What to Do When Stagflation Returns? Monetary and Fiscal Policy Strategies for a Monetary Union

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First Draft

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 of a monetary union for analyzing 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: one cooperative (Pareto optimal) and one noncooperative game type (the Nash game for the feedback information pattern). Applying the OPTGAME algorithm to the MUMOD1 model we show how the policy makers react upon supply shocks according to these solution concepts. To this end we calibrate the model and the path of the exogenous variables so as to replicate some stylized facts of the Euro Area developments during the Great Recession and the following sovereign debt crisis. Next, we analyze different kinds of supply side shocks and discuss the best macroeconomic policy strategies for possible future scenarios under assumptions about strategic interactions among monetary and fiscal policy makers.

Keywords Numerical methods for control and dynamic games; Economic dynamics; Monetary union; Open economy macroeconomics.

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1 Introduction

The economic situation in the European Monetary Union is nowadays relatively unstable due to the economic crisis 2008-2010 (the Great Recession) and a wide range of structural problems in the affected countries. At the beginning of this crisis policy-makers tried to cooperate and to use coordinated anti-cyclical fiscal and monetary policies to reduce the negative impacts of the crisis, giving high importance to GDP growth and unemployment. Unfortunately, the public debt situation worsened dramatically and we face a sovereign debt crisis in Europe since 2010. During the latter crisis politicians show no consensus on what is the best way out of this crisis. And suddenly the European Monetary Union seems to be not a union of cooperating partners speaking with one voice but a pool of independent players which seek the profits for their own country only. Strategic considerations play an important role in this situation. Hence, it is useful to run a study of a monetary union using concepts of dynamic game theory.

The framework of dynamic games is suitable to describe the dynamics of a monetary union because a monetary union consists of several players with independent or rather different aims and instruments. Even if there exist common, union-wide indexes each of the players may give different importance (weights) to these targets. In addition, the willingness to cooperate in order to achieve the common goal may be country-specific as well. Because of these reasons it is indispensable to model the conflicts ('non-cooperation') between the players. Such problems can be best modeled using 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., Basar and Olsder (1999); van Aarle *et al.* (2002)).

In this paper we present an application of the dynamic tracking game framework to a monetary union model. Dynamic games have been used for modeling conflicts between monetary and fiscal policies by several authors. There is also a large body of literature on dynamic conflicts between policy-makers from different countries on issues of international stabilization. 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 can be analysed using either large empirical macroeconomic models (e.g. Haber *et al.* (2002)) or small stylized models (e.g. Dixit and Lambertini (2001); Neck and Behrens (2009); Neck and Blueschke (2014)). We follow the latter 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 of these decision makers. Using the OPTGAME algorithm we calculate solutions for two game strategies: one cooperative (Pareto optimal) and one non-cooperative game type (the Nash game for the feedback information pattern).

Applying the OPTGAME algorithm to the MUMOD1 model we show how the policy makers react optimally upon supply shocks. First we reproduce the basic dynamics of economic crisis 2007-2010 and the sovereign debt crisis in Europe. Next we assume several future supply side shocks acting on the monetary union and analyze what would be the best strategies in such a hypothetical case.

Negative supply shocks imply increasing inflation and decreasing or negative output growth or stagflation. In general, such a development is regarded as the most undesirable constellation for macroeconomic policy makers: if they act in an expansionary way, they increase inflation further; if they apply their instruments in a restrictive way, they decrease output (and employment) further. At first sight, it may seem strange to investigate effects of stagflation at times where most policy makers are afraid of deflation. However, the current decline in energy and some food prices will not last forever, and if inflation rises again a switch from the present very low interest rates to a more restrictive monetary policy may be rather difficult as reactions to recent announcements of the Fed have shown. If the enormous amount of liquidity created by central banks all over the world combines with increases in prices of some necessities like energy or food we may encounter substantial inflation very fast. Therefore, it makes sense to deal with the problem of adequate macroeconomic policies in a monetary union in such a situation.

2 Nonlinear dynamic tracking games

We consider nonlinear dynamic game-theoretic problems which are given in tracking form. The players aim at minimizing quadratic deviations of the equilibrium values from given target (desired) values. Thus each player minimizes an objective function J^i given by:

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

with

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

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

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

which consists of an $(n_x \times 1)$ vector of state variables

$$x_t := [x_t^1 \;\; x_t^2 \;\; \ldots \;\; x_t^{n_x}]' \tag{4}$$

and N $(n_i \times 1)$ vectors of control variables determined by the players $i = 1, ..., N$:

$$\begin{aligned} u_t^1 &:= [u_t^{11} \;\; u_t^{12} \;\; \ldots \;\; u_t^{1n_1}]', \\ u_t^2 &:= [u_t^{21} \;\; u_t^{22} \;\; \ldots \;\; u_t^{2n_2}]', \\ &\vdots \\ u_t^N &:= [u_t^{N1} \;\; u_t^{N2} \;\; \ldots \;\; u_t^{Nn_N}]'. \end{aligned} \tag{5}$$

Thus X_t (for all $t = 1, \ldots, T$) is an r-dimensional vector, where

$$r := n_x + n_1 + n_2 + \cdots + n_N. \tag{6}$$

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

$$\tilde{X}_t^i := [\tilde{x}_t^i \;\; \tilde{u}_t^{i1} \;\; \tilde{u}_t^{i2} \;\; \ldots \;\; \tilde{u}_t^{iN}]'. \tag{7}$$

Finally, equation (2) contains an $(r \times r)$ penalty matrix Ω_t^i $(i = 1, \ldots, N)$, weighting the deviations of states and controls from their desired levels in any time period t $(t = 1, ..., T)$. Thus the matrices

$$\Omega_t^i = \begin{bmatrix} Q_t^i & 0 & \cdots & 0 \\ 0 & R_t^{i1} & 0 & \vdots \\ \vdots & 0 & \ddots & 0 \\ 0 & \cdots & 0 & R_t^{iN} \end{bmatrix}, \; i = 1, \ldots, N, \; t = 1, \ldots, T, \tag{8}$$

are of block-diagonal form, where the blocks Q_t^i and R_t^{ij} $(i, j = 1, \ldots, N)$ are symmetric. These blocks Q_t^i and R_t^{ij} correspond to penalty matrices for the states and the controls, respectively. The matrices $Q_t^i \geq 0$ are positive semi-definite for all $i = 1, \ldots, N$; the matrices R_t^{ij} are positive semi-definite for $i \neq j$ but positive definite for $i = j$. This guarantees that the matrices $R_t^{ii} > 0$ are invertible, a necessary prerequisite for the analytical tractability of the algorithm.

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

$$\Omega_t^i = \alpha^{t-1}\Omega_0^i, \tag{9}$$

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:

$$x_t = f(x_{t-1}, x_t, u_t^1, \ldots, u_t^N, z_t), \quad x_0 = \bar{x}_0. \tag{10}$$

$\bar{x}_0$ contains the initial values of the state variables. The vector z_t contains non-controlled exogenous variables. f is a vector-valued function where f^k ($k = 1, ..., n_x$) denotes the kth component of f. 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 $u_t^1, ..., u_t^N$ exist and are continuous. The assumption of a first-order system of difference equations as stated in (10) is not really restrictive as higher-order difference equations can be reduced to systems of first-order difference equations by suitably redefining variables as new state variables and augmenting the state vector.

Equations (1), (2) and (10) define a nonlinear dynamic tracking game problem to be solved. That means, we try to find N trajectories of control variables u_t^i, $i = 1, ..., N$, which minimize the postulated objective functions subject to the dynamic system. Using the OPTGAME algorithm (see Blueschke *et al.* (2013)) we are able to solve the stated dynamic tracking game problem. Applying the OPTGAME algorithm to the MUMOD1 model we calculate optimal macroeconomic policies in a monetary union for different solution concepts, namely the noncooperative feedback Nash equilibrium solution, which is subgame perfect, and an efficient Pareto optimal solution which is not an equilibrium of the dynamic game but requires some external mechanism of implementation to become effective.

3 The MUMOD1 model

In this paper we use a simplified model of a monetary union which is called MUMOD1 and which slightly improves the one introduced in Blueschke and Neck (2011) in order to derive optimal fiscal and monetary policies of the economies in a monetary union. 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 European Union but no attempt is made to describe a monetary union in general or the EMU in every detail. The model builds on discrete data, which is a popular way in economics. One of the most important features of our model is the fact that it allows for different kinds of exogenous shocks acting in a symmetric or an asymmetric way on the economies in the monetary union. Analyzing the impacts of these different shocks allows us to get basic insights into the dynamic of a monetary union.

In this paper we introduce two sequences of different shocks on the monetary union. The first sequence includes a negative asymmetric demand side shock aimed at calibrating the dynamics in a monetary union in a situation similar to the economic crisis (2007-2010) and the sovereign debt crisis in Europe (since 2010). The second sequence of the shocks, consisting of different kinds of supply side shocks, serves to discuss the best macroeconomic policy strategies for possible future scenarios characterized by cost-push inflationary global developments. Before we present these studies it is appropriate to describe the model in detail.

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 blocs of countries, which in the current European context might be identified with the stability-oriented, "core" bloc and the "periphery" bloc (countries with problems due to high public debt and/or high budget deficits).

