"Core" and "Periphery" in a Monetary Union:

A Macroeconomic Policy Game

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Abstract: We develop a dynamic game model of a two-country monetary union to study strategic interactions between macroeconomic policy makers, namely the central bank and governments. 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. For a symmetric demand shock, we derive numerical solutions of the dynamic game between the governments and the central bank using the OPTGAME algorithm. We show that mildly active cooperative countercyclical policies dominate noncooperative solutions and a scenario of no policy intervention. Optimal policies call for a brief expansionary action to bolster the effects on output and a return to a small fiscal primary surplus as soon as the crisis is over until the targeted level of public debt is reached.

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

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 (see, for example Arghyrou and Tsoukalas, 2010). Other countries are about to follow, 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 gaining acceptance in the media and among politicians.

In this paper we will consider the design of stabilization policies for monetary union using 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 level of public debt. We investigate how a negative demand side shock, such as the one which led to the "Great Recession", affects 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 several 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 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 situation after the "Great Recession" in Europe by outlining some of the most 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 optimal 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, 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) 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 open-loop and the feedback Nash equilibrium solution, the feedback Stackelberg 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 actual macroeconomic policy problems in Europe by comparing and interpreting results from this modeling exercise.

The Model

A simplified macroeconomic model of a monetary union consisting of two countries (or two blocks of countries) with a common central bank is presented in this section, with no 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 public debt targeting 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, 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 blocks 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). We are aware of the fact that 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 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 (or, 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:

$$r_{it} = I_{it} - \pi_{it}^{e}, \tag{2}$$

where π_{it}^{e} $(i = 1,2)$ 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

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

where R_{Et} denotes the common nominal rate of interest determined by the central bank of the monetary union (its control variable). $-\lambda_i$ 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).

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 the 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 $(i = 1,2)$:

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

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.

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

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

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

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)–(10) constitute a dynamic game with 3 players, each of them having one control variable. The model contains 14 endogenous variables, four 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 non-cooperative 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, the EMU is divided into two blocks of "core" ("country" or bloc 1) and "periphery" ("country" or bloc 2). The first block includes ten EMU countries (Germany, France, Cyprus, Luxembourg, Malta, Netherlands, Austria, Slovenia, Slovakia and Finland) with a more solid fiscal situation and inflation performance. For reasons of simplification, this block 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 block has a weight of 40% in the economy of the union; in the EMU, it consists of six countries with higher public debt and/or deficits and higher interest and inflation rates, on average (Belgium, Ireland, Greece, Spain, Italy and Portugal) 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	δ_i, ε_i, λ_i	γ_i, ρ_i, κ_i, β_i, ξ_i	ω	η_i, α's	μ_i, μ_E
30	3	0.5	0.25	0.6	1.0	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" (and the initial) rate of inflation is calibrated at 1.8 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_i
0	1.8	1.8	60	80	3	0

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	1.8	1.8	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 a temporary negative symmetric demand shock influencing the economies of the two countries in the same way. This shock should 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 $t \geq 4$, $i = 1,2$.

In this section, we investigate how the dynamics of the model and the results of the policy game (1)–(10) depend on the strategy choice of the decision makers. For this game, we calculate five different solutions: a baseline solution with the shock but with policy instruments held at pre-shock levels (zero for the fiscal balance, three for the central bank's interest rate by construction), three non-cooperative game solutions and one cooperative game solution. The baseline solution does not include any policy intervention and describes a simple simulation of the dynamic system; it can be interpreted as resulting from a policy ideology of "market fundamentalism" prescribing non-intervention in case of a recession.

In the baseline scenario without policy intervention (shown by the path denoted as "simulat" in Figures 3, 5 and 6), the demand shock leads to lower output during the first five periods (a drop by about 2.5% in first period, about 5.6% in the second period, about 4.2% in the third period, and then slowly returning to the long-run value of zero). This non-controlled (no policy) simulation also results in lower inflation than the desired level of 1.8 (decreasing during the first two periods, resulting even in a slight deflation in periods 3 and 4, and then hovering around 0), and a dramatic increase in public debt. Due to the fall in real GDP and the increase in interest payments, and given the non-availability of policy intervention in this scenario, the public debt of country 1 (the "core" bloc) increases up to 135% of GDP while the public debt of the fiscally less prudent country 2 (the "periphery" bloc) even rises to 180% of GDP at the end of the planning horizon.

