”Core” and “Periphery” in a Monetary Union:

A Macroeconomic Policy Game

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Abstract: We use a dynamic game model of a two-country monetary union to study the impacts of an exogenous fall in aggregate demand, the resulting increase in public debt, and the consequences of a sovereign debt haircut for a member country or bloc of the union. In this union, the governments of participating countries pursue national goals when deciding on fiscal policies, whereas the common central bank's monetary policy aims at union-wide objective variables. The union considered is asymmetric, consisting of a "core" with lower initial public debt, and a "periphery" with higher initial public debt. The ''periphery'' may experience a haircut due to high level of its sovereign debt. We calculate numerical solutions of the dynamic game between the governments and the central bank using the OPTGAME algorithm. We show that a haircut as modeled in our study is disadvantageous for both the "core" and the "periphery" of the monetary union. Moreover, the cooperative solution is preferable to the noncooperative equilibrium solution (both without and with a haircut), providing an argument for coordinated fiscal policies in a monetary union.

Keywords: monetary union; asymmetric union; dynamic game; numerical solutions; Nash equilibrium; Pareto solution; fiscal policy; monetary policy; policy cooperation.

JEL Code: E6

Introduction

In the aftermath of the recent financial and economic crisis, the so-called "Great Recession", many countries found themselves in the uncomfortable situation of rising public sector deficits and debts due to expansionary fiscal policies enacted during the crisis to reduce the loss in output and employment. As it turns out, those countries which entered the crisis with a lower stock of government debt definitely had fewer difficulties in maintaining macroeconomic and political stability than those which already had a high burden of public debt before the crisis started. Greece is the most prominent example of a country struggling with the consequences of many years of irresponsible fiscal policy, and although it has survived the "Great Recession" with less damage to its production and employment than some other European countries, in the aftermath of the crisis it found itself at the forefront of the countries threatened by bankruptcy. Other countries are about to follow the Greek example, and the idea of splitting up the European Economic and Monetary Union (EMU) into a "core" of fiscally sound and a "periphery" of unstable "PIIGS" (Portugal, Ireland, Italy, Greece and Spain) states is prominent in the media and among politicians.

The Greek bonds are rated 'CC', 'CCC' and 'Ca' by S&P's, Fitch and Moody's respectively. The 'CCC' rating of Greek bonds by S&P's is now the lowest in the world. The last bail-out package for Greece by the troika of IMF, European Central Bank and European Commission includes a "haircut" (debt reduction) of 50% by the banks. There is a long discussion about the costs of such a haircut for the economy (e.g., Bulow and Rogoff (1989); Panizza *et al.* (2009)). The key question is whether the financial markets forget the haircut or rather how soon they forget. In our study we assume an overall 40% haircut for the "periphery" of which three quarters are paid by the "core". Due to the high level of the haircut financial markets punish this event by a higher risk premium (Cruces and Trebesch (2011)).

In this paper we will consider the impact of a negative demand shock, the resulting problems for government debt and the consequences of such a haircut for a monetary union. We use a small macroeconomic model of an asymmetric union consisting of two countries or blocs. As in the EMU, national currencies and national central banks are completely replaced by a common currency and a common central bank, which implies that the exchange rate is no longer available as an instrument of adjustment between the members of a monetary union. The two blocs are a “core” and a “periphery”, distinct in terms of the initial levels of public debt and budget deficit. We investigate how a negative demand side shock, such as the one which led to the “Great Recession”, and a haircut for public debt affect the main macroeconomic variables in the union under different policy arrangements. A no-policy scenario assuming no active role for either fiscal or monetary policy is contrasted with scenarios of noncooperative (not coordinated) and cooperative (coordinated) macroeconomic policies. The main trade-off in this model occurs between output and public debt, and the way in which this conflict is resolved is what distinguishes the different scenarios considered. Although our model is only a distant approximation to an actual monetary union such as the EMU, we hope to be able to derive some results which are relevant for the current situation in Europe by outlining some essential features of policy design in a monetary union model.

We follow the theory of quantitative economic policy in regarding dynamic macroeconomic policy making in a single country as an optimum control problem with respect to a single national policy maker’s objective function. However, if we have to deal with an open economy, the interaction of several decision makers with conflicting objectives constitutes an essential element of a policy making process. Different policy making institutions, which are responsible for specific policy instruments, often differ with respect to their preferences. More important, conflicts arise between policy makers from different countries, who primarily pursue their own national interests and do not care about the

spillovers of their actions to other countries. These conflicts can best be modeled by using the concepts and methods of dynamic game theory, which has been developed mostly by engineers and mathematicians but which has proved to be a valuable analytical tool for economists, too (see, e.g., Başar and Olsder (1999), Petit (1990), Dockner et al. (2000)).

Dynamic games have been used as models for conflicts between monetary and fiscal policies by several authors (e.g. Pohjola (1986)). There is also a large body of literature on dynamic conflicts between policy makers from different countries on issues of international stabilization (e.g. Miller and Salmon (1985)). Both types of conflict are present in a monetary union, because a supranational central bank interacts strategically with sovereign governments as national fiscal policy makers in the member states. Such conflicts have previously been analyzed using either large empirical macroeconomic models (e.g. Haber *et al.* (2002)) or small stylized models (e.g. van Aarle *et al*. (2002), Neck and Behrens (2009)). In the present paper we add to this an analysis of the consequences of asymmetry with respect to the initial level of government debt and introduce of an exogenous debt reduction for the "periphery" bloc, a problem of obvious practical importance in the context of the current situation of the EMU.

As dynamic game models are usually too complex to allow for an analytical solution, numerical solutions or approximations are generally the only tool available. Here we use the OPTGAME algorithm (Behrens and Neck (2003), Blueschke (2011)) to analyze a macroeconomic policy problem for a two-country asymmetric monetary union. The OPTGAME algorithm delivers approximate solutions of dynamic games with a finite planning horizon for discrete-time nonlinear-quadratic difference games, i.e. games with quadratic objective functions and a nonlinear dynamic system. We apply OPTGAME to calculate the feedback Nash equilibrium solution and a cooperative Pareto-optimal solution for our model of an asymmetric monetary union. In spite of the simple character of the model,

we can shed some light on current sovereign debt problems in Europe by comparing and interpreting results from this haircut modeling exercise.

The Model

For our study we use a slightly extended version of the MUMOD1 model as presented in Blueschke and Neck (2011). This is a simplified macroeconomic model of a monetary union consisting of two countries (or two blocs of countries) with a common central bank. We do not attempt to describe a monetary union in general or the EMU in every detail. Instead, the aim is to introduce a model which can help to analyze the interactions between the governments of the two countries (fiscal policy) and the common central bank (monetary policy) in a monetary union when confronted with exogenous shocks on the whole system. Special attention is paid to the problem of containing public debt in a situation that resembles the one currently prevailing in the European Union.