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

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:

$$y_{it} = \delta_i(\pi_{jt} - \pi_{it}) - \gamma_i(r_{it} - \theta) + \rho_i y_{jt} - \beta_i \pi_{it} + \kappa_i y_{i(t-1)} - \eta_i g_{it} + z d_{it}, \quad (11)$$

for $i \neq j$ ($i, j = 1, 2$). The variable π_{it} denotes the rate of inflation in country i, r_{it} represents country i's real rate of interest and g_{it} denotes country i's real fiscal surplus (or, if negative, its fiscal deficit), measured in relation to real GDP. g_{it} in (11) 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 $\delta_i, \gamma_i, \rho_i, \beta_i, \kappa_i, \eta_i$, in (11) 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:

$$r_{it} = I_{it} - \pi^e_{it}, \tag{12}$$

where π^e_{it} denotes the expected rate of inflation in country i and I_{it} denotes the nominal interest rate for country i, which is given by:

$$I_{it} = R_{Et} - \lambda_i g_{it} + \chi_i D_{it}, \tag{13}$$

where R_{Et} denotes the prime rate determined by the central bank of the monetary union (its control variable); $-\lambda_i$ and χ_i (λ_i and χ_i are assumed to be positive) are risk premia for country i's fiscal deficit and public debt level respectively. 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):

$$\pi_{it} = \pi^e_{it} + \xi_i y_{it} + zs_{it}, \tag{14}$$

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; π^e_{it} denotes the rate of inflation in country i expected to prevail during time period t, which is formed at (the end of) time period $t-1$. Inflationary expectations are formed according to the hypothesis of adaptive expectations:

$$\pi^e_{it} = \varepsilon_i \pi_{i(t-1)} + (1 - \varepsilon_i)\pi^e_{i(t-1)}, \tag{15}$$

where $\varepsilon_i \in [0,1]$ 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:

$$y_{Et} = \omega y_{1t} + (1-\omega) y_{2t}, \;\; \omega \in [0,1], \tag{16}$$

$$\pi_{Et} = \omega\pi_{1t} + (1-\omega)\pi_{2t}, \ \ \omega \in [0,1]. \tag{17}$$

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 Eq. (17).

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

$$D_{it} = (1 + BI_{i,t-1} - \pi^e_{i,t-1})D_{i,t-1} - g_{it}, \tag{18}$$

where D_i denotes real public debt of country i measured in relation to (real) GDP. No seigniorage effects on governments' debt are assumed to be present. The interest rate on public debt (on bonds) is denoted by BI_{it}, which assumes an average bond maturity of six years, as estimated in Krause and Moyen (2013):

$$BI_{it} = \frac{1}{6}\sum_{\tau=t-5}^{t} I_{it}. \tag{19}$$

Both national fiscal authorities are assumed to care about stabilizing inflation (π), output (y), debt (D), and fiscal deficits of their own countries (g) 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 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 and its Stability and Growth Pact. 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. Hence, the individual objective functions of the national governments and of the common central bank are given by:

$$J_i = \frac{1}{2}\sum_{t=1}^{T}(\frac{1}{1+\theta})^{t-1}\{\alpha_{\pi i}(\pi_{it} - \tilde{\pi}_{it})^2 + \alpha_{yi}(y_{it} - \tilde{y}_{it})^2 + \alpha_{Di}(D_{it} - \tilde{D}_{it})^2 + \alpha_{gi}g^2_{it}\} \tag{20}$$

$$J_E = \frac{1}{2}\sum_{t=1}^{T}(\frac{1}{1+\theta})^{t-1}\{\alpha_{\pi E}(\pi_{Et} - \tilde{\pi}_{Et})^2 + \alpha_{yE}(y_{Et} - \tilde{y}_{Et})^2 + \alpha_{E}(R_{Et} - \tilde{R}_{Et})^2\} \tag{21}$$

where J_i ($i = 1, 2$) denotes the objective function of the respective country or bloc and J_E denotes the objective function of the central bank.

The corresponding weights of the objective variables (their importance to the respective policy maker) are given in Table 1

Table 1: Weights of the objective variables

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	2.5

Equations (11)-(18) constitute a dynamic game with three 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. The game is nonlinear-quadratic and hence cannot be solved analytically but only numerically. To this end, we have to specify the parameters of the model.

The parameters of the model are specified for a slightly asymmetric monetary union; see Table 2. Here an attempt has been made to calibrate the model parameters so as to fit for the EMU. The data used for calibration includes average economic indicators for the 16 EMU countries from EUROSTAT up to the year 2007. Mainly based on the public finance situation, the EMU is divided into two blocs of core (consisting of the following countries: Austria, Belgium, Estonia, Finland, France, Germany, Luxembourg, Malta, Netherlands and Slovakia) and periphery (consisting of the following countries: Cyprus, Greece, Ireland, Italy, Portugal, Slovenia and Spain). The first bloc 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; it consists of countries with higher public debt and deficits and higher interest and inflation rates, on average. The weights correspond to the respective shares in EMU real GDP. For the other parameters of the model, we use values in accordance with econometric studies and plausibility considerations.

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

T	θ	ω	$\delta_i, \eta_i, \varepsilon_i$	$\beta_i, \gamma_i, \rho_i, \kappa_i, \lambda_i$	ξ_i	χ_i	μ_i, μ_E
30	3	0.6	0.5	0.25	0.1	0.0125	0.333

The initial values of the state variables of the dynamic game model, are presented in Table 3. The ideal or target values assumed for the objective variables of the players are given in Table 4. Country 1 (the core bloc) has an initial debt level of 60% of GDP and aims to hold this level over time. 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 is going to fulfil the Maastricht criterion for this economic indicator. The ideal rate of inflation is calibrated at 2%, which corresponds to the Eurosystem's aim of keeping inflation below, but close to, 2%. The initial values of the two blocs' government debts and budget deficits 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 3: Initial values of the two-country monetary union

$y_{i,0}$	$\pi_{i,0}$	$\pi^e_{i,0}$	$D_{1,0}$	$D_{2,0}$	$R_{E,0}$	$g_{1,0}$	$g_{2,0}$
0	2	2	60	80	3	0	0

Table 4: Target values for an 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$\searrow$60	2	2	0	0	0	3

4 Baseline Scenario: Calibration for the Great Recession and the Sovereign Debt Crisis

The MUMOD1 model can be used to simulate the effects of different shocks hitting the monetary union, which are reflected in the paths of the exogenous non-controlled variables, and of policy reactions towards these shocks. In this paper we introduce two sequences of different shocks on the monetary union. The first sequence consists of a negative asymmetric demand side shock (zd_i), as given in Table 5, which aims at calibrating the macroeconomic dynamics of a monetary union in a situation similar to the economic crisis (2007-2010) and the ensuing sovereign debt crisis in Europe (since 2010). The values of the shock variables are calibrated so as to yield (pessimistic) estimates of the fall in GDP during these years. This scenario is used as baseline for comparison with further experiments.

In the following figures, we show the time paths of the policy instruments and the endogenous variables for a simulation assuming constant values for the instruments ("simulation") and for the feedback Nash equilibrium solution ("Nash-FB") and the collusive Pareto-optimal solution ("Pareto").

Table 5: Negative asymmetric shock on the demand side

t	1	2	3	4	5	6	7	8	9	...
zd_{1t}	-1	-6	-1	0	0	0	0	0	0	0
zd_{2t}	-1	-6	-1	-6	-8	-6	-4	-2	0	0

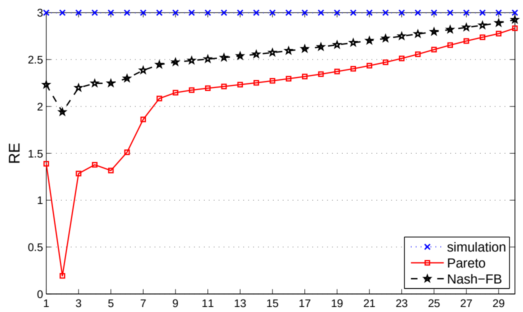


Figure 1: prime rate R_{Et} controlled by the central bank

In the baseline scenario, both countries suffer dramatically from the economic downturn modelled by the demand side shock in the first three periods. Output drops by more than 6%, which for several European countries is a fairly good approximation of what happened in reality. The periphery suffers additionally in the periods 4-8 due to the second negative demand shock, hitting the second bloc only. Without policy intervention a combination of persistent budget deficits and an adverse economic environment leads to skyrocketing public debts, which go up to 200% of GDP for country 1 (core bloc) and 450% for country 2 (periphery bloc). Without active policy intervention at least the second country would go bankrupt long before this level of public debt is achieved. Although such a solution may be regarded as unrealistic, it clearly shows the need for policy actions to stabilize the economies of the monetary union.

The calculated solutions of the baseline scenario imply that the optimal policies of both the governments and the common central bank are countercyclical 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 core bloc, which gives higher importance to the public debt target, follows this line and creates budget surpluses. In contrast, the periphery bloc runs a less

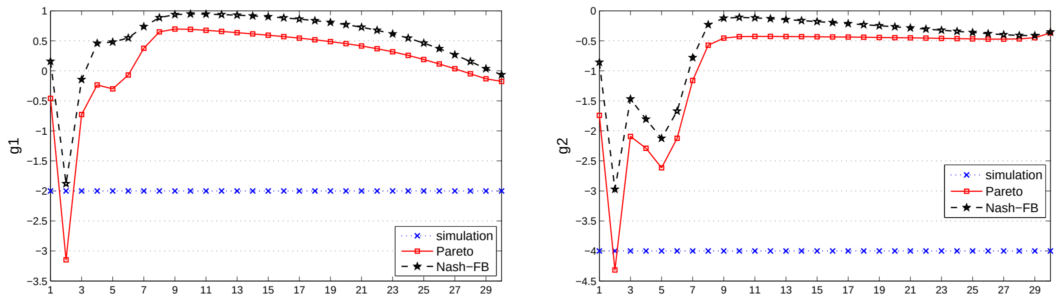


Figure 2: country i's fiscal surplus g_{it} (control variable) for $i = 1$ (core; left) and $i = 2$ (periphery; right)

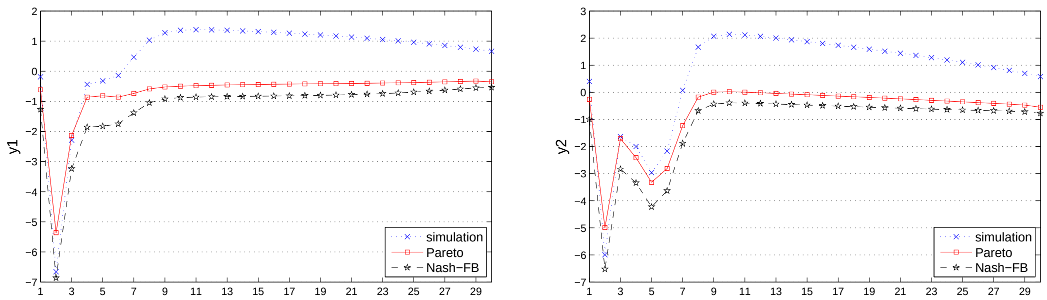


Figure 3: country i's output y_{it} for $i = 1$ (core; left) and $i = 2$ (periphery; right)

prudent fiscal policy. As a result, the public debt of the periphery bloc goes up to 185% of GDP in the case of the Pareto solution and up to 220% of GDP in the case of the feedback Nash equilibrium solution.

