Fiscal and Monetary Policies in a Monetary Union: Conflict or Cooperation?

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Abstract In this paper we present an application of the dynamic tracking games framework to a monetary union. We use a small stylized nonlinear two-country macroeconomic model (MUMOD1) of a monetary union to analyse the interactions between fiscal (governments) and monetary (common central bank) policy makers, assuming different objective functions of these decision makers. Using the OPTGAME algorithm we calculate solutions for two game strategies: a cooperative solution (Pareto optimal) and a non-cooperative equilibrium solution (the Nash game for the feedback information pattern). We show how the policy makers react to demand shocks under non-cooperation and cooperation scenarios. The cooperative solution dominates the non-cooperative solution in all scenarios, which may be interpreted as an argument for coordinating fiscal and monetary policies in a monetary union in a situation of high public debt such as in the recent sovereign debt crisis in Europe.

1 Introduction

Economic decisions usually aim to achieve goals as successfully as possible according to some system of preferences, both at the level of an individual firm or household and at the level of an entire economy. As economic systems usually involve relations over time, both microeconomic and macroeconomic models are mostly dynamic. Therefore dynamic optimization or optimum control techniques are appropriate instruments for determining optimal decisions in economics. This has been recognized for quite some time now; see e.g. Feichtinger and Hartl (1986). However, there is a broad class of problems in economics where decisions also have to take other rational decision makers into account. In a dynamic context, this opens the way for the application of dynamic game theory, whose development started even before most current techniques for dynamic optimization were known.

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H. Dawid et al. (eds.), *Dynamic Perspectives on Managerial Decision Making*, Dynamic Modeling and Econometrics in Economics and Finance 22,
DOI 10.1007/978-3-319-39120-5_12

Nowadays, dynamic game theory is fairly well developed and several applications to economics have shown its potential for providing a framework for interactive economic strategic decision making [see e.g. Acocella et al. (2013), Basar and Olsder (1999), Petit (1990), van Aarle et al. (2002)].

In this paper we present an application of the dynamic tracking game framework to a macroeconomic model of a monetary union. In such a union a supranational central bank interacts strategically with sovereign governments as national fiscal policy makers in the member states. Such conflicts can be analysed using either large empirical macroeconomic models or small stylized models. We follow the second line of research and use a small stylized nonlinear two-country macroeconomic model of a monetary union (called MUMOD1) for analysing the interactions between fiscal (governments) and monetary (common central bank) policy makers, assuming different objective functions for these decision makers. Using the OPTGAME algorithm we calculate equilibrium solutions for two game strategies: one cooperative (Pareto optimal) and one non-cooperative game (the Nash game for the feedback information pattern). Applying the OPTGAME algorithm to the MUMOD1 model we show how the policy makers react optimally to symmetric and asymmetric demand shocks. Some comments are given about possible applications to the recent sovereign debt crisis in Europe.

2 Nonlinear Dynamic Tracking Games

The nonlinear dynamic game-theoretic problem which we consider in this paper is given in tracking form. The players are assumed to aim at minimizing quadratic deviations of the equilibrium or optimal values (according to the respective solution concept) of state and control variables over time from given desired values. Thus each player minimizes an objective function J^i given by:

$$\min_{u_1^i,\dots,u_T^i} J^i = \sum_{t=1}^{T} L_t^i(x_t, u_t^1, \dots, u_t^N), \qquad i = 1, \dots, N, \tag{1}$$

with

$$L_t^i(x_t, u_t^1, \dots, u_t^N) = \frac{1}{2}[X_t - \tilde{X}_t^i]' \Omega_t^i [X_t - \tilde{X}_t^i], \qquad i = 1, \dots, N. \tag{2}$$

The parameter N denotes the number of players (decision makers). T is the terminal period of the finite planning horizon, i.e. the duration of the game. X_t is an aggregated vector

$$X_t := [x_t \;\; u_t^1 \;\; u_t^2 \;\; \dots \;\; u_t^N]', \tag{3}$$

which consists of an $(n_x \times 1)$ vector of state variables and N $(n_i \times 1)$ vectors of control variables determined by the players $i = 1, \ldots, N$. Thus X_t (for all $t = 1, \ldots, T$) is an r-dimensional vector where

$$r := n_x + n_1 + n_2 + \cdots + n_N. \tag{4}$$

The desired levels of the state variables and the control variables of each player enter the quadratic objective functions [as given by Eqs. (1) and (2)] via the terms

$$\tilde{X}_t^i := [\tilde{x}_t^i \;\; \tilde{u}_t^{i1} \;\; \tilde{u}_t^{i2} \;\; \ldots \;\; \tilde{u}_t^{iN}]'. \tag{5}$$

Equation (2) contains an $(r \times r)$ penalty matrix Ω_t^i, weighting the deviations of states and controls from their desired levels in any time period t. Thus the matrices

$$\Omega_t^i = \begin{bmatrix} Q_t^i & 0 & \cdots & 0 \\ 0 & R_t^{i1} & 0 & \vdots \\ \vdots & 0 & \ddots & 0 \\ 0 & \cdots & 0 & R_t^{iN} \end{bmatrix}, \; i = 1, \ldots, N, \; t = 1, \ldots, T, \tag{6}$$

are in block-diagonal form, where the blocks Q_t^i and R_t^{ij} $(i, j = 1, \ldots, N)$ are symmetric and the R^{ii} are positive definite. Blocks Q_t^i and R_t^{ij} correspond to penalty matrices for the states and the controls respectively.

