Expectations and Systemic Risk in EMU Government Bond Spreads

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Motivation

Recent developments in the European government bond market has prompt many to revise their view on the underlying causes of debt crisis in the Euro Zone, giving rise to a new set of models that emphasize new risks: the risk of contagion and the risk of a Euro break-up.
Examples are:

- Arghyrou and Tsoukalas (2011) who advanced a model of EMU participation where sovereign spreads reflect both currency risk and default risk.
- De Grauwe (2011) who proposed a theory of the fragility of a monetary union to show that government bond markets are exposed to self-fulfilling liquidity and solvency crises.
- Bolton and Jaenne (2011) who advanced a model of contagion through the banking system in financially, but not fiscally, integrated unions.

Motivation

This study aims at understanding the role played by contagion risk and expectations of a euro breakup in the dynamics of sovereign spreads over the period 2000-2012 in a number of euro-area countries. The study contributes to the literature in two ways.

- We make use of a novel index of (shadow) exchange market pressure derived in an earlier work (Canofari, Marini and Piersanti (CMP), 2012) to measure investors' concerns about EMU sustainability and contagion effects among euro-area countries.
- We tests the power of this index *vis à vis* a broad set of fundamentals found in the extant literature on EZ crisis.

Motivation

- Earlier papers dealing with issue of a systemic risk in the euro area are Eichler (2011), Hui and Chung (2011), Di Cesare *et al.* (2012), Klose and Weigert (2012).
  These studies looked at the issue from a union-aggregate perspective, as their proxies for crash expectations are from the EUR risk premium - that is, from markets expectations on the stability of euro *vis à vis* the other major currencies - or from internet virtual expectations.
- By contrast, we focus on the incentive to leave the euro and hence to breakup the union at the country level.
  We use the concept of shadow exchange rate and a cost-benefit analysis to provide a sustainability index for currency unions that can be used to derive model-based expectations of exit and of exchange rate change for each member countries, thus allowing the systemic risk to be theory driven and consistently estimated.

Facts and literature review

Countries examined are: Portugal, Ireland, Italy, Greece and Spain.
The paths of the 10-year government bonds returns and differentials against the German Bund benchmark since 2000 are in Fig 1.
Two broad distinct phases can be identified.

- Between 2000 and 2008 most of these returns and differentials approached and lingered in a narrow range.
- After 2008 government bond yields and spreads heightened considerably. In particular, countries such as Greece, Ireland and Portugal experienced the largest increase in their bond spreads, followed by Italy and Spain

Facts and literature review

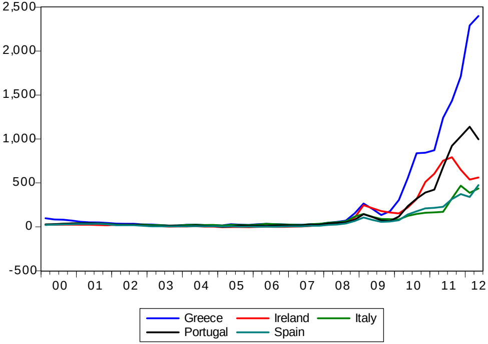

Figure: 1. Ten-year government bond spreads *vis-à-vis* the German Bund (basis points)

Facts and literature review

Spreads started to widen in September 2008, following the Lehman Brothers collapse and the Irish banking crisis; decreased in the course of 2009, after the announcement of strong budgetary austerity measures by the Irish government on February 2009, and started to rise again in November 2009, when the new Greek government revealed a budget deficit twice as large as previously estimated.
After the financial crisis there is a dramatic worsening of public finances, spillover effects across countries and markets, and economic recession (Tables 2-4). Since 2008, economic growth plummeted whereas government deficits- and debt-to-GDP ratios rose to record levels in all countries in spite of severe austerity measures taken by the European authorities and national governments.

Facts and literature review

Table 2	Real GDP growth					
Country	2007	2008	2009	2010	2011	2012*
Portugal	2.365	-0.009	-2.908	1.401	-1.669	-3.005
Ireland	5.445	-2.109	-5.456	-0.766	1.431	0.353
Italy	1.683	-1.156	-5.494	1.804	0.400	-2.100
Greece	2.996	-0.157	-3.250	-3.517	-6.906	-6.000
Spain	3.479	0.893	-3.742	-0.322	0.400	-1.400
Germany	3.388	0.802	-5.073	4.024	3.100	0.900
*Forecast. Source: World Economic Outlook						

Table 3	Government Budget Deficit/GDP ratio						
Country	2000	2007	2008	2009	2010	2011	2012*
Portugal	-3.31	-3.21	-3.69	-10.17	-9.84	-4.24	-4.99
Ireland	4.68	0.06	-7.34	-13.93	-30.94	-12.75	-8.30
Italy	-0.91	-1.59	-2.67	-5.36	-4.47	-3.82	-2.72
Greece	-3.73	-6.80	-9.91	-15.56	-10.49	-9.11	-7.52
Spain	-0.99	1.90	-4.15	-11.19	-9.36	-8.93	-6.99
Germany	1.32	0.23	-0.06	-3.21	-4.14	-0.78	-0.39

