

Every Country for Itself, and the Central Bank for Us All?

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The Euro Area: Spillover in the crisis?



Dynamic policy game

- 4 Players with different objectives J_1, J_2, J_3, J_E and targets
- the dynamic model MUMOD2 as a constraint
- solution algorithm: OPTGAME

OPTGAME

can deliver approximate solutions for '**tracking games**' with quadratic objective functions and nonlinear dynamic system.

Calibration for EMU

'Core': Austria, Belgium, Estonia, Finland, France, Germany, Luxembourg, Malta, Netherlands and Slovakia

'Periphery': Cyprus, Greece, Ireland, Italy, Portugal, Slovenia and Spain

Dynamic optimization problem

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

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

with

$$x_t = f(x_{t-1}, x_t, u_t^1, \dots, u_t^N, z_t)$$

where $X_t = [x_t \ u_t^1 \ \dots \ u_t^N]'$ - aggregated vector, x_t - state variables,
 u_t - control variables, z_t - exogenous variables
 $\tilde{X}_t^i = [x_t^i \ u_t^{i1} \ \dots \ u_t^{iN}]'$ - aggregated vector of desired values,
 Ω_t^i - penalty matrix

The MUMOD2 model

Table 1: Variables of the three-country ($i=1:3$) monetary union model MUMOD2

Control variables	
g_{it}	real fiscal surplus of country i
R_{Et}	prime rate
Endogenous variables	
y_{it}	short-term deviations from the LR equilibrium output level
π_{it}	inflation rate of country i
π_{it}^e	expected inflation rate of country i
D_{it}	real government debt of country i
π_{Et}	weighted inflation rate in the monetary union
y_{Et}	weighted output in the monetary union
l_{it}	nominal interest rate in country i
r_{it}	real interest rate in country i
Bl_{it}	average interest rate for government bonds of country i

$$y_{it} = \delta_i \left(\frac{\pi_{jt} + \pi_{kt}}{2} - \pi_{it} \right) - \gamma_i (r_{it} - \theta) + \rho_{ij} y_{jt} + \rho_{ik} y_{kt} - \beta_i \pi_{it} + \kappa_i y_{i,t-1} - \eta_i g_{it} + z d_{it}, \quad (1)$$

$$r_{it} = l_{it} - \pi_{it}^e, \quad (2)$$

$$l_{it} = R_{Et} - \lambda_i g_{it} + \chi_i D_{it} + z h p_{it}, \quad (3)$$

$$\pi_{it} = \pi_{it}^e + \xi_i y_{it} + z s_{it}, \quad (4)$$

$$\pi_{it}^e = \varepsilon_i \pi_{i,t-1} + (1 - \varepsilon_i) \pi_{i,t-1}^e, \quad \varepsilon \in [0, 1], \quad (5)$$

$$y_{Et} = \sum_{i=1}^3 \omega_i y_{it}, \quad \pi_{Et} = \sum_{i=1}^3 \omega_i \pi_{it}, \quad \sum_{i=1}^3 \omega_i = 1, \quad (6)$$

$$D_{it} = (1 + B l_{i,t-1} - \pi_{i,t-1}^e) D_{i,t-1} - g_{it} + z h_{it}, \quad (7)$$

$$B l_{it} = \frac{1}{6} \sum_{\tau=t-5}^t l_{it}. \quad (8)$$

4 decision-makers with different objectives

$$\mathbf{J}_i = \frac{1}{2} \sum_{t=1}^T \left(\frac{1}{1 + \frac{\theta}{100}} \right)^t \{ \alpha_{\pi i} (\pi_{it} - \tilde{\pi}_{it})^2 + \alpha_{y_i} (y_{it} - \tilde{y}_{it})^2 + \alpha_{D_i} (D_{it} - \tilde{D}_{it})^2 + \alpha_{g_i} g_{it}^2 \},$$

($i = 1, 2, 3$).

$$\mathbf{J}_E = \frac{1}{2} \sum_{t=1}^T \left(\frac{1}{1 + \frac{\theta}{100}} \right)^t \{ \alpha_{\pi E} (\pi_{Et} - \tilde{\pi}_{Et})^2 + \alpha_{y_E} (y_{Et} - \tilde{y}_{Et})^2 + \alpha_E (R_{Et} - \tilde{R}_{Et})^2 \}.$$

cooperative Pareto-optimal solution:

$$J = \mu_1 J_1 + \mu_2 J_2 + \mu_3 J_3 + \mu_E J_E, \quad (\mu_1 + \mu_2 + \mu_3 + \mu_E = 1)$$