In a frequent special case, a discount factor α is used to calculate the penalty matrix Ω_t^i in time period t:

$$\Omega_t^i = \alpha^{t-1} \Omega_0^i, \tag{7}$$

where the initial penalty matrix Ω_0^i of player i is given.

The dynamic system, which constrains the choices of the decision makers, is given in state-space form by a first-order system of nonlinear difference equations:

$$x_t = f(x_{t-1}, x_t, u_t^1, \ldots, u_t^N, z_t), \quad x_0 = \bar{x}_0. \tag{8}$$

$\bar{x}_0$ contains the initial values of the state variables. Vector z_t contains non-controlled exogenous variables. For the algorithm, we require that the first and second derivatives of the system function f with respect to x_t, x_{t-1} and $u_t^1, \ldots, u_t^N$ exist and are continuous.

Equations (1), (2) and (8) define a nonlinear dynamic tracking game problem. For each solution concept, the task is to find N trajectories of control variables u_t^i which minimize the postulated objective functions subject to the dynamic system.

In order to solve the stated game we use the OPTGAME algorithm as described in Behrens and Neck (2015) and Blueschke et al. (2013). The OPTGAME algorithm allows us to approximate game solutions for different game strategies. In this paper we consider two solution concepts: a cooperative game (Pareto optimal) and a non-cooperative Nash game.

3 The MUMOD1 Model

We use a dynamic macroeconomic model of a monetary union consisting of two countries (or two blocs of countries) with a common central bank. This model is called MUMOD1 and slightly improves on the one introduced in Blueschke and Neck (2011) and Neck and Blueschke (2014). For a similar framework in continuous time, see van Aarle et al. (2002). The model is calibrated so as to deal with the problem of public debt targeting in a situation that resembles the one currently prevailing in the Eurozone.

The model is formulated in terms of deviations from a long-run growth path and includes three decision makers. The common central bank decides on the prime rate R_{Et}, a nominal rate of interest under its direct control. The national governments decide on the fiscal policy instruments, where g_{it} denotes country i's ($i = 1, 2$) real fiscal surplus (or, if negative, its fiscal deficit), measured in relation to real GDP.

The model consists of the following equations:

$$y_{it} = \delta_i(\pi_{jt} - \pi_{it}) - \gamma(r_{it} - \theta) + \rho_i y_{jt} - \beta_i \pi_{it} + \kappa_i y_{i,t-1} - \eta_i g_{it} + zd_{it}, \quad (9)$$

$$r_{it} = I_{it} - \pi^e_{it}, \quad (10)$$

$$I_{it} = R_{Et} - \lambda_i g_{it} + \chi_i D_{it}, \quad (11)$$

$$\pi_{it} = \pi^e_{it} + \xi_i y_{it}, \quad (12)$$

$$\pi^e_{it} = \varepsilon_i \pi_{i,t-1} + (1 - \varepsilon_i)\pi^e_{i,t-1}, \ \ \varepsilon \in [0, 1], \quad (13)$$

$$y_{Et} = \omega y_{1t} + (1 - \omega) y_{2t}, \ \ \omega \in [0, 1], \quad (14)$$

$$\pi_{Et} = \omega \pi_{1t} + (1 - \omega)\pi_{2t}, \ \ \omega \in [0, 1], \quad (15)$$

$$D_{it} = (1 + BI_{i,t-1} - \pi^e_{i,t-1}) D_{i,t-1} - g_{it}, \quad (16)$$

$$BI_{it} = \frac{1}{6} \sum_{\tau=t-5}^{t} I_{it}. \tag{17}$$

List of variables:

y_{it}	real output (deviation from natural output)
π_{it}	inflation rate
r_{it}	real interest rate
g_{it}	real fiscal surplus
I_{it}	nominal interest rate
π^e_{it}	expected inflation rate
R_{Et}	prime rate
D_{it}	real government debt
B_{it}	interest rate on public debt

The goods markets are modelled for each country i by the short-run income-expenditure equilibrium relation (IS curve) (9) for real output y_{it} at time t ($t = 1, \ldots, T$). The natural real rate of output growth, $\theta \in [0, 1]$, is assumed to be equal to the natural real rate of interest.

The current real rate of interest r_{it} is given by Eq. (10). The nominal rate of interest I_{it} is given by Eq. (11), where $-\lambda_i$ and χ_i (assumed to be positive) are risk premiums for country i's fiscal deficit and public debt level respectively. This allows for different nominal rates of interest in the union in spite of a common monetary policy.