The non-cooperative feedback Nash equilibrium solution and the Pareto optimal solution prescribe qualitatively similar but in detail different optimal policies. In comparison to the Pareto optimal solution, the central bank acts less actively and the countries run more restrictive fiscal policies in the non-cooperative Nash equilibrium solution. As a result, output and inflation are slightly below the values achieved in the cooperative solution, and public debt is slightly above. In the Pareto solution the central bank cooperates and is willing to be more active in order to support the countries, which in turn may use fiscal policies to deal with the problem of the recessions by more expansionary activities.

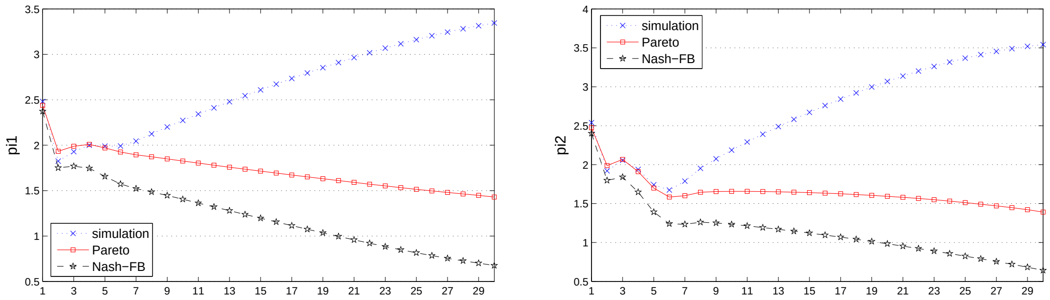


Figure 4: country i's inflation rate π_{it} for $i = 1$ (core; left) and $i = 2$ (periphery; right)

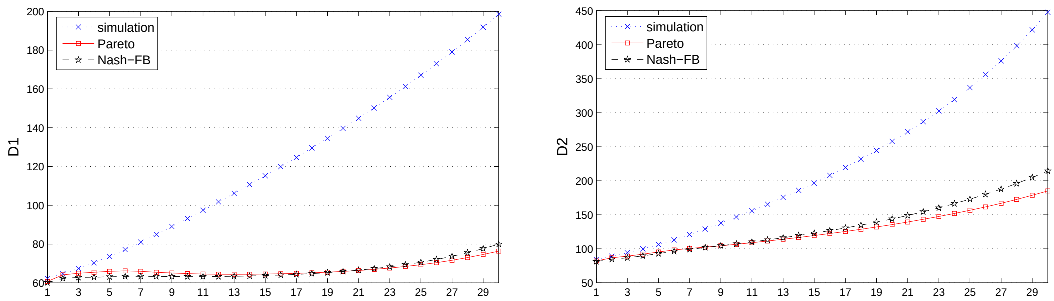


Figure 5: country i's debt level D_{it} for $i = 1$ (core; left) and $i = 2$ (periphery; right)

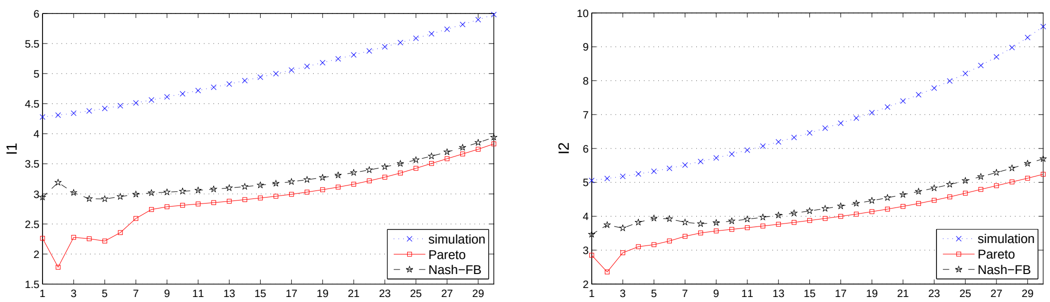


Figure 6: country i's nominal interest rate I_{it} for $i = 1$ (core; left) and $i = 2$ (periphery; right)

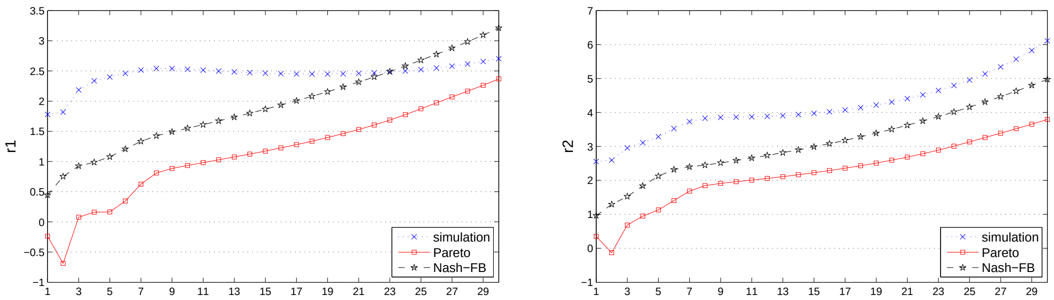


Figure 7: country i's real interest rate r_{it} for $i = 1$ (core; left) and $i = 2$ (periphery; right)

5 Effects and Optimal Policies under Stagflation Shocks

The second sequence of shocks serves to investigate the best macroeconomic policy strategies against different kinds of stagflationary supply side shocks hitting the monetary union several periods after the demand side shock (starting in $t = 9$). We concentrate on four different shocks, a temporary, a reverse and two persistent ones, one expected and one unexpected.

5.1 Impacts of a temporary supply side shock

We first consider a symmetric supply side shock (zs_i), which hits the system only temporarily (for two periods) and then disappears, as shown in Table 6. Furthermore, we run two different experiments for this scenario. In the first experiment, the supply side shock is already known by the players at the beginning of the game (expected), in the second experiment this shock is unexpected for the players.

Table 6: A temporary symmetric shock on the supply side

t	9	10	11	...
zs_{1t}	5	2	0	0
zs_{2t}	5	2	0	0

In the following Figures 8–20, the time paths of the control variables (Figures 8–10) and relevant endogenous variables (11–20) are shown for the feedback Nash equilibrium solution ("Nash-FB") and the Pareto optimal solution ("Pareto"), together with the simulation assuming the constant values of the policy instruments ("simulation"). The left hand panels show the scenario with the shock expected at $t = 0$ ("expected") while the right hand panels present the scenario where the shock is "expected" only at $t = 9$ when it actually occurs, i.e. only the fact that the shock will diminish in period 10 and will be over afterwards is actually expected ("unexpected").

Consider first the expected shock (left panels). Here we can distinguish three consecutive regimes: the Great Recession (periods 1–3), the sovereign debt crisis (periods 4–8) affecting the periphery only, and the supply shock (periods 9–10) and its aftermath. The central bank (Figure 8) applies a more restrictive policy than without a future supply side shock (Figure 1), fixing its prime rate at about one percentage point higher in each period during the first two regimes and approaching the "ideal" value of 3 percent from above

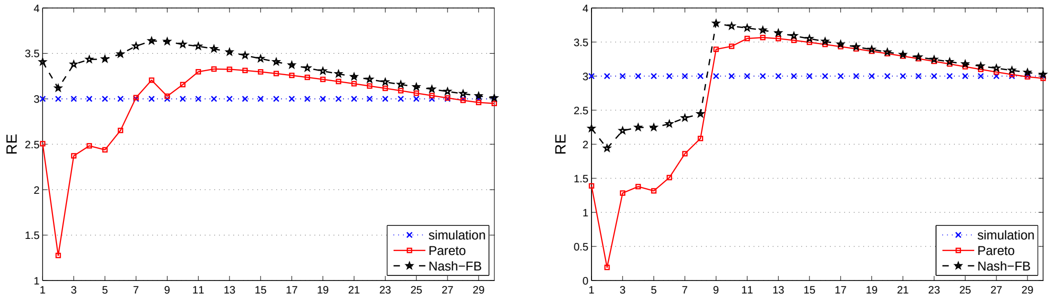


Figure 8: prime rate R_{Et} controlled by the central bank (left: expected scenario; right: unexpected)

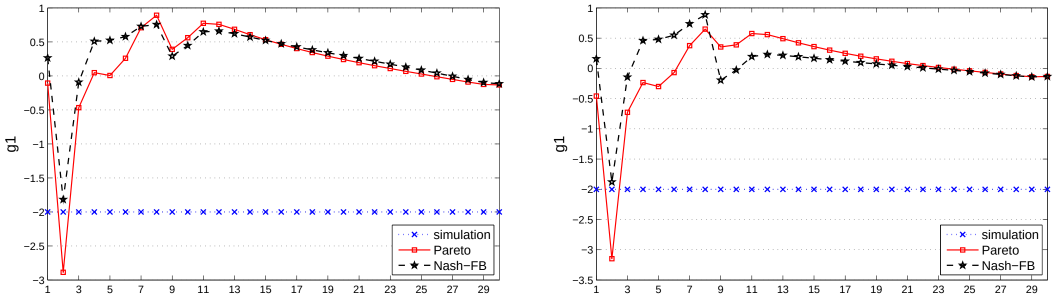


Figure 9: fiscal surplus in country 1, g_{1t} (left: expected scenario; right: unexpected)

after the supply shock. The reason for this is the emphasis of the central bank on the objective of price stability. This pattern holds for both the noncooperative and the cooperative solution, with the latter reacting much more actively in a (weakly) expansionary way during the first and partly the second regime because only in the cooperative solution monetary policy takes account of the preferences of the two governments which are more strongly committed to the output target and less inflation averse because inflation may help them in keeping the public debt down. Also fiscal policies (Figures 9–10) are now more restrictive than without the expected supply side shock, although during the shock the budget surplus is temporarily decreased. It is remarkable that the core produces no budget deficit after the first regime and even the periphery converges quickly to a balanced budget in the third regime, with an even more restrictive fiscal policy course in the cooperative