Table 2: Parameter values for an asymmetric monetary union ($i=1,2,3$)

Var	Initial	Target	Weight
y_i	0	0	1
y_E	0	0	0.5
π_i	2.5	2	0.5
π_E	2.5	2	2
D_1	60	60	1
D_2	80	60	1
D_3	80	60	0.1
g_1	-2	0	1
$g_{2,3}$	-4	0	1
R_E	3	3	5

Table 3: Additional parameters of the game set-up

Parameter	Value	Description
T	30	length of planning horizon
ω_1	0.6	measure of the economic importance of core
ω_2, ω_3	0.2	measure of the economic importance of periphery

Negative demand shocks

Table 4: Reconstruction of the financial and sovereign debt crises

t	1	2	3	4	5	6	7	8	9	...
year	'08	'09	'10	'11	'12	'13	'14	'15	'16	...
zd_{1t}	-1	-6	-1	0	0	0	0	0	0	0
zd_{2t}	-1	-6	-1	-3	-4	-3	-1	0	0	0
zd_{3t}	-1	-6	-1	-3	-4	-3	-1	0	0	0

Coalition strategies by facing negative demand shocks

	scenario	game strategy
1	everyone for itself	Nash FB with 4 players
2	core vs periphery: coalition of periphery countries	Nash FB with 3 players
3	thrifty vs thriftless: coalition of countries 1 & 2	Nash FB with 3 players
4	fiscal union: coalition of 3 countries	Nash FB with 2 players
5	fiscal and monetary union	Pareto solution

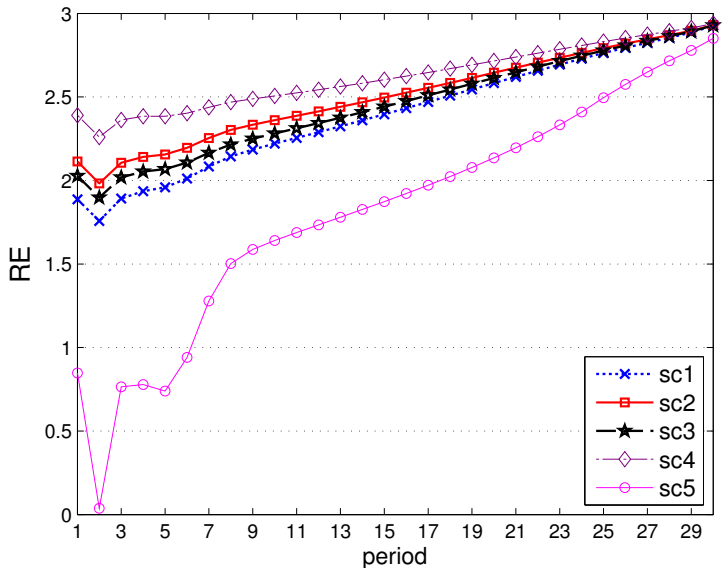


Figure 1: prime rate R_{Et} controlled by the central bank

Table 5: Objective function values

sc	CB	C1	C2	C3
sc1	81.21	62.08	145.56	95.13
sc2	62.69	56.48	138.89	109.44
sc3	68.27	75.99	139.60	86.11
sc4	41.74	80.55	125.16	111.05
sc5	101.44	33.43	46.13	44.91

