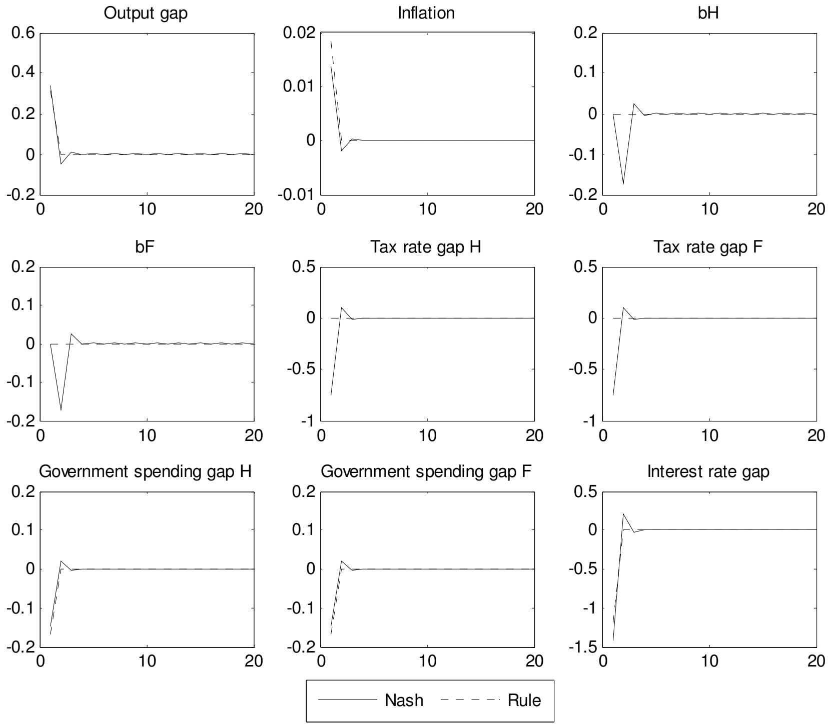

Figure 25: Percentage response to a 1% a symmetric negative productivity shock under large debts

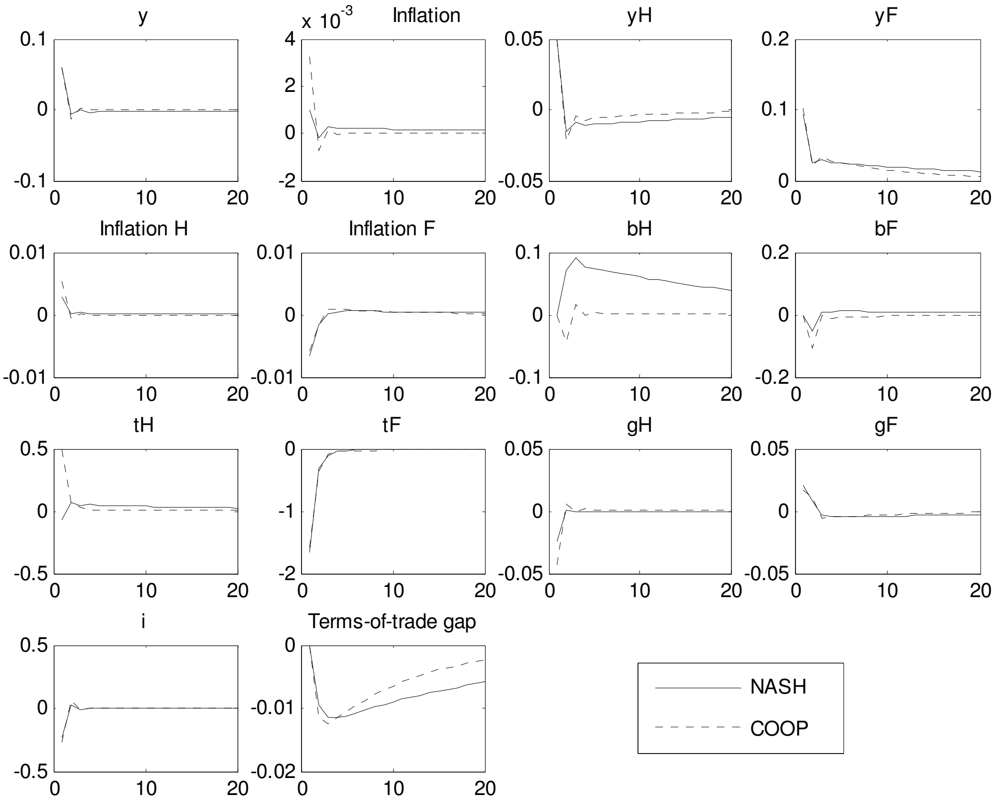

Figure 26: Percentage response to a 1% a positive mark-up shock at the large country (H) under large debts

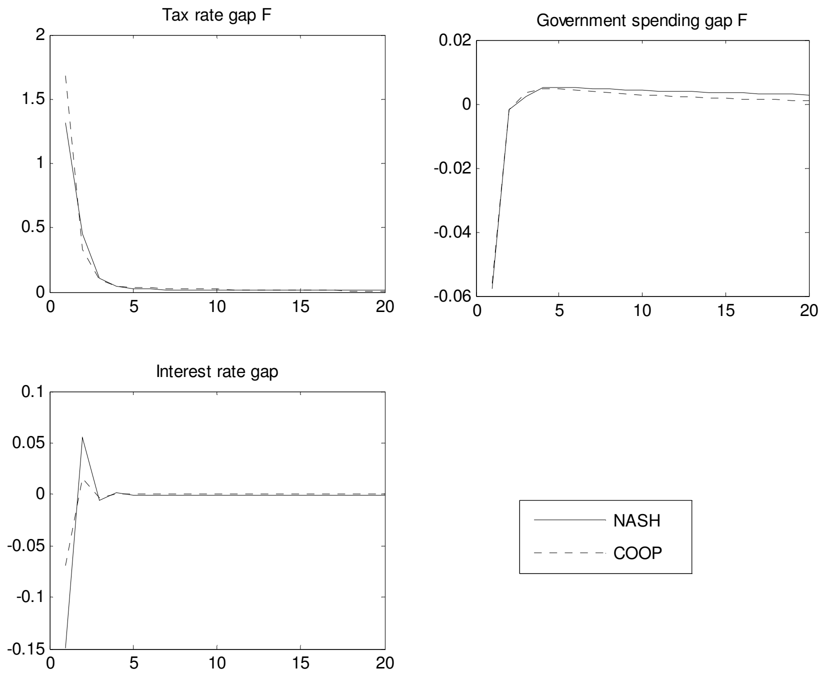

Figure 27: Percentage response to a 1% a positive mark-up shock at the small country (F) under large debts

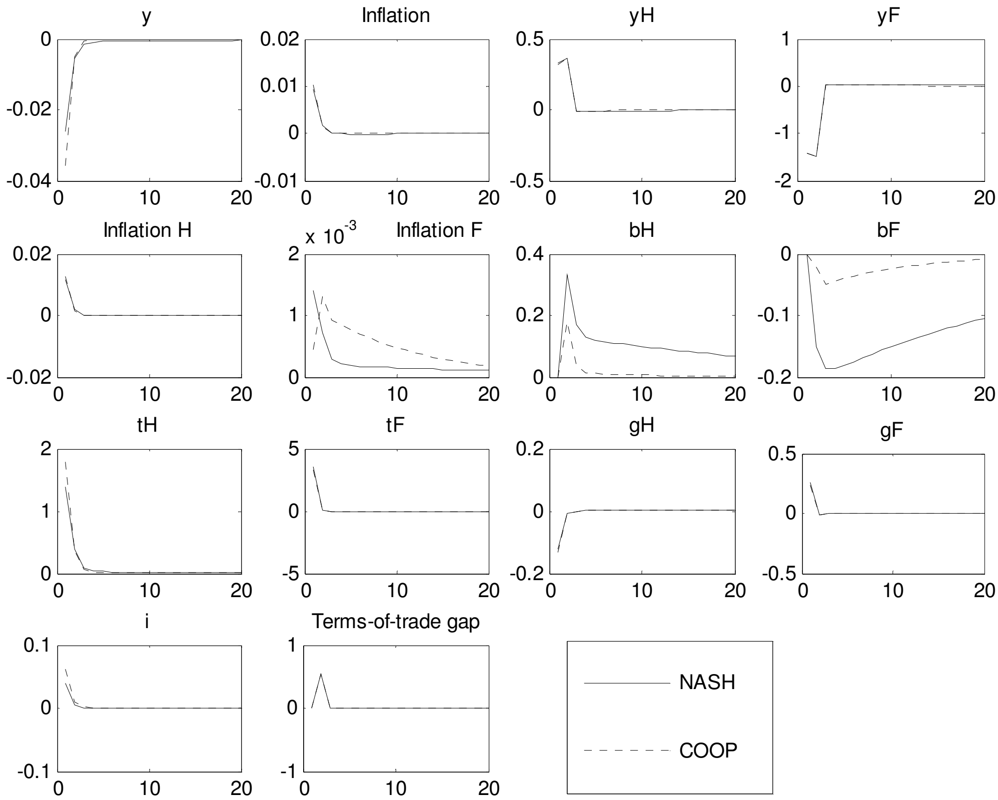

Figure 28: Percentage response to a 1% a negative productivity shock at the large country under small debts

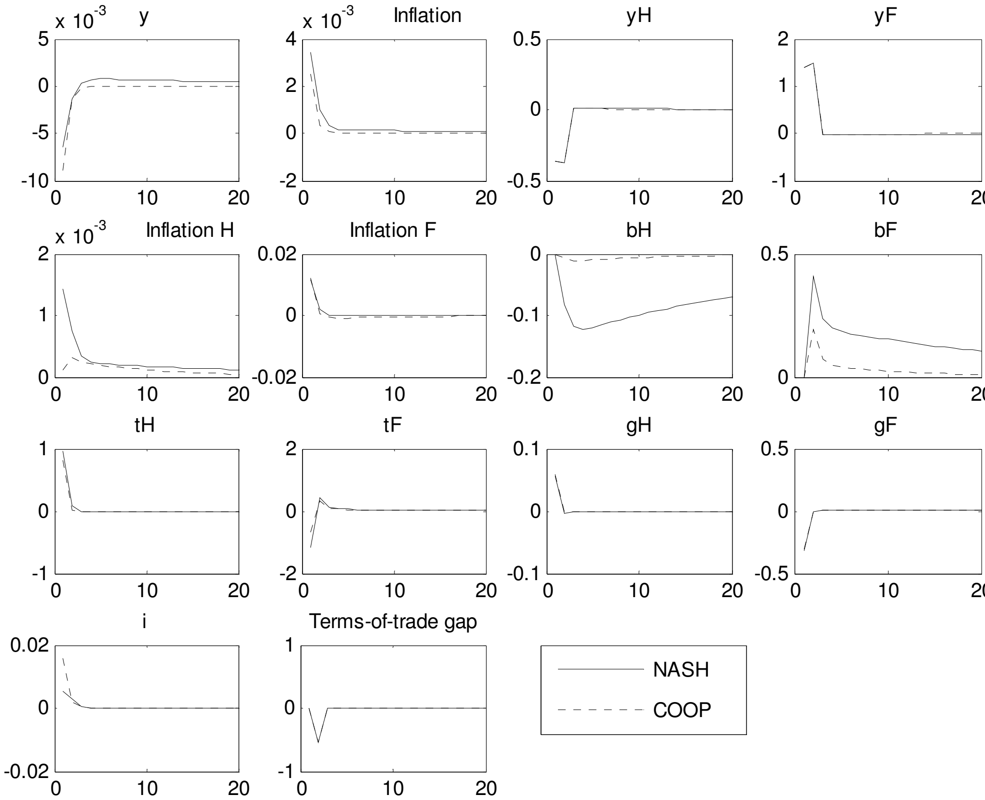

Figure 29: Percentage response to a 1% a negative productivity shock at the small country under small debts

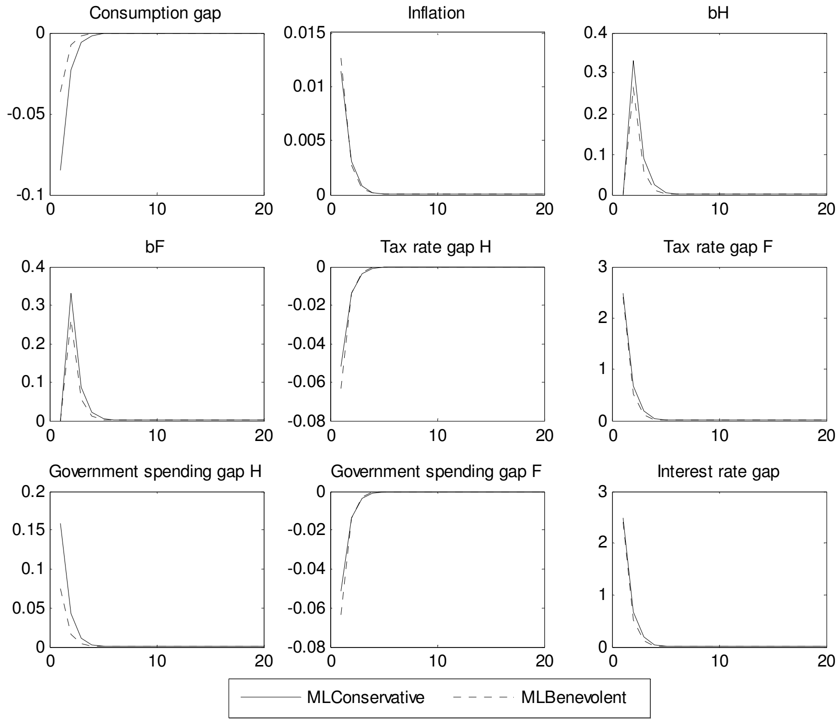

Figure 30: Percentage response to a 1% a symmetric negative productivity shock under small debts

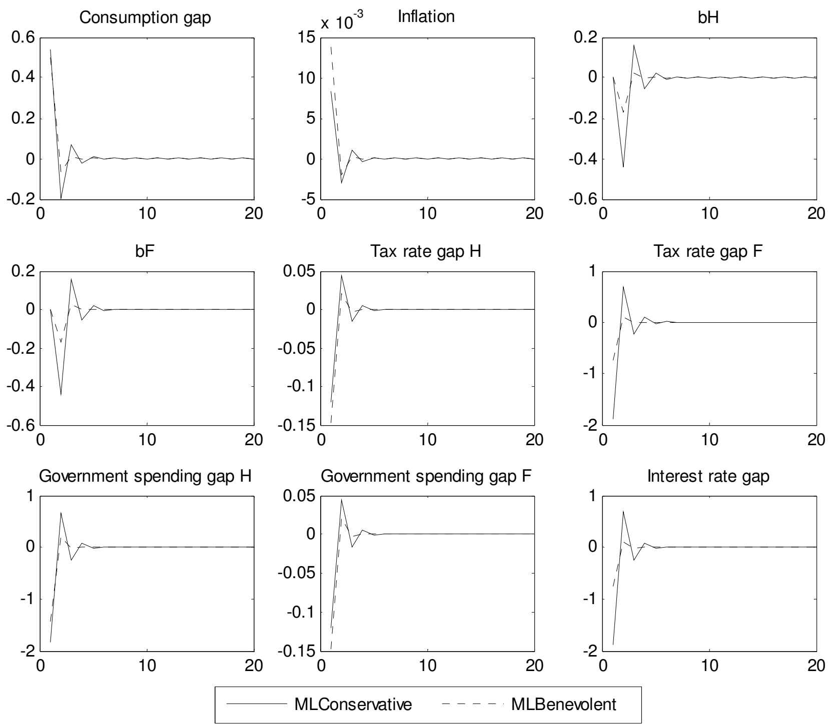

Figure 31: Percentage response to a 1% a symmetric negative productivity shock under large debts

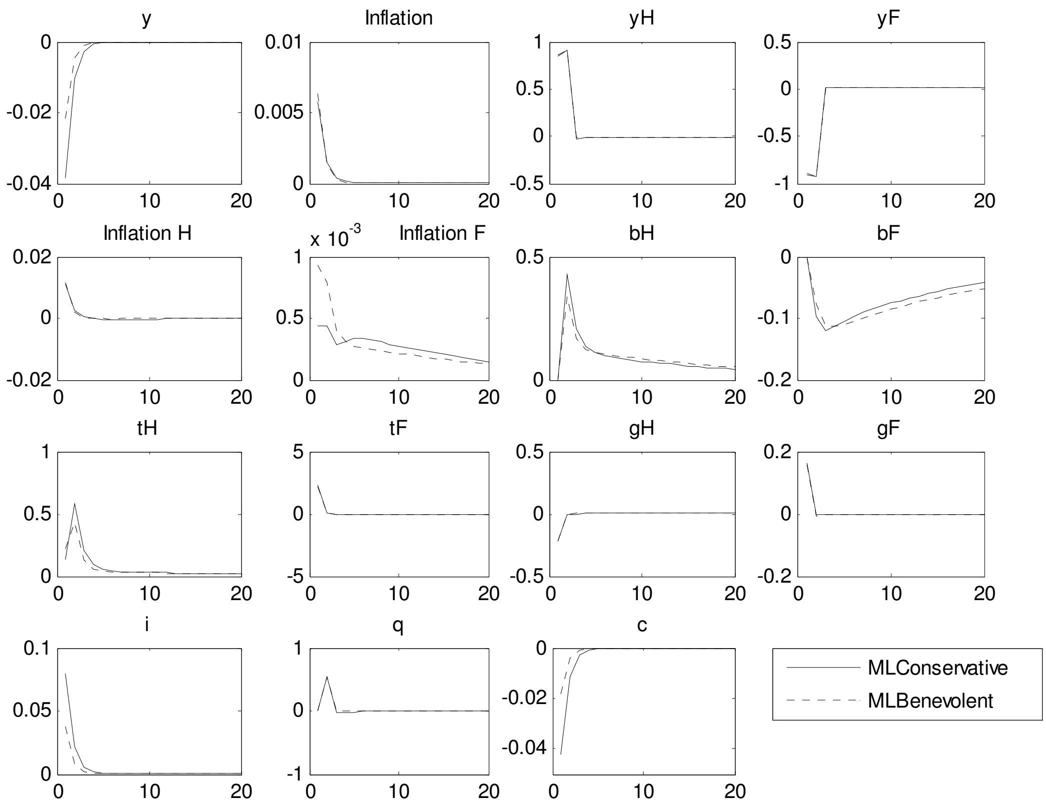

Figure 32: Percentage response to a 1% a negative productivity shock at H under small debts