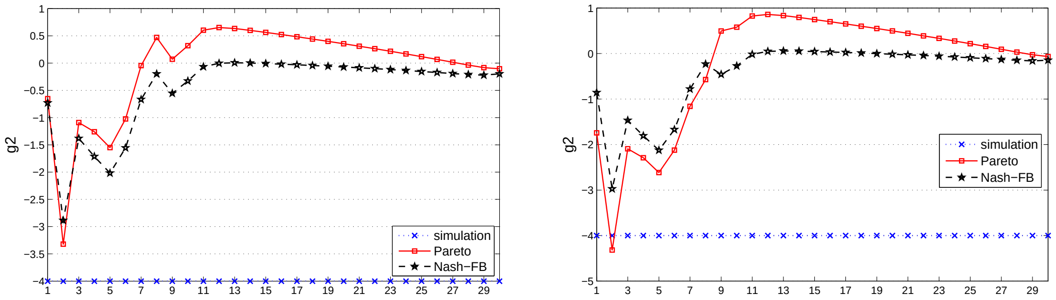


Figure 10: fiscal surplus in country 2, g_{2t} (left: expected scenario; right: unexpected)

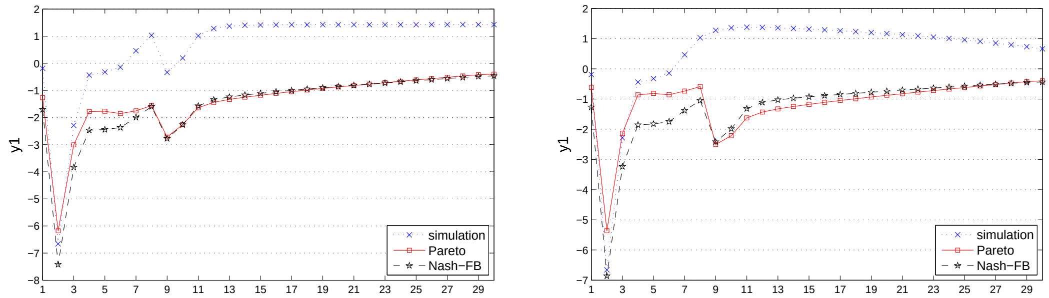


Figure 11: output in country 1, y_{1t} (left: expected scenario; right: unexpected)

solution. This can be interpreted to mean that the much debated short run tradeoff between inflation and unemployment (or short run growth in our model) is superimposed or even dominated by the tradeoff between public debt and short run growth when designing policies towards a stagflationary shock. Monetary policy targets primarily inflation while fiscal policy tries to cope with the dual evil of low short run growth and high government debt.

The results of this policy mix are shown in Figures 11–20. Output remains below the steady state path (the zero level) until the end of the planning period in both blocs, especially in the periphery, resulting in a prolonged recession in the union, in contrast to the baseline scenario (Figure 3) where convergence toward the steady state takes place in the core and the output gap remains below one percent after the first two regimes. The rates of inflation jump upwards by the amount of the initial shock in period 9 and decline

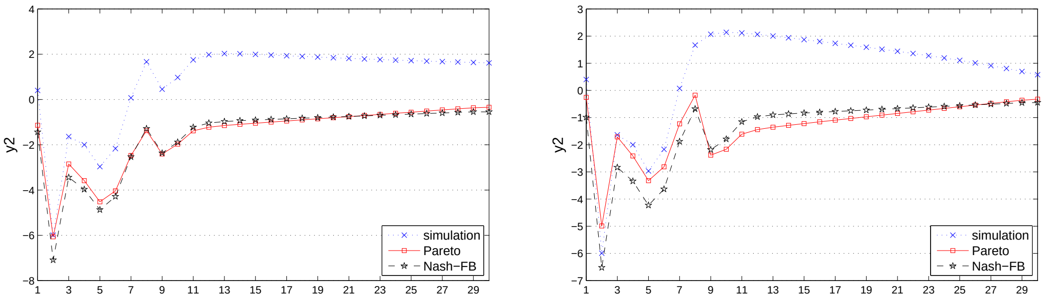


Figure 12: output in country 2, y_{2t} (left: expected scenario; right: unexpected)

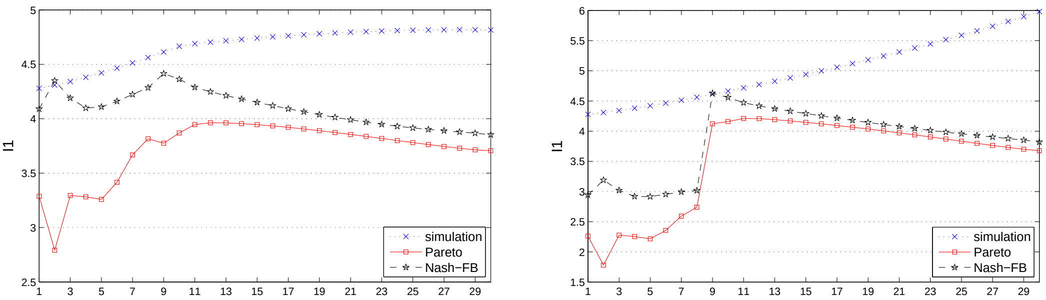


Figure 13: nominal interest rate in country 1, I_{1t} (left: expected scenario; right: unexpected)

afterwards to a permanent level of approx. 4 percent in both blocs. Apart from being undesirable *per se* this higher rate of inflation has two advantages for the governments: it reduces their debt, and it facilitates growth by depressing the real interest rates in spite of the higher nominal interest rates compared to the case without the supply shock (cf. Figures 13–16 with Figures 6 and 7). The effect on government debt seems to be the stronger one, reducing the rise of debt from 20 to around 5 percentage points at the end of the planning period in the core and from around 100 to 25 in the cooperative solution and 60 in the noncooperative solution in the periphery bloc (Figures 5 versus 19–20). Note that the cooperative solution clearly dominates the noncooperative in terms of output and escpecially public debt without much difference with respect to the inflation rate.

Comparing the results for the expected supply shock (left panel) with

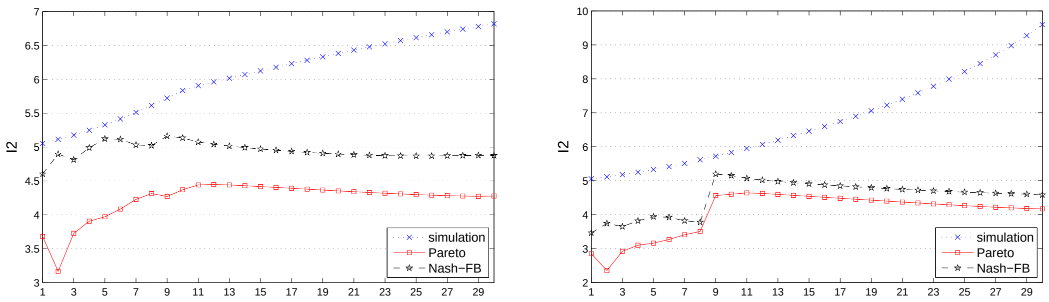


Figure 14: nominal interest rate in country 1, I_{2t} (left: expected scenario; right: unexpected)

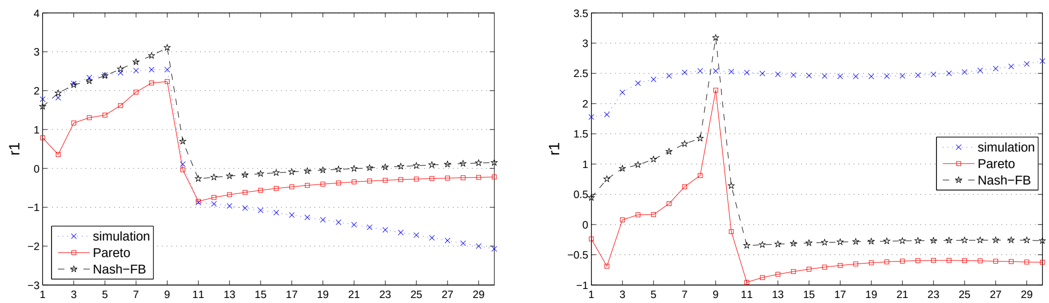


Figure 15: real interest rate in country 1, r_{1t} (left: expected scenario; right: unexpected)

those for the unexpected shock (right panel), we see that in the latter case the reactions of policies during the first two regimes are nearly the same as in the baseline scenario. The immediate policy reactions of both the central bank and the governments on the supply shock are stronger than when the shock is expected, but afterwards all policy makers pursue similar strategies, combating the supply shock by mildly restrictive policies. The policy regime change due to the stagflationary shock results in stronger output and inflation effects than under the expected shock but to a more favorable development of public debt in both blocs. Again, the higher inflation is mainly responsible for this last result, which can be interpreted as unexpected inflation working as a blessing for indebted governments (but, of course, not for their creditors). Except for the inflation rate the better performance for both countries in the cooperative solution than in the noncooperative equilibrium is obtained also

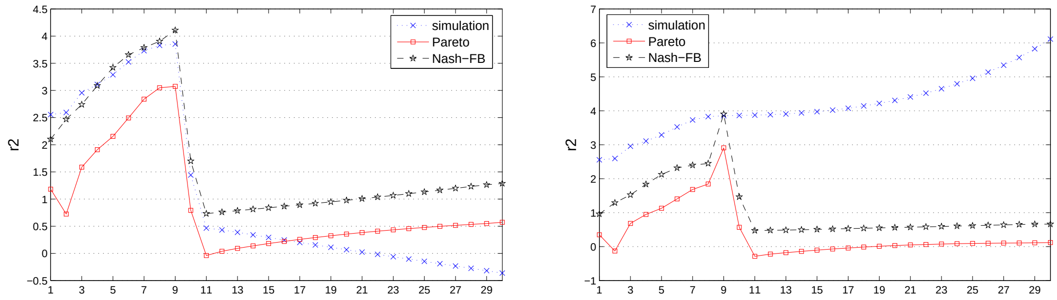


Figure 16: real interest rate in country 2, r_{2t} (left: expected scenario; right: unexpected)

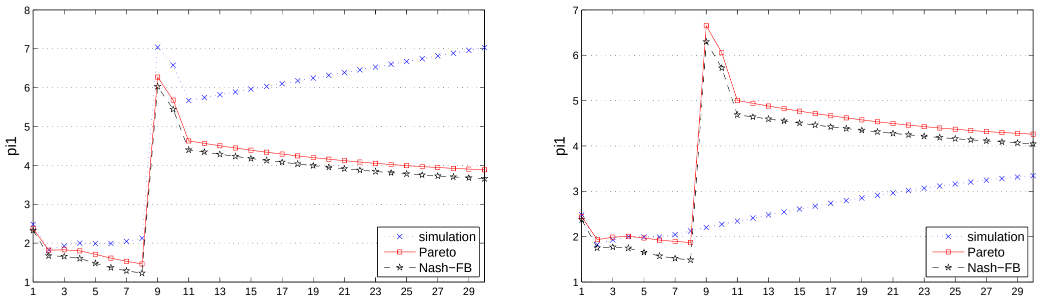


Figure 17: inflation rate in country 1, π_{1t} (left: expected scenario; right: unexpected)

under the unexpected supply side shock.