When policy makers are assumed to react to the negative demand shock according to their preferences as expressed by their objective functions, the overall outcomes depend on the assumptions made about the behavior of all 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 three non-cooperative equilibrium solutions of the resulting dynamic game, namely the open-loop Nash, the feedback Nash and the feedback Stackelberg equilibrium solution, and one cooperative solution, the 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 feedback Nash equilibrium solution is subgame perfect (Markov perfect, implying strong time consistency) while the open-loop Nash equilibrium solution requires the assumption that all policy makers commit themselves unilaterally and decide upon trajectories of their instrument variables once and for all at t = 0 (which implies only weak time consistency). In the case of the feedback Stackelberg equilibrium solution, the players are assigned asymmetric roles by identifying one player as the leader and imposing his strategy on the other ones, the followers. This solution concept also implies Markov perfectness, or strong time consistency, and can be regarded as a limiting case of a feedback Nash equilibrium solution. Here the central bank is assumed to be the leader and thus to be first to make a decision at the beginning of each period t, t = 1,...,T; the two governments are the followers, playing Nash against each other.

The following figures show the time paths for all three control variables and the eight most relevant endogenous variables. The solutions for the feedback Nash and the feedback Stackelberg game strategies show very similar results. In order to keep the graphs clear, the Stackelberg solution is not presented. For the four dynamic game solution concepts considered, Figures 1 and 2 show the trajectories of the control variables: real fiscal surplus g_{it} ($i = 1,2$) for both countries and the common central bank's rate of interest R_{Et}. Figures 3, 4, 5 and 6 show the trajectories of the (short-run deviation of) output y_{it}, the individual (national) nominal interest rates I_{it}, the inflation rates π_{it} and public debt D_{it}, respectively.

As can be seen from Figures 1 and 2, 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. All the equilibrium solutions give better values of output in the first three periods than the uncontrolled baseline solution. However, this policy has a price in terms of its influence on public debt, and requires a restrictive fiscal policy after the crisis. The magnitude of the (absolute) values of the instruments, the quality of reducing the effects of the crisis and the required after-crisis policy reactions depend on the assumed solution concept of the game. In any case, the policies can be characterized as expansionary during the immediate impact of the shock and restrictive afterwards in order to keep public debt close to its desired path.

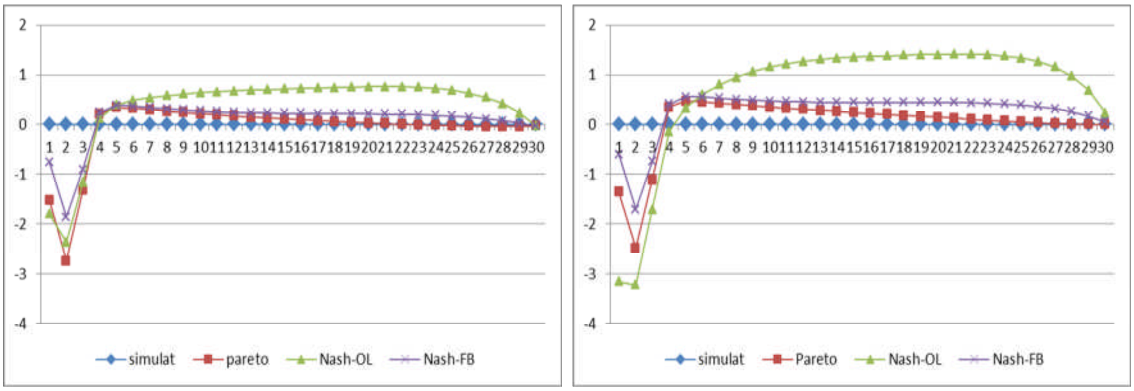

Fig. 1 Country i's fiscal surplus g_{it} (control variable) for i = 1 ("core"; left) and i = 2 ("periphery"; right)