The inflation rates for each country π_{it} are determined in Eq. (12) according to an expectations-augmented Phillips curve. π^e_{it} denotes the rate of inflation expected to prevail during time period t, which is formed according to the hypothesis of adaptive expectations at (the end of) time period $t-1$ [Eq. (13)]. $\varepsilon_i \in [0, 1]$ 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 Eqs. (14) and (15), where 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.

The government budget constraint is given as an equation for real government debt D_{it} (measured in relation to GDP) and is shown in Eq. (16). The interest rate on public debt (on government bonds) is denoted by BI_{it}, which assumes an average government bond maturity of 6 years, as estimated in Krause and Moyen (2013).

The parameters of the model are specified for a slightly asymmetric monetary union. Here an attempt has been made to calibrate the model parameters so as to fit the Euro Area (EA). The data used for calibration include average economic indicators for the 19 EA countries from EUROSTAT up to the year 2014. Mainly based on the public finance situation, the EA is divided into two blocs: a "core" (country or bloc 1) and a "periphery" (country or bloc 2). The first bloc includes twelve EA countries (Austria, Belgium, Estonia, Finland, France, Germany, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, and Slovakia) with a more solid fiscal situation and inflation performance. This bloc has a weight of 67 % in the entire economy of the monetary union. The second bloc has a weight of 33 % in the economy of the union; it consists of seven countries in the EA with higher public debt and/or deficits and higher interest and inflation rates on average (Cyprus, Greece, Ireland, Italy, Portugal, Slovenia, and Spain). These weights correspond to the blocs' shares in EA real GDP.

The initial values of all players are calibrated based on the data from 2014 and presented in Table 1. For the other parameters of the model, we use values in accordance with econometric studies and plausibility considerations (see Table 2).

For the intertemporal nonlinear policy game, the individual objective functions of the national governments ($i = 1, 2$) and of the common central bank (E) are given by

$$J_i = \frac{1}{2}\sum_{t=1}^{T}\left(\frac{1}{1+\frac{\theta}{100}}\right)^t\{\alpha_{\pi i}(\pi_{it}-\tilde{\pi}_{it})^2+\alpha_{yi}(y_{it}-\tilde{y}_{it})^2+\alpha_{Di}(D_{it}-\tilde{D}_{it})^2+\alpha_{gi}g_{it}^2\} \quad (18)$$

$$J_E = \frac{1}{2}\sum_{t=1}^{T}\left(\frac{1}{1+\frac{\theta}{100}}\right)^t\{\alpha_{\pi E}(\pi_{Et}-\tilde{\pi}_{Et})^2+\alpha_{yE}(y_{Et}-\tilde{y}_{Et})^2+\alpha_{E}(R_{Et}-\tilde{R}_{Et})^2\} \quad (19)$$

where all α are the weights of state variables representing their relative importance to the policy maker in question. A tilde denotes the desired ("ideal") values of the variable. Note that we assume different weights between the core and periphery for the state variable public debt: the core is assumed to care much more about its budgetary situation compared to the periphery (Tables 3 and 4).

Using a finite planning horizon T seems adequate for short-run problems of stabilization policy but has the consequence of neglecting developments at $t > T$. This leads to well-known end-of-planning period effects unless one introduces a

Table 1 Initial values ($t = 0$) of the two-country monetary union

y_1	y_2	π_1	π_2	I_1	I_2	D_1	D_2	g_1	g_2
−1	−1.3	0.7	0	1.4	3.1	81	121	−1.6	−4.2

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

T	θ	ω	$\delta_i, \eta_i, \varepsilon_i$	$\beta_i, \gamma_i, \rho_i, \kappa_i$	λ_i	ξ_i	χ_i	μ_i, μ_E
30	2	0.67	0.5	0.25	0.125	0.1	0.00625	0.333

Table 3 Weights of the variables in the objective functions

α_{yi}, α_{gi}	$\alpha_{\pi E}$	$\alpha_{yE}, \alpha_{\pi i}$	α_{D1}	α_{D2}	α_{RE}
1	2	0.5	0.01	0.0001	6

Table 4 Target values for the asymmetric monetary union

$\tilde{D}_{1t}$	$\tilde{D}_{2t}$	$\tilde{\pi}_{it}$	$\tilde{\pi}_{Et}$	$\tilde{y}_{it}$	$\tilde{y}_{Et}$	$\tilde{g}_{it}$	$\tilde{R}_{Et}$
60	80↘60	2	2	0	0	0	3

scrap value for the last period in the objective function. The present version of OPTGAME does not allow for this; hence results for the last few periods should be neglected when interpreting the trajectories of the state and control variables.

The joint objective function for calculating the cooperative Pareto-optimal solution is given by the weighted sum of the three objective functions:

$$J = \mu_1 J_1 + \mu_2 J_2 + \mu_E J_E, \qquad (\mu_1 + \mu_2 + \mu_3 = 1). \tag{20}$$

Here we assume equal weights for the three players ($\mu_i = 1/3, i = 1, 2, E$).