In the following, capital letters indicate nominal values, while lower case letters correspond to real values. Variables are denoted by Roman letters and model parameters are denoted by Greek letters. Three active policy makers are considered: the governments of the two countries (blocs), responsible for decisions about fiscal policy, and the common central bank of the monetary union, controlling monetary policy. The two countries are labeled 1 and 2 or “core” and “periphery” respectively. The idea is to create a stylized model of a monetary union consisting of two homogeneous blocs of countries, which in the current European context might be identified with the stability-oriented bloc (“core”) and the “PIIGS” bloc (countries with problems due to high public debt). Of course, in Europe neither of these two blocs is homogeneous in terms of its economic structure or the fiscal policies which are pursued, nor is the distinction between “core” and “periphery” as clear-cut as assumed here. Nevertheless, some insights relevant to current macroeconomic problems in the EMU can be obtained from the model.

The model is formulated in terms of deviations from a long-run growth path and exhibits some Keynesian features of goods and financial markets. The goods markets are modeled for each country by a short-run income-expenditure equilibrium relation (IS curve). The two countries under consideration are linked through national goods markets, namely exports and imports of goods and services. The common central bank decides on the prime rate, a nominal rate of interest under its direct control (for instance, the rate at which it lends money to private banks), and can influence the linked goods markets in the union in this way.

Real output (or the deviation of short-run output from a long-run growth path) in country i ($i = 1,\ 2$) at time t ($t = 1,...,T$) is determined by a reduced form demand-side equilibrium equation:

$$y_{it} = \delta_i(\pi_{jt} - \pi_{it}) - \gamma_i(r_{it} - \theta) + \rho_i y_{jt} - \beta_i \pi_{it} + \kappa_i y_{i(t-1)} - \eta_i g_{it} + zd_{it}\ , \qquad (1)$$

for $i \neq j$ ($i, j = 1,2$). The variable π_{it} ($i = 1,2$) denotes the rate of inflation in country i, r_{it} ($i = 1,2$) represents country i's real rate of interest, and g_{it} ($i = 1,2$) denotes country i's real fiscal surplus (if negative, its fiscal deficit), measured in relation to real GDP. g_{it} ($i = 1,2$) in (1) is assumed to be country i's fiscal policy instrument or control variable. The natural real rate of output growth, $\theta \in [0,1]$, is assumed to be equal to the natural real rate of interest. The parameters δ_i, γ_i, ρ_i, β_i, κ_i, η_i, $i = 1,2$, in (1) are assumed to be positive. The variables zd_{1t} and zd_{2t} are non-controlled exogenous variables and represent exogenous demand-side shocks in the goods market.

For $t = 1,...,T$, the current real rate of interest for country i ($i = 1,2$) is given by:

$$r_{it} = I_{it} - \pi^e_{it}, \qquad (2)$$

where π^e_{it} ($i = 1,2$) denotes the expected rate of inflation of country i ($i = 1,2$) and I_{it} denotes the nominal interest rate for country i ($i = 1,2$), which is given by

$$I_{it} = R_{Et} - \lambda_i g_{it} + zhp_{it}\,, \tag{3}$$

where R_{Et} denotes the common nominal rate of interest determined by the central bank of the monetary union (its control variable). λ_i is a risk premium for country *i*'s fiscal deficit, i.e., country *i*'s nominal rate of interest increases by λ_i percentage points for each percentage point of the real fiscal deficit-to-GDP ratio; λ_i is assumed to be positive. This allows for different nominal (and a fortiori also real) rates of interest in the union in spite of a common monetary policy due to the possibility of default or similar risk of a country (a bloc of countries) with high government deficit (and debt). zhp_{it} is an exogenous variable which models an additional risk premium after a haircut occurs (a "haircut penalty" by financial markets).

The inflation rates for each country $i = 1,2$ and $t = 1,...,T$ are determined according to an expectations-augmented Phillips curve, i.e. the actual rate of inflation depends positively on the expected rate of inflation and on goods market excess demand (a demand-pull relation):

$$\pi_{it} = \pi_{it}^{e} + \xi_i y_{it} + zs_{it}\,, \tag{4}$$

where ξ_1 and ξ_2 are positive parameters. zs_{1t} and zs_{2t} denote non-controlled exogenous variables and represent exogenous supply-side shocks such as, for instance, oil price increases, introducing the possibility of cost-push inflation (which is not investigated in the present paper). π_{it}^{e} $(i = 1,2)$ denotes the rate of inflation of country *i* $(i = 1,2)$ expected to prevail during time period *t*, which is formed at the end of time period $t - 1$, $t = 1,...,T$. Inflationary expectations are formed according to the hypothesis of adaptive expectations:

$$\pi_{it}^{e} = \varepsilon_i \pi_{i(t-1)} + (1 - \varepsilon_i)\pi_{i(t-1)}^{e}, \tag{5}$$

where $\varepsilon_i \in [0,1]$ for $i = 1,2$ are positive parameters determining the speed of adjustment of expected to actual inflation.

The average values of output and inflation in the monetary union are given by

$$y_{Et} = \omega y_{1t} + (1-\omega) y_{2t}, \quad \omega \in [0,1], \tag{6}$$

$$\pi_{Et} = \omega \pi_{1t} + (1-\omega) \pi_{2t}, \quad \omega \in [0,1]. \tag{7}$$

The parameter ω expresses the weight of country 1 in the economy of the whole monetary union as defined by its output level. The same weight ω is used for calculating union-wide inflation in equation (7).

The government budget constraint is given as an equation for government debt of country i ($i = 1,2$):

$$D_{it} = \left(1 + r_{i(t-1)}\right) D_{i(t-1)} - g_{it} + \mathrm{zh}_{it}, \qquad D_{i0} \text{ given}, \tag{8}$$

where D_i denotes real public debt of country i measured in relation to real GDP. No seignorage effects on governments' debt are assumed to be present. zh_i denotes an exogenous haircut effect on the public debt.

Both national fiscal authorities are assumed to care about stabilizing inflation, output, debt and fiscal deficits of their own countries at each time t. This is a policy setting which seems plausible for the real EMU as well, with full employment (output at its potential level) and price level stability (no inflation) relating to country (or bloc) i's primary domestic goals, and government debt and deficit relating to its obligations according to the Maastricht Treaty of the European Union. The common central bank is interested in stabilizing inflation and output in the entire monetary union, taking into account also a goal of low and stable interest rates in the union.