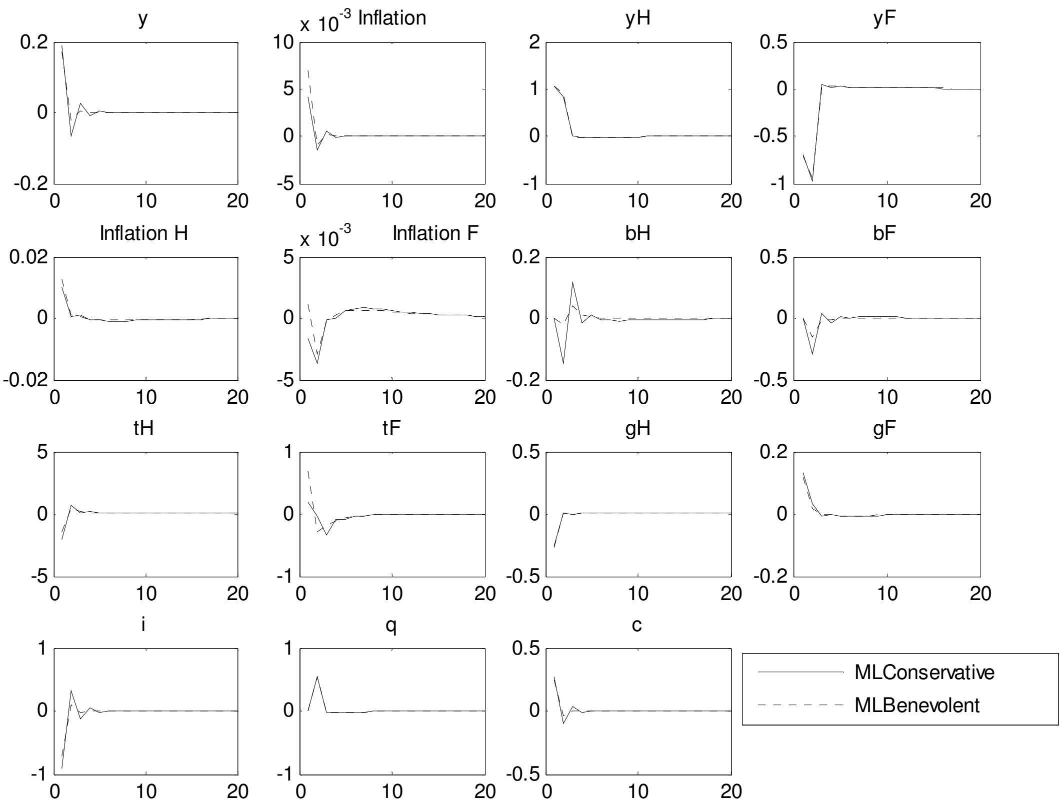

Figure 33: Percentage response to a 1% a negative productivity shock at H under large debts

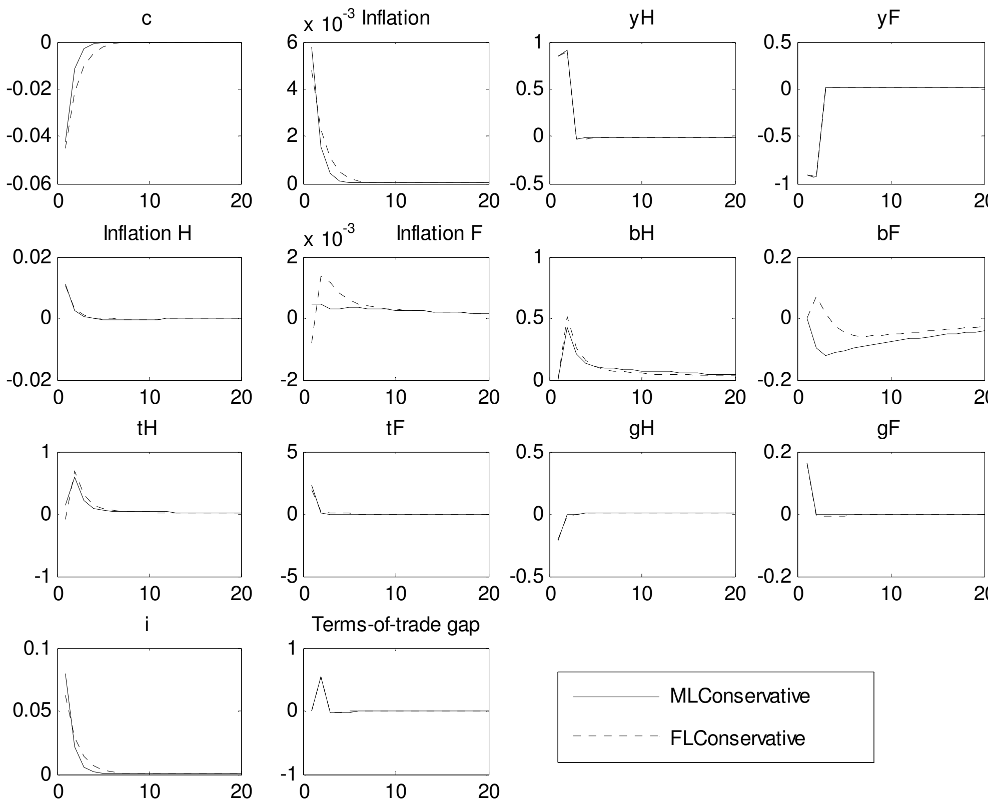

Figure 34: Percentage response to a 1% a negative productivity shock at H under small debts

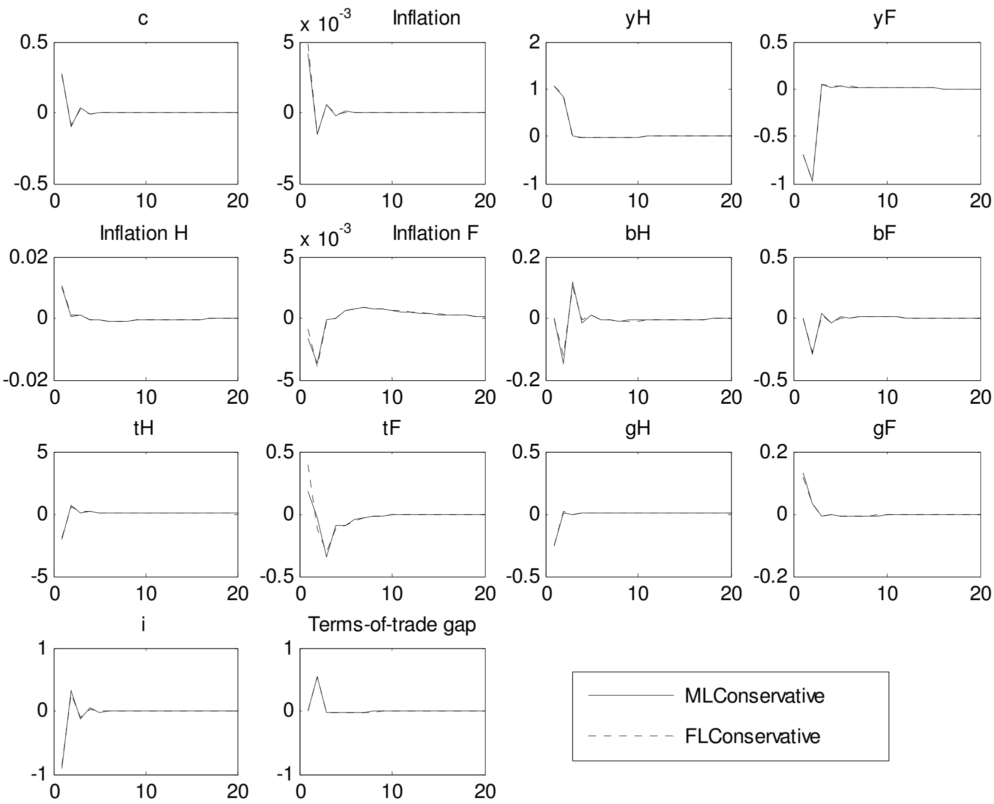

Figure 35: Percentage response to a 1% a negative productivity shock at H under large debts

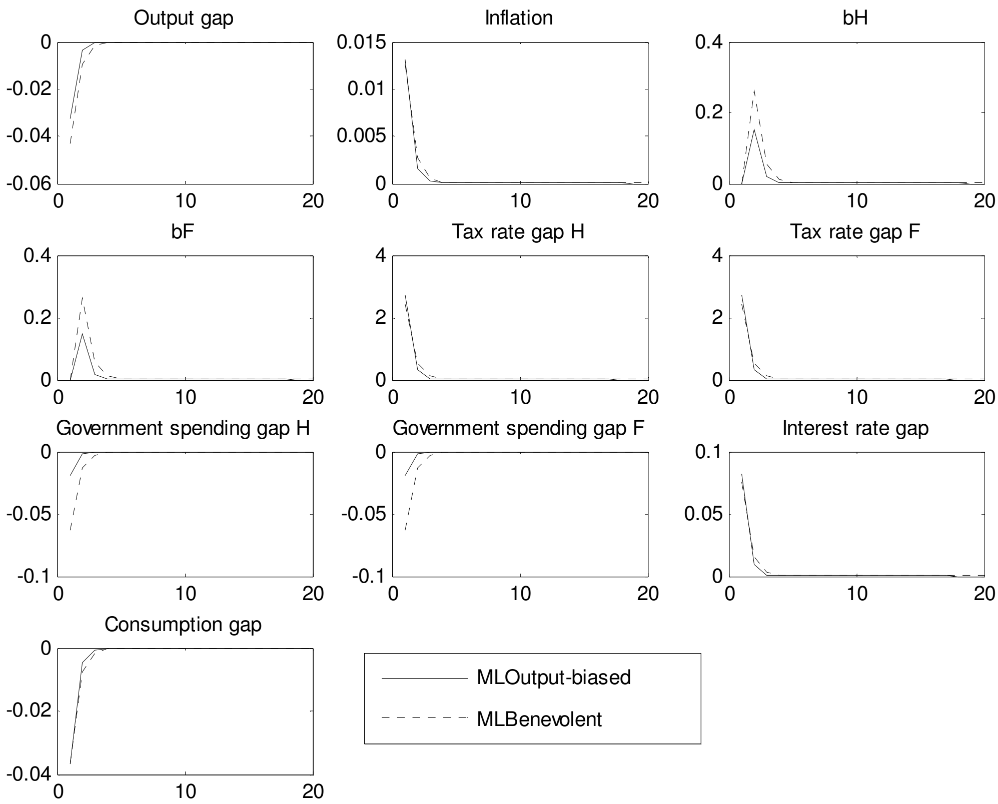

Figure 36: Percentage response to a 1% a symmetric negative productivity shock under small debts

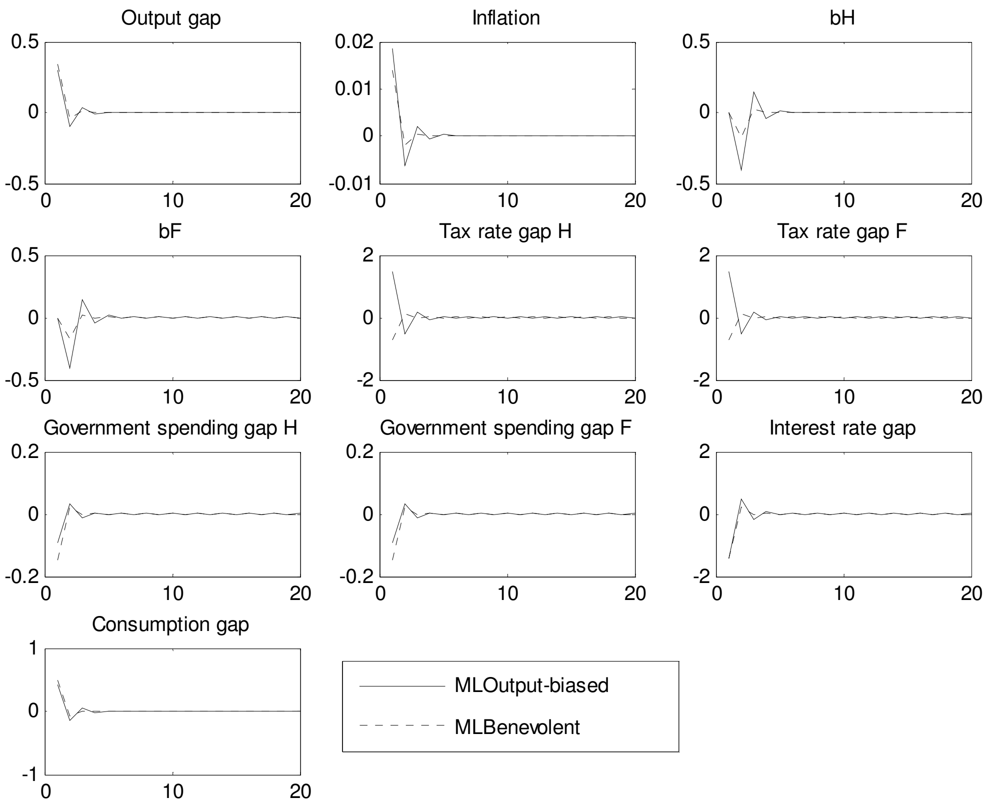

Figure 37: Percentage response to a 1% a symmetric negative productivity shock under large debts

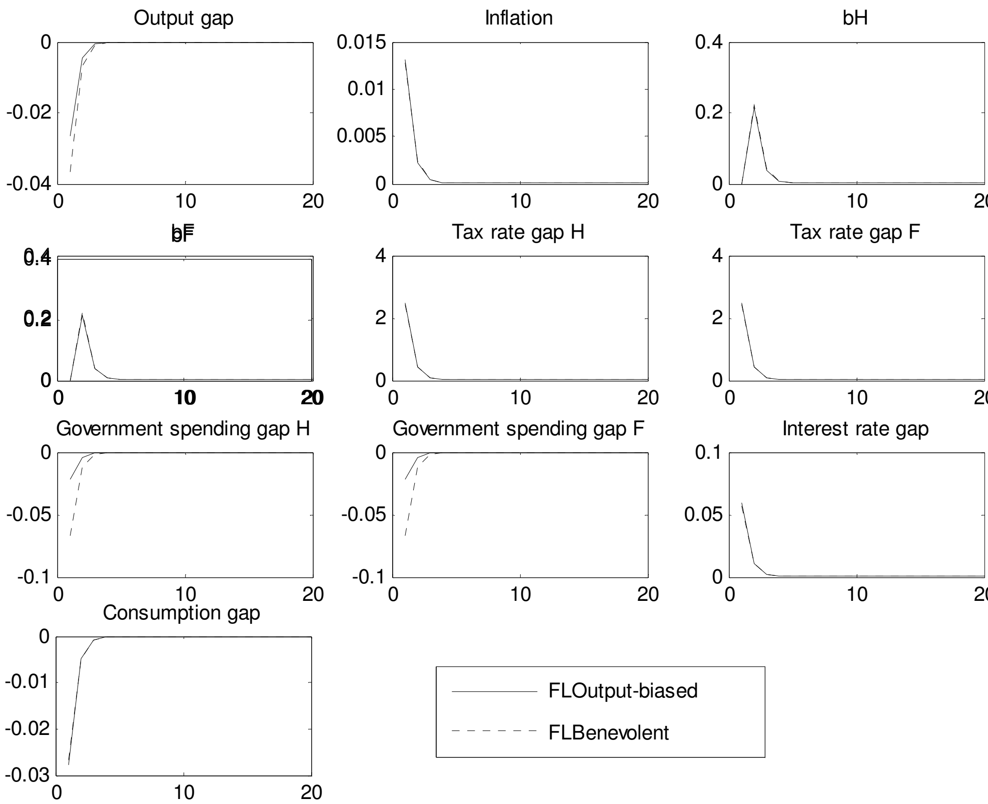

Figure 38: Percentage response to a 1% a symmetric negative productivity shock under small debts

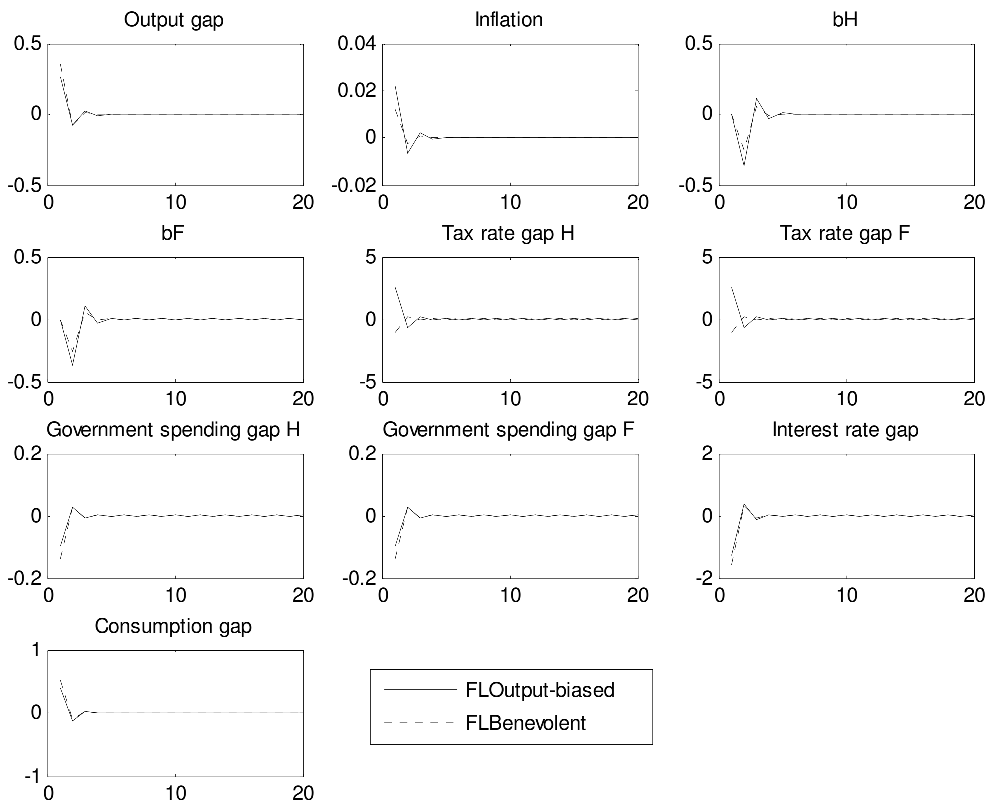

Figure 39: Percentage response to a 1% a symmetric negative productivity shock under large debts