The dynamic system, which constrains the choices of the decision makers, is given in state-space form by the MUMOD1 model as presented in Eqs. (9)–(17). Equations (18), (19) and the dynamic system (9)–(17) define a nonlinear dynamic tracking game problem which can be solved for different solution concepts using the OPTGAME3 algorithm (see Blueschke et al. 2013).

4 Simulation Results

The MUMOD1 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 the effects of policy reactions towards these shocks. In this study we consider demand-side shocks in the goods markets as represented by the variables $zd_{it} (i = 1, 2)$. First, we assume a negative symmetric demand shock as given in Table 5. After that, we analyze the effects of asymmetric shocks affecting the core ($zd_{2t} = 0$) or the periphery ($zd_{1t} = 0$) only.

4.1 *Effects of a Negative Symmetric Demand-Side Shock*

In this section we investigate how the dynamics of the model and the results of the policy game (9)–(17) depend on the strategy choice of the decision makers in the case of a symmetric demand-side shock. We calculate three different solutions: a non-controlled simulation (no-policy scenario, keeping control variables at their desired levels), a non-cooperative feedback Nash equilibrium solution (which is strongly time-consistent) and one cooperative Pareto game solution. The non-controlled scenario does not include any policy intervention and describes a simple simulation of the dynamic system.

Table 5 Negative demand shocks in the asymmetric monetary union

t	1	2	3	4	5	6	$\cdots$	30
zd_1	−2	−4	−2	0	0	0	$\cdots$	0
zd_2	−2	−4	−2	0	0	0	$\cdots$	0

Figures 1, 2, 3, 4, and 5 show the results of these simulations. Figures 1 and 2 show the results for the control variables of the players while Figures 3, 4, and 5 show the results of selected state variables: namely output, inflation, and public debt.

Without policy intervention (the scenario denoted by 'simulation'), both countries suffer from the economic downturn caused by the demand-side shock during the first three periods. The output in the core drops by about 5 % points and the output in the periphery drops by about 3 % points. The development of public debt is even more dramatic. Without policy intervention it increases during the whole planning horizon and arrives at levels of 190 % of GDP for country 1 (or the core bloc) and 470 % for country 2 (or the periphery bloc). We are aware that this is not a realistic scenario as both countries (or at least the periphery) would go bankrupt

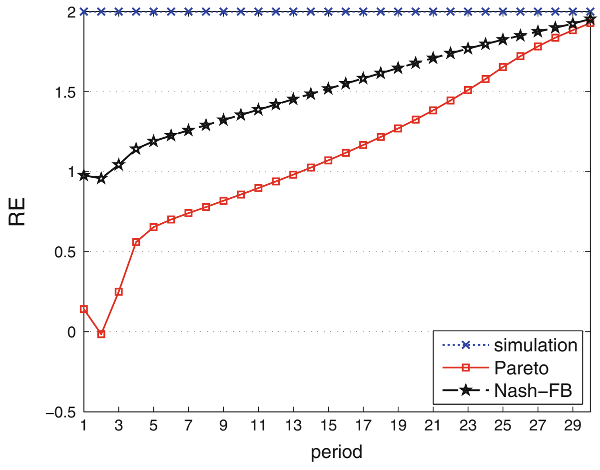

Fig. 1 Prime rate R_{Et} controlled by the central bank

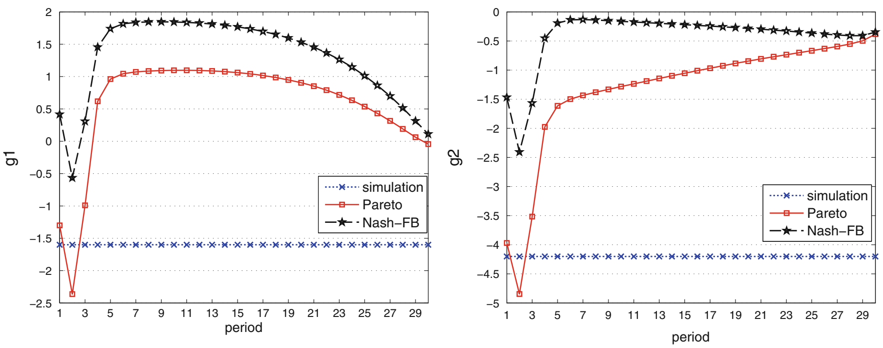

Fig. 2 Country i's fiscal surplus g_{it} (control variable) for $i = 1$ (core; *left*) and $i = 2$ (periphery; *right*)