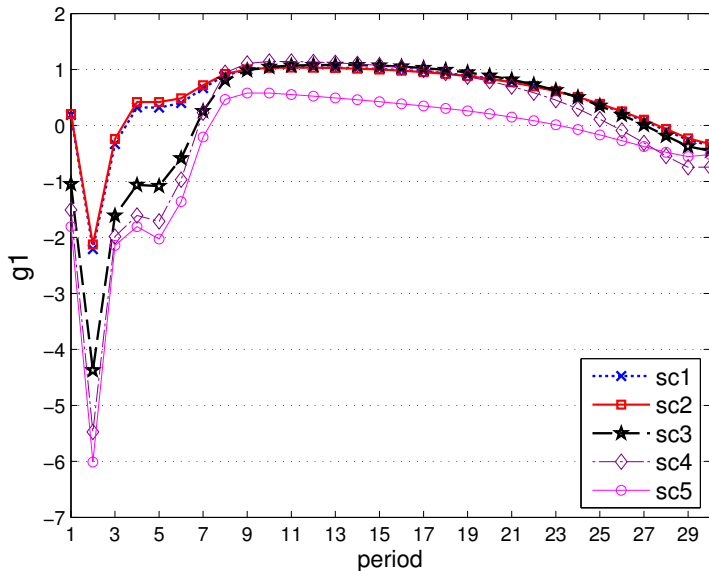


Figure 2: country 1's fiscal surplus g_{1t} (control variable)

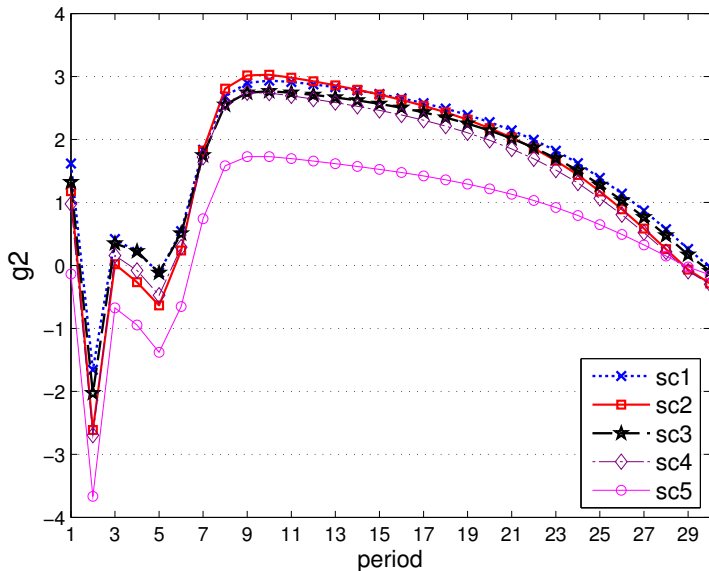


Figure 3: country 2's fiscal surplus g_{2t} (control variable)

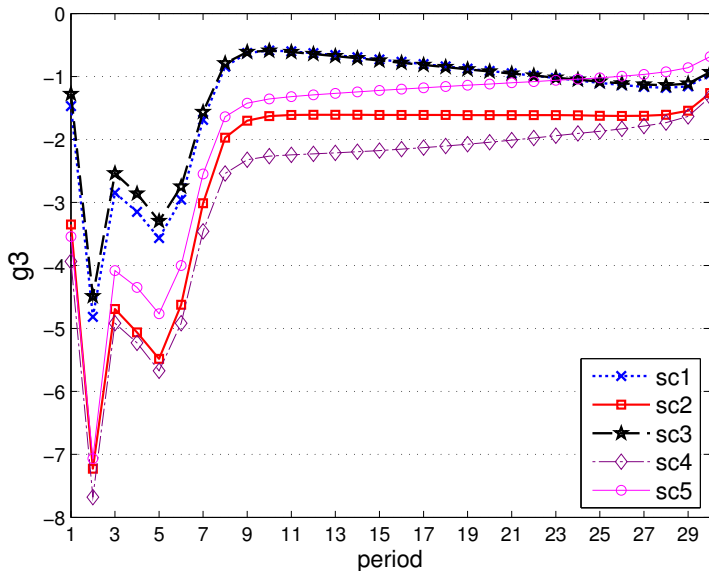


Figure 4: country 3's fiscal surplus g_{3t} (control variable)