As usual in the theory of macroeconomic policy, we assume quadratic loss functions to be minimized by each decision maker (player). Hence, the individual objective functions of the national governments ($i = 1,2$) and of the common central bank are given by

$$J_i = \tfrac{1}{2}\sum_{t=1}^{T}\left(\alpha_{iy}\left(y_{it}-\bar{y}_{it}\right)^2+\alpha_{i\pi}\left(\pi_{it}-\bar{\pi}_{it}\right)^2+\alpha_{iD}\left(D_{it}-\bar{D}_{it}\right)^2\right) + \tfrac{1}{2}\sum_{t=1}^{T}\left(\alpha_{ig}\left(g_{it}-\bar{g}_{it}\right)^2\right), \tag{9}$$

$$J_E = \tfrac{1}{2}\sum_{t=1}^{T}\left(\alpha_{Ey}\left(y_{Et}-\bar{y}_{Et}\right)^2+\alpha_{E\pi}\left(\pi_{Et}-\bar{\pi}_{Et}\right)^2\right) + \tfrac{1}{2}\sum_{t=1}^{T}\left(\alpha_{ER}\left(R_{Et}-\bar{R}_{Et}\right)^2\right), \tag{10}$$

where all weights α are positive numbers $\in [0,1]$. A bar denotes desired ("ideal") values of the respective variable. The joint objective function for calculating the cooperative Pareto-optimal solution is given by the weighted sum of the three objective functions:

$$J = \mu_1 J_1 + \mu_2 J_2 + \mu_E J_E,\ (\mu_1,\mu_2,\mu_E \geq 0,\ \mu_1+\mu_2+\mu_E = 1). \tag{11}$$

Equations (1)–(11) constitute a dynamic game with 3 players, each of them having one control variable. The model contains 14 endogenous variables, seven exogenous variables and is assumed to be played over a finite time horizon. The objective functions are quadratic in the paths of deviations of state and control variables from their respective desired values. Several noncooperative and cooperative solutions can be determined for the game, which is nonlinear-quadratic and hence cannot be solved analytically but only numerically. To this end, we have to specify the parameters of the model. This is done with a view to creating a model resembling the macroeconomics of EMU.

The parameters of the model are specified for a slightly asymmetric monetary union; see Table 1. Here an attempt has been made to calibrate the model parameters so as to fit for the EMU. The data used for calibration basically include average economic indicators for the 16 EMU countries from EUROSTAT up to the year 2007. Mainly based on the public debt to GDP ratio and fiscal deficits, the EMU is divided into two blocs of "core" (country or bloc 1) and "periphery" (country or bloc 2). The first bloc includes ten EMU countries (Austria,

Estonia, Finland, France, Germany, Luxembourg, Malta, Netherlands, Slovakia and Slovenia) with a more solid fiscal situation and inflation performance. For reasons of simplification, this bloc is called the "core"; it has a weight of 60% in the entire economy of the monetary union (i.e. the parameter ω is equal to 0.6). The second bloc has a weight of 40% in the economy of the union; in the EMU, it consists of seven countries with higher public debt and/or deficits and higher interest and inflation rates, on average (Belgium, Cyprus, Greece, Ireland, Italy, Portugal and Spain) and is called the "periphery". The weights correspond to the respective shares in EMU real GDP; we apply them to our model to make it resemble the macroeconomic relations in the EMU as closely as possible, given the simplified framework of our model. For the other parameters of the model, we use values in accordance with econometric studies and plausibility considerations.

TABLE 1

Parameter values for an asymmetric monetary union, $i = 1,2$

T	θ	$\eta_i, \delta_i, \varepsilon_i, \lambda_i, \alpha_{Ey}$	$\gamma_i, \rho_i, \kappa_i, \beta_i, \xi_i$	ω	$\alpha_{iy}, \alpha_{i\pi}, \alpha_{ig}, \alpha_{E\pi}$	α_{iD}	α_{ER}	μ_i, μ_E
30	3	0.5	0.25	0.6	1.0	0.05	3	0.333

The initial values of the macroeconomic variables, which are the state variables of the dynamic game model, are presented in Table 2. The desired or "ideal" values assumed for the objective variables of the players are given in Table 3. Country 1 (the "core" bloc) has an initial debt level of 60% of GDP and aims to decrease this level in a linear way over time to arrive at a public debt of 50% at the end of the planning horizon. Country 2 (the "periphery" bloc) has an initial debt level of 80% of GDP and aims to decrease its level to 60% at the end of the planning horizon, which means that it will fulfill the Maastricht criterion for this economic indicator. The "ideal" rate of inflation is calibrated at 2 percent, which corresponds

to the Eurosystem's aim of keeping inflation close to but below 2 percent. The initial values of the two blocs' government debts correspond to those at the beginning of the "Great Recession", the recent financial and economic crisis. Otherwise, the initial situation is assumed to be close to equilibrium, with parameter values calibrated accordingly.

TABLE 2

Initial values ($t = 0$) for an asymmetric monetary union, $i = 1,2$

y_i	π_i	π_i^e	D_1	D_2	R_E	g_1	g_2
0	2.5	2.5	60	80	3	-2	-4

TABLE 3

Target values for an asymmetric monetary union, $i = 1,2$ and $t = 1,...,T$,

$\bar{y}_{it}$	$\bar{y}_{Et}$	$\bar{\pi}_{it}$	$\bar{\pi}_{Et}$	$\bar{D}_{1t}$	$\bar{D}_{2t}$	$\bar{g}_{it}$	$\bar{R}_{Et}$
0	0	2	2	60↓50	80↓60	0	3

Optimal Fiscal and Monetary Policies under a Demand Shock

The model can be used to simulate the effects of different shocks acting on the monetary union, which are reflected in the paths of the exogenous non-controlled variables, and of policy reactions towards these shocks. It is assumed that policy makers (the governments of each country or bloc, assumed to be homogeneous, and the central bank) aim to minimize their respective objective function subject to constraints which are given by the model, interacting according to some particular solution concept of the dynamic policy game. Here the results are considered which are based on the assumption of two different exogenous

shocks. In the first three periods both countries (blocs) of the monetary union experience a negative symmetric demand shock influencing their economies in the same way. This shock shall reflect a financial and economic crisis like the "Great Recession" of 2007–2010, which hit not only the EMU but nearly all countries in the world. It is widely agreed that this crisis can be regarded as a demand-side shock to some advanced economies (notably, the U.S.), which was transmitted to other countries through trade and financial channels. In particular, we assume a negative demand shock of 2.0 % for the first period, 4.0 % for the second period, and 2.0 % for the third period, after which the disturbance vanishes: $zd_{i0} = 0$, $zd_{i1} = -2$, $zd_{i2} = -4$, $zd_{i3} = -2$, and $zd_{it} = 0$ for $t \geq 4$, $i = 1,2$.