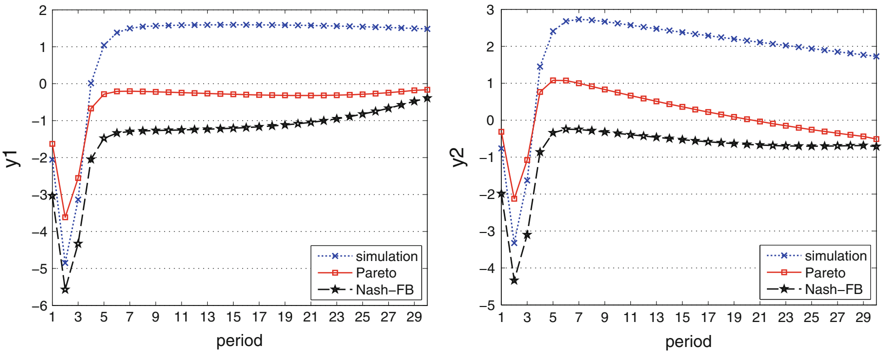

Fig. 3 Country i's output y_{it} for $i = 1$ (core; *left*) and $i = 2$ (periphery; *right*)

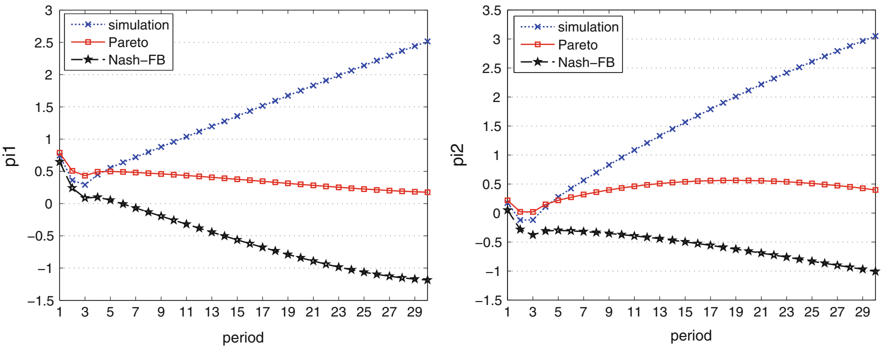

Fig. 4 Country i's inflation rate π_{it} for $i = 1$ (core; *left*) and $i = 2$ (periphery; *right*)

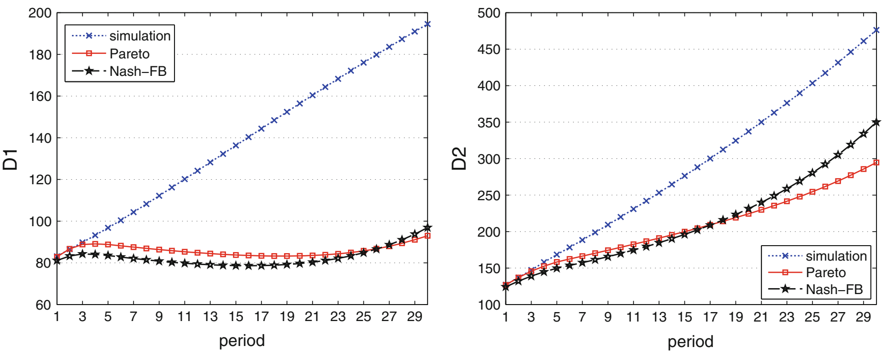

Fig. 5 Country i's debt level D_{it} for $i = 1$ (core; *left*) and $i = 2$ (periphery; *right*)

long before the end of the planning horizon. Instead, the non-controlled simulation scenario points toward a need for policy actions to preserve the solvency of the governments in the monetary union.

An optimal reaction of the players (in terms of the defined objective function) depends on the presence or absence of cooperation. For example, optimal monetary policy has to be expansionary (lowering the prime rate) in both solution concepts considered, but in the cooperative Pareto solution it is more active when compared to the non-cooperative feedback Nash equilibrium solution.

With respect to fiscal policy, even stronger differences can be seen between optimal policies for the core and the periphery. The periphery is required to set expansionary actions and to create deficits in the first three periods in order to help absorb the demand-side shock. This expansionary fiscal policy is much more active in the case of the cooperative solution compared to the feedback Nash equilibrium solution. Such fiscal policies help reduce the effects of the demand-side shock on output but result in relatively small improvements in the public debt situation. Government debt still goes up to very high values of around 300 % of GDP in the Pareto solution and 350 % of GDP in the Nash solution. Compared to 470 % in the non-controlled simulation this is a significant improvement but these levels of public debt are still unsustainable.

The core bloc in the Pareto solution also creates deficits during the presence of the demand-side shock but switches to a restrictive fiscal policy directly afterwards. In the case of the feedback Nash equilibrium solution, fiscal policy is even more restrictive and allows for a small deficit only at the peak of the negative shock in period 2. The effects of this more restrictive fiscal policy on economic performance are relatively small except for public debt. Although it does not allow the bloc to fulfill the Maastricht criteria it nevertheless leads to a significant decrease in public debt, which stays below 100 % of GDP.