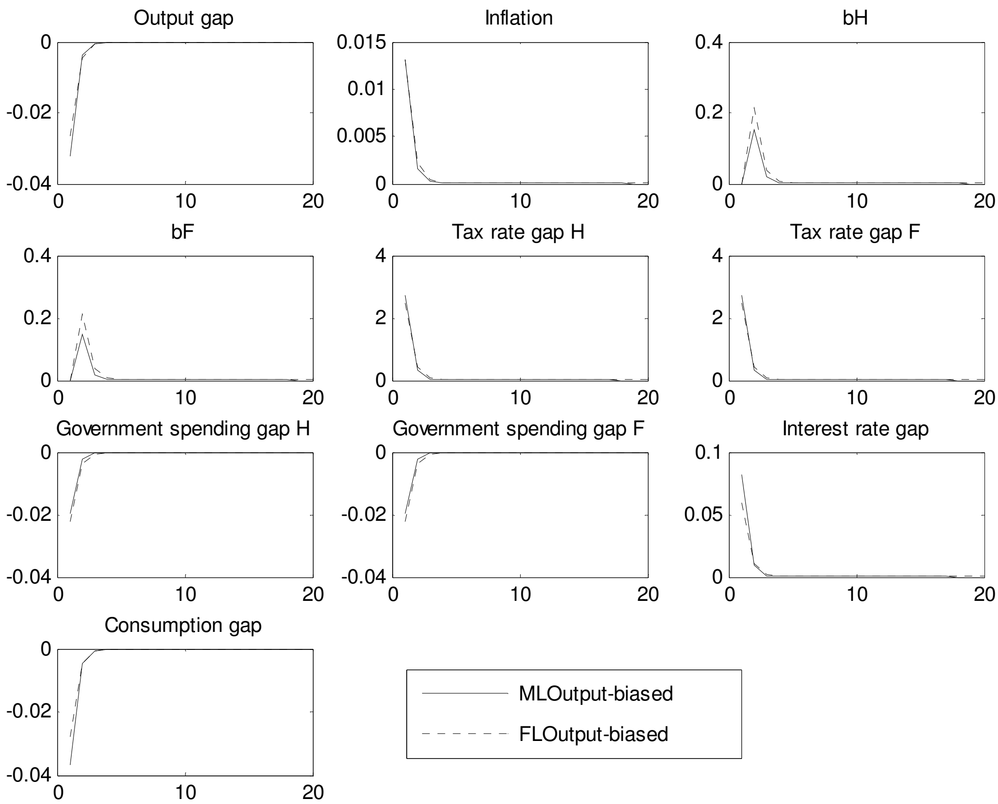

Figure 40: Percentage response to a 1% a symmetric negative productivity shock under small debts

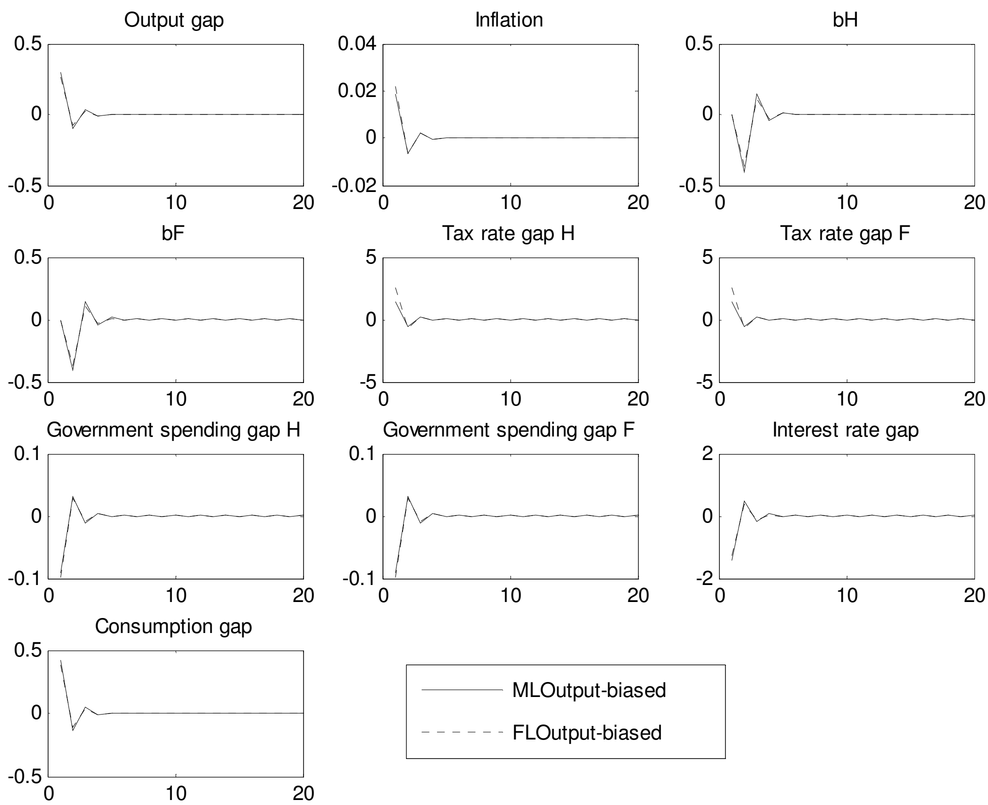

Figure 41: Percentage response to a 1% a symmetric negative productivity shock under large debts

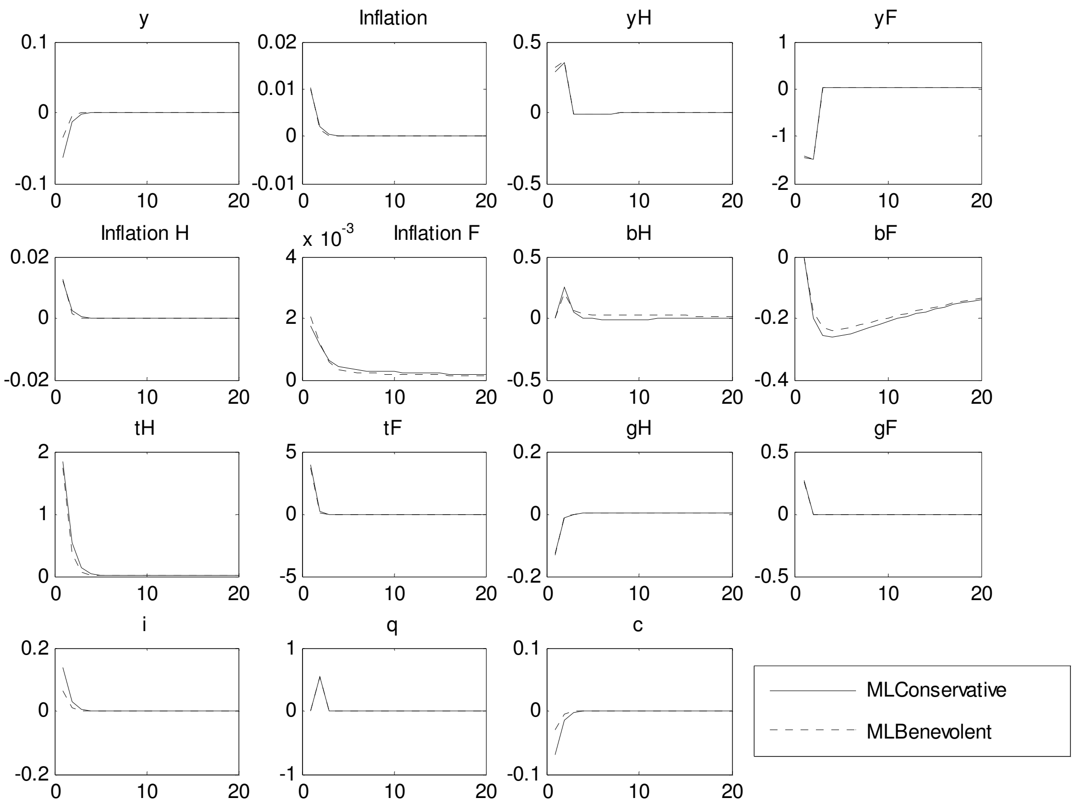

Figure 42: Percentage response to a 1% a negative productivity shock at the large country H under small debts

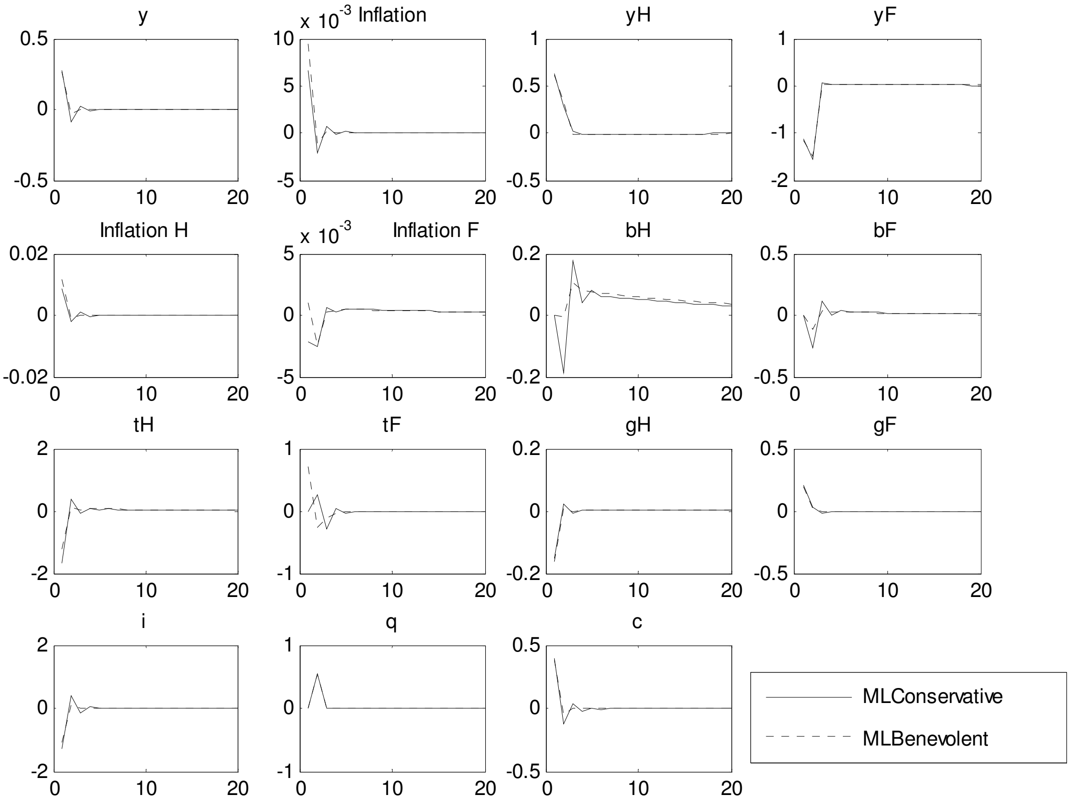

Figure 43: Percentage response to a 1% a negative productivity shock at the large country H under large debts

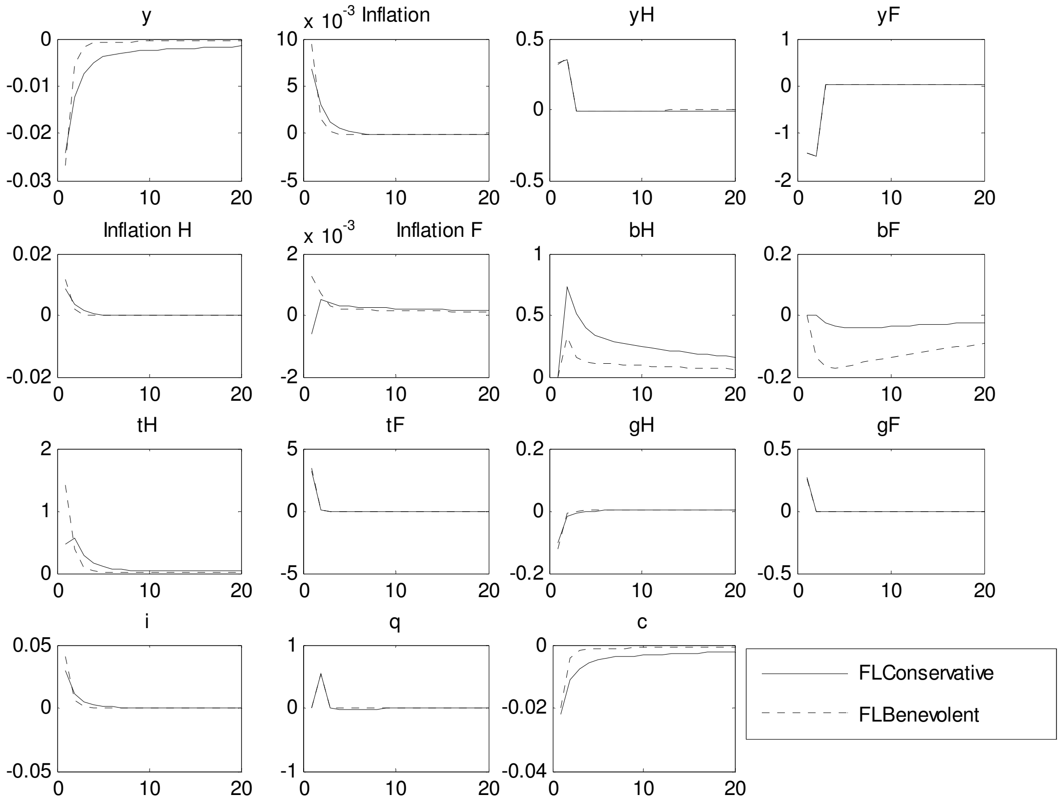

Figure 44: Percentage response to a 1% a negative productivity shock at the large country H under small debts

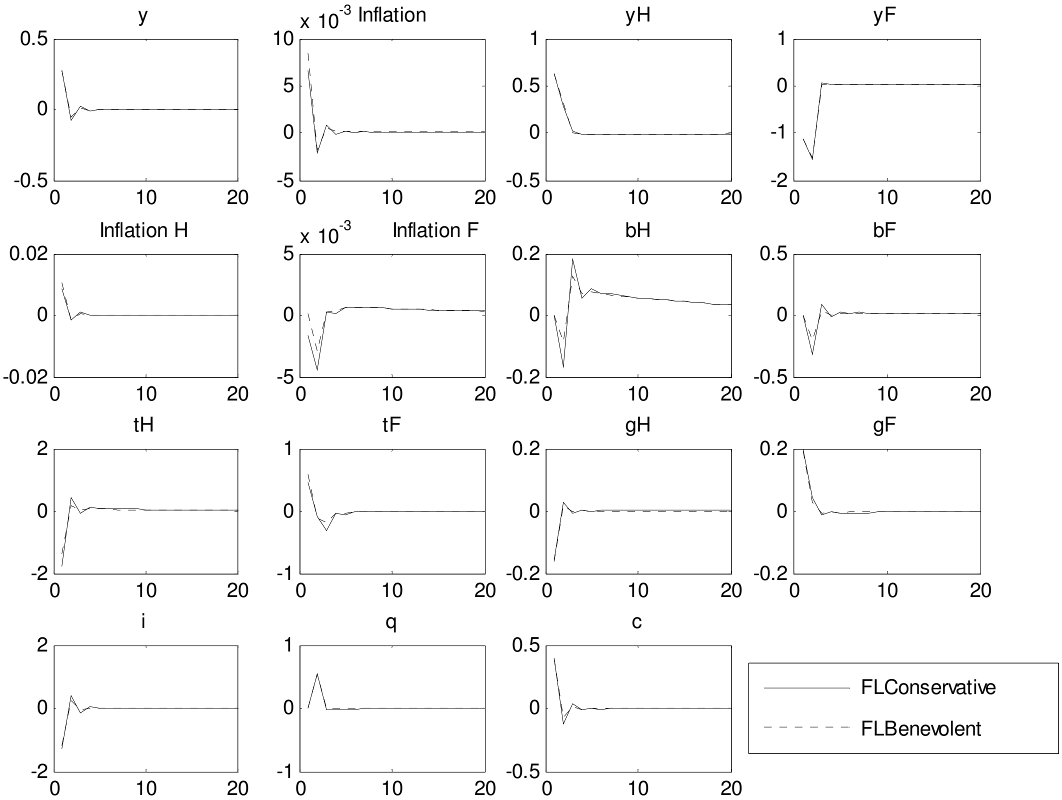

Figure 45: Percentage response to a 1% a negative productivity shock at the large country H under large debts

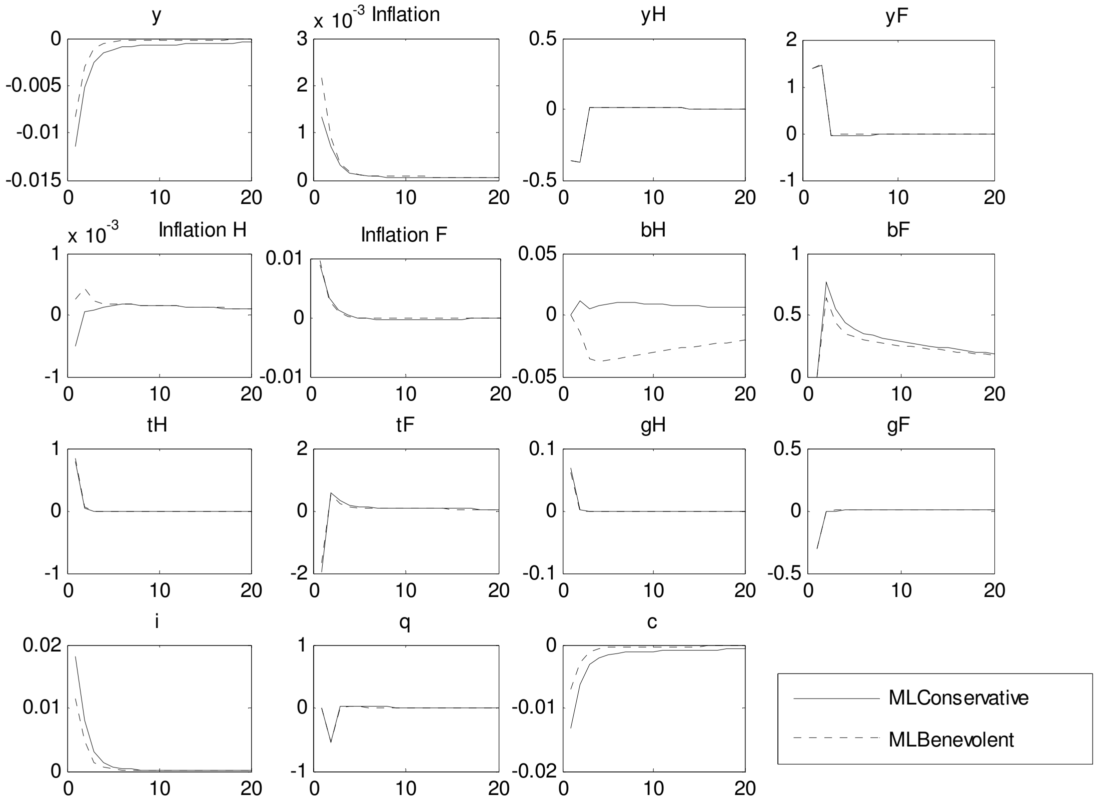

Figure 46: Percentage response to a 1% a negative productivity shock at the small country F under small debts