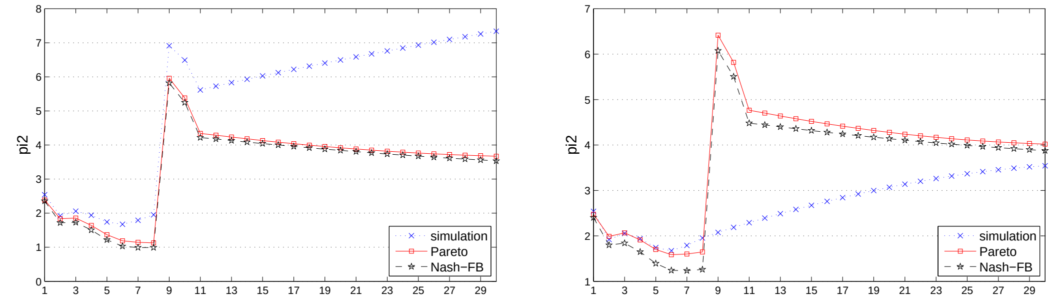


Figure 18: inflation rate in country 2, π_{2t} (left: expected scenario; right: unexpected)

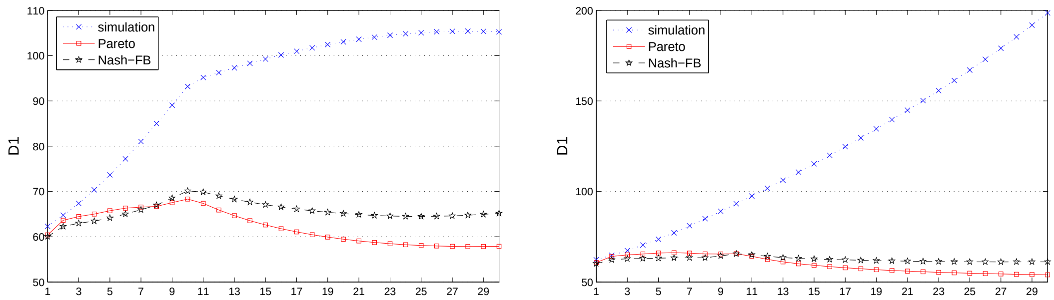


Figure 19: public debt in country 1, D_{1t} (left: expected scenario; right: unexpected)

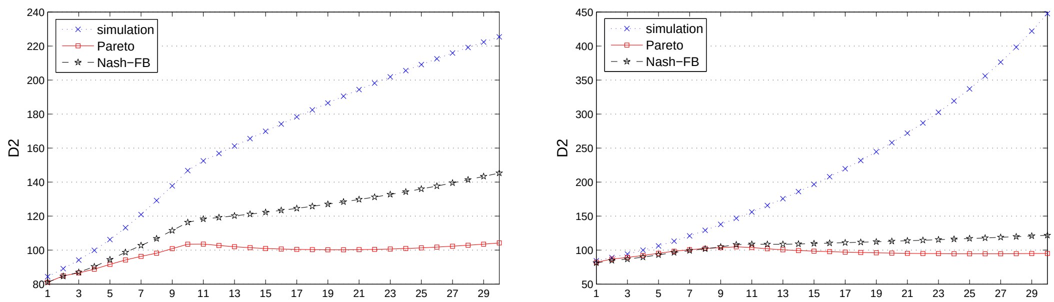


Figure 20: public debt in country 2, D_{2t} (left: expected scenario; right: unexpected)

5.2 Impacts of a reverse supply side shock

Next, we consider a symmetric supply side shock (zs_i), which hits the system for two periods and then reverses as given in Table 7. Furthermore, we again run two different experiments for this scenario. In the first experiment, the supply side shock is already known by the players at the beginning of the game (i.e. expected); in the second experiment this shock is unexpected by the players. Figures 21–33 show the results in a similar way as before.

Table 7: A reverse symmetric shock on the supply side

t	9	10	11	12	13	14	15	...
zs_{1t}	5	2	-2	-2	-2	-1	0	0
zs_{2t}	5	2	-2	-2	-2	-1	0	0

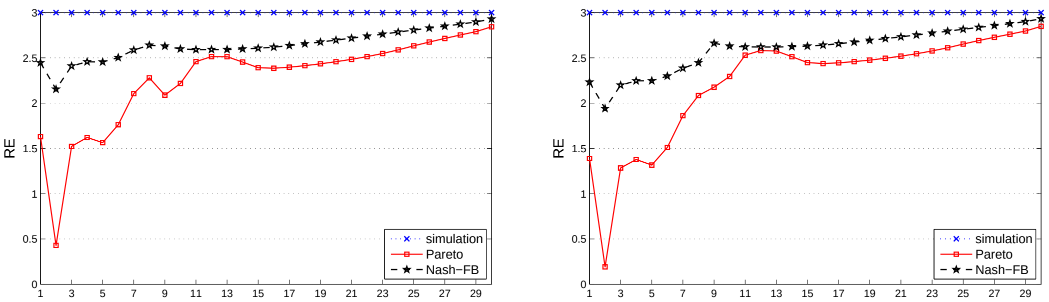


Figure 21: prime rate R_{Et} controlled by the central bank (left: expected scenario; right: unexpected)

Comparing the results with the corresponding ones for the temporary shock without reversion (Figures 8–20), we see that the need for restrictive demand management is much reduced in these scenarios, and the difference between the expected and the unexpected shock scenarios are much smaller (as is their difference from the baseline). The reverse shock requires some fine tuning by the central bank and the governments (stronger for fiscal than monetary policy), and there is a second business cycle due to the shock, but the long run output effect is more favorable than with the temporary shock in spite of higher nominal and real interest rates due to the reversion and even decline of inflation after the shock. On the other hand, the lower inflation causes government debt to rise considerably more than under the termporary shock, in the case of bloc 2 to nearly 200 percent at the end of

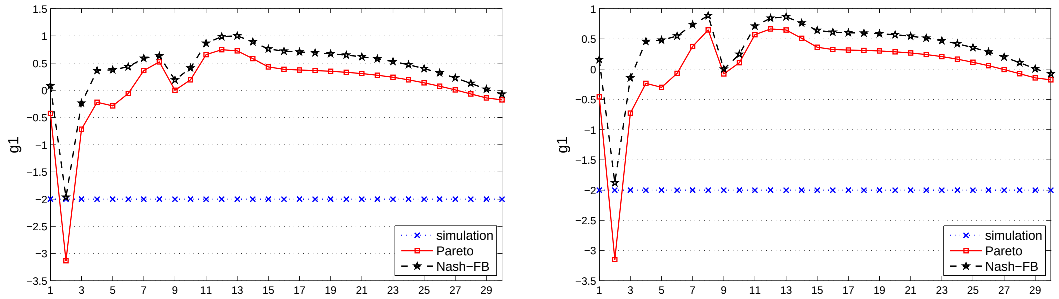


Figure 22: fiscal surplus in country 1, g_{1t} (left: expected scenario; right: unexpected)

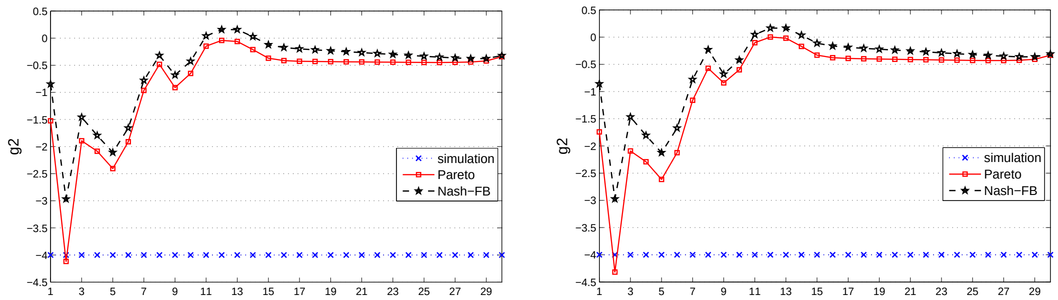


Figure 23: fiscal surplus in country 2, g_{2t} (left: expected scenario; right: unexpected)

the planning period. Again the cooperative solution gives higher (and closer to steady state) output and lower debt increases than the noncooperative equilibrium but higher inflation rates, showing that higher inflation may be in the interest of highly indebted governments.