*Forecast. Source: World Economic Outlook

Facts and literature review

Table 4	Government Debt/GDP ratio						
Country	2000	2007	2008	2009	2010	2011	2012*
Portugal	48.36	68.26	71.58	83.05	93.32	107.82	119.07
Ireland	37.49	24.99	44.48	64.86	92.17	106.46	117.74
Italy	108.47	103.08	105.75	115.99	118.60	120.10	126.33
Greece	103.44	107.45	112.62	128.95	144.55	165.41	170.73
Spain	59.38	36.30	40.17	53.92	61.32	69.12	90.69
Germany	60.18	65.35	66.91	74.72	82.39	80.55	83.04
*Forecast. Source: World Economic Outlook							

Facts and literature review

Existing studies have identified a number of explanatory factors.

- Some highlighted the role of the **global or common risk aversion** (Barrios et al., 2009; Haugh, Ollivaud and Turner, 2009; Manganelli and Wolswijk, 2009; Sgherry and Zoli, 2009; Gerlach, Schulz and Wolff, 2010; von Hagen, Schuknecht and Wolswijk, 2011).
- Others pointed out the role of a country's creditworthiness or **default risk** (Attinasi, Checherita and Nickel (2010; Amisano and Tristano, 2011; Aizenman, Hutchison and Jinjarak, 2011; Bernoth, von Hagen and Schuknecht, 2012; Borgy et al., 2012; Favero and Missale, 2012).
- Several papers also underlined the role of **liquidity risk premium** (Gomez-Puig, 2006; Beber, Brandt and Kavajecz, 2009; Favero, Pagano and von Thadden, 2010).
- News and rating announcements was also identified at high-frequency data (Alfonso, Furceri and Gomez, 2011; Arezki, Candelon and Sy, 2011; Arru et al., 2012; De Santis, 2012; Gärtner and Griesbach, 2012).

Facts and literature review

These variables cannot explain a significant portion of sovereign spreads movements occurred after 2010 (Aizenman, Hutchison and Jinjarak, 2011; Ardagna et al., 2012; De Grauwe and Ji, 2012; IMF, 2012; Di Cesare et al., 2012).

- Some argued that this reflects spillover effects and financial contagion from Greece and other non-core countries (Caceres, Guzzo and Segoviano, 2010; Arezki, Candelon and Sy, 2011; Amisano and Tristani, 2011; Gómez-Puig and Sosvilla-Rivero, 2011; De Santis, 2012; Metiu, 2012).
- Others pointed out to a new, systemic risk emerged since 2010: the risk of a euro break-up (Eichler, 2011; Hui and Chung, 2011; Di Cesare *et al*., 2012; Woo and Vamvakidis, 2012; Klose and Weigert, 2012).

To test for the presence of such risks in the interst spreads, we applied a new synthetic index measuring the incentive to stay in or exit from a monetary union for each member country.

Our testing strategy builds around the following two equations:

$$s_t^i - \bar{s}^i = -\frac{\gamma_i}{\gamma_i^2 + \theta^i} \left(y_t^{i,F} - \bar{y}^i \right), \tag{1}$$

$$\frac{\partial \pi_t^i}{\partial \pi_t^j} = G\left(\bar{u}_{t+1}^i \middle| \, s_{t+1}^j = s_t^j \right) - G\left(\bar{u}_{t+1}^i \middle| \, s_{t+1}^j = s_t^j + \xi^j \right) > 0 \, , \tag{2}$$

where s = nominal (shadow) exchange rate, $\bar{s}$ = entry currency parity, γ = elasticity of (aggregate) demand to the real exchange rate, θ = inflation aversion coefficient, y^F = real output required to stay in the union, $\bar{y}$ = output target, π_t = expected exit probability, $\bar{u}$ = threshold value of random (demand) shock, ξ = devaluation size conditional on exit from the union.

- Equation (1) expresses the policymaker's optimal switching rule as a linear relationship between the shadow devaluation rate $\left(s_t^i - \bar{s}^i\right)$ and the output gap $\left(y_t^{i,F} - \bar{y}^i\right)$ required to remain in the monetary union. It can be rewritten as

$$s_t^i - \bar{s}^i \geq \bar{\mathbb{C}}^i, \tag{1a}$$

  to show that the policymaker will optimally choose to exit and devalue when the shadow exchange rate exceeds the entry parity by the critical value $\bar{\mathbb{C}}^i$, that is, when a random shock greater than a critical value occurs.
- We use equation (1) as the theoretical relationship of the way market's concern about the risk of a euro break up could be measured.