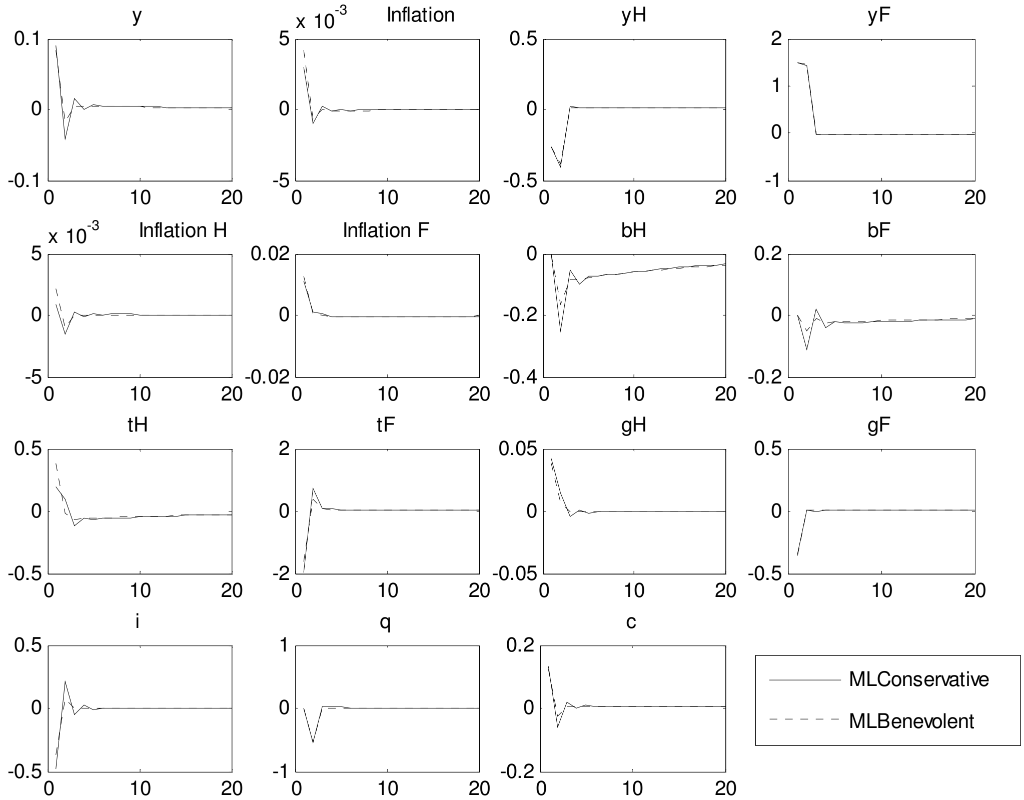

Figure 47: Percentage response to a 1% a negative productivity shock at the small country F under large debts

TABLES

		Baseline	EMU	
n^H	=	0.5; 0.8	0.8	Size of country H (Germany+France+Italy in EMU)
β	=	0.99	0.99	Household discount factor
η	=	0.47	0.47	Inverse Frisch elasticity
α^H	=	0.75	0.76	Degree of price rigidity in country H
α^F	=	0.75	0.72	Degree of price rigidity in country F
$\omega^H = 1\text{-}\lambda^H$	=	0.5; 0	0.26	Fraction of rule-of-thumb firms in country H
$\omega^F = 1\text{-}\lambda^F$	=	0.5; 0	0.56	Fraction of rule-of-thumb firms in country F
$1/\sigma$	=	2.5	2.5	Coefficient of private consumption risk aversion
$1/\psi$	=	2.5	2.5	Coefficient of public spending risk aversion
θ	=	11	11	Elasticity of substitution among domestically produced goods
ρ	=	4.5	4.5	Elasticity of substitution between H and F produced goods
s_c	=	0.75	0.74	s.s. consumption-output ratio
$\left(\overline{b}/4\overline{Y}\right)^H$	=	15%; 60%	80%	s.s. debt-output ratio at H
$\left(\overline{b}/4\overline{Y}\right)^F$	=	15%; 60%	50%	s.s. debt-output ratio at F
$\overline{\tau}^H$	=		29.12%	s.s. tax rate at H
$\overline{\tau}^F$	=		27.88%	s.s. tax rate at F
ρ_a	=	0.85	0.815	Persistence of productivity shock
ρ_c	=	0.85	0.842	Persistence of consumption shock
ρ_μ	=	0	0	Persistence of mark-up shock
σ_a^2	=	0.001	0.00624	Variance of productivity shock
σ_c^2	=	0.001	0.00392	Variance of consumption shock
σ_μ^2	=	0.001	0.00295	Variance of mark-up shock

Table D.1. Calibration and implied steady-state (s.s.) values: baseline and EMU scenarios

		a_t^R	a_{t-1}^R	u_t^H	u_t^F	π_{t-1}^H	π_{t-1}^F	q_{t-1}	i_t	g_t^H	g_t^F
Baseline: σ=ψ=0.4; ρ=4.5; θ=11; η=0.47; β=0.99; α^H=α^F=0.75; λ^H=λ^F=0.5; $\rho_a = 0$; n=0.5											
	g_t^H	-0.1758	0.1734	-0.0065	0.0065	-0.0762	0.0762	-0.3106			
Coop	g_t^F	0.1758	-0.1734	0.0065	-0.0065	0.0762	-0.0762	0.3106			
	i_t	0.0000	-0.0000	0.1042	0.1042	1.6516	1.6516	0.0000			
Const	i_t	0.0000	-0.0000	0.1042	0.1042	1.6516	1.6516	0.0000			
Baseline + n=0.8											
	g_t^H	-0.0703	0.0694	-0.0026	0.0026	-0.0305	0.0305	-0.1243			
Coop	g_t^F	0.2812	-0.2775	0.0103	-0.0103	0.1219	-0.1219	0.4970			
	i_t	-0.0000	0.0000	0.1667	0.0417	2.6426	0.6607	-0.0000			
Const	i_t	-0.0000	0.0000	0.1667	0.0417	2.6426	0.6607	-0.0000			

Table D.2. Feedback coefficients of policy rules - cooperation

		a_t^R	a_{t-1}^R	u_t^H	u_t^F	π_{t-1}^H	π_{t-1}^F	q_{t-1}	i_t	g_t^H	g_t^F
Baseline: σ=ψ=0.4; ρ=4.5; θ=11; η=0.47; β=0.99; α^H=α^F=0.75; λ^H=λ^F=0.5; $\rho_a = 0$; n=0.5											
	g_t^H	-0.1765	0.1998	-0.0057	0.0064	-0.0091	0.0480	-0.3580			
Nash	g_t^F	0.1765	-0.1998	0.0064	-0.0057	0.0480	-0.0091	0.3580			
	i_t	-0.0000	-0.0000	0.1042	0.1042	1.6526	1.6526	0.0000			
	g_t^H	-0.1717	0.1651	-0.0020	0.0027	0.0647	-0.0256	-0.2958			
FL	g_t^F	0.1717	-0.1651	0.0027	-0.0020	-0.0256	0.0647	0.2958			
	i_t	0.0000	-0.0000	0.1042	0.1042	1.6505	1.6505	0.0000		0.0515	0.0515
	g_t^H	-0.1765	0.1998	-0.0128	-0.0007	-0.1216	-0.0645	-0.3580	0.0681		
ML	g_t^F	0.1765	-0.1998	-0.0007	-0.0128	-0.0645	-0.1216	0.3580	0.0681		
	i_t	-0.0000	0.0000	0.1042	0.1042	1.6518	1.6518	-0.0000			
Baseline + n=0.8											
	g_t^H	-0.0703	0.0829	-0.0022	0.0025	0.0044	0.0113	-0.1485			
Nash	g_t^F	0.2836	-0.3080	0.0106	-0.0095	0.1080	-0.0460	0.5517			
	i_t	0.0000	0.0001	0.1667	0.0417	2.6433	0.6612	-0.0001			
	g_t^H	-0.0672	0.0606	0.0002	0.0001	0.0516	-0.0359	-0.1086			
FL	g_t^F	0.2806	-0.2859	0.0083	-0.0072	0.0612	0.0010	0.5121			
	i_t	-0.0009	0.0010	0.1666	0.0417	2.6405	0.6614	-0.0017		0.0824	0.0206
	g_t^H	-0.0703	0.0829	-0.0135	-0.0003	-0.1750	-0.0335	-0.1485	0.0678		
ML	g_t^F	0.2836	-0.3080	-0.0008	-0.0124	-0.0726	-0.0911	0.5517	0.0683		
	i_t	-0.0000	0.0000	0.1667	0.0417	2.6427	0.6608	-0.0000			

Table D.3. Feedback coefficients of policy rules - non cooperation

		a_t^R	a_{t-1}^R	u_t^H	u_t^F	π_{t-1}^H	π_{t-1}^F	q_{t-1}	i_t	g_t^H	g_t^F
Baseline:σ=ψ=0.4; ρ=4.5;θ=11; η=0.47;β=0.99; α^H=α^F=0.75; λ^H=λ^F=0.5;$\rho_a = 0$; n=0.5											
Conservative Central Bank - $\rho^c = 0.75; 1 - \rho^c = 0.25$											
	g_t^H	-0.1762	0.1946	0.0019	0.0136	0.1622	0.2128	-0.3486			
Nash	g_t^F	0.1762	-0.1946	0.0136	0.0019	0.2128	0.1622	0.3486			
	i_t	-0.0000	-0.0000	0.2048	0.2048	2.7836	2.7836	0.0000			
	g_t^H	-0.1717	0.1651	0.0017	0.0064	0.1475	0.0572	-0.2958			
FL	g_t^F	0.1717	-0.1651	0.0064	0.0017	0.0572	0.1475	0.2958			
	i_t	-0.0000	-0.0000	0.2040	0.2040	2.7686	2.7686	-0.0000		0.0515	0.0515
	g_t^H	-0.1762	0.1947	-0.0113	0.0003	-0.0181	0.0325	-0.3487	0.0647		
ML	g_t^F	0.1762	-0.1947	0.0003	-0.0113	0.0325	-0.0181	0.3487	0.0647		
	i_t	0.0000	-0.0000	0.2043	0.2043	2.7783	2.7783	0.0000			
Baseline + n=0.8											
	g_t^H	-0.0701	0.0796	0.0097	0.0053	0.2774	0.0770	-0.1425			
Nash	g_t^F	0.2834	0.3046	0.0223	-0.0064	0.3727	0.0228	0.5457			
	i_t	0.0001	0.0001	0.3276	0.0819	4.4532	1.1133	-0.0001			
	g_t^H	-0.0672	0.0606	0.0026	0.0007	0.1046	-0.0227	-0.1086			
FL	g_t^F	0.2806	-0.2859	0.0177	-0.0048	0.2725	0.0539	0.5121			
	i_t	-0.0000	0.0010	0.3264	0.0816	4.4313	1.1096	-0.0017		0.0824	0.0206
	g_t^H	-0.0701	0.0796	-0.0111	0.0001	-0.0067	0.0060	-0.1425	0.0637		
ML	g_t^F	0.2834	-0.3047	0.0008	-0.0118	0.0799	-0.0504	0.5458	0.0656		
	i_t	0.0000	0.0000	0.3269	0.0817	4.4452	1.1112	-0.0001			

Table D.4. Feedback coefficients of policy rules - conservative CB

		a_t^R	a_{t-1}^R	u_t^H	u_t^F	π_{t-1}^H	π_{t-1}^F	q_{t-1}	i_t	g_t^H	g_t^F
Baseline:σ=ψ=0.4; ρ=4.5;θ=11; η=0.47;β=0.99; α^H=α^F=0.75; λ^H=λ^F=0.5;$\rho_a = 0$; n=0.5											
Output-biased FAs - $\rho^e = 0.75; 1 - \rho^e = 0.25$											
	g_t^H	-0.1693	0.1660	0.0033	0.0053	0.2125	0.0318	-0.2974			
Nash	g_t^F	0.1693	-0.1660	0.0053	0.0033	0.0318	0.2125	0.2974			
	i_t	0.0000	-0.0000	0.1045	0.1045	1.6574	1.6574	0.0000			
	g_t^H	-0.1680	0.1546	0.0025	0.0020	0.1818	-0.0485	-0.2770			
FL	g_t^F	0.1680	-0.1546	0.0020	0.0025	-0.0485	0.1818	0.2770			
	i_t	0.0000	0.0000	0.1041	0.1041	1.6479	1.6479	-0.0000		0.0515	0.0515
	g_t^H	-0.1693	0.1660	-0.0026	-0.0006	0.1187	-0.0621	-0.2974	0.0565		
ML	g_t^F	0.1693	-0.1660	-0.0006	-0.0026	-0.0621	0.1187	0.2974	0.0565		
	i_t	-0.0000	0.0000	0.1042	0.1042	1.6535	1.6535	-0.0000			
Baseline + n=0.8											
	g_t^H	-0.0675	0.0662	0.0062	0.0021	0.2191	0.0118	-0.1187			
Nash	g_t^F	0.2720	-0.2663	0.0085	0.0003	0.0545	0.2031	0.4771			
	i_t	0.0000	-0.0000	0.1673	0.0418	2.6514	0.6630	0.0000			
	g_t^H	-0.0666	0.0589	0.0018	-0.0000	0.0929	-0.0396	-0.1056			
FL	g_t^F	0.2712	-0.2591	0.0064	0.0008	0.0028	0.2100	0.4641			
	i_t	-0.0000	0.0005	0.1666	0.0417	2.6387	0.6598	-0.0008		0.0824	0.0206
	g_t^H	-0.0675	0.0662	-0.0032	-0.0003	0.0703	-0.0254	-0.1187	0.0560		
ML	g_t^F	0.2720	-0.2663	-0.0010	-0.0021	-0.0969	0.1653	0.4771	0.0569		
	i_t	0.0000	-0.0000	0.1668	0.0417	2.6455	0.6614	0.0000			

Table D.5. Feedback coefficients of policy rules - output-biased FAs

Benevolent	$n^H = 0.5$	$n^H = 0.8$
LCommit*100	2.6809	1.7356
LCoop	2.7015	1.7542
LML	2.7034	1.7549
LFL	2.7043	1.7553
LNash	2.7034	1.7549
LRule	2.7775	1.8028
Non-benevolent: conservative and output-biased $\rho = 0.75; 1 - \rho = 0.25$		
LMLconservative	2.7117	1.7663
LFLconservative	2.7128	1.7668
LNashconservative	2.7118	1.7664
LRuleconservative	2.7859	1.8143
LMLoutputbiased	2.7063	1.7571
LFLoutputbiased	2.7070	1.7573
LNashoutputbiased	2.7063	1.7570

Table D.6. Union-wide Loss

Benevolent	$n^H = 0.5$	$n^H = 0.8$
LHCommit*100	2.6809	1.1353
LHCoop*100	2.7015	1.1470
LHML*100	2.7034	1.1473
LHFL*100	2.7043	1.1468
LHNash	2.7034	1.1472
LHRule*100	2.7775	1.1531
LFCommitment*100	2.6809	4.1369
LFCoop*100	2.7015	4.1830
LFML*100	2.7034	4.1852
LFFL*100	2.7043	4.1891
LFNash	2.7034	4.1855
LFRule*100	2.7775	4.4018
Non-benevolent: conservative and output-biased $\rho = 0.75; 1 - \rho = 0.25$		
LHMLconservative	2.7117	1.1536
LHFLconservative	2.7128	1.1534
LHNashconservative	2.7118	1.1536
LHRuleconservative	2.7859	1.1595
LFMLconservative	2.7117	4.2173
LFFLconservative	2.7128	4.2205
LFNashconservative	2.7118	4.2177
LFRuleconservative	2.7859	4.4336
LHMLoutputbiased	2.7063	1.1470
LHFLoutputbiased	2.7070	1.1469
LHNashoutputbiased	2.7063	1.1469
LFMLoutputbiased	2.7063	4.1971
LFFLoutputbiased	2.7070	4.1989
LFNashoutputbiased	2.7063	4.1976

Table D.7. Loss of a representative H and F household

Asymmetric shocks only	**Productivity shock**		**Mark-up shock**	
$\rho_a = 0.85$	nH = 0.5	nH = 0.8	nH = 0.5	nH = 0.8
LCoop	2.6213	1.6776	0.080186	0.076561
LML	2.6231	1.6783	0.080226	0.076584
LFL	2.6241	1.6787	0.080215	0.076577
LNash	2.6231	1.6783	0.080224	0.076581
LRule	2.6974	1.7263	0.080113	0.076514
LMLConservative	2.6230	1.6783	0.088662	0.088063
LFLConservative	2.6241	1.6787	0.088692	0.088091
LNashConservative	2.6230	1.6783	0.088751	0.088181
LRuleConservative	2.6974	1.7263	0.088568	0.088014
LMLoutputbiased	2.6261	1.6804	0.080274	0.076639
LFLoutputbiased	2.6268	1.6807	0.080257	0.076597
LNashoutputbiased	2.6261	1.6804	0.080264	0.076626

Table D.8. Union-wide Loss, mark-up and productivity shocks

$$L_{CB} = n\Lambda_\pi^H \left(\pi_t^H\right)^2 + (1-n)\Lambda_\pi^F \left(\pi_t^F\right)^2 + n\Lambda_{\Delta\pi}^H \left(\Delta\pi_t^H\right)^2 + (1-n)\Lambda_{\Delta\pi}^F \left(\Delta\pi_t^F\right)^2$$
$$L_{FA}^H = \Lambda_c \left(c_t^w\right)^2 + \Lambda_g \left(g_t^H\right)^2 + \Lambda_{gc} c_t^w g_t^H + \Lambda_T q_t^2 + \frac{1}{n}\Lambda_{gT} g_t^H q_t$$
$$L_{FA}^F = \Lambda_c \left(c_t^w\right)^2 + \Lambda_g \left(g_t^F\right)^2 + \Lambda_{gc} c_t^w g_t^F + \Lambda_T q_t^2 - \frac{1}{1-n}\Lambda_{gT} g_t^F q_t$$
$$L_W = nL_{FA}^H + (1-n) L_{FA}^F + L_{CB}$$