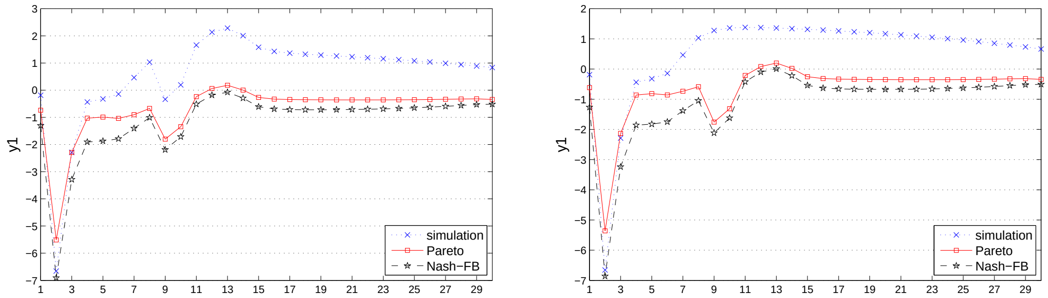


Figure 24: output in country 1, y_{1t} (left: expected scenario; right: unexpected)

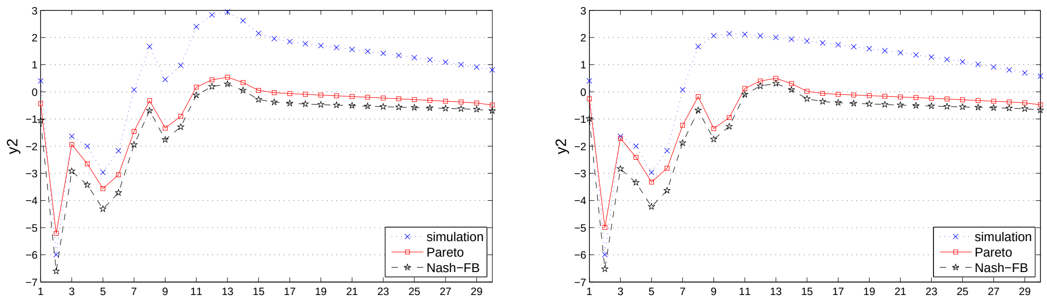


Figure 25: output in country 2, y_{2t} (left: expected scenario; right: unexpected)

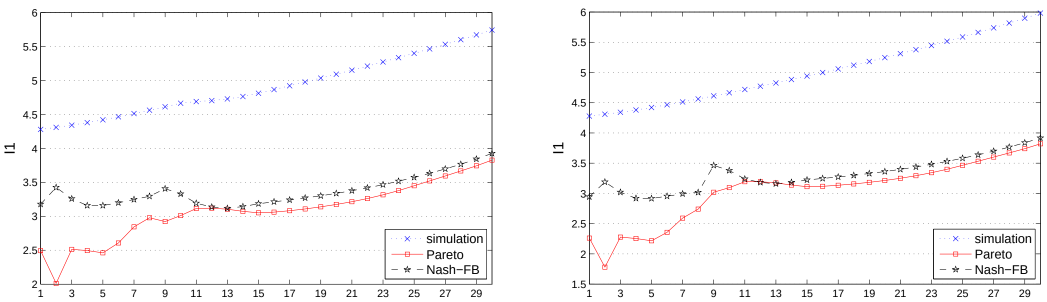


Figure 26: nominal interest rate in country 1, I_{1t} (left: expected scenario; right: unexpected)

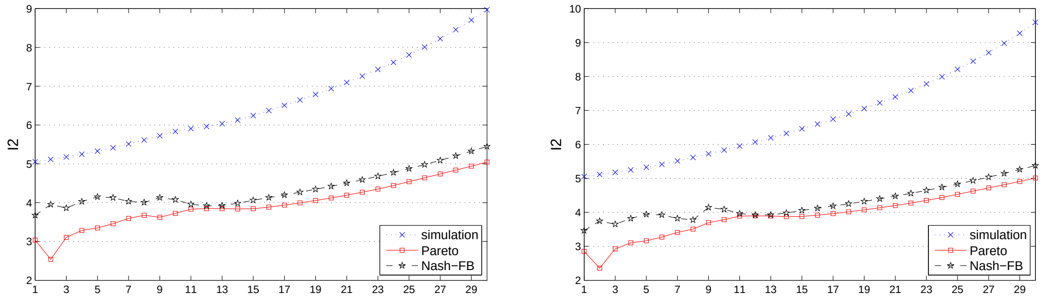


Figure 27: nominal interest rate in country 1, I_{2t} (left: expected scenario; right: unexpected)

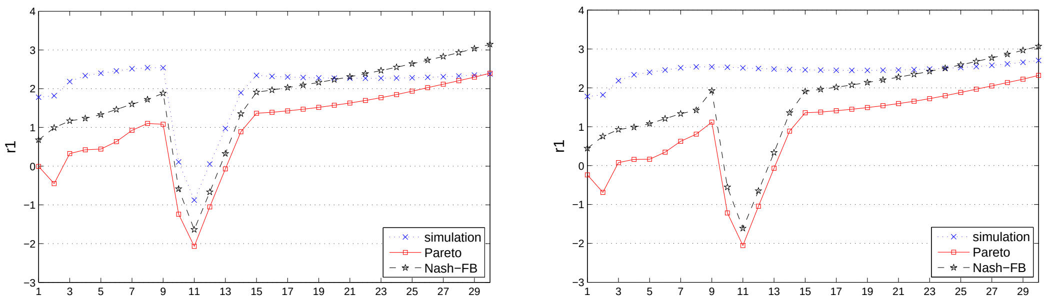


Figure 28: real interest rate in country 1, r_{1t} (left: expected scenario; right: unexpected)

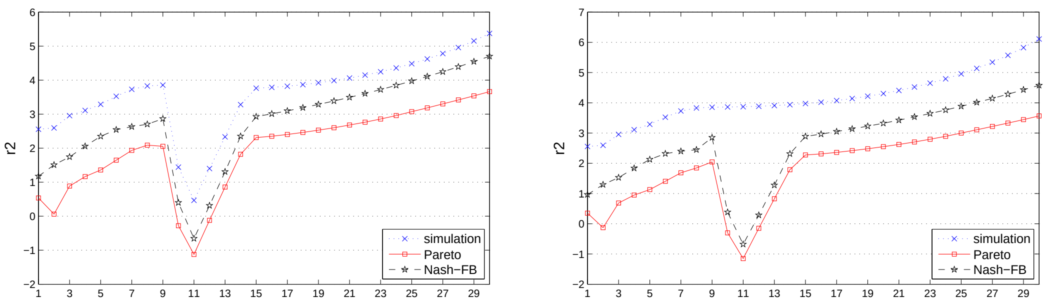


Figure 29: real interest rate in country 2, r_{2t} (left: expected scenario; right: unexpected)

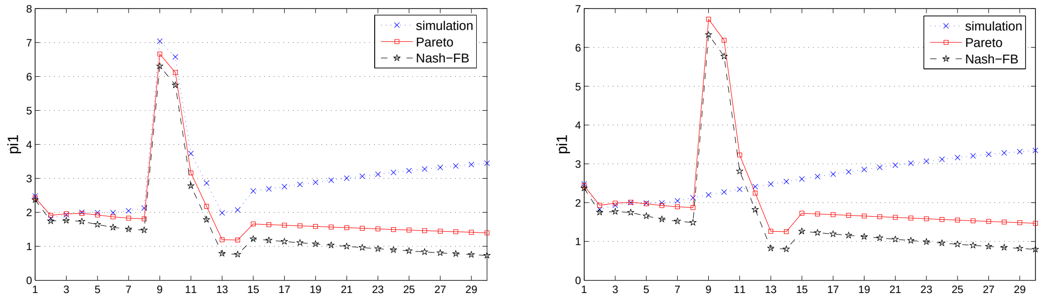


Figure 30: inflation rate in country 1, π_{1t} (left: expected scenario; right: unexpected)

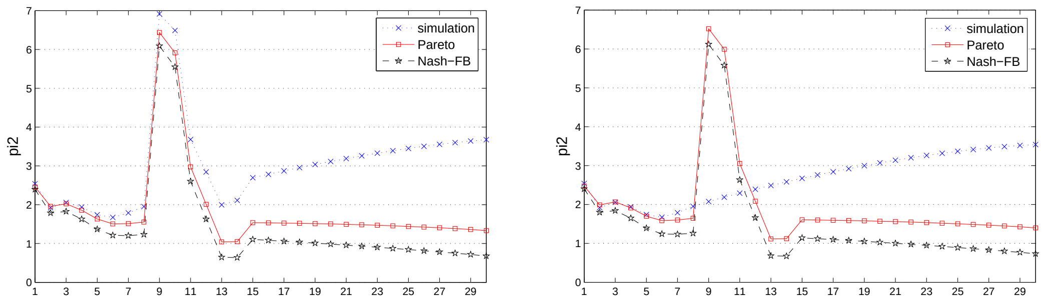


Figure 31: inflation rate in country 2, π_{2t} (left: expected scenario; right: unexpected)

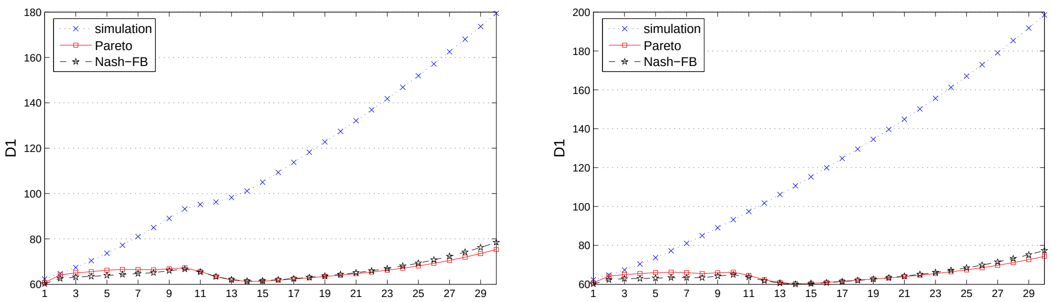
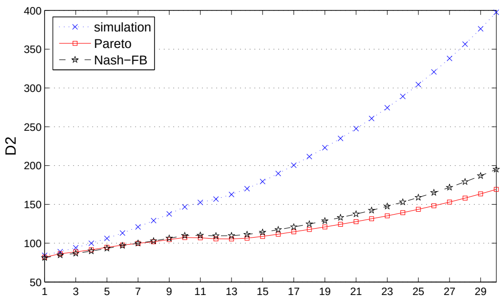


Figure 32: public debt in country 1, D_{1t} (left: expected scenario; right: unexpected)



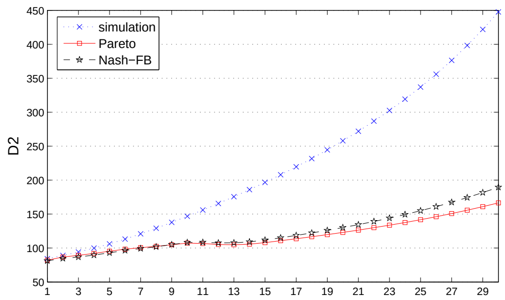


Figure 33: public debt in country 2, D_{2t} (left: expected scenario; right: unexpected)

5.3 Impacts of an expected persistent supply side shock

In this section we consider a symmetric supply side shock (zs_i), which hits the union for two periods and then persists in a reduced form until the end of the planning horizon as given in Table 8. We assume that policy makers know from the beginning that his shock will occur.