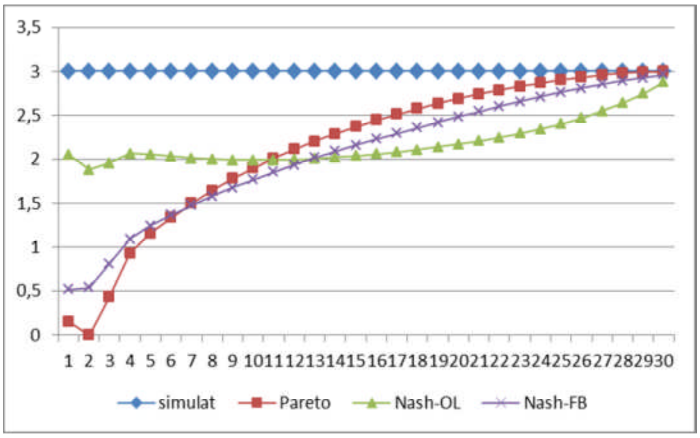

Fig. 2 Union-wide short-term nominal interest rate R_{Et} controlled by the central bank

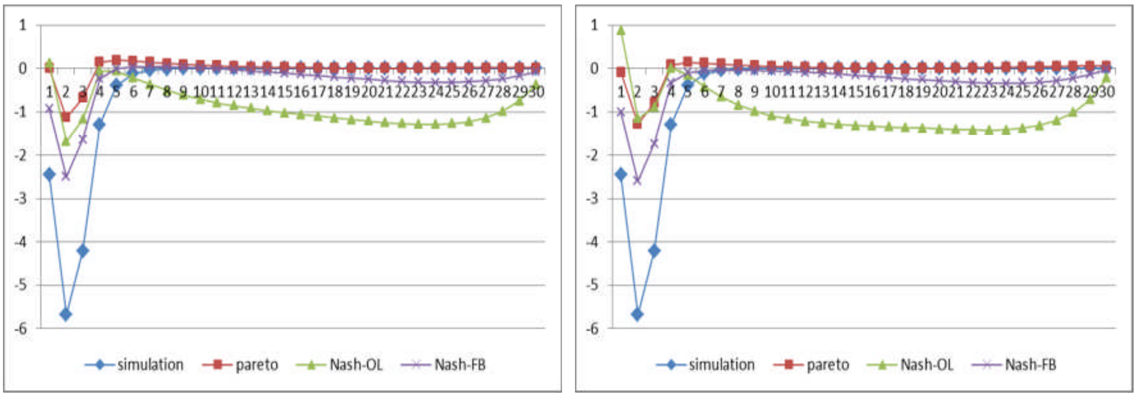

Fig. 3 Country i's output y_{it} for i = 1 ("core"; left) and i = 2 ("periphery"; right)