Asymmetric shocks	nH = 0.5	nH = 0.5	nH = 0.5	nH = 0.8	nH = 0.8	nH = 0.8
Both FAs minimize	L_{FA}	L_W	L_W	L_{FA}	L_W	L_W
CB minimize	L_{CB}	L_{CB}	L_W	L_{CB}	L_{CB}	L_W
LML_{CB}	1.3437	1.3323	1.3577	0.8597	0.8527	0.8872
LML_{FA}^H	1.4608	1.4649	1.3438	1.0471	1.0490	0.8843
LML_{FA}^F	1.4608	1.4649	1.3438	0.9569	0.9624	0.7976
LML_W	2.8044	2.7972	2.7015	1.8888	1.8843	1.7542
LFL_{CB}	1.3436	1.3323	1.3577	0.8597	0.8527	0.8872
LFL_{FA}^H	1.4603	1.4643	1.3438	1.0465	1.0483	0.8843
LFL_{FA}^F	1.4603	1.4643	1.3438	0.9557	0.9612	0.7976
LFL_W	2.8039	2.7966	2.7015	1.8880	1.8835	1.7542
LN_{CB}	1.3437	1.3323	1.3577	0.8597	0.8527	0.8872
LN_{FA}^H	1.4608	1.4649	1.3438	1.0471	1.0490	0.8843
LN_{FA}^F	1.4608	1.4649	1.3438	0.9569	0.9624	0.7976
LN_W	2.8044	2.7972	2.7015	1.8888	1.8843	1.7542

Table D.9. Extreme Preferences

$L_{CB} = n\Lambda_{\pi}^{H}\left(\pi_t^H\right)^2 + (1-n)\Lambda_{\pi}^{F}\left(\pi_t^F\right)^2 + n\Lambda_{\Delta\pi}^{H}\left(\Delta\pi_t^H\right)^2 + (1-n)\Lambda_{\Delta\pi}^{F}\left(\Delta\pi_t^F\right)^2$ $L_{FA}^{H} = \Lambda_c\left(c_t^w\right)^2 + \Lambda_g\left(g_t^H\right)^2 + \Lambda_{gc}c_t^w g_t^H + \Lambda_T q_t^2 + \frac{1}{n}\Lambda_{gT}g_t^H q_t$ $L_{FA}^{F} = \Lambda_c\left(c_t^w\right)^2 + \Lambda_g\left(g_t^F\right)^2 + \Lambda_{gc}c_t^w g_t^F + \Lambda_T q_t^2 - \frac{1}{1-n}\Lambda_{gT}g_t^F q_t$ $L_W = nL_{FA}^{H} + (1-n)L_{FA}^{F} + L_{CB}$				
Asymmetric shocks	EMU calibration			
Both FAs minimize CB minimize	L_{FA} L_{CB}	L_W L_{CB}	L_W L_W	L_{FA} L_W
LML_{CB}	43.0326	42.6028	43.5649	43.9945
LML_{FA}^{H}	54.1122	54.2143	49.2021	49.0966
LML_{FA}^{F}	48.8402	49.1947	44.2753	43.9163
LML_W	96.0903	95.8133	91.7816	92.0551
LFL_{CB}	43.0365	42.6040	43.5649	43.9959
LFL_{FA}^{H}	54.0879	54.1944	49.2021	49.0971
LFL_{FA}^{F}	48.7962	49.1395	44.2753	43.9144
LFL_W	96.0661	95.7875	91.7816	92.0565
LN_{CB}	43.0329	42.6019	43.5649	43.9908
LN_{FA}^{H}	54.1118	54.2156	49.2021	49.1005
LN_{FA}^{F}	48.8398	49.1957	44.2753	43.9197
LN_W	96.0903	95.8135	91.7816	92.0551

Table D.10. Extreme Preferences - EMU scenario

Benevolent	nH = 0.5			nH = 0.8		
	LCoop	LML	LFL	LCoop	LML	LFL
$\alpha^H = 0.85$ $\alpha^F = 0.85$	2.5961	2.5966	2.5969	1.6722	1.6723	1.6724
$\alpha^H = 0.75$ $\alpha^F = 0.75$	2.7015	2.7034	2.7043	1.7542	1.7549	1.7553
$\alpha^H = 2/3$ $\alpha^F = 2/3$	2.7282	2.7318	2.7334	1.7840	1.7855	1.7862
$\alpha^H = 0.5$ $\alpha^F = 0.5$	2.7204	2.7291	2.7320	1.8000	1.8044	1.8055
$\alpha^H = 0.3$ $\alpha^F = 0.3$	2.7374	2.7543	2.7585	1.8264	1.8359	1.8376
$\alpha^H = 0.75$ $\alpha^F = 2/3$	2.6894	2.6918	2.6931	1.7427	1.7437	1.7447
$\alpha^H = 0.75$ $\alpha^F = 0.5$	2.5331	2.5359	2.5378	1.6395	1.6414	1.6435
$\alpha^H = 0.75$ $\alpha^F = 0.3$	2.2449	2.2476	2.2496	1.4774	1.4807	1.4838
$\alpha^H = 2/3$ $\alpha^F = 0.75$	2.6894	2.6918	2.6931	1.7739	1.7750	1.7751
$\alpha^H = 0.5$ $\alpha^F = 0.75$	2.5331	2.5359	2.5378	1.7550	1.7565	1.7563
$\alpha^H = 0.3$ $\alpha^F = 0.75$	2.2449	2.2476	2.2496	1.6426	1.6442	1.6438

Table D.11. Union-wide Loss - nominal rigidities

Benevolent	nH = 0.5						nH = 0.8					
	LHC	LHML	LHFL	LFC	LFML	LFFL	LHC	LHML	LHFL	LFC	LFML	LFFL
$\alpha^H = 0.85$ $\alpha^F = 0.85$	2.5961	2.5966	2.5969	2.5961	2.5966	2.5969	1.2866	1.2867	1.2866	3.2143	3.2146	3.2158
$\alpha^H = 0.75$ $\alpha^F = 0.75$	2.7015	2.7034	2.7043	2.7015	2.7034	2.7043	1.1470	1.1473	1.1468	4.1830	4.1852	4.1891
$\alpha^H = 2/3$ $\alpha^F = 2/3$	2.7282	2.7318	2.7334	2.7282	2.7318	2.7334	1.0649	1.0655	1.0646	4.6603	4.6655	4.6723
$\alpha^H = 0.5$ $\alpha^F = 0.5$	2.7204	2.7291	2.7320	2.7204	2.7291	2.7320	0.9766	0.9785	0.9766	5.0937	5.1080	5.1212
$\alpha^H = 0.3$ $\alpha^F = 0.3$	2.7374	2.7543	2.7585	2.7374	2.7543	2.7585	0.9752	0.9813	0.9783	5.2311	5.2544	5.2748
$\alpha^H = 0.75$ $\alpha^F = 2/3$	2.6080	2.6115	2.6120	2.7707	2.7721	2.7742	1.0395	1.0403	1.0394	4.5555	4.5574	4.5657
$\alpha^H = 0.75$ $\alpha^F = 0.5$	2.3894	2.3952	2.3955	2.6768	2.6767	2.6800	0.9301	0.9322	0.9313	4.4770	4.4785	4.4920
$\alpha^H = 0.75$ $\alpha^F = 0.3$	2.1039	2.1108	2.1117	2.3859	2.3845	2.3875	0.8952	0.8997	0.9007	3.8061	3.8049	3.8164
$\alpha^H = 2/3$ $\alpha^F = 0.75$	2.7707	2.7721	2.7742	2.6080	2.6115	2.6120	1.1777	1.1778	1.1775	4.1588	4.1635	4.1655
$\alpha^H = 0.5$ $\alpha^F = 0.75$	2.6768	2.6767	2.6800	2.3894	2.3952	2.3955	1.2281	1.2279	1.2279	3.8626	3.8711	3.8700
$\alpha^H = 0.3$ $\alpha^F = 0.75$	2.3859	2.3845	2.3875	2.1039	2.1108	2.1117	1.2352	1.2347	1.2351	3.2719	3.2823	3.2789

Table D.12. Loss of a representative H and F household - nominal rigidities

Benevolent Cooperative	nH = 0.5		nH = 0.8	
Shocks	Productivity	Mark-up	Productivity	Mark-up
$\alpha^H = 0.85$ $\alpha^F = 0.85$	2.5658	0.0303	1.6421	0.0300
$\alpha^H = 0.75$ $\alpha^F = 0.75$	2.6213	0.0802	1.6776	0.0766
$\alpha^H = 2/3$ $\alpha^F = 2/3$	2.5910	0.1372	1.6583	0.1257
$\alpha^H = 0.5$ $\alpha^F = 0.5$	2.4259	0.2945	1.5526	0.2474
$\alpha^H = 0.3$ $\alpha^F = 0.3$	2.1599	0.5775	1.3823	0.4440
$\alpha^H = 0.75$ $\alpha^F = 2/3$	2.5821	0.1073	1.6518	0.0909
$\alpha^H = 0.75$ $\alpha^F = 0.5$	2.3675	0.1656	1.5103	0.1292
$\alpha^H = 0.75$ $\alpha^F = 0.3$	2.0175	0.2273	1.2937	0.1836
$\alpha^H = 2/3$ $\alpha^F = 0.75$	2.5821	0.1073	1.6642	0.1097
$\alpha^H = 0.5$ $\alpha^F = 0.75$	2.3675	0.1656	1.5850	0.1700
$\alpha^H = 0.3$ $\alpha^F = 0.75$	2.0175	0.2273	1.4209	0.2217

Table D.13. Union-wide Loss, mark-up and productivity shocks - nominal rigidities

Benevolent Cooperative	nH = 0.5				nH = 0.8			
Shocks	Productivity		Mark-up		Productivity		Mark-up	
	LHC	LFC	LHC	LFC	LHC	LFC	LHC	LFC
$\alpha^H = 0.85$ $\alpha^F = 0.85$	2.5658	2.5658	0.0303	0.0303	1.2573	3.1813	0.0293	0.0331
$\alpha^H = 0.75$ $\alpha^F = 0.75$	2.6213	2.6213	0.0802	0.0802	1.0762	4.0835	0.0708	0.0995
$\alpha^H = 2/3$ $\alpha^F = 2/3$	2.5910	2.5910	0.1372	0.1372	0.9552	4.4707	0.1097	0.1897
$\alpha^H = 0.5$ $\alpha^F = 0.5$	2.4259	2.4259	0.2945	0.2945	0.7880	4.6108	0.1885	0.4830
$\alpha^H = 0.3$ $\alpha^F = 0.3$	2.1599	2.1599	0.5775	0.5775	0.6833	4.1783	0.2918	1.0527
$\alpha^H = 0.75$ $\alpha^F = 2/3$	2.5132	2.6510	0.0949	0.1197	0.9647	4.4002	0.0748	0.1553
$\alpha^H = 0.75$ $\alpha^F = 0.5$	2.2466	2.4884	0.1428	0.1884	0.8383	4.1986	0.0919	0.2785
$\alpha^H = 0.75$ $\alpha^F = 0.3$	1.8875	2.1476	0.2164	0.2383	0.7635	3.4148	0.1317	0.3914
$\alpha^H = 2/3$ $\alpha^F = 0.75$	2.6510	2.5132	0.1197	0.0949	1.0725	4.0310	0.1052	0.1278
$\alpha^H = 0.5$ $\alpha^F = 0.75$	2.4884	2.2466	0.1884	0.1428	1.0656	3.6627	0.1625	0.2000
$\alpha^H = 0.3$ $\alpha^F = 0.75$	2.1476	1.8875	0.2383	0.2164	1.0276	2.9940	0.2076	0.2779

Table D.14. Loss of a representative H and F household, mark-up and productivity shocks - nominal rigidities

Benevolent	nH = 0.5						nH = 0.8					
	Productivity			Mark-up			Productivity			Mark-up		
	LC	LHC	LFC	LC	LHC	LFC	LC	LHC	LFC	LC	LHC	LFC
$\lambda^H = 0.5$ $\lambda^F = 0.5$	2.6213	2.6213	2.6213	0.0802	0.0802	0.0802	1.6776	1.0762	4.0835	0.0766	0.0708	0.0995
$\lambda^H = 0.75$ $\lambda^F = 0.75$	2.4830	2.4830	2.4830	0.1038	0.1038	0.1038	1.5891	1.0095	3.9075	0.0994	0.0911	0.1326
$\lambda^H = 1$ $\lambda^F = 1$	2.3404	2.3404	2.3404	0.1068	0.1068	0.1068	1.4978	0.9657	3.6264	0.1028	0.0946	0.1358
$\lambda^H = 0.5$ $\lambda^F = 1$	2.4644	2.2888	2.6399	0.0933	0.0835	0.1032	1.5275	0.9447	3.8589	0.0819	0.0712	0.1247
$\lambda^H = 1$ $\lambda^F = 0.5$	2.4644	2.6399	2.2888	0.0933	0.1032	0.0835	1.6344	1.1017	3.7650	0.0973	0.0943	0.1094

Table D.15. Loss of a representative H and F household - inflation persistence

Baseline: σ=ψ=0.4; ρ=4.5; θ=11; η=0.47; β=0.99; α^H=α^F=0.75; λ^H=λ^F=1; $\rho_\mu = 0$; n = 0.5; B/4Y=15%											
		a_t^H	a_t^F	μ_t^H	μ_t^F	$\bar{c}_t^w$	a_{t-1}^H	a_{t-1}^F	q_{t-1}	b_{t-1}^H	b_{t-1}^F
Coop	i_t	-0.0392	-0.0392	0.0396	0.0396	-0.0016	0.0000	-0.0000	0.0000	0.0319	0.0319
	g_t^H	0.2217	-0.1488	-0.0663	-0.0072	0.0015	-0.2167	0.2167	-0.3881	-0.0534	-0.0058
	τ_t^H	-0.5701	-2.0372	2.4255	0.2031	-0.0531	1.1064	-1.1064	1.9819	1.9561	0.1638
	g_t^F	-0.1488	0.2217	-0.0072	-0.0663	0.0015	0.2167	-0.2167	0.3881	-0.0058	-0.0534
	τ_t^F	-2.0372	-0.5701	0.2031	2.4255	-0.0531	-1.1064	1.1064	-1.9819	0.1638	1.9561
Rule	i_t	0.5062	0.5062	-0.5104	-0.5104	0.0206	0	0	0	0	0

Table D.16. Feedback coefficients of policy rules (small debt) - cooperation

Baseline: σ=ψ=0.4; ρ=4.5; θ=11; η=0.47; β=0.99; α^H=α^F=0.75; λ^H=λ^F=1; $\rho_\mu = 0$; n = 0.5; B/4Y=60%											
		a_t^H	a_t^F	μ_t^H	μ_t^F	$\bar{c}_t^w$	a_{t-1}^H	a_{t-1}^F	q_{t-1}	b_{t-1}^H	b_{t-1}^F
Coop	i_t	0.7052	0.7052	-0.1734	-0.1734	-0.2400	-0.0000	-0.0000	-0.0000	-0.5733	-0.5733
	g_t^H	0.2642	-0.1062	-0.0497	0.0109	-0.0269	-0.2053	0.2053	- 0.3678	-0.1644	0.0359
	τ_t^H	0.4607	-0.8773	1.0910	-0.9886	0.0709	0.6206	-0.6206	1.1117	3.6068	-3.2681
	g_t^F	-0.1062	0.2642	0.0109	-0.0497	-0.0269	0.2053	-0.2053	0.3678	0.0359	-0.1644
	τ_t^F	-0.8773	0.4607	-0.9886	1.0910	0.0709	-0.6206	0.6206	-1.1117	-3.2681	3.6068
Rule	i_t	0.5912	0.5912	-0.1454	-0.1454	-0.2012	0	0	0	0	0

Table D.17. Feedback coefficients of policy rules (large debt) - cooperation

Baseline: σ=ψ=0.4; ρ=4.5; θ=11; η=0.47; β=0.99; α^H=α^F=0.75; λ^H=λ^F=1; $\rho_\mu = 0$; n = 0.5; B/4Y=15%																
		a_t^H	a_t^F	μ_t^H	μ_t^F	$\overline{c}_t^w$	a_{t-1}^H	a_{t-1}^F	q_{t-1}	b_{t-1}^H	b_{t-1}^F	i_t	g_t^H	τ_t^H	g_t^F	τ_t^F
	i_t	-0.0261	-0.0261	0.0263	0.0263	-0.0011	-0.0000	0.0000	-0.0000	0.0212	0.0212					
	g_t^H	0.2230	-0.1563	-0.0594	-0.0078	0.0014	-0.3985	0.3985	-0.7138	-0.0479	-0.0063					
N	τ_t^H	-0.2434	-2.1553	2.1416	0.2766	-0.0489	6.8393	-6.8393	12.2515	1.7271	0.2231					
	g_t^F	-0.1563	0.2230	-0.0078	-0.0594	0.0014	0.3985	-0.3985	0.7138	-0.0063	-0.0479					
	τ_t^F	-2.1553	-0.2434	0.2766	2.1416	-0.0489	-6.8393	6.8393	-12.2515	0.2231	1.7271					
	i_t	0.0988	0.0988	-0.0996	-0.0996	0.0040	-0.0000	0.0000	-0.0000	-0.0803	-0.0803		0.0174	0.0527	0.0174	0.0527
	g_t^H	0.2229	-0.1562	-0.0594	-0.0079	0.0014	-0.3821	0.3821	-0.6845	-0.0479	-0.0063					
FL	τ_t^H	-0.3320	-2.1059	2.2453	0.2125	-0.0497	6.3636	-6.3636	11.3994	1.8108	0.1714					
	g_t^F	-0.1562	0.2229	-0.0079	-0.0594	0.0014	0.3821	-0.3821	0.6845	-0.0063	-0.0479					
	τ_t^F	-2.1059	-0.3320	0.2125	2.2453	-0.0497	-6.3636	6.3636	-11.3994	0.1714	1.8108					
	i_t	-0.0375	-0.0375	0.0378	0.0378	-0.0015	-0.0000	0.0000	-0.0000	0.0305	0.0305					
	g_t^H	0.2239	-0.1552	-0.0603	-0.0089	0.0014	-0.3913	0.3913	-0.7010	-0.0487	-0.0072	0.0667				
ML	τ_t^H	-0.0960	-2.0709	1.9921	0.1924	-0.0442	6.2414	-6.2414	11.1803	1.6066	0.1552	3.1149				
	g_t^F	-0.1552	0.2239	-0.0089	-0.0603	0.0014	0.3913	-0.3913	0.7010	-0.0072	-0.0487	0.0667				
	τ_t^F	-2.0709	-0.0960	0.1924	1.9921	-0.0442	-6.2414	6.2414	-11.1803	0.1552	1.6066	3.1149				