Most countries reacted to the financial and economic crisis by extending public spending and found themselves in the uncomfortable situation of rising public debts. Greece is the most prominent example with its bond rated close to default. A bailing-out package for Greece is on the way which includes a 50 percent haircut by non-institutional foreign creditors. In order to simulate this event in our model, we introduce a 40 percentage points haircut for the public debt of country 2 ("periphery" bloc) at time 11, i.e. $zh_{2,11} = -40$ in t=11 and zero for $t \neq 11$. Two thirds of this haircut are assumed to be paid by the "core" bloc. This (taking different ω_i into account) results in an increase of public debt for country 1 (the "core" bloc) of 20 percentage points. That means, the variable $zh_{1,t}$ is set equal to 20 in t=11 and to zero otherwise.

According to a recent study by Cruces and Trebesch (2011), larger haircuts are not forgotten soon by the markets; instead, the country which experiences such a haircut has to pay a higher risk premium for several years to follow. We use the average values from the results of their study to calibrate the exogenous variable $zhp_{2,t}$ which denotes the additional risk premium after the haircut: $zhp_{2,11} = 10$, $zhp_{2,12} = 6$, $zhp_{2,13} = 5.5$, $zhp_{2,14} = 5$,

$zhp_{2,15} = 4.5$, $zhp_{2,16} = 4$, $zhp_{2,17} = 3.5$, $zhp_{2,18} = 3$, $zhp_{2,19} = 2$, $zhp_{2,20} = 1$ and $zhp_{2,t} = 0$ otherwise.

Using the two shocks described above, the immediate negative symmetric demand shock and the haircut for the "periphery" after ten periods of (endogenously) increasing government debt, we run the policy game (1)–(11) for different strategy choices of the policy makers. We calculate three solutions for the dynamic game: a baseline solution with the shocks but with policy instruments held at pre-shock levels (-2 for the fiscal surplus of the "core", -4 for the fiscal surplus of the "periphery", 3 for the central bank's prime rate), a noncooperative (Nash feedback) equilibrium solution and a cooperative (Pareto) solution. The results are shown in Figures 1 to 13, with the left panel showing the scenario without haircut and the right panel showing the results with the haircut for the "periphery" bloc.

In the baseline scenario without policy intervention (shown by the path denoted by "simulat"), the demand shock leads to lower output during the first five periods (a drop by about 1.5% in the first period, about 4.2% in the second period, about 2.5% in the third period, and then slowly returning to the long-run value of zero). This non-controlled ("no policy") simulation also results in a significant increase of inflation (but slightly decreasing during the first three periods) and a dramatic increase in real public debt until period 22. Due to the permanent public deficits, the fall in real GDP and the increase in interest payments, and given the non-availability of policy intervention in this scenario, public debt of country 1 (the "core" bloc) increases up to 120% of GDP; the public debt of the fiscally less prudent country 2 (the "periphery" bloc) even rises to 220% of GDP in period 24 and is still higher than 200% at the end of the planning horizon.

Including the haircut shock (a 40 percentage points haircut of public debt for the "periphery" bloc and a 20 percentage points increase of public debt for the "core" bloc in t=11) implies several changes in the results. In the baseline scenario without policy

intervention, such a haircut produces higher nominal interest rates for the "periphery" bloc and a correspondingly higher increase of public debt, despite the temporary reduction of public debt through the haircut. At the end of the planning horizon, this results in a real public debt which is significantly higher than in scenario without haircut. In addition, the real debt of the "core" country is also higher than in the scenario without haircut. The values are 140% and 280% of GDP for the "core" and "periphery" blocs, respectively.

When policy makers are assumed to react to the exogenous shocks according to their preferences as expressed by their objective functions, the overall outcomes depend on the assumptions made about the behavior of the policy makers and their interactions as expressed by the solution concept of the dynamic game; see Başar and Olsder (1999), Petit (1990) or Dockner et al. (2000) for details. Here we consider the non-cooperative feedback Nash equilibrium solution of the dynamic game and the cooperative Pareto-optimal collusive solution. In the latter, we assume all players' objectives to be equally important, as expressed by assuming identical weights, $\mu_i = 1/3$, $i = 1, 2, E$).

The following figures show the time paths for all three control variables and the five most relevant endogenous variables. For the two dynamic game solution concepts considered, Figures 1, 2 and 3 show the trajectories of the control variables: real fiscal surplus g_{it} for both countries and the common central bank's prime rate R_{Et}. Figures 4 to 13 show the trajectories of the (short-run deviation of) output y_{it}, the individual (national) nominal interest rates I_{it}, the individual (national) real interest rates r_{it}, public debt D_{it} and the inflation rates π_{it}, respectively.

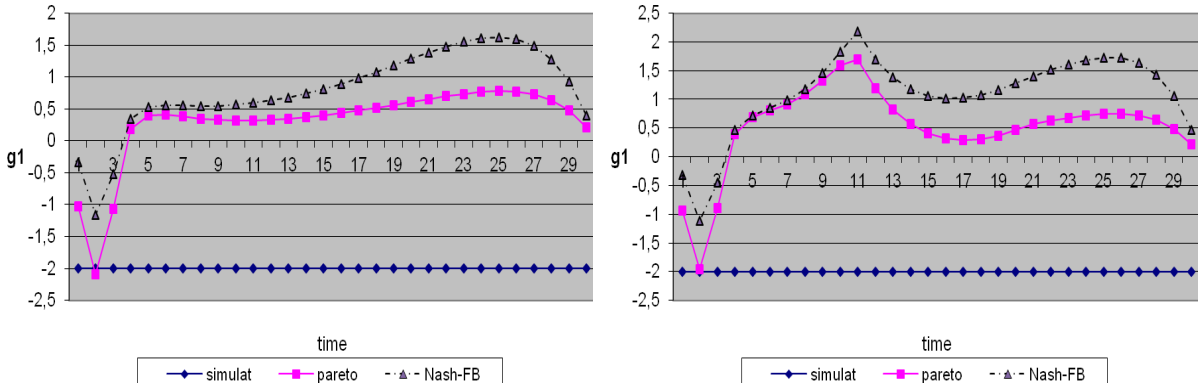

Fig. 1 Country 1's fiscal surplus g_{1t} (left: without haircut; right: with haircut)