Table 8: A persistent symmetric shock on the supply side

t	9	10	11	...
zs_{1t}	5	2	0.5	0.5
zs_{2t}	5	2	0.5	0.5

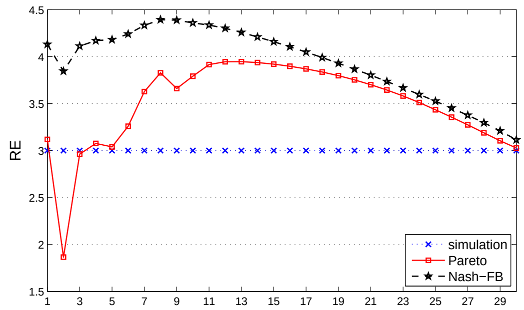


Figure 34: prime rate R_{Et} controlled by the central bank

From the point of view of the output-inflation tradeoff, the scenario of permanent stagflation is the worst of all possible worlds: permanently higher or even increasing inflation and lower or even decreasing actual and potential output. We have seen so far that in our framework optimal policies towards supply shocks tend to be restrictive; especially monetary policy reacts by increasing the prime rate above its target value to keep inflation under control. This is even more the case in the present scenario of permanent stagflation (Figure 34), and a similar though weaker tendency applies to fiscal policy (Figure 35). Now the negative effects on output are stronger although in the long run its behavior is similar to the scenarios with a temporary supply shock. In spite of the restrictive demand side policies inflation increases permanently after the initial shock (Figure 37).

This results in a fall of the real interest rate well below zero and a reversion of the increase in public debt, especially in the core but also in the periphery

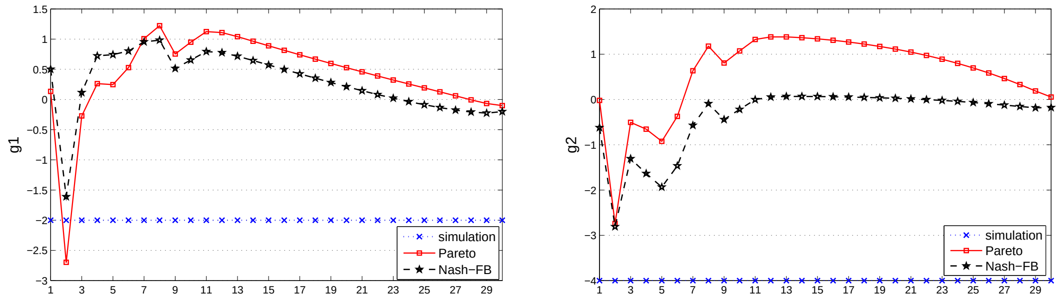


Figure 35: country i's fiscal surplus g_{it} (control variable) for $i = 1$ (core; left) and $i = 2$ (periphery; right)

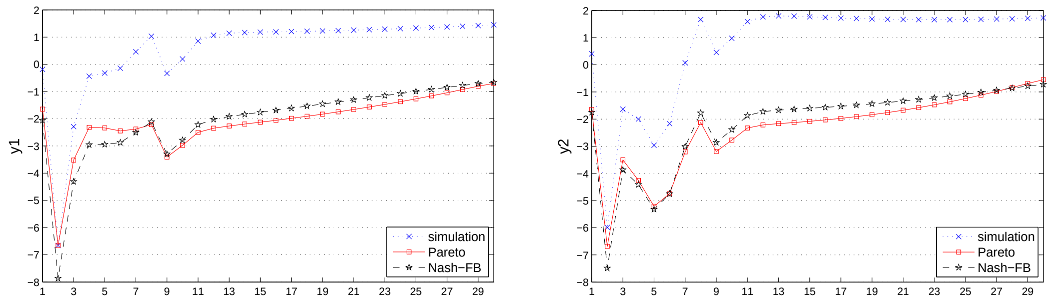


Figure 36: country i's output y_{it} for $i = 1$ (core; left) and $i = 2$ (periphery; right)

in the cooperative solution. The decline of public debt contributes to the fall in real interest rates by reversing also nominal interest rate increases. For a government with a low preference for price stability but high public debt, such a scenario of a permanent negative supply shock is not too bad altogether: it gets rid of a considerable portion of its debt with only minor output losses. The price to be paid in terms of higher and increasing inflation may seem to be acceptable for such a country. What cannot be inferred from the present analysis is, however, the long run negative allocative effect of an inflation that may sooner or later become a hyperinflation, in particular because additional antiinflationary monetary policy measures may be exhausted soon.

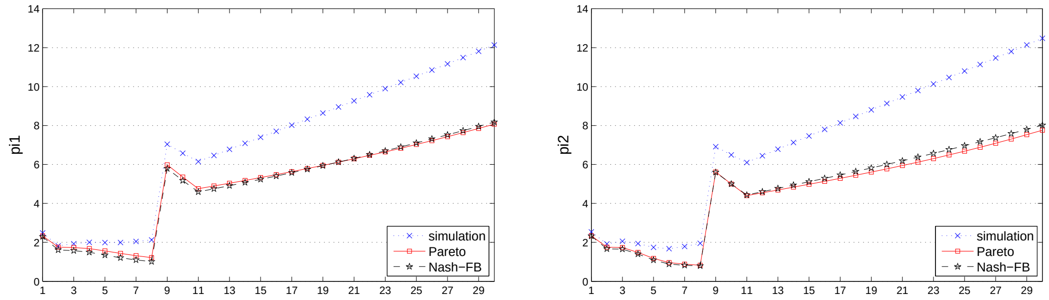


Figure 37: country i's inflation rate π_{it} for $i = 1$ (core; left) and $i = 2$ (periphery; right)

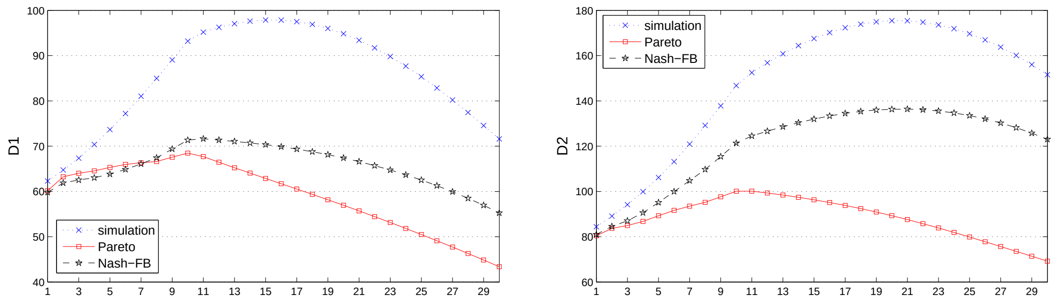


Figure 38: country i's debt level D_{it} for $i = 1$ (core; left) and $i = 2$ (periphery; right)

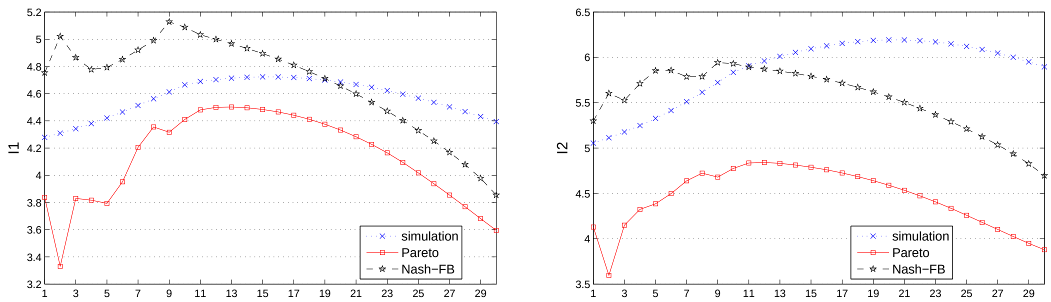


Figure 39: country i's nominal interest rate I_{it} for $i = 1$ (core; left) and $i = 2$ (periphery; right)

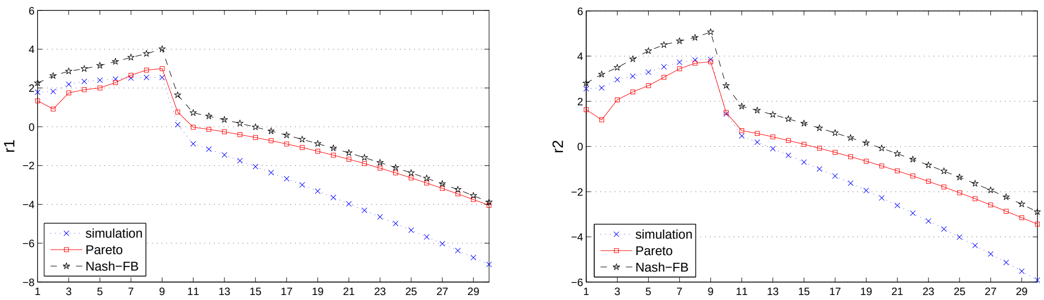


Figure 40: country i's real interest rate r_{it} for $i = 1$ (core; left) and $i = 2$ (periphery; right)

5.4 Impacts of an unexpected persistent supply side shock

Finally, in this section we consider again a persistent supply side shock as in the previous section (see Table 8). This shock hits the monetary union for two periods and then persists in a reduced form until the end of the planning horizon. In contrast to the previous section, in this experiment the shock is unexpected, however. It means that the players get information about the occurrence and the size of the shock only in time period 9.