Table D.18. Feedback coefficients of policy rules (small debt) - non-cooperation

Baseline: σ=ψ=0.4; ρ=4.5; θ=11; η=0.47; β=0.99; α^{H}=α^{F}=0.75; λ^{H}=λ^{F}=1; $\rho_{\mu}=0$; n = 0.5; B/4Y=60%																
		a_t^H	a_t^F	μ_t^H	μ_t^F	$\overline{c}_t^w$	a_{t-1}^H	a_{t-1}^F	q_{t-1}	b_{t-1}^H	b_{t-1}^F	i_t	g_t^H	τ_t^H	g_t^F	τ_t^F
	i_t	0.7769	0.7769	-0.1911	-0.1911	-0.2644	0.0000	-0.0000	0.0000	-0.6316	-0.6316					
	g_t^H	0.2616	-0.1234	-0.0471	0.0131	-0.0235	-0.2269	0.2269	-0.4065	-0.1557	0.0433					
N	τ_t^H	1.6351	-0.5481	0.5464	-0.8137	-0.1850	-1.8627	1.8627	-3.3367	1.8061	-2.6899					
	g_t^F	-0.1234	0.2616	0.0131	-0.0471	-0.0235	0.2269	-0.2269	0.4065	0.0433	-0.1557					
	τ_t^F	-0.5481	1.6351	-0.8137	0.5464	-0.1850	1.8627	-1.8627	3.3367	-2.6899	1.8061					
	i_t	0.7491	0.7491	-0.1842	-0.1842	-0.2550	0.0000	-0.0000	0.0000	-0.6090	-0.6090		-0.0588	0.0332	-0.0588	0.0332
	g_t^H	0.2582	-0.1197	-0.0437	0.0097	-0.0236	-0.1830	0.1830	-0.3278	-0.1445	0.0320					
FL	τ_t^H	1.7424	-0.6456	0.4446	-0.7143	-0.1866	-2.6778	2.6778	-4.7968	1.4696	-2.3613					
	g_t^F	-0.1197	0.2582	0.0097	-0.0437	-0.0236	0.1830	-0.1830	0.3278	0.0320	-0.1445					
	τ_t^F	-0.6456	1.7424	-0.7143	0.4446	-0.1866	2.6778	-2.6778	4.7968	-2.3613	1.4696					
	i_t	0.7162	0.7162	-0.1761	-0.1761	-0.2437	0.0000	-0.0000	0.0000	-0.5823	-0.5823					
	g_t^H	0.3232	-0.0615	-0.0621	-0.0023	-0.0445	-0.2350	0.2350	-0.4210	-0.2052	-0.0076	-0.0803				
ML	τ_t^H	-0.7074	-2.8514	1.1360	-0.2607	0.6056	-1.5500	1.5500	-2.7766	3.7553	-0.8619	3.0057				
	g_t^F	-0.0615	0.3232	-0.0023	-0.0621	-0.0445	0.2350	-0.2350	0.4210	-0.0076	-0.2052	-0.0803				
	τ_t^F	-2.8514	-0.7074	-0.2607	1.1360	0.6056	1.5500	-1.5500	2.7766	-0.8619	3.7553	3.0057				

Table D.19. Feedback coefficients of policy rules (large debt) - non-cooperation

Baseline: σ=ψ=0.4; ρ=4.5; θ=11; η=0.47; β=0.99; α^H=α^F=0.75; λ^H=λ^F=1; $\rho_\mu=0$; n = 0.8; B/4Y=15%											
		a_t^H	a_t^F	μ_t^H	μ_t^F	$\overline{c}_t^w$	a_{t-1}^H	a_{t-1}^F	q_{t-1}	b_{t-1}^H	b_{t-1}^F
Coop	i_t	-0.0628	-0.0157	0.0633	0.0158	-0.0016	0.0000	-0.0000	0.0000	0.0510	0.0128
	g_t^H	0.1324	-0.0595	-0.0706	-0.0029	0.0015	-0.0867	0.0867	-0.1552	-0.0569	-0.0023
	τ_t^H	-1.7924	-0.8149	2.5474	0.0812	-0.0531	0.4426	-0.4426	0.7928	2.0543	0.0655
	g_t^F	-0.2381	0.3109	-0.0115	-0.0619	0.0015	0.3467	-0.3467	0.6210	-0.0093	-0.0500
	τ_t^F	-3.2595	0.6522	0.3249	2.3037	-0.0531	-1.7702	1.7702	-3.1711	0.2620	1.8578
Rule	i_t	0.8100	0.2025	-0.8166	-0.2041	0.0206	0	0	0	0	0

Table D.20. Feedback coefficients of policy rules (small debt, size-asymmetry) - cooperation

Baseline: σ=ψ=0.4; ρ=4.5; θ=11; η=0.47; β=0.99; α^H=α^F=0.75; λ^H=λ^F=1; $\rho_\mu=0$; n = 0.8; B/4Y=60%											
		a_t^H	a_t^F	μ_t^H	μ_t^F	$\overline{c}_t^w$	a_{t-1}^H	a_{t-1}^F	q_{t-1}	b_{t-1}^H	b_{t-1}^F
Coop	i_t	1.1283	0.2821	-0.2775	-0.0694	-0.2400	0.0000	-0.0000	0.0000	-0.9173	-0.2293
	g_t^H	0.2005	-0.0425	-0.0432	0.0043	-0.0269	-0.0821	0.0821	-0.1471	-0.1428	0.0144
	τ_t^H	-0.0657	-0.3509	0.4979	-0.3954	0.0709	0.2482	-0.2482	0.4447	1.6459	-1.3072
	g_t^F	-0.1699	0.3279	0.0174	-0.0562	-0.0269	0.3285	-0.3285	0.5885	0.0574	-0.1859
	τ_t^F	-1.4037	0.9871	-1.5817	1.6842	0.0709	-0.9929	0.9929	-1.7786	-5.2289	5.5676
Rule	i_t	0.9460	0.2365	-0.2327	-0.0582	-0.2012	0	0	0	0	0

Table D.21. Feedback coefficients of policy rules (large debt, size-asymmetry) - cooperation

Baseline: σ=ψ=0.4; ρ=4.5; θ=11; η=0.47; β=0.99; α^{H}=α^{F}=0.75; λ^{H}=λ^{F}=1; $\rho_{\mu}=0$; n = 0.8; B/4Y=15%

		a_t^H	a_t^F	μ_t^H	μ_t^F	$\overline{c}_t^w$	a_{t-1}^H	a_{t-1}^F	q_{t-1}	b_{t-1}^H	b_{t-1}^F	i_t	g_t^H	τ_t^H	g_t^F	τ_t^F
	i_t	-0.0395	-0.0055	0.0337	0.0116	-0.0009	0.0809	-0.0809	0.1449	0.0272	0.0094					
	g_t^H	0.1235	-0.0555	-0.0604	-0.0081	-0.0014	-0.3152	0.3152	-0.5646	-0.0487	-0.0065					
N	τ_t^H	-1.3848	-0.9624	2.1126	0.2538	-0.0478	7.4588	-7.4588	13.3612	1.7037	0.2047					
	g_t^F	-0.2581	0.3223	-0.0119	-0.0529	0.0013	0.5957	-0.5957	1.0670	-0.0096	-0.0427					
	τ_t^F	-3.5163	1.1845	0.4026	1.9483	-0.0475	-10.2829	10.2829	-18.4200	0.3246	1.5712					
	i_t	0.1505	0.0451	-0.1442	-0.0531	0.0040	-0.2637	0.2637	-0.4724	-0.1163	-0.0428		0.0325	0.0808	0.0029	0.0232
	g_t^H	0.1233	-0.0556	-0.0601	-0.0082	0.0014	-0.3073	0.3073	-0.5504	-0.0485	-0.0066					
FL	τ_t^H	-1.4113	-0.9376	2.1521	0.2160	-0.0479	7.3468	-7.3468	13.1606	1.7356	0.1742					
	g_t^F	-0.2586	0.3233	-0.0114	-0.0539	0.0013	0.5801	-0.5801	1.0392	-0.0092	-0.0435					
	τ_t^F	-3.4870	1.1031	0.3646	2.0388	-0.0486	-9.9185	9.9185	-17.7673	0.2940	1.6442					
	i_t	-0.0638	-0.0114	0.0639	0.0120	-0.0015	-0.0422	0.0422	-0.0755	0.0515	0.0097					
	g_t^H	0.1365	-0.0616	-0.0731	-0.0025	0.0015	-0.1325	0.1325	-0.2373	-0.0589	-0.0020	0.0675				
ML	τ_t^H	-1.5298	-0.7924	2.2790	0.0622	-0.0473	1.7297	-1.7297	3.0984	1.8379	0.0502	3.2302				
	g_t^F	-0.2528	0.3094	-0.0164	-0.0407	0.0012	0.6863	-0.6863	1.2294	-0.0132	-0.0328	0.0654				
	τ_t^F	-3.4474	1.7321	0.3414	1.3880	-0.0350	-11.5969	11.5969	-20.7739	0.2753	1.1194	3.0009				

Table D.22. Feedback coefficients of policy rules (small debt, size-asymmetry) - non-cooperation

Baseline: σ=ψ=0.4; ρ=4.5; θ=11; η=0.47; β=0.99; α^H=α^F=0.75; λ^H=λ^F=1; $\rho_\mu = 0$; n = 0.8; B/4Y=60%																
		a_t^H	a_t^F	μ_t^H	μ_t^F	$\overline{c}_t^w$	a_{t-1}^H	a_{t-1}^F	q_{t-1}	b_{t-1}^H	b_{t-1}^F	i_t	g_t^H	τ_t^H	g_t^F	τ_t^F
	i_t	1.1694	0.3891	-0.2338	-0.1495	-0.2652	-3.1787	3.1787	-5.6941	-0.7730	-0.4942					
	g_t^H	0.1619	-0.0396	-0.0242	-0.0059	-0.0208	-0.3065	0.3065	-0.5490	-0.0800	-0.0194					
N	τ_t^H	1.3014	-0.3765	-0.0721	-0.1553	-0.1574	-3.5439	3.5439	-6.3483	-0.2384	-0.5135					
	g_t^F	-0.1984	0.3480	0.0210	-0.0578	-0.0255	0.4076	-0.4076	0.7302	0.0694	-0.1910					
	τ_t^F	-0.4382	1.8071	-1.6558	1.3191	-0.2330	-16.9330	16.9330	-30.3326	-5.4738	4.3608					
	i_t	1.1514	0.3466	-0.1666	-0.2018	-0.2549	-2.3561	2.3561	-4.2206	-0.5509	-0.6670		-0.0552	0.0259	-0.0623	0.0398
	g_t^H	0.1603	-0.0378	-0.0226	-0.0075	-0.0208	-0.2692	0.2692	-0.4823	-0.0747	-0.0249					
FL	τ_t^H	1.3680	-0.4020	-0.1151	-0.1225	-0.1644	-4.0777	4.0777	-7.3045	-0.3805	-0.4048					
	g_t^F	-0.1945	0.3440	0.0172	-0.0539	-0.0254	0.3051	-0.3051	0.5466	0.0568	-0.1783					
	τ_t^F	-0.5850	1.9612	-1.5078	1.1694	-0.2342	-13.0557	13.0557	-23.3870	-4.9846	3.8657					
	i_t	1.0652	0.3740	-0.1957	-0.1582	-0.2449	-3.0052	3.0052	-5.3833	-0.6470	-0.5231					
	g_t^H	0.2077	-0.0223	-0.0323	-0.0133	-0.0315	-0.4877	0.4877	-0.8736	-0.1069	-0.0438	-0.0432				
ML	τ_t^H	-0.0952	-0.8401	0.2100	0.0200	0.1592	-0.0250	0.0250	-0.0447	0.6942	0.0662	1.2287				
	g_t^F	-0.1055	0.3864	0.0069	-0.0760	-0.0478	0.0574	-0.0574	0.1028	0.0227	-0.2512	-0.0824				
	τ_t^F	-4.2353	0.3678	-1.0044	1.9556	0.6582	-4.6962	4.6962	-8.4124	-3.3203	6.4647	3.3086				

Table D.23. Feedback coefficients of policy rules (large debt, size-asymmetry) - non-cooperation

Baseline: σ=ψ=0.4; ρ=4.5; θ=11; η=0.47; β=0.99; α^H=α^F=0.75; λ^H=λ^F=1; $\rho_\mu = 0$; n = 0.5; B/4Y=15%;ρ^c=0.75;ρ^{eH}=ρ^{eF}=0.5																
		a_t^H	a_t^F	μ_t^H	μ_t^F	$\overline{c}_t^w$	a_{t-1}^H	a_{t-1}^F	q_{t-1}	b_{t-1}^H	b_{t-1}^F	i_t	g_t^H	τ_t^H	g_t^F	τ_t^F
R	i_t	0.4868	0.4868	-0.4908	-0.4908	0.0198	-0.0000	0.0000	-0.0000							
	i_t	0.1269	0.1269	-0.1280	-0.1280	0.0052	-0.0000	0.0000	-0.0000	-0.1032	-0.1032		0.0076	0.0901	0.0076	0.0901
	g_t^H	0.2158	-0.1607	-0.0523	-0.0032	0.0011	-0.3449	0.3449	-0.6178	-0.0422	-0.0026					
FL	τ_t^H	-0.0925	-2.0084	2.0141	0.1040	-0.0428	4.2763	-4.2763	7.6602	1.6243	0.0839					
	g_t^F	-0.1607	0.2158	-0.0032	-0.0523	0.0011	0.3449	-0.3449	0.6178	-0.0026	-0.0422					
	τ_t^F	-2.0084	-0.0925	0.1040	2.0141	-0.0428	-4.2763	4.2763	-7.6602	0.0839	1.6243					
	i_t	-0.0719	-0.0719	0.0725	0.0725	-0.0029	-0.0000	0.0000	-0.0000	0.0584	0.0584					
	g_t^H	0.2204	-0.1583	-0.0569	-0.0058	0.0013	-0.3641	0.3641	-0.6522	-0.0459	-0.0047	0.0586				
ML	τ_t^H	0.1135	-2.0691	1.7792	0.1924	-0.0398	4.2208	-4.2208	7.5609	1.4348	0.1552	3.4871				
	g_t^F	-0.1583	0.2204	-0.0058	-0.0569	0.0013	0.3641	-0.3641	0.6522	-0.0047	-0.0459	0.0586				
	τ_t^F	-2.0691	0.1135	0.1924	1.7792	-0.0398	-4.2208	4.2208	-7.5609	0.1552	1.4348	3.4871				

Table D.24. Feedback coefficients of policy rules (small debt) - conservative CB

Baseline: σ=ψ=0.4; ρ=4.5; θ=11; η=0.47; β=0.99; α^H=α^F=0.75; λ^H=λ^F=1; $\rho_\mu = 0$; n = 0.5; B/4Y=60%;ρ^c=0.75;ρ^{eH}=ρ^{eF}=0.5																
		a_t^H	a_t^F	μ_t^H	μ_t^F	$\bar{c}_t^w$	a_{t-1}^H	a_{t-1}^F	q_{t-1}	b_{t-1}^H	b_{t-1}^F	i_t	g_t^H	τ_t^H	g_t^F	τ_t^F
R	i_t	0.5880	0.5880	-0.1446	-0.1446	-0.2001	-0.0000	0.0000	-0.0000							
	i_t	0.8422	0.8422	-0.2071	-0.2071	-0.2867	0.0000	-0.0000	0.0000	-0.6848	-0.6848		-0.0725	0.0165	-0.0725	0.0165
	g_t^H	0.2556	-0.1194	-0.0419	0.0084	-0.0232	-0.1839	0.1839	-0.3295	-0.1386	0.0279					
FL	τ_t^H	1.8705	-0.4515	0.4380	-0.7870	-0.2415	-2.4486	2.4486	-4.3863	1.4481	-2.6017					
	g_t^F	-0.1194	0.2556	0.0084	-0.0419	-0.0232	0.1839	-0.1839	0.3295	0.0279	-0.1386					
	τ_t^F	-0.4515	1.8705	-0.7870	0.4380	-0.2415	2.4486	-2.4486	4.3863	-2.6017	1.4481					
	i_t	0.8880	0.8880	-0.2184	-0.2184	-0.3022	0.0000	-0.0000	-0.0000	-0.7219	-0.7219					
	g_t^H	0.3184	-0.0670	-0.0613	-0.0005	-0.0428	-0.2148	0.2148	-0.3849	-0.2026	-0.0018	-0.0716				
ML	τ_t^H	-0.4613	-2.7103	1.0391	-0.2590	0.5398	-2.2958	2.2958	-4.1125	3.4350	-0.8563	2.7478				
	g_t^F	-0.0670	0.3184	-0.0005	-0.0613	-0.0428	0.2148	-0.2148	0.3849	-0.0018	-0.2026	-0.0716				
	τ_t^F	-2.7103	-0.4613	-0.2590	1.0391	0.5398	2.2958	-2.2958	4.1125	-0.8563	3.4350	2.7478				