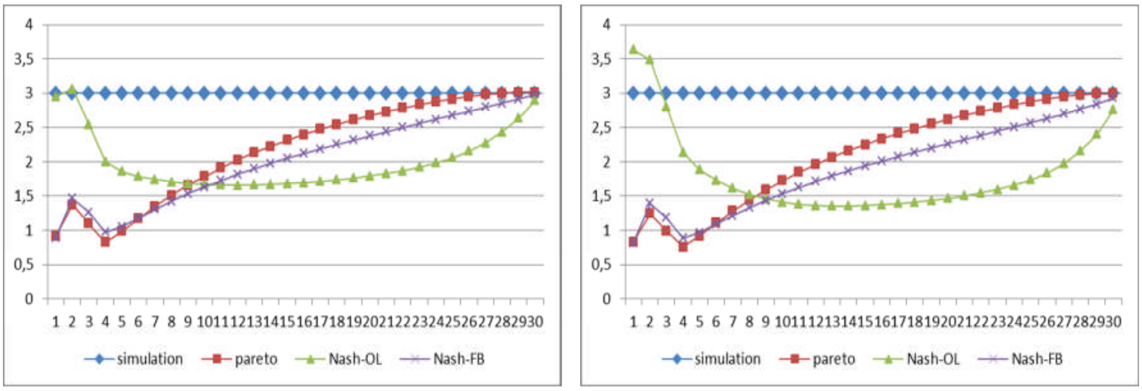

Fig. 4 Country i's nominal interest rate I_{it} for i = 1 ("core"; left) and i = 2 ("periphery"; right)

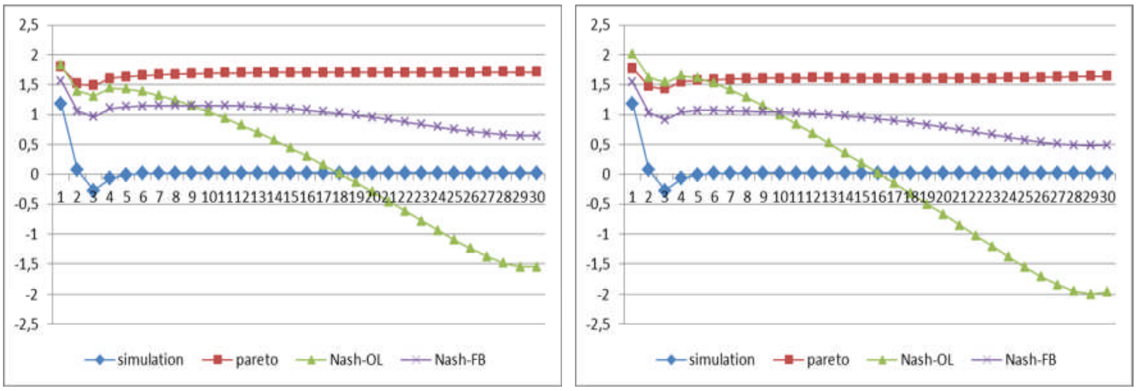

Fig. 5 Country i's inflation level π_{it} for i = 1 ("core"; left) and i = 2 ("periphery"; right)

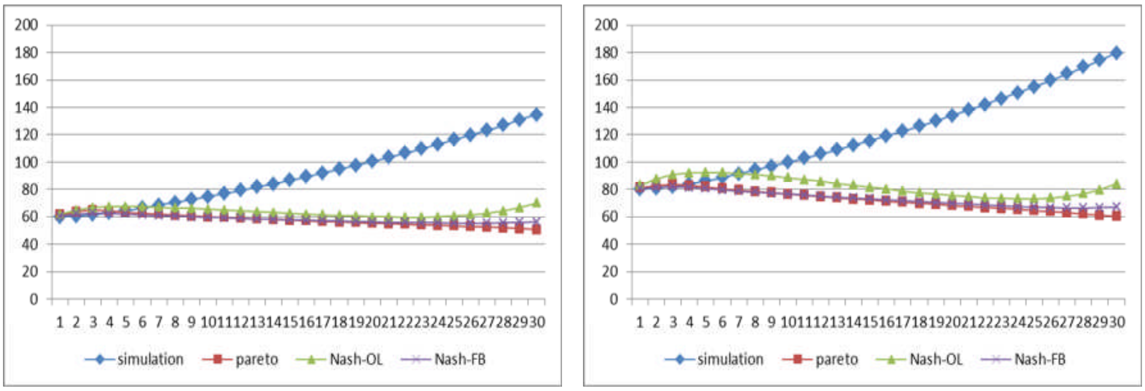

Fig. 6 Country *i*'s debt level D_{it} (in % of GDP) for $i = 1$ ("core"; left) and $i = 2$ ("periphery"; right)