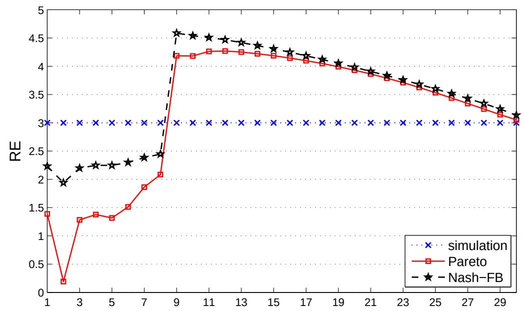


Figure 41: prime rate R_{Et} controlled by the central bank

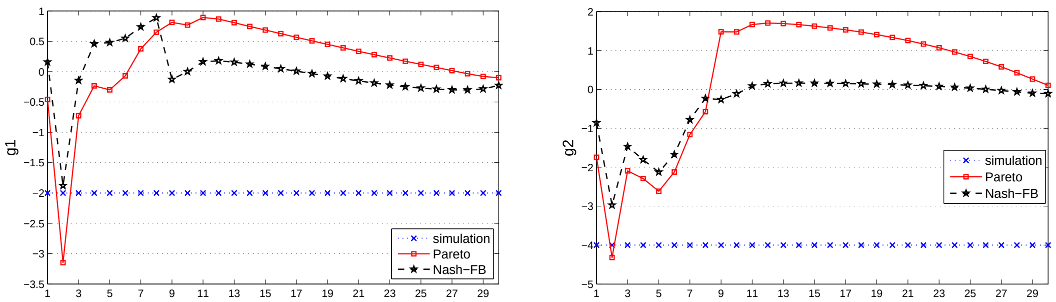


Figure 42: country i's fiscal surplus g_{it} (control variable) for $i = 1$ (core; left) and $i = 2$ (periphery; right)

As the mechanism of the model and the policy reactions to various supply side shocks should have become clear by now, we confine ourselves to a few remarks here. A comparison of the results with those of Section 5.3 shows that we have a regime change in fiscal and especially monetary policies from expansionary leaning against the wind during the Great Recession

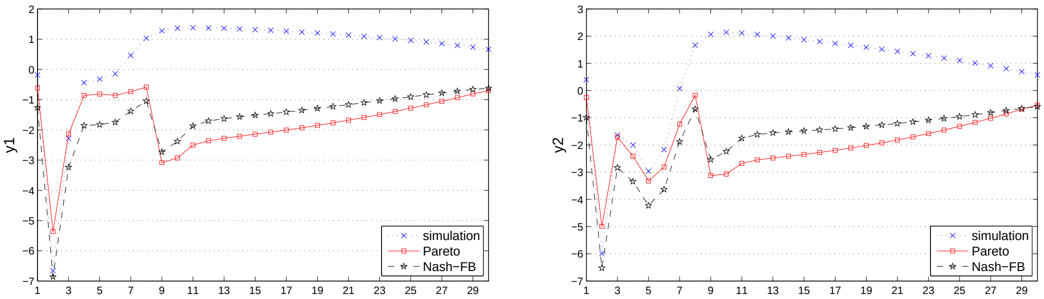


Figure 43: country i's output y_{it} for $i = 1$ (core; left) and $i = 2$ (periphery; right)

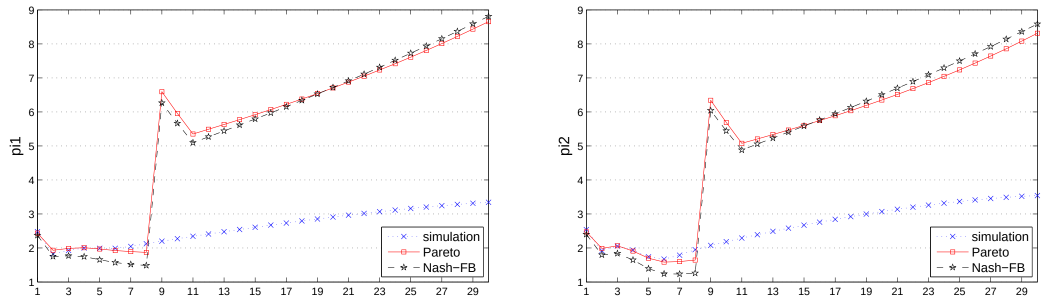


Figure 44: country i's inflation rate π_{it} for $i = 1$ (core; left) and $i = 2$ (periphery; right)

(and, for monetary policy, during the sovereign debt crisis) to more restrictive antiinflation policies after the supply side shock occurs. Inflation increases more than under the expected shock, unwanted output effects are smaller, and government debts decrease more, especially in the periphery which in the cooperative solution commits itself to considerable budget surpluses over several years to reduce its debt by about one third of the initial level (relative to output). It seems as if the advent of an exogenous unexpected price shock were an appropriate way of solving temporarily the problem of the indebtedness of the periphery. The price to be paid for this effect is minor in terms of output losses but high in terms of inflation in the entire monetary union.

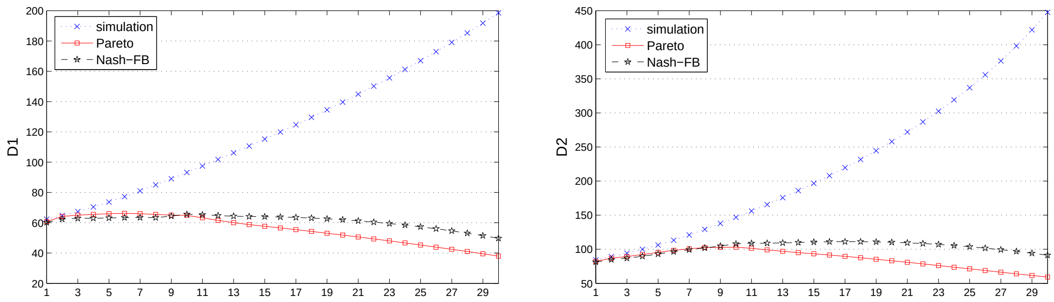


Figure 45: country i's debt level D_{it} for $i = 1$ (core; left) and $i = 2$ (periphery; right)

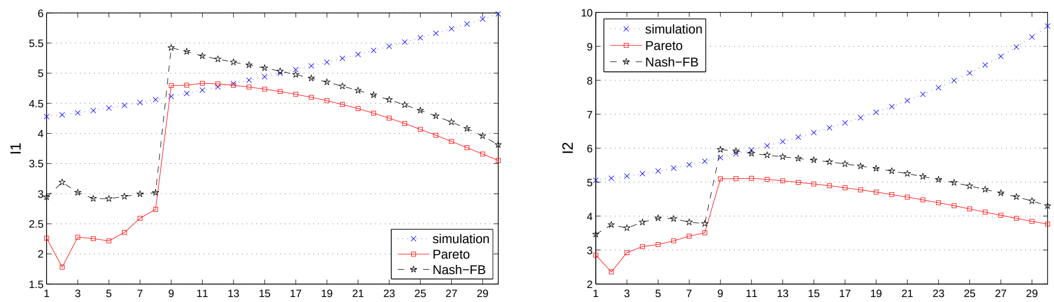


Figure 46: country i's nominal interest rate I_{it} for $i = 1$ (core; left) and $i = 2$ (periphery; right)

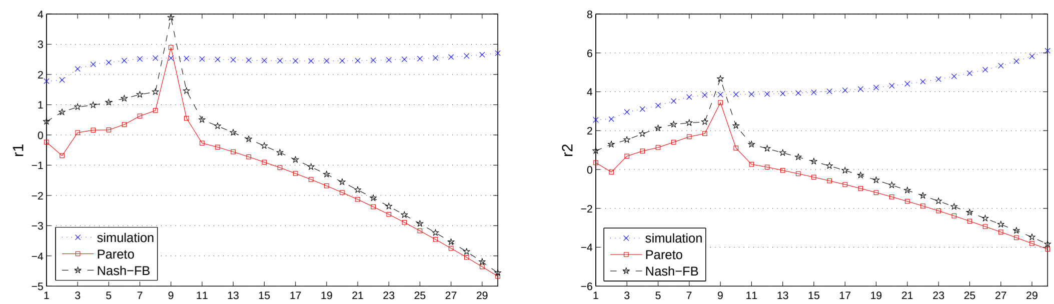


Figure 47: country i's real interest rate r_{it} for $i = 1$ (core; left) and $i = 2$ (periphery; right)

6 Concluding Remarks

In this paper we analyzed noncooperative equilibrium and cooperative strategies of fiscal and monetary policy makers in a macroeconomic model of a monetary union consisting of two blocs (treated as countries), core and periphery. The model was calibrated so as to mirror some essential aspects of the Euro Area from the Great Recession to the sovereign debt crisis and to serve as basis for investigating macroeconomic effects of possible future developments. In particular, various adverse (stagflationary) supply side shocks and their effects on key macroeconomic variables and on optimal policy strategies were examined; a temporary, a reverse, and a persistent drop of exogenous aggregate supply affecting the entire monetary union. The results show that such shocks provide a challenge for the policy makers of the monetary union, with a tradeoff especially between the requirement of keeping output (and implicitly employment) close to its natural levels containing the increase in inflation, and the avoidance of excessive government debt threatening the solvency of the union, in particular its periphery bloc. It seems that the tradeoff between high inflation and increasing public debt is stronger than that between output and inflation, as restrictive monetary and fiscal policies have only relatively small negative side effects on output. The policies called for are mildly restrictive; monetary policy is directed primarily towards combating inflation while fiscal policies are concerned about government debt with only small side effects on output. An unexpected increase in inflation may help reduce the periphery's public debt considerable. In all scenarios, the cooperative solution dominates the nooncooperative equilibrium solution, which may be interpreted as an argument in favor of an enforceable pact among governments and the common central bank.

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