Table D.25. Feedback coefficients of policy rules (large debt) - conservative CB

Baseline: σ=ψ=0.4; ρ=4.5; θ=11; η=0.47; β=0.99; α^{H}=α^{F}=0.75; λ^{H}=λ^{F}=1; $\rho_{\mu}=0$; n = 0.8; B/4Y=15%, ρ^{c}=0.75;ρ^{eH}=ρ^{eF}=0.5																
		a_t^H	a_t^F	μ_t^H	μ_t^F	$\bar{c}_t^w$	a_{t-1}^H	a_{t-1}^F	q_{t-1}	b_{t-1}^H	b_{t-1}^F	i_t	g_t^H	τ_t^H	g_t^F	τ_t^F
R	i_t	0.7789	0.1947	-0.7852	-0.1963	0.0198	-0.0000	0.0000	-0.0000							
	i_t	0.1831	0.0751	-0.1484	-0.1119	0.0053	-0.8300	0.8300	-1.4868	-0.1196	-0.0903		0.0292	0.1264	-0.0154	0.0452
	g_t^H	0.1083	-0.0534	-0.0450	-0.0104	0.0011	-0.4259	0.4259	-0.7630	-0.0363	-0.0084					
FL	τ_t^H	-0.6257	-0.9105	1.3665	0.1823	-0.0313	9.1959	-9.1959	16.4729	1.1020	0.1470					
	g_t^F	-0.2672	0.3342	-0.0030	-0.0645	0.0014	0.3866	-0.3866	0.6926	-0.0024	-0.0520					
	τ_t^F	-3.2426	0.6111	0.1162	2.5369	-0.0536	-3.2433	3.2433	-5.8099	0.0937	2.0459					
	i_t	-0.1248	-0.0173	0.1265	0.0167	-0.0029	-0.1849	0.1849	-0.3313	0.1021	0.0135					
	g_t^H	0.1345	-0.0658	-0.0709	0.0016	0.0014	-0.0744	0.0744	-0.1333	-0.0572	0.0013	0.0583				
ML	τ_t^H	-1.3333	-0.7335	2.0832	0.0004	-0.0421	-0.5291	0.5291	-0.9478	1.6800	0.0004	3.7629				
	g_t^F	-0.2555	0.3042	-0.0134	-0.0357	0.0010	0.6655	-0.6655	1.1922	-0.0108	-0.0288	0.0595				
	τ_t^F	-3.4735	1.9674	0.3661	1.1523	-0.0307	-9.3738	9.3738	-16.7916	0.2952	0.9293	3.0595				

Table D.26. Feedback coefficients of policy rules (small debt, size-asymmetry) - conservative CB

Baseline: σ=ψ=0.4; ρ=4.5; θ=11; η=0.47; β=0.99; α^H=α^F=0.75; λ^H=λ^F=1; $\rho_\mu = 0$; n = 0.8; B/4Y=60%, ρ^c=0.75; ρ^{eH}=ρ^{eF}=0.5																
		a_t^H	a_t^F	μ_t^H	μ_t^F	$\overline{c}_t^w$	a_{t-1}^H	a_{t-1}^F	q_{t-1}	b_{t-1}^H	b_{t-1}^F	i_t	g_t^H	τ_t^H	g_t^F	τ_t^F
R	i_t	0.9409	0.2352	-0.2314	-0.0578	-0.2001	0.0000	-0.0000	0.0000							
	i_t	1.3016	0.3855	-0.1713	-0.2436	-0.2871	-2.6368	2.6368	-4.7233	-0.5662	-0.8054		-0.0685	-0.0093	-0.0769	0.0428
	g_t^H	0.1584	-0.0372	-0.0215	-0.0083	-0.0206	-0.2710	0.2710	-0.4854	-0.0712	-0.0274					
FL	τ_t^H	1.6818	-0.2057	-0.1177	-0.2454	-0.2512	-4.6132	4.6132	-8.2638	-0.3890	-0.8111					
	g_t^F	-0.1975	0.3433	0.0179	-0.0538	-0.0248	0.2777	-0.2777	0.4975	0.0592	-0.1777					
	τ_t^F	-0.5032	2.0796	-1.4682	1.0805	-0.2683	-11.6668	11.6668	-20.8990	-4.8537	3.5720					
	i_t	1.2661	0.4651	-0.2212	-0.2046	-0.2946	-3.3766	3.3766	-6.0486	-0.7313	-0.6762					
	g_t^H	0.2050	-0.0230	-0.0318	-0.0130	-0.0310	-0.4669	0.4669	-0.8364	-0.1050	-0.0429	-0.0403				
ML	τ_t^H	-0.1935	-0.8875	0.2248	0.0410	0.1840	-0.0103	0.0103	-0.0184	0.7433	0.1356	1.4020				
	g_t^F	-0.1116	0.3851	0.0086	-0.0759	-0.0465	0.0491	-0.0491	0.0880	0.0284	-0.2508	-0.0763				
	τ_t^F	-4.0427	0.4840	-1.0115	1.8868	0.6056	-3.6964	3.6964	-6.6214	-3.3439	6.2372	3.0994				

Table D.27. Feedback coefficients of policy rules (large debt, size-asymmetry) - conservative CB

Baseline: σ=ψ=0.4; ρ=4.5; θ=11; η=0.47; β=0.99; α^H=α^F=0.75; λ^H=λ^F=1; $\rho_\mu = 0$; n = 0.5; B/4Y=15%; ρ^c=0.5;ρ^{eH}=ρ^{eF}=0.75																
		a_t^H	a_t^F	μ_t^H	μ_t^F	$\overline{c}_t^w$	a_{t-1}^H	a_{t-1}^F	q_{t-1}	b_{t-1}^H	b_{t-1}^F	i_t	g_t^H	τ_t^H	g_t^F	τ_t^F
	i_t	0.1023	0.1023	-0.1031	-0.1031	0.0042	0.0000	-0.0000	0.0000	-0.0832	-0.0832		0.0161	0.0533	0.0161	0.0533
	g_t^H	0.1859	-0.1590	-0.0238	-0.0034	0.0005	-0.1924	0.1924	-0.3446	-0.0192	-0.0027					
FL	τ_t^H	-0.6231	-1.8818	2.4964	0.0290	-0.0510	2.0627	-2.0627	3.6950	2.0133	0.0234					
	g_t^F	-0.1590	0.1859	-0.0034	-0.0238	0.0005	0.1924	-0.1924	0.3446	-0.0027	-0.0192					
	τ_t^F	-1.8818	-0.6231	0.0290	2.4964	-0.0510	-2.0627	2.0627	-3.6950	0.0234	2.0133					
	i_t	-0.0407	-0.0407	0.0410	0.0410	-0.0017	-0.0000	0.0000	-0.0000	0.0331	0.0331					
	g_t^H	0.1873	-0.1582	-0.0253	-0.0040	0.0006	-0.1909	0.1909	-0.3419	-0.0204	-0.0032	0.0578				
ML	τ_t^H	-0.5064	-1.8738	2.3321	0.0677	-0.0485	2.3321	-2.3321	4.1775	1.8807	0.0546	3.4670				
	g_t^F	-0.1582	0.1873	-0.0040	-0.0253	0.0006	0.1909	-0.1909	0.3419	-0.0032	-0.0204	0.0578				
	τ_t^F	-1.8738	-0.5064	0.0677	2.3321	-0.0485	-2.3321	2.3321	-4.1775	0.0546	1.8807	3.4670				

Table D.28. Feedback coefficients of policy rules (small debt) - output-biased FAs

Baseline: σ=ψ=0.4; ρ=4.5; θ=11; η=0.47; β=0.99; α^{H}=α^{F}=0.75; λ^{H}=λ^{F}=1; $\rho_{\mu}=0$; n = 0.5; B/4Y=60%; ρ^{c}=0.5;ρ^{eH}=ρ^{eF}=0.75																
		a_t^H	a_t^F	μ_t^H	μ_t^F	$\overline{c}_t^w$	a_{t-1}^H	a_{t-1}^F	q_{t-1}	b_{t-1}^H	b_{t-1}^F	i_t	g_t^H	τ_t^H	g_t^F	τ_t^F
	i_t	0.6987	0.6987	-0.1719	-0.1719	-0.2378	-0.0000	0.0000	-0.0000	-0.5681	-0.5681		-0.0514	0.0229	-0.0514	0.0229
	g_t^H	0.2244	-0.1180	-0.0231	-0.0031	-0.0181	-0.1376	0.1376	-0.2464	-0.0763	-0.0101					
FL	τ_t^H	-0.0370	-1.8449	1.0769	-0.6141	0.3203	-4.7126	4.7126	-8.4417	3.5601	-2.0301					
	g_t^F	-0.1180	0.2244	-0.0031	-0.0231	-0.0181	0.1376	-0.1376	0.2464	-0.0101	-0.0763					
	τ_t^F	-1.8449	-0.0370	-0.6141	1.0769	0.3203	4.7126	-4.7126	8.4417	-2.0301	3.5601					
	i_t	0.7088	0.7088	-0.1743	-0.1743	-0.2413	0.0000	-0.0000	0.0000	-0.5763	-0.5763					
	g_t^H	0.2364	-0.1098	-0.0274	-0.0037	-0.0215	-0.1549	0.1549	-0.2775	-0.0906	-0.0123	-0.0191				
ML	τ_t^H	-2.4334	-4.0810	1.7245	-0.1224	1.1086	-4.0844	4.0844	-7.3166	5.7010	-0.4045	3.7767				
	g_t^F	-0.1098	0.2364	-0.0037	-0.0274	-0.0215	0.1549	-0.1549	0.2775	-0.0123	-0.0906	-0.0191				
	τ_t^F	-4.0810	-2.4334	-0.1224	1.7245	1.1086	4.0844	-4.0844	7.3166	-0.4045	5.7010	3.7767				

Table D.29. Feedback coefficients of policy rules (large debt) - output-biased FAs

Baseline: σ=ψ=0.4; ρ=4.5; θ=11; η=0.47; β=0.99; α^{H}=α^{F}=0.75; λ^{H}=λ^{F}=1; $\rho_{\mu}=0$; n = 0.8; B/4Y=15%; ρ^{c}=0.5;ρ^{eH}=ρ^{eF}=0.75																
		a_t^H	a_t^F	μ_t^H	μ_t^F	$\overline{c}_t^w$	a_{t-1}^H	a_{t-1}^F	q_{t-1}	b_{t-1}^H	b_{t-1}^F	i_t	g_t^H	τ_t^H	g_t^F	τ_t^F
	i_t	0.1529	0.0458	-0.1447	-0.0556	0.0040	-0.2559	0.2559	-0.4585	-0.1167	-0.0448		0.0322	0.0803	0.0021	0.0236
	g_t^H	0.0872	-0.0598	-0.0243	-0.0033	0.0006	-0.1368	0.1368	-0.2450	-0.0196	-0.0027					
FL	τ_t^H	-1.4716	-0.7973	2.1786	0.1088	-0.0462	5.3041	-5.3041	9.5013	1.7569	0.0878					
	g_t^F	-0.2633	0.2901	-0.0045	-0.0225	0.0005	0.2942	-0.2942	0.5271	-0.0037	-0.0182					
	τ_t^F	-3.2335	0.6022	0.1489	2.5040	-0.0536	-4.2152	4.2152	-7.5507	0.1200	2.0193					
	i_t	-0.0669	-0.0136	0.0685	0.0127	-0.0016	-0.1038	0.1038	-0.1859	0.0552	0.0103					
	g_t^H	0.0941	-0.0630	-0.0312	-0.0002	0.0006	-0.0403	0.0403	-0.0722	-0.0251	-0.0002	0.0581				
ML	τ_t^H	-1.8516	-0.6470	2.5586	-0.0395	-0.0509	-1.2857	1.2857	-2.3031	2.0634	-0.0319	3.7417				
	g_t^F	-0.2587	0.2840	-0.0086	-0.0170	0.0005	0.3728	-0.3728	0.6678	-0.0069	-0.0137	0.0576				
	τ_t^F	-3.2699	1.2306	0.2417	1.8142	-0.0416	-8.8948	8.8948	-15.9335	0.1949	1.4631	3.0863				

Table D.30. Feedback coefficients of policy rules (small debt, size-asymmetry) - output-biased FAs

Baseline: σ=ψ=0.4; ρ=4.5; θ=11; η=0.47; β=0.99; α^H=α^F=0.75; λ^H=λ^F=1; $\rho_\mu = 0$; n = 0.8; B/4Y=60%; ρ^c=0.5;ρ^{eH}=ρ^{eF}=0.75																
		a_t^H	a_t^F	μ_t^H	μ_t^F	$\bar{c}_t^w$	a_{t-1}^H	a_{t-1}^F	q_{t-1}	b_{t-1}^H	b_{t-1}^F	i_t	g_t^H	τ_t^H	g_t^F	τ_t^F
	i_t	1.0937	0.3012	-0.1895	-0.1536	-0.2374	-1.3145	1.3145	-2.3546	-0.6263	-0.5078		-0.0569	0.0167	-0.0455	0.0292
	g_t^H	0.1434	-0.0421	-0.0196	-0.0053	-0.0172	-0.1625	0.1625	-0.2912	-0.0647	-0.0177					
FL	τ_t^H	-1.1895	-0.9379	0.5603	-0.0371	0.3620	0.2331	-0.2331	0.4176	1.8523	-0.1227					
	g_t^F	-0.1974	0.3079	-0.0024	-0.0247	-0.0188	0.1590	-0.1590	0.2849	-0.0080	-0.0818					
	τ_t^F	-2.4836	0.9486	-1.3434	1.7209	0.2612	-1.2761	1.2761	-2.2859	-4.4410	5.6890					
	i_t	1.0572	0.3140	-0.2281	-0.1092	-0.2334	-1.2710	1.2710	-2.2767	-0.7540	-0.3609					
	g_t^H	0.1535	-0.0409	-0.0228	-0.0049	-0.0192	-0.1838	0.1838	-0.3293	-0.0755	-0.0160	-0.0131				
ML	τ_t^H	-3.6055	-1.5808	1.1413	0.1343	0.8826	3.5091	-3.5091	6.2860	3.7728	0.4440	2.4378				
	g_t^F	-0.1818	0.3142	-0.0050	-0.0276	-0.0225	0.1724	-0.1724	0.3088	-0.0164	-0.0912	-0.0196				
	τ_t^F	-6.5617	-0.4126	-0.5241	2.2394	1.1869	2.2800	-2.2800	4.0843	-1.7327	7.4031	4.4861				

Table D.31. Feedback coefficients of policy rules (large debt, size-asymmetry) - output-biased FAs

Idiosyncratic	B/4Y = 15%	B/4Y = 15%	B/4Y= 60%	B/4Y = 60%
Benevolent	$n^H = 0.5$	$n^H = 0.8$	$n^H = 0.5$	$n^H = 0.8$
LCommit*100	3.9719	2.5309	3.9791	2.5384
LCoop	4.9082	3.3339	4.8950	3.3917
LML	4.7941	3.2523	5.0697	3.4625
LFL	4.8393	3.2771	5.3826	3.5623
LNash	4.8134	3.2617	5.1264	3.5174
LSGP	19.0535	15.8344	20.9953	20.4378
Non-benevolent: conservative and output-biased $\rho = 0.75; 1 - \rho = 0.25$				
LMLconservative	4.7527	3.2645	5.2812	3.5302
LFLconservative	4.7521	3.4264	5.2958	3.4638
LSGPconservative	14.3621	10.8245	17.6939	16.0476
LMLoutputbiased	4.8562	3.3321	5.5657	3.4574
LFLoutputbiased	4.8685	3.3357	5.8475	3.5671

Table D.32. Union-wide Loss (debt model)

Idiosyncratic	B/4Y = 15%	B/4Y = 15%	B/4Y= 60%	B/4Y = 60%
Benevolent	n^H = 0.5	n^H = 0.8	n^H =0.5	n^H = 0.8
LHCommit*100	3.9719	2.2346	3.9791	2.2359
LHCoop*100	4.9082	2.6778	4.8950	2.7272
LHML*100	4.7941	2.8883	5.0697	2.5531
LHFL*100	4.8393	2.6682	5.3826	2.4701
LHNash	4.8134	2.6668	5.1264	2.5232
LHSGP*100	19.0535	12.5095	20.9953	17.8389
LFCommitment*100	3.9719	3.7158	3.9791	3.7482
LFCoop*100	4.9082	5.9584	4.8950	6.0497
LFML*100	4.7941	4.7085	5.0697	7.1002
LFFL*100	4.8393	5.7125	5.3826	7.9314
LFNash	4.8134	5.6416	5.1264	7.4944
LFSGP*100	19.0535	29.1342	20.9953	30.8335
Non-benevolent: conservative and output-biased $\rho = 0.75; 1 - \rho = 0.25$				
LHMLconservative	4.7527	2.9407	5.2812	2.6257
LHFLconservative	4.7521	2.4945	5.2958	2.5010
LHSGPconservative	14.3621	7.3225	17.6939	13.0614
LFMLconservative	4.7527	4.5595	5.2812	7.1485
LFFLconservative	4.7521	7.1537	5.2958	7.3151
LFSGPconservative	14.3621	24.8326	17.6939	27.9925
LHMLoutputbiased	4.8562	2.8677	5.5657	2.7015
LHFLoutputbiased	4.8685	2.6630	5.8475	2.6492
LFMLoutputbiased	4.8562	5.1897	5.5657	6.4814
LFFLoutputbiased	4.8685	6.0267	5.8475	7.2384

Table D.33. Loss of a representative H and F household (debt model)

Symmetric	B/4Y = 15%	B/4Y = 15%	B/4Y= 60%	B/4Y = 60%
Benevolent	n^H = 0.5	n^H = 0.8	n^H =0.5	n^H = 0.8
LCommit*100	0.0139	0.0139	0.0149	0.0159
LCoop	0.5351	0.5351	0.7192	0.7192
LML	0.5355	0.5324	0.7259	0.7283
LFL	0.5417	0.5462	0.7323	0.7376
LNash	0.5441	0.5488	0.7320	0.7371
LSGP	10.1117	10.1117	19.4468	19.4468
Non-benevolent: conservative and output-biased $\rho = 0.75; 1 - \rho = 0.25$				
LMLconservative	0.5136	0.5007	0.7992	0.7859
LFLconservative	0.4634	0.4809	0.7683	0.7714
LSGPconservative	4.5354	4.5354	13.1210	13.1210
LMLoutputbiased	0.5459	0.5409	0.7535	0.7872
LFLoutputbiased	0.5516	0.5517	0.7839	0.8041

Table D.34. Union-wide Loss (debt model) - symmetric shocks

Symmetric	B/4Y = 15%	B/4Y = 15%	B/4Y= 60%	B/4Y = 60%
Benevolent	n^H = 0.5	n^H = 0.8	n^H =0.5	n^H = 0.8
LHCommit*100	0.0139	0.0139	0.0149	0.0157
LHCoop*100	0.5351	0.5351	0.7192	0.7192
LHML*100	0.5355	0.5392	0.7259	0.7284
LHFL*100	0.5417	0.5458	0.7323	0.7404
LHNash	0.5441	0.5490	0.7320	0.7400
LHSGP*100	10.1117	10.1117	19.4468	19.4468
LFCommitment*100	0.0139	0.0139	0.0149	0.0169
LFCoop*100	0.5351	0.5351	0.7192	0.7192
LFML*100	0.5355	0.5052	0.7259	0.7277
LFFL*100	0.5417	0.5476	0.7323	0.7267
LFNash	0.5441	0.5479	0.7320	0.7253
LFSGP*100	10.1117	10.1117	19.4468	19.4468
Non-benevolent: conservative and output-biased $\rho = 0.75; 1-\rho = 0.25$				
LHMLconservative	0.5136	0.5069	0.7992	0.7891
LHFLconservative	0.4634	0.4717	0.7683	0.7714
LHSGPconservative	4.5354	4.5354	13.1210	13.1210
LFMLconservative	0.5136	0.4763	0.7992	0.7729
LFFLconservative	0.4634	0.5178	0.7683	0.7712
LFSGPconservative	4.5354	4.5354	13.1210	13.1210
LHMLoutputbiased	0.5459	0.5437	0.7535	0.8021
LHFLoutputbiased	0.5516	0.5500	0.7839	0.8139
LFMLoutputbiased	0.5459	0.5298	0.7535	0.7275
LFFLoutputbiased	0.5516	0.5584	0.7839	0.7647