One major reason for the need for a more restrictive (less expansionary) fiscal policy in the non-cooperative than in the cooperative solution is the less expansionary monetary policy in the former. This leads to higher nominal interest rates in both countries. The more restrictive overall policy stance causes (mild) deflation in the non-cooperative solution which, in combination with higher nominal interest rates, leads to high and increasing real interest rates, which contribute to strongly increasing public debt in spite of lower budget deficits than in the cooperative solution.

Finally Table 6 summarizes the objective function values as calculated by Eqs. (18) and (19), showing the advantages of cooperation (lower values of the objective functions) for all three players.

Table 6 Values of the objective functions (loss functions, to be minimized)

Strategy	J_E	J_1('core')	J_2('periphery')	$J_E + J_1 + J_2$
Simulation	45.95	686.88	374.03	1106.86
Pareto	146.36	69.28	93.93	309.57
Nash-FB	185.35	125.91	102.99	414.25

4.2 Effects of a Negative Demand-Side Shock in the Core

In this section we analyze a negative demand-side shock which occurs in the core bloc, with the same values for zd_1 as in Table 5 and $zd_2 = 0$ for all t. Figures 6, 7, 8, and 9 show the results of this experiment.

As the shock influences the core bloc only, its effects are smaller than under a symmetric shock in both countries. Optimal monetary policy remains expansionary but significantly less so than in the previous scenario. The fiscal policy of the core also remains expansionary during the shock, becoming restrictive immediately after it disappears. A comparison between the cooperative and the non-cooperative solution for the periphery shows the effects of cooperation. Even without being

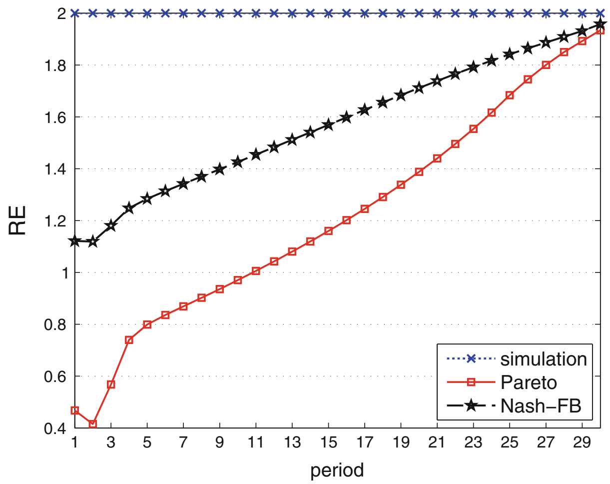

Fig. 6 Prime rate R_{Et} controlled by the central bank

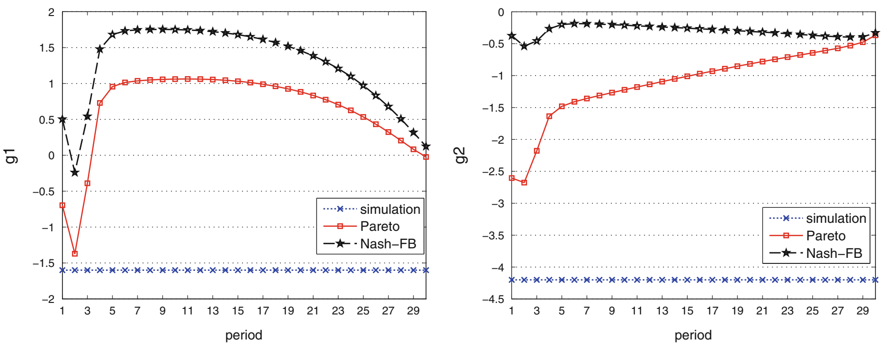

Fig. 7 Country i's fiscal surplus g_{it} (control variable) for $i = 1$ (core; *left*) and $i = 2$ (periphery; *right*)

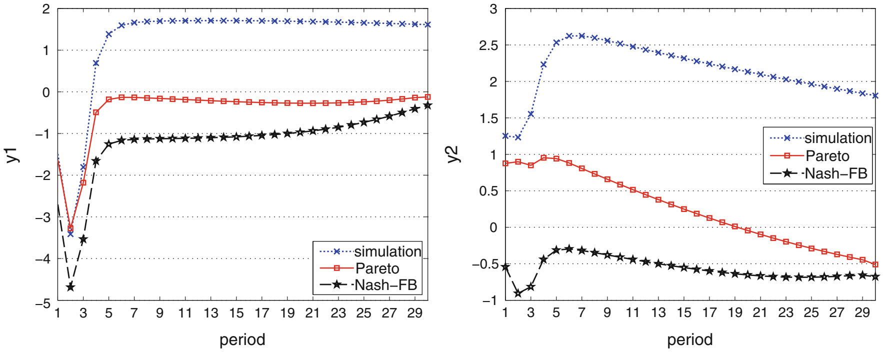

Fig. 8 Country i's output y_{it} for $i = 1$ (core; *left*) and $i = 2$ (periphery; *right*)