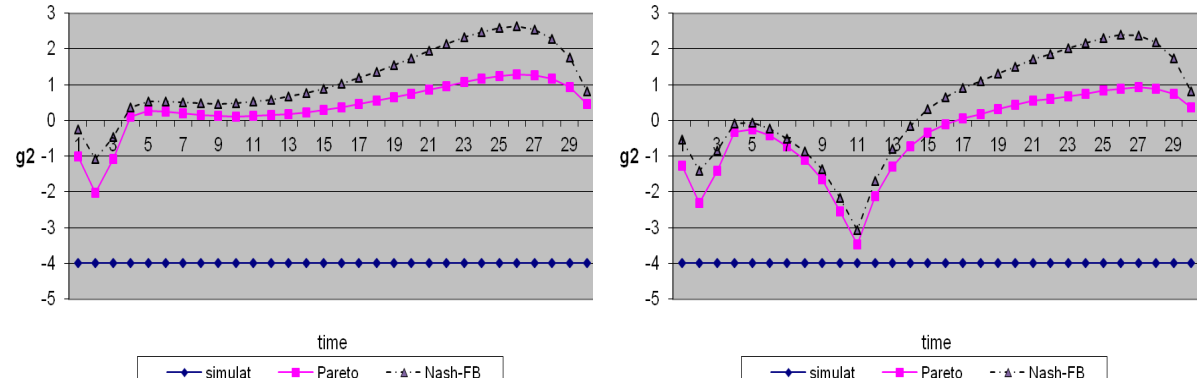

Fig. 2 Country 2's fiscal surplus g_{2t} (left: without haircut; right: with haircut)

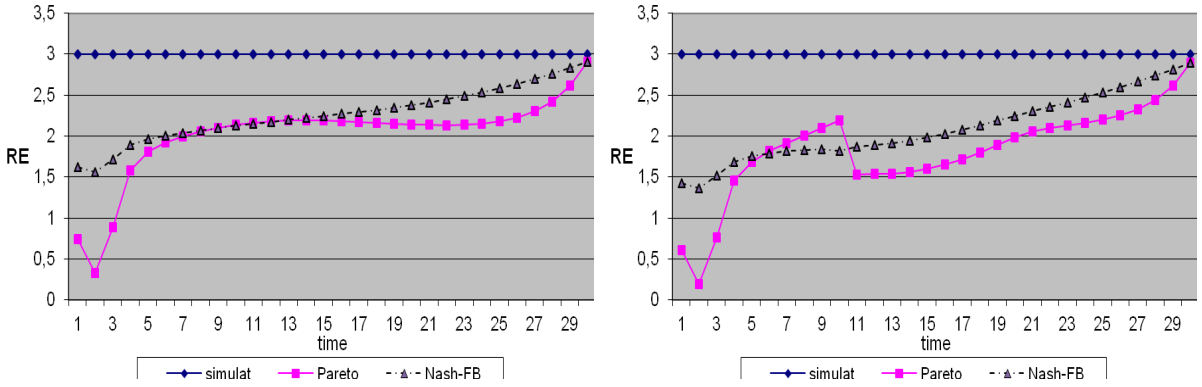

Fig. 3 Union-wide prime rate R_{Et} controlled by the central bank (left: without haircut; right: with haircut)

As can be seen from the left panels of Figures 1, 2 and 3, both fiscal and monetary policies react to the negative demand shock in an expansionary and hence countercyclical way: both countries create a fiscal deficit during the first three periods, and the central bank decreases its nominal interest rate. These Keynesian policy reactions help to absorb the negative demand shock to some extent. However, this policy has a price in terms of its influence on public debt, and requires a restrictive fiscal policy after the crisis.

The expected effect of a haircut influences the policy choice at this stage dramatically. If we compare the policy scenarios without haircut (left panels) and with haircut (right panels) in the first two figures, we observe different intertemporal behavior of national decision-makers. On the one hand the “core” bloc exhibits an even more restrictive fiscal policy and creates significant budget surpluses in the haircut scenarios because it expects the loss to be written off by the haircut, which amounts to an additional payment to the “periphery”. In contrast, the “periphery” bloc produces budget deficits in expectation of a haircut, which shows the moral hazard effect of the announcement of a haircut. Afterwards the “periphery” bloc reduces its deficits and runs a more restrictive fiscal policy. Starting with time period 17 in the cooperative Pareto game (period 15 in the Nash game), the “periphery” bloc produces the budget surpluses as well to deal with the rising public debt under the high interest regime following the haircut. The central Bank’s policy is affected by the haircut in the cooperative scenario only, where it lowers its prime rate after the haircut to support the debt reduction policy of the entire union.

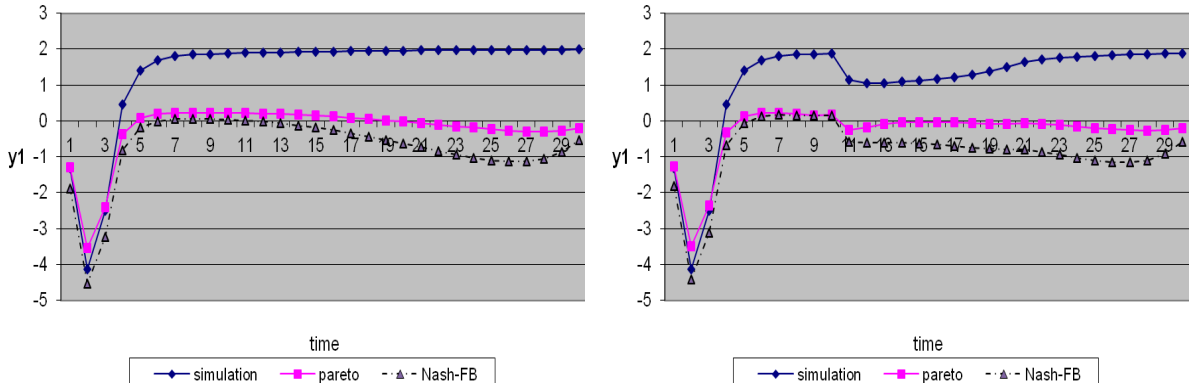

Fig. 4 Country 1's output y_{1t} (left: without haircut; right: with haircut)