Table D.35. Loss of a representative H and F household (dbt model) - symmetric shocks

Symmetric shocks	LCoop	L^HCoop	L^FCoop	LML	LML^H	LML^F
Benevolent	$n^H = 0.5$	$n^H = 0.5$	$n^H = 0.5$	$n^H = 0.5$	$n^H = 0.5$	$n^H = 0.5$
B/4Y = 10%	0.4268	0.4268	0.4268	0.4269	0.4269	0.4269
$(B/4Y)^H = 10\%$ $(B/4Y)^F = 20\%$	0.5405	0.4630	0.6179	0.5275	0.4493	0.6057
B/4Y = 20%	0.6323	0.6323	0.6323	0.6421	0.6421	0.6421
B/4Y = 60%	0.7192	0.7192	0.7192	0.7259	0.7259	0.7259
$(B/4Y)^H = 60\%$ $(B/4Y)^F = 70\%$	0.7084	0.7091	0.7078	0.7196	0.7351	0.7040
B/4Y = 70%	0.6944	0.6944	0.6944	0.7002	0.7002	0.7002
Non-benevolent	LMLc	$LMLc^H$	$LMLc^F$	LMLe	$LMLe^H$	$LMLe^F$
B/4Y = 10%	0.4087	0.4087	0.4087	0.4551	0.4551	0.4551
$(B/4Y)^H = 10\%$ $(B/4Y)^F = 20\%$	0.4779	0.4002	0.5555	0.5570	0.4840	0.6299
B/4Y = 20%	0.6490	0.6490	0.6490	0.6456	0.6456	0.6456
B/4Y = 60%	0.7992	0.7992	0.7992	0.7535	0.7535	0.7535
$(B/4Y)^H = 60\%$ $(B/4Y)^F = 70\%$	0.7777	0.7821	0.7734	0.7472	0.7373	0.7572
B/4Y = 70%	0.7502	0.7502	0.7502	0.7335	0.7335	0.7335

Table D.36. Union-wide and H and F representative household's Losses (debt model) - symmetric shocks, debt-asymmetry

Asymmetric shocks	LCoop	L^{H}Coop	L^{F}Coop	LML	LML^{H}	LML^{F}
Benevolent	n^{H} = 0.5	n^{H} = 0.5	n^{H} = 0.5	n^{H} = 0.5	n^{H} =0.5	n^{H} =0.5
B/4Y = 10%	4.8459	4.8459	4.8459	4.7047	4.7047	4.7047
$(B/4Y)^{H}$ = 10% $(B/4Y)^{F}$ = 20%	4.8932	4.7748	5.0116	4.8577	4.4766	5.2387
B/4Y = 20%	4.9509	4.9509	4.9509	4.8943	4.8943	4.8943
B/4Y = 60%	4.8950	4.8950	4.8950	5.0697	5.0697	5.0697
$(B/4Y)^{H}$ = 60% $(B/4Y)^{F}$ = 70%	4.8812	5.0224	4.7401	5.5028	6.8653	4.1402
B/4Y = 70%	4.8790	4.8790	4.8790	5.2227	5.2227	5.2227
Non-benevolent	LMLc	$LMLc^{H}$	$LMLc^{F}$	LMLe	$LMLe^{H}$	$LMLe^{F}$
B/4Y = 10%	4.7656	4.7656	4.7656	4.8659	4.8659	4.8659
$(B/4Y)^{H}$ = 10% $(B/4Y)^{F}$ = 20%	4.9161	4.6343	5.1980	4.8596	4.6334	5.0859
B/4Y = 20%	4.9241	4.9241	4.9241	4.8855	4.8855	4.8855
B/4Y = 60%	5.2812	5.2812	5.2812	5.5657	5.5657	5.5657
$(B/4Y)^{H}$ = 60% $(B/4Y)^{F}$ = 70%	5.5625	6.6302	4.4947	5.5807	6.2126	4.9489
B/4Y = 70%	5.3866	5.3866	5.3866	5.8230	5.8230	5.8230

Table D.37. Union-wide and H and F representative household's Losses (debt model) - asymmetric shocks, debt-asymmetry

Asymmetric shocks	LCoop	L^HCoop	L^FCoop	LML	LML^H	LML^F
Benevolent	$n^H = 0.8$	$n^H = 0.8$	$n^H = 0.8$	$n^H = 0.8$	n^H =0.8	n^H =0.8
B/4Y = 10%	3.2550	2.5388	6.1200	3.1760	2.7997	4.6808
$(B/4Y)^H$ = 10% $(B/4Y)^F$ = 20%	3.2274	2.5513	5.9321	3.1723	2.6625	5.2114
$(B/4Y)^H$ = 20% $(B/4Y)^F$ = 10%	3.4211	2.7910	5.9414	3.4607	3.2519	4.2957
B/4Y = 20%	3.3962	2.7876	5.8307	3.3273	2.9507	4.8339
B/4Y = 60%	3.3917	2.7272	6.0497	3.4625	2.5531	7.1002
$(B/4Y)^H$ = 60% $(B/4Y)^F$ = 70%	3.3861	2.7532	5.9175	3.5858	2.5061	7.9047
$(B/4Y)^H$ = 70% $(B/4Y)^F$ = 60%	3.3722	2.6577	6.2302	3.4161	2.5415	6.9142
B/4Y = 70%	3.3726	2.6810	6.1391	3.5078	2.5040	7.5228
Non-benevolent	LMLc	$LMLc^H$	$LMLc^F$	LMLe	$LMLe^H$	$LMLe^F$
B/4Y = 10%	3.2257	2.8182	4.8556	3.2723	2.7012	5.5565
$(B/4Y)^H$ = 10% $(B/4Y)^F$ = 20%	3.1924	2.8019	4.7547	3.2310	2.7259	5.2513
$(B/4Y)^H$ = 20% $(B/4Y)^F$ = 10%	3.4835	3.2800	4.2976	3.4378	3.0325	5.0590
B/4Y = 20%	3.3293	2.8766	5.1402	3.3727	2.8992	5.2667
B/4Y = 60%	3.5302	2.6257	7.1485	3.4574	2.7015	6.4814
$(B/4Y)^H$ = 60% $(B/4Y)^F$ = 70%	3.6835	2.6226	7.9268	3.5432	2.6962	6.9312
$(B/4Y)^H$ = 70% $(B/4Y)^F$ = 60%	3.4725	2.5953	6.9809	3.4291	2.6496	6.5471
B/4Y = 70%	3.5881	2.5943	7.5637	3.4947	2.6378	6.9220

Table D.38. Union-wide and H and F representative household's Losses (debt model) - symmetric shocks, debt and size asymmetry

Benevolent	$nH = 0.5$ $B/4Y = 15\%$			$nH = 0.5$ $B/4Y = 60\%$		
	LCoop	LML	LFL	LCoop	LML	LFL
$\alpha^H = 0.85$ $\alpha^F = 0.85$	4.6606	4.6776	4.6779	4.7575	4.7495	4.8253
$\alpha^H = 0.75$ $\alpha^F = 0.75$	4.9082	4.7941	4.8393	4.8950	5.0697	5.3826
$\alpha^H = 2/3$ $\alpha^F = 2/3$	5.2144	4.8353	5.0086	5.0062	5.5604	5.8580
$\alpha^H = 0.5$ $\alpha^F = 0.5$	4.3833	3.9227	4.5187	4.9059	5.4059	5.4353
$\alpha^H = 0.3$ $\alpha^F = 0.3$	-	2.3988	-	2.5427	2.6435	2.6328
$\alpha^H = 0.75$ $\alpha^F = 2/3$	5.0307	4.7782	4.9180	4.9008	5.4121	5.8360
$\alpha^H = 0.75$ $\alpha^F = 0.5$	4.2406	-	4.2154	4.6361	4.8726	5.0010
$\alpha^H = 0.75$ $\alpha^F = 0.3$	2.8714	-	3.0128	3.9435	4.2467	4.3353
$\alpha^H = 2/3$ $\alpha^F = 0.75$	5.0307	4.7782	4.9180	4.9008	5.4121	5.8360
$\alpha^H = 0.5$ $\alpha^F = 0.75$	4.2406	-	4.2154	4.6361	4.8726	5.0010
$\alpha^H = 0.3$ $\alpha^F = 0.75$	2.8714	-	3.0128	3.9435	4.2467	4.3353

Table D.39. Union-wide Loss (debt model) - nominal rigidities

Benevolent	$nH = 0.5$ $B/4Y = 15\%$						$nH = 0.5$ $B/4Y = 60\%$					
	LHC	LHML	LHFL	LFC	LFML	LFFL	LHC	LHML	LHFL	LFC	LFML	LFFL
$\alpha^H = 0.85$ $\alpha^F = 0.85$	4.6606	4.6776	4.6779	4.6606	4.6776	4.6779	4.7575	4.7495	4.8253	4.7575	4.7495	4.8253
$\alpha^H = 0.75$ $\alpha^F = 0.75$	4.9082	4.7941	4.8393	4.9082	4.7941	4.8393	4.8950	5.0697	5.3826	4.8950	5.0697	5.3826
$\alpha^H = 2/3$ $\alpha^F = 2/3$	5.2144	4.8353	5.0086	5.2144	4.8353	5.0086	5.0062	5.5604	5.8580	5.0062	5.5604	5.8580
$\alpha^H = 0.5$ $\alpha^F = 0.5$	4.3833	3.9227	4.5187	4.3833	3.9227	4.5187	4.9059	5.4059	5.4353	4.9059	5.4059	5.4353
$\alpha^H = 0.3$ $\alpha^F = 0.3$	-	2.3988	-	-	2.3988	-	2.5427	2.6435	2.6328	2.5427	2.6435	2.6328
$\alpha^H = 0.75$ $\alpha^F = 2/3$	4.2846	4.2653	4.2354	5.7767	5.2911	5.6006	4.7652	6.7513	8.0259	5.0365	4.0728	3.6462
$\alpha^H = 0.75$ $\alpha^F = 0.5$	3.6455	-	3.4380	4.8357	-	4.9928	4.4270	5.8877	6.4018	4.8452	3.8576	3.6003
$\alpha^H = 0.75$ $\alpha^F = 0.3$	2.8523	-	3.1513	2.8905	-	2.8743	3.7945	5.1603	5.4256	4.0925	3.3330	3.2451
$\alpha^H = 2/3$ $\alpha^F = 0.75$	5.7767	5.2911	5.6006	4.2846	4.2653	4.2354	5.0365	4.0728	3.6462	4.7652	6.7513	8.0259
$\alpha^H = 0.5$ $\alpha^F = 0.75$	4.8357	-	4.9928	3.6455	-	3.4380	4.8452	3.8576	3.6003	4.4270	5.8877	6.4018
$\alpha^H = 0.3$ $\alpha^F = 0.75$	2.8905	-	2.8743	2.8523	-	3.1513	4.0925	3.3330	3.2451	3.7945	5.1603	5.4256

Table D.40. Loss of a representative H and F household (debt model) - nominal rigidities

Benevolent	$nH = 0.8$ $B/4Y = 15\%$			$nH = 0.8$ $B/4Y = 60\%$		
	LCoop	LML	LFL	LCoop	LML	LFL
$\alpha^H = 0.85$ $\alpha^F = 0.85$	3.0499	3.0769	3.0768	3.2112	3.2298	3.2965
$\alpha^H = 0.75$ $\alpha^F = 0.75$	3.3339	3.2523	3.2771	3.3917	3.4625	3.5623
$\alpha^H = 2/3$ $\alpha^F = 2/3$	3.6697	3.4239	3.5951	3.5019	3.4658	3.4848
$\alpha^H = 0.5$ $\alpha^F = 0.5$	2.8854	-	6.2913	3.4704	3.1918	3.4669
$\alpha^H = 0.75$ $\alpha^F = 2/3$	3.3295	3.0713	3.3669	3.3487	3.9588	4.4228
$\alpha^H = 0.75$ $\alpha^F = 0.5$	2.9793	-	3.6676	3.1726	3.9421	4.8188
$\alpha^H = 2/3$ $\alpha^F = 0.75$	3.6443	3.5473	3.4646	3.4942	3.3448	3.3525
$\alpha^H = 0.5$ $\alpha^F = 0.75$	2.8468	-	2.8420	3.4590	3.2680	3.2340

Table D.41. Union-wide loss (debt model) - size-asymmetry, nominal rigidities

Benevolent	$nH = 0.8$ $B/4Y = 15\%$						$nH = 0.8$ $B/4Y = 60\%$					
	LHC	LHML	LHFL	LFC	LFML	LFFL	LHC	LHML	LHFL	LFC	LFML	LFFL
$\alpha^H = 0.85$ $\alpha^F = 0.85$	2.7551	2.8806	2.8528	4.2292	3.8623	3.9724	2.9821	3.0151	2.9786	4.1274	4.0884	4.5678
$\alpha^H = 0.75$ $\alpha^F = 0.75$	2.6778	2.8883	2.6682	5.9584	4.7085	5.7125	2.7272	2.5531	2.4701	6.0497	7.1002	7.9314
$\alpha^H = 2/3$ $\alpha^F = 2/3$	2.7327	3.1158	2.4983	7.4179	4.6567	7.9824	2.4299	2.0919	2.0100	7.7900	8.9612	9.3844
$\alpha^H = 0.5$ $\alpha^F = 0.5$	1.3634	-	3.6655	8.9731	-	16.7945	1.9322	2.8078	3.2538	9.6235	4.7282	4.3195
$\alpha^H = 0.75$ $\alpha^F = 2/3$	2.2319	2.6294	2.2564	7.7198	4.8390	7.8089	2.3970	2.1010	2.4002	7.1556	11.3898	12.5131
$\alpha^H = 0.75$ $\alpha^F = 0.5$	1.6655	-	1.9452	8.2345	-	10.5575	1.9654	3.7160	5.1969	8.0012	4.8468	3.3064
$\alpha^H = 2/3$ $\alpha^F = 0.75$	3.1522	3.2995	2.9595	5.6131	4.5385	5.4851	2.7763	2.5462	2.4801	6.3657	6.5390	6.8421
$\alpha^H = 0.5$ $\alpha^F = 0.75$	2.2153	-	2.3128	5.3724	-	4.9588	2.7432	2.5794	2.5503	6.3221	6.0223	5.9690

Table D.42. Loss of a representative H and F household (debt model) - size-asymmetry, nominal rigidities

Idiosyncratic	$(B/4Y)^H = 80\%$ $(B/4Y)^F = 50\%$
Benevolent	$n^H = 0.8$
LCommit*100	138.732
LCoop	181.241
LML	178.961
LFL	179.909
LNash	179.390
LSGP	946.268
Non-benevolent: conservative and output-biased $\rho = 0.75; 1 - \rho = 0.25$	
LMLconservative	180.990
LFLconservative	179.275
LNashconservative	179.971
LSGPconservative	777.480
LMLoutputbiased	182.771
LFLoutputbiased	184.150
LNashoutputbiased	183.389

Table D.43. Union-wide loss (debt model) - EMU scenario

Idiosyncratic	$(B/4Y)^H = 80\%$ $(B/4Y)^F = 50\%$
Benevolent	$n^H = 0.8$
LHCommit*100	127.757
LHCoop*100	151.426
LHML*100	148.785
LHFL*100	148.642
LHNash	149.872
LHSGP*100	864.277
LFCommitment*100	182.630
LFCoop*100	300.502
LFML*100	299.665
LFFL*100	304.977
LFNash	297.463
LFSGP*100	1274.231
Non-benevolent: conservative and output-biased $\rho = 0.75; 1 - \rho = 0.25$	
LHMLconservative	149.373
LHFLconservative	148.462
LHNashconservative	149.338
LHSGPconservative	677.403
LFMLconservative	307.456
LFFLconservative	302.525
LFNashconservative	302.500
LFSGPconservative	1177.788
LHMLoutputbiased	152.754
LHFLoutputbiased	151.981
LHNashoutputbiased	153.314
LFMLoutputbiased	302.840
LFFLoutputbiased	312.825
LFNashoutputbiased	303.689

Table D.44. Loss of a representative H and F household (debt model) - EMU scenario

$L_{CB} = n\Lambda_{\pi}^{H}\left(\pi_t^H\right)^2 + (1-n)\Lambda_{\pi}^{F}\left(\pi_t^F\right)^2 + n\Lambda_{\Delta\pi}^{H}\left(\Delta\pi_t^H\right)^2 + (1-n)\Lambda_{\Delta\pi}^{F}\left(\Delta\pi_t^F\right)^2$ $L_{FA}^{H} = \Lambda_c\left(c_t^w\right)^2 + \Lambda_g\left(g_t^H\right)^2 + \Lambda_{gc}c_t^w g_t^H + \Lambda_T q_t^2 + \frac{1}{n}\Lambda_{gT}g_t^H q_t$ $L_{FA}^{F} = \Lambda_c\left(c_t^w\right)^2 + \Lambda_g\left(g_t^F\right)^2 + \Lambda_{gc}c_t^w g_t^F + \Lambda_T q_t^2 - \frac{1}{1-n}\Lambda_{gT}g_t^F q_t$ $L_W = nL_{FA}^{H} + (1-n)L_{FA}^{F} + L_{CB}$				
Asymmetric shocks	EMU calibration			
Both FAs minimize CB minimize	L_{FA} L_{CB}	L_W L_{CB}	L_W L_W	L_{FA} L_W
LML_{CB}	9891.76	45.18	50.64	9891.76
LML_{FA}^{H}	47.55	156.51	132.41	47.55
LML_{FA}^{F}	42.35	147.75	123.38	42.355
LML_W	9938.27	199.94	181.24	9938.27
LFL_{CB}	11954.40	54.32	50.64	11937.66
LFL_{FA}^{H}	47.56	139.45	132.41	47.56
LFL_{FA}^{F}	42.37	132.35	123.38	42.37
LFL_W	12000.93	192.35	181.24	11984.18

Table D.45. Union-wide loss (debt model) - Extreme Preferences, EMU scenario