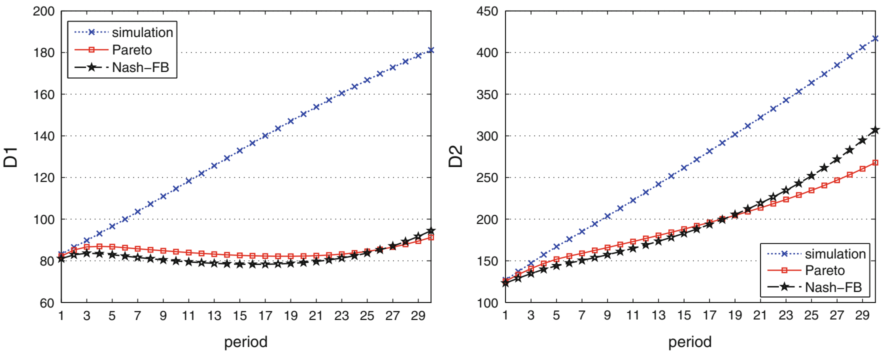

Fig. 9 Country i's debt level D_{it} for $i = 1$ (core; *left*) and $i = 2$ (periphery; *right*)

directly affected by the shock the periphery bloc nevertheless runs an expansionary fiscal policy in order to improve upon the joint objective function, which causes only small additional costs due to its weaker preference for fiscal prudence. In contrast, in the non-cooperative Nash solution we see nearly no reaction in the periphery's fiscal policy to the shock.

The asymmetric shock also produces asymmetric results for the state variables. While there is nearly no effect on the output of the second bloc, the first bloc experiences a significant decrease in output. However this small spillover of the negative shock does not help the second bloc to get its public debt situation under control. Its public debt grows further and arrives at a value of 270 % of GDP in the Pareto solution and 310 % of GDP in the feedback Nash equilibrium solution. This result indicates that the problem of the periphery's high public debt cannot be solved without deeper changes in the affected economies, which can be modelled in our framework by giving a higher weight to this state variable in the objective function of the periphery. In contrast, the core bloc can hold its public debt on a relatively constant level despite the occurrence of the negative shock. The effects on inflation are similar to those in the previous subsection.

Table 7 summarizes the objective function values as calculated by Eqs. (18) and (19). Note that the periphery does not suffer from cooperating with the core even though it is only minimally affected directly by the core-specific shock.

4.3 *Effects of a Negative Demand-Side Shock in the Periphery*

In this section we analyze a negative demand-side shock of the same size as before which occurs in the periphery bloc only. Figures 10, 11, 12, and 13 and Table 8 show the results.

Reversing the shock to affect the periphery only also turns around the results. The periphery is now affected negatively and is required to run a stronger expansionary fiscal policy in order to mitigate the effects of the shock. The core bloc instead can concentrate more on its public debt, which stays below 85 % of GDP most of the time in this scenario. This is achieved by creating nearly constant budget surpluses. The only exceptions are the first two periods in the cooperative Pareto solution, where small deficits occur. The optimal monetary policy is still expansionary but slightly less active than in the other two scenarios.

Table 7 Values of the objective functions (loss functions, to be minimized)

Strategy	J_E	J_1(‘core’)	J_2(‘periphery’)	$J_E + J_1 + J_2$
Simulation	34.90	592.47	345.38	972.75
Pareto	113.77	57.78	62.21	233.75
Nash-FB	144.64	104.10	62.93	311.67

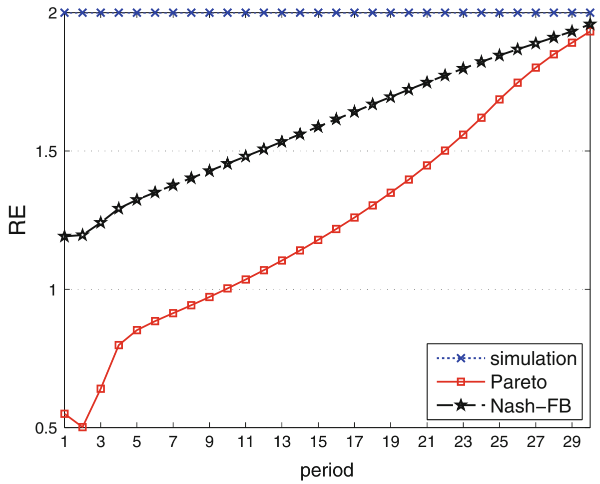

Fig. 10 Prime rate R_{Et} controlled by the central bank

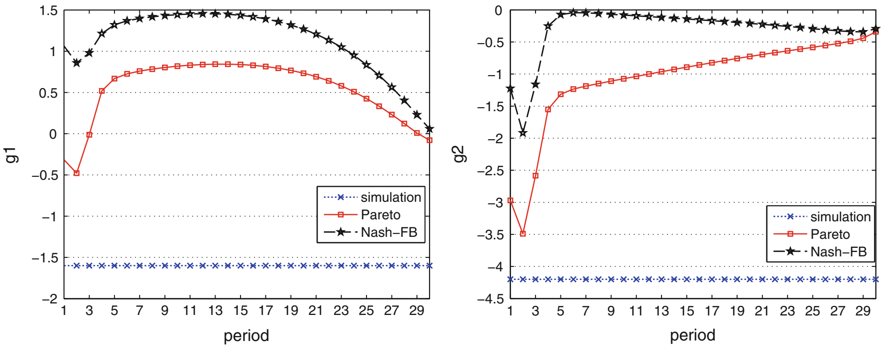

Fig. 11 Country i's fiscal surplus g_{it} (control variable) for $i = 1$ (core; *left*) and $i = 2$ (periphery; *right*)