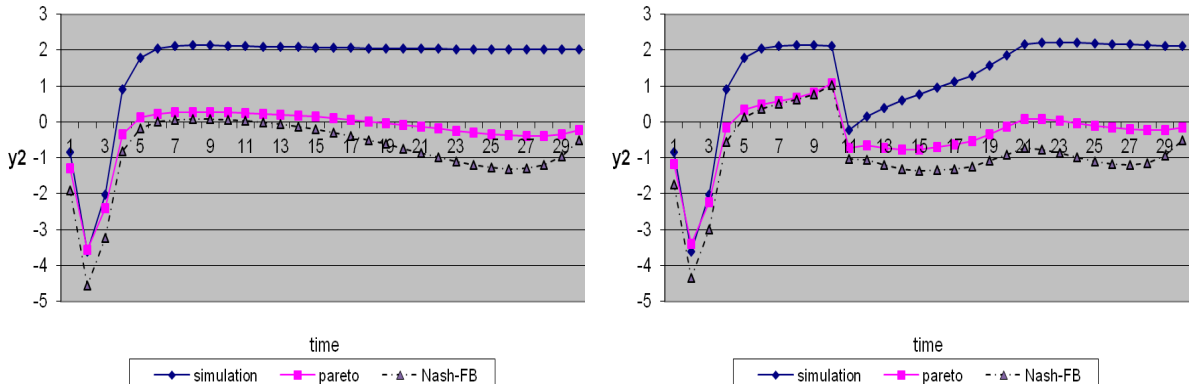

Fig. 5 Country 2's output y_{2t} (left: without haircut; right: with haircut)

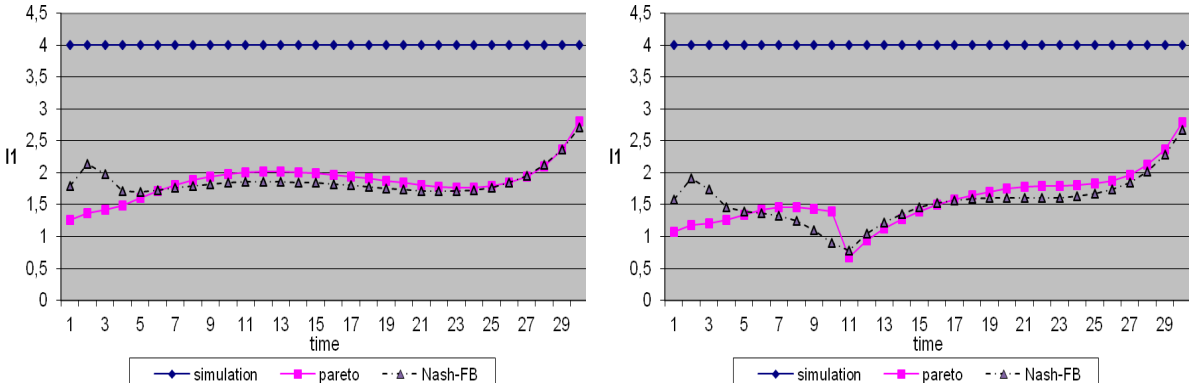

Fig. 6 Country 1's nominal interest rate I_{1t} (left: without haircut; right: with haircut)

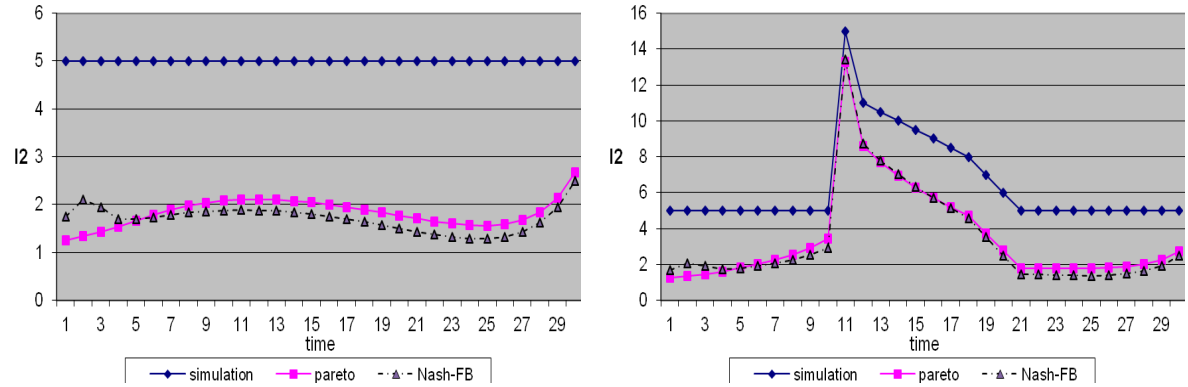

Fig. 7 Country 2's nominal interest rate I_{2t} (left: without haircut; right: with haircut)

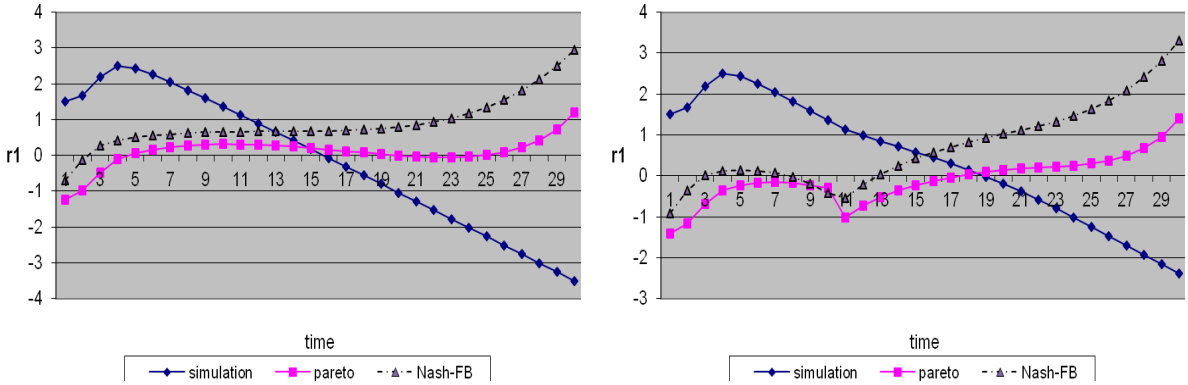

Fig. 8 Country 1's real interest rate r_{1t} (left: without haircut; right: with haircut)