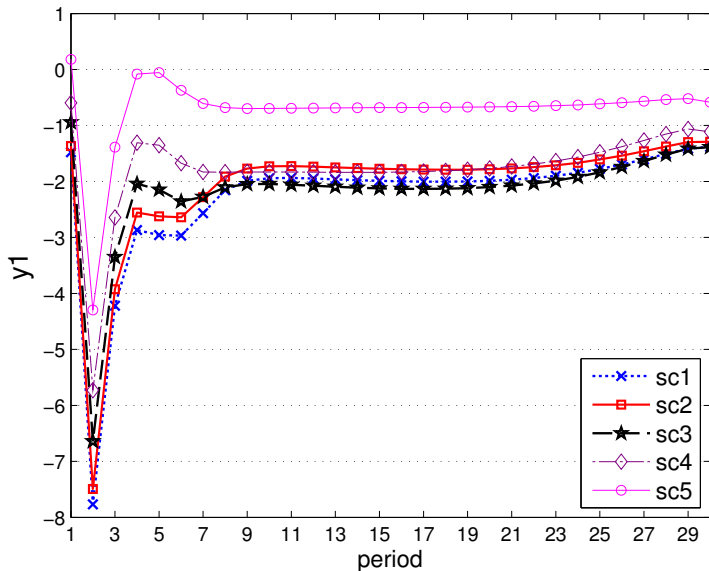


Figure 5: country 1's output y_{1t}

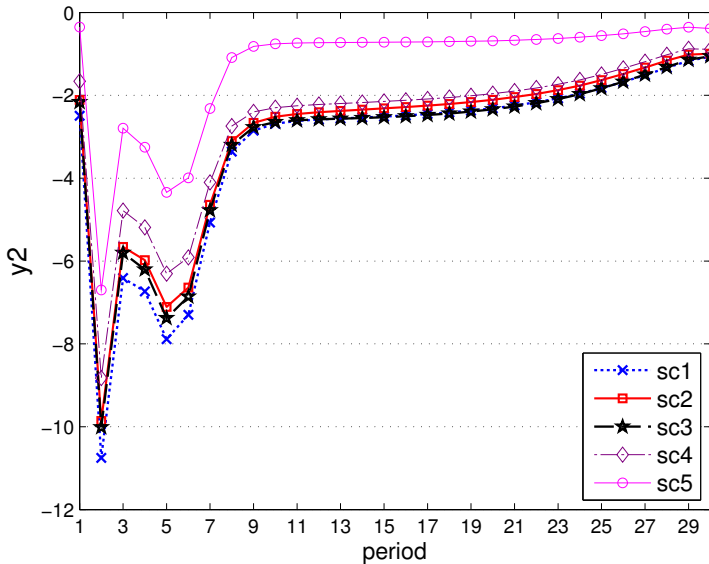


Figure 6: country 2's output y_{2t}

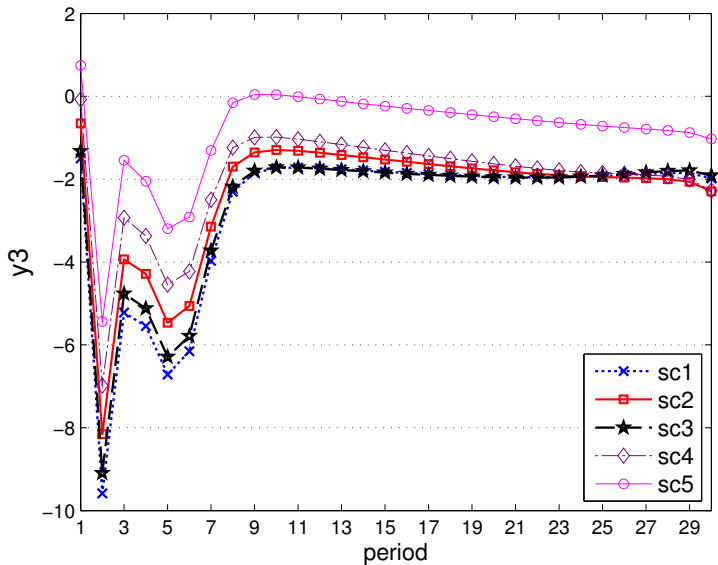


Figure 7: country 3's output y_{3t}

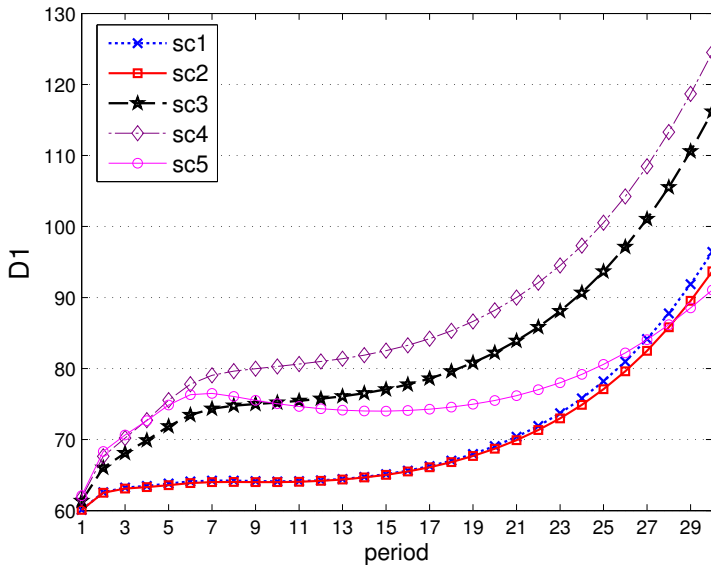


Figure 8: country 1's debt level D_{1t}

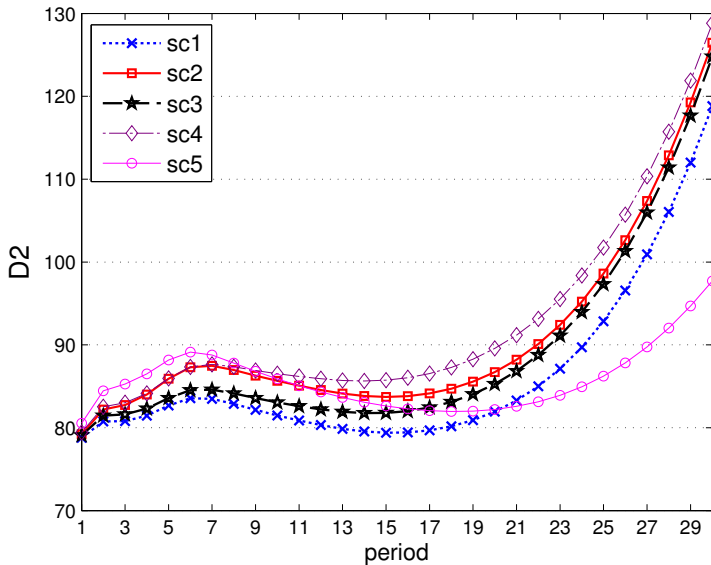


Figure 9: country 2's debt level D_{2t}

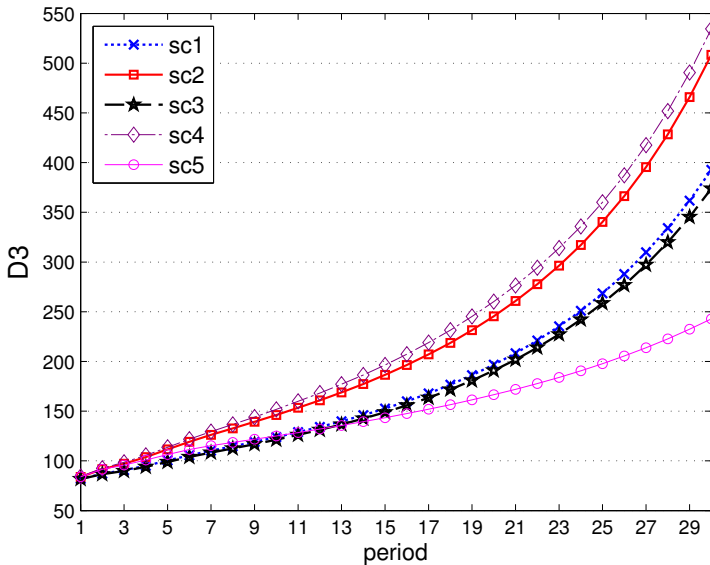


Figure 10: country 3's debt level D_{3t}

Table 6: Objective function values

sc	CB	C1	C2	C3
sc1	81.21	62.08	145.56	95.13
sc2	62.69	56.48	138.89	109.44
sc3	68.27	75.99	139.60	86.11
sc4	41.74	80.55	125.16	111.05
sc5	101.44	33.43	46.13	44.91
sc	C1+C2	C2+C3	C1+C2+C3	CB+C1+C2+C3
sc1	207.64	240.69	302.76	383.97
sc2	195.37	248.33	304.81	367.50
sc3	215.59	225.71	301.70	369.97
sc4	205.70	236.20	316.75	358.49
sc5	79.56	91.04	124.46	225.91

Thank you for your attention!