In the case of the open-loop Nash solution, all policy makers decide on trajectories of their instrument variables once and for all time periods of the entire horizon. This is a very inflexible policy strategy which is assumed not to be adjustable during the planning horizon. As can be seen from Figure 2, it implies a less active monetary policy as compared to the Pareto and the feedback Nash solution, resulting in long-run deflation, which aggravates the problem of increasing public debt. As a result, fiscal policies have to be more active, both during (expansionary) and after (restrictive) the negative shock. Such a fiscal policy reaction has negative influence on other indicators, especially output after the shock, which is reduced by more than one percent over a long period by the implied need for fiscal policy to create primary surpluses to come close to the public debt targets. This policy hits the "periphery" more than the "core" and cannot be recommended for either country (bloc). Interestingly, the lack of Markov perfectness of the open-loop Nash equilibrium solution is reflected in a very slow return of all policy instruments to levels compatible with steady state equilibrium.

Comparing the Pareto and the feedback Nash solution shows that the Pareto solution requires more active fiscal and monetary policies during the crisis (and a few periods after) and less active policies afterwards. 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 and the open-loop Nash solution as well.

This fact can be also seen by looking at the minimum values of the loss functions calculated by (9) and (10) and presented in Table 4. The Pareto solution outperforms all the other game strategies in terms of the sum of J_E, J_1 and J_2. The feedback Nash and the feedback Stackelberg solutions imply lower values of the loss for all players than the open-loop Nash solution, and the uncontrolled baseline simulation fares worst for the two governments and the three players together, but better than all the noncooperative solutions 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 unambiguous winner in this macroeconomic policy game.

TABLE 4

Values of the objective functions (9) and (10) (loss functions, to be minimized)

strategy	J_E	J_1 ("core")	J_2("periphery")	$J_E + J_1 + J_2$
simulation	75.68	1509.90	3042.04	4627.63
Pareto	69.43	13.25	13.49	96.17
Nash-OL	111.24	139.60	251.73	502.56
Nash-FB	79.97	26.00	34.54	140.51

Concluding Remarks

By applying a dynamic game approach to a simple macroeconomic model of fiscal and monetary policies in a two-country monetary union, we obtain some insights into the design of economic policies facing a symmetric excess demand shock. 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. This is meant to reflect the situation in the EMU, where the divergence of public debt developments in some countries (including, but not confined to, Greece) from those in the "core" 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 results show that, in the absence of further shocks, a policy of maintaining primary surpluses of less than one percent of GDP for the "core" and less than 1.5 percent in the "periphery" may be sufficient to reduce government debt to the value implied by the Maastricht Treaty. These figures are lower than what was already achieved in several of the fiscally sound countries of Europe (such as Sweden, Finland or Estonia, for example) during the years preceding the "Great Recession" and should therefore be viable for countries like Greece or Portugal during the next few years.

In contrast to a study conducted with a somewhat different macroeconomic model where the monetary union was symmetric (Neck and Behrens 2009), in the present model the outcomes of the different solution concepts of dynamic game theory are not close to each other. For example, a periodic update of information and a related reduction of commitment (a change from an open-loop to a feedback Nash equilibrium solution) provides considerable benefits to all policy makers. Cooperative fiscal and monetary policies are more active than non-cooperative ones, resulting in a different policy mix with higher stabilization effects. In particular, the role of the central bank becomes more productive in the cooperative solution by reducing its interest rate instrument (even to zero in one period) during the shock and increasing it only gradually to its long-run steady state value to support the governments' efforts to decrease their debt.

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 the superiority of mildly active (expansionary) policies during the crisis and of policies directed towards fiscal sustainability starting as soon as possible after the crisis and implemented in a cooperative way between the central bank and all the governments concerned. This approach to policy making is close to what the European Central Bank and most EMU member states' governments recommend. At least during the crisis, these policies did in fact contribute to preventing a disaster like the Great Depression of the 1930s. It remains to be seen whether governments in Europe will succeed in solving the more difficult task of implementing the second part of the recommended strategy, the cooperative return to sound public finances. If we rely on the numerical results of the present paper, this task should not be insurmountable.

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