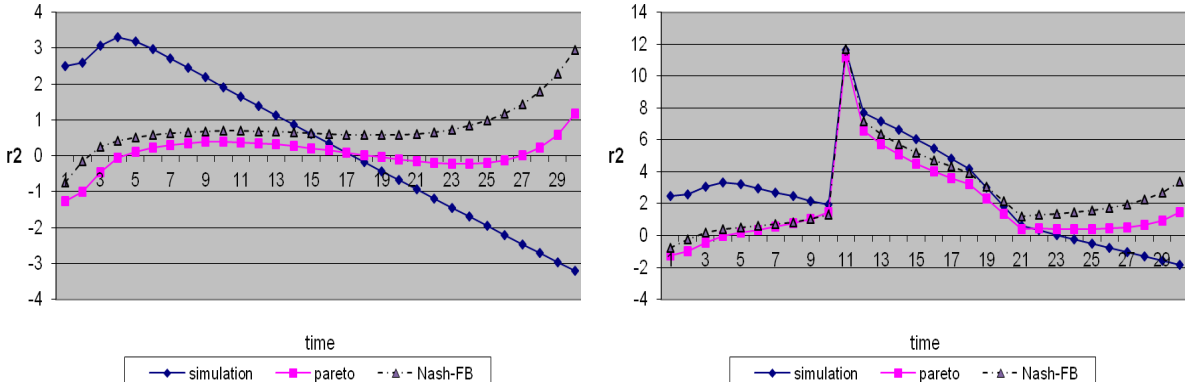

Fig. 9 Country 2's real interest rate r_{2t} (left: without haircut; right: with haircut)

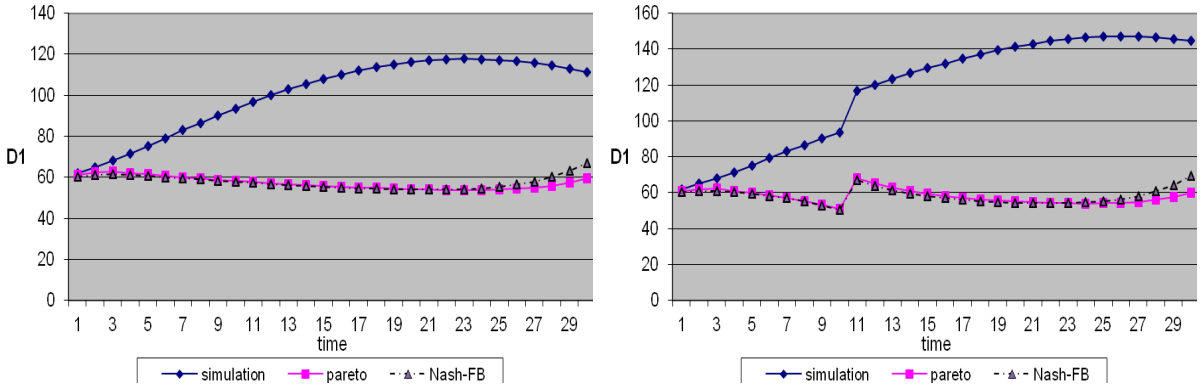

Fig. 10 Country 1's debt level D_{1t} (in % of GDP) (left: without haircut; right: with haircut)

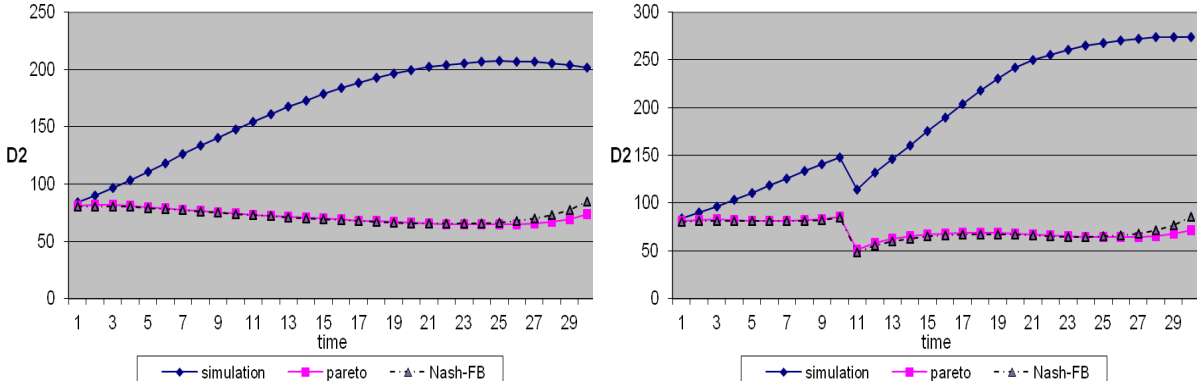

Fig. 11 Country 2's debt level D_{2t} (in % of GDP) (left: without haircut; right: with haircut)

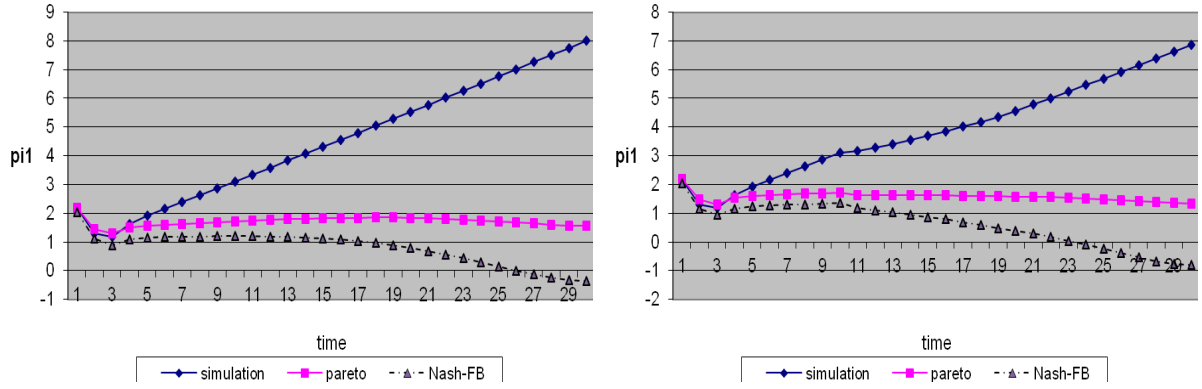

Fig. 12 Country 1's inflation level π_{1t} (left: without haircut; right: with haircut)

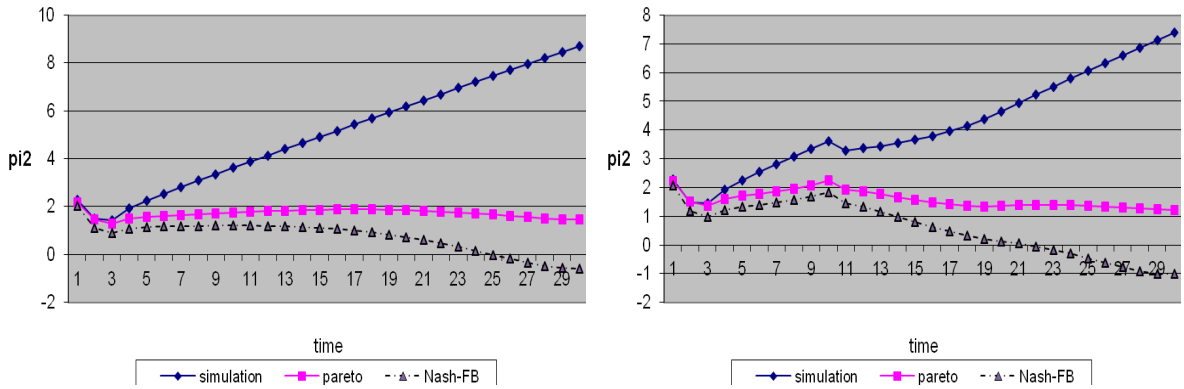

Fig. 13 Country 2's inflation level π_{2t} (left: without haircut; right: with haircut)