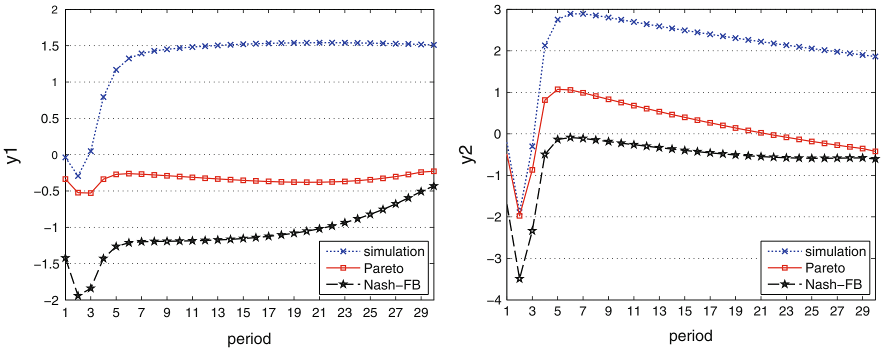

Fig. 12 Country i's output y_{it} for $i = 1$ (core; *left*) and $i = 2$ (periphery; *right*)

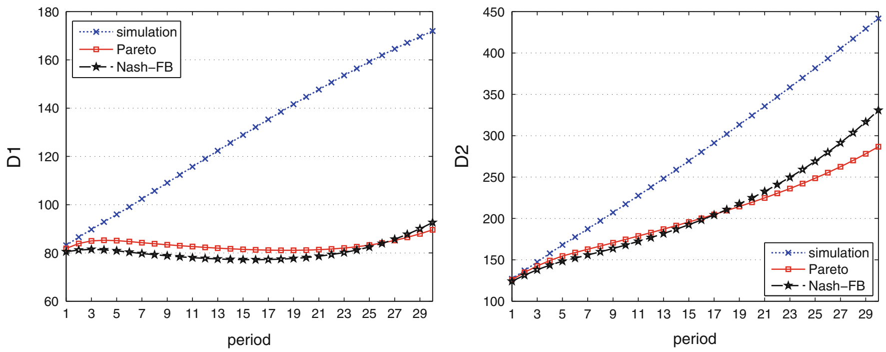

Fig. 13 Country i's debt level D_{it} for $i = 1$ (core; *left*) and $i = 2$ (periphery; *right*)

Finally Table 8 summarizes the objective function values as calculated by Eqs. (18) and (19).

Table 8 Values of the objective functions (loss functions, to be minimized)

Strategy	J_E	J_1('core')	J_2('periphery')	$J_E + J_1 + J_2$
Simulation	30.91	506.93	363.30	901.14
Pareto	102.88	38.10	74.95	215.92
Nash-FB	128.29	74.19	84.13	286.62

5 Concluding Remarks

In this paper we analysed the interactions between fiscal (governments) and monetary (common central bank) policy makers by applying a dynamic game approach to a simple macroeconomic model of a two-country monetary union in a situation of high public debt. Using the OPTGAME3 algorithm, which allows us to find approximate solutions for nonlinear-quadratic dynamic tracking games, we obtained some insights into the design of economic policies when facing negative shocks on the demand side. To this end we introduced three different shocks on the monetary union: a negative symmetric and two negative asymmetric demand-side shocks. The monetary union was assumed to be asymmetric in the sense of consisting of a core with smaller initial public debt and a periphery with higher initial public debt, which was meant to reflect the current situation in the Eurozone.

Our results show that there is a trade-off between sovereign debt sustainability and output (and hence employment) stability when the monetary union is confronted with a negative demand-side shock. Fiscal policy decisions in the periphery tend towards prioritizing the output target at the expense of its budgetary targets while the core, with its higher preference for fiscal prudence, acts in a more restrictive way without much of a negative side effect on its output. The cooperative solution in all cases gives better results for all decision makers, even in the case of an asymmetric shock. An expansionary (low interest rate) monetary policy contributes to accommodating fiscal policy in combating the shocks, especially in the cooperative solution. If the cooperative solution is interpreted as a form of fiscal and monetary union or pact, this can provide an argument for greater coordination among fiscal policies and between monetary and fiscal policies. However, this presumes a binding and permanent agreement among the policy makers, which is notoriously difficult to achieve on a supranational level.

Acknowledgements Thanks are due to an anonymous referee for helpful suggestions for improvement.

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