Comparing the Pareto and the feedback Nash solution shows that the Pareto solution requires more active (expansionary) fiscal and monetary policies during the crisis and a few periods after, and less active (restrictive) policies afterwards in the scenario without haircut. This results in a smaller drop in output for both countries over the whole planning horizon. In addition, the Pareto solution results in rates of inflation which are closer to the desired value and in slightly lower debt to GDP ratios. Altogether one can say that the cooperative Pareto solution outperforms the feedback Nash solution.

In the haircut scenarios, in both the Pareto and the feedback Nash equilibrium solution show different policies for "core" and "periphery", where the main difference occurs in the fiscal policy even already before the haircut takes place. The "core" bloc runs an even more restrictive fiscal policy while the "periphery" bloc relaxes its austerity policy. This result applies both for Pareto and Nash solution, but it is much stronger in the noncooperative case. If we interpret the cooperative solution, which presumes a binding agreement among all parties involved (the "core", the "periphery" and the central bank), as a fiscal pact or even a fiscal union, this shows the advantage of such an institutional arrangement: it allows countries to rely on the joint effort to reduce public debt by (less) restrictive fiscal policies and a lower prime rate by the central bank relying on the cooperation by the governments.

The qualitative behavior of the central bank in the haircut scenarios depends particularly on the solution concept. In the case of the noncooperative feedback Nash equilibrium solution, the central bank shows nearly no reaction. In the case of the cooperative Pareto solution, the central bank after the crisis first disciplines the governments (especially that of the "periphery") by a higher prime rate, but supports them by an expansionary monetary policy after the haircut shock. As a result, the impact of the haircut shock on the output y_{it} can be reduced nearly completely for the "core" bloc and to large extent for the "periphery" bloc.

Similarly to the scenarios without haircut one can say that the cooperative Pareto solution outperforms the feedback Nash equilibrium solution also in the scenarios with the haircut. These facts can be also seen by looking at the minimum values of the loss functions calculated by (9) and (10) and presented in Tables 4 and 5. The Pareto solution outperforms the feedback Nash equilibrium solution and the uncontrolled baseline simulation in terms of J_1, J_2 and the sum of J_E, J_1 and J_2. The feedback Nash solutions imply lower values of the loss as compared to the Pareto solution for the central bank only. As our model does not contain rational expectations, we do not have a counterproductive effect of cooperation here. Instead, the collusive solution, giving equal weights to the two governments and the central bank, comes out as the winner in this macroeconomic policy game.

TABLE 4

Values of the objective functions (9) and (10) (loss functions, to be minimized) for the scenarios without haircut

strategy	J_E	J_1 ("core")	J_2("periphery")	$J_E + J_1 + J_2$
simulation	111.73	1,203.48	5,126.72	6,441.93
Pareto	51.62	19.45	22.62	93.68
Nash-FB	48.82	49.80	67.15	165.77

TABLE 5

Values of the objective functions (9) and (10) (loss functions, to be minimized) for the scenarios with haircut

strategy	J_E	J_1 ("core")	J_2("periphery")	$J_E + J_1 + J_2$
simulation	67.47	2,184.77	7,845.21	10,097.46
Pareto	67.45	29.67	56.86	153.98
Nash-FB	66.17	68.41	104.93	239.50

Concluding Remarks

By applying a dynamic game approach to a simple macroeconomic model of fiscal and monetary policies in a two-country (two-bloc) monetary union, we obtain some insights into the design of economic policies facing a symmetric excess demand shock, an increase in public debt as a consequence thereof, and possibly a haircut (public debt relief) for the country (bloc) with higher debt to GDP ratio. The monetary union is assumed to be

asymmetric in the sense of consisting of a “core” with less initial public debt and a periphery with higher initial public debt. Ten periods after the crisis, public debt in the “periphery” reaches a level of 150% of GDP unless fiscal policy action is taken. In this situation, we investigate the consequences of a 40 percentage points haircut of the public debt paid mostly by the government of the “core”. This is meant to reflect the current situation in the EMU, where the high level of public debt accompanied by the concerns about irresponsible fiscal policy creates a stability problem for the entire union and seems to threaten the whole project of monetary unification in Europe.

Our model implies that optimal policies of both the governments and the common central bank are counter-cyclical during the immediate influence of the demand shock but not afterwards; instead, if governments want (or are obliged by the union’s rules) to keep their public debt under control and avoid state bankruptcy, they have to implement prudent fiscal policies as soon as the crisis is over. The first choice for such a policy is the creation of (primary) budget surpluses, which must be maintained over an extended period. The suggested alternative of a haircut is shown to be counterproductive under our assumptions. It creates different incentives and as a consequence different policies for the countries of the monetary union. In expectation of a haircut the “best” strategy for the “periphery” is to produce even more budget deficits until this event. This result occurs for both the cooperative Pareto solution and the noncooperative feedback Nash equilibrium solution. Taking the higher risk premium that is usually paid after a haircut into account results in the outcome that all players of the monetary union performs worse as compared to the scenario without haircut.

Of course, it would be very premature to infer strong conclusions for the current macroeconomic situation of the EMU from a very stylized model of strategic interactions between fiscal and monetary policy makers in an asymmetric monetary union such as ours. Nevertheless, a tentative result which we consider to be robust is that a haircut of public debt

is in long run hurtful for both, the core and the periphery bloc of the monetary union. Instead, a policy of fiscal prudency with permanent budget surpluses over an extended period is called for to deal with the government debt crisis. Moreover, as in many other macroeconomic dynamic game models, the cooperative solution dominates the noncooperative equilibrium, which is inefficient. This can be interpreted, in terms of the present situation of the Euro Area, that a fiscal pact or a fiscal union is preferable to noncooperative (nation based) fiscal policies, provided it is based on principles of balanced budgets (or budget surpluses) in normal times. It goes without saying that such an agreement presupposes a strong and credible commitment of all participants and an effective mechanism for monitoring and enforcing its rules.

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