- Equation (2) highlights the mutual interdependence of private agents' expectations in different countries, and computes the effect on the expected exit probability for country i of a change in the perceived probability of exit in country j $(j \neq i)$.
  It implies that a rise in π_t^j can push the exit probability in country i high enough that an opting out choice can hardly be avoided, thus modelling a powerful mechanism by which financial instability can become so widespread that a crisis reaches systemic dimensions. Fear of a crisis and exit in one country can spread to other countries, making the union crash more likely to occur.
- We use equation (2) as the theoretical relationship for estimating contagion effects.

The baseline model specification we used in the empirical investigation is as follows

$$l_{it} = \mathbf{b}'\mathbf{X}_t + \varepsilon_{it} \ , \tag{3}$$

where l_{it} is the spread between the 10-year government bond yield in country i and the German Bund benchmark in period t, ε_{it} a standard error term, and $\mathbf{X}_t$ a vector of explanatory variables that includes:

- **global risk aversion**, measured by the spread between the yields on US corporate bonds and US treasury bills or the CBOE Volatility Index (VIX);
- **sovereign solvency risk**, measured by a country's *de-facto* fiscal space (debt/tax base) or government debt (deficit) to GDP ratios;
- **liquidity risk**, measured by the ratio of a country's outstanding general government debt to euro-area-wide total;
- variables proxing **market confidence about EMU survival** and **contagion effects**.

- To compute the shadow devaluation rate described in (1), we relied on estimates provided by CMP (2012) for EZ countries over the period 1980Q1-2010Q3 for γ and θ. We used the Hodrick-Prescott filter to obtain estimates of the output gap $\left(y_t^F - \bar{y}\right)$ for each country. The nominal entry parities $\left(\bar{s}^i\right)$ were given by Euro official fixed conversion rates for each country.
- Panel Least Squares estimates for the period 2000Q1-2012Q2 and the two sub-period (2000Q1-2007Q4) and (2008Q1-2012Q2) are shown in Tables 5 and 6.
- *dsr* = Shadow devaluation rate differential over Germany; *dfs* = Fiscal space differential over Germany; *liq* = Ratio of government debt to euro-area-wide total; *cbs* = US corporate bond spread; $\overline{R}^2$ = Adjusted R^2; *SE* = Standard error of regression; *DW* = Durbin Watson statistic; *FE* = Redundant fixed effects test (p-value); t statistics in parentheses.

Estimation Results

A) The euro break-up risk and macro indicators

Table 5 Panel Least Squares estimates: 10-year government bond yield spreads over Germany (is)

Sample period: 2000Q1 2012Q2

$$is_t = \underset{(1.967)}{3.081} + \underset{(5.961)}{3.235} dsr_t + \underset{(7.532)}{0.045} dfs_t - \underset{(3.158)}{0.726} liq_t + \underset{(1.981)}{0.007} cbs_t$$

$\overline{R}^2 = 0.402$; $SE = 2.504$; $DW = 0.181$; $FE = 0.000$

Pre-crisis period: 2000Q1 2007Q4

$$is_t = \underset{(4.823)}{1.019} + \underset{(0.988)}{0.049} dsr_t + \underset{(5.493)}{0.003} dfs_t - \underset{(4.701)}{0.156} liq_t + \underset{(3.335)}{0.001} cbs_t$$

$\overline{R}^2 = 0.590$; $SE = 0.104$; $DW = 0.241$; $FE = 0.000$

Crisis period: 2008Q1 2012Q2

$$is_t = \underset{(1.191)}{3.880} + \underset{(8.167)}{5.756} dsr_t + \underset{(5.500)}{0.052} dfs_t - \underset{(3.154)}{1.377} liq_t + \underset{(2.770)}{0.030} cbs_t$$

$\overline{R}^2 = 0.670$; $SE = 2.742$; $DW = 0.517$; $FE = 0.044$

Note: All the data are expressed in percentages.

Estimation Results

A) The euro break-up risk and macro indicators

Table 6 Panel Least Squares estimates: 10-year government bond yield spreads over Germany (is)

Sample period: 2000Q1 2012Q2

$$is_t = -0.254 + 1.132 is_{t-1} + 0.065 dsr_t - 0.002 dfs_t + 0.031 liq_t + 0.001 cbs_t$$

(0.684) (64.643) (0.473) (1.350) (0.569) (1.245)

$\overline{R}^2 = 0.968$; $SE = 0.584$; $DW = 1.526$; $FE = 0.418$

Pre-crisis period: 2000Q1 2007Q4

$$is_t = 0.145 + 0.842 is_{t-1} + 0.037 dsr_t + 0.001 dfs_t - 0.017 liq_t - 0.000 cbs_t$$

(1.572) (23.431) (1.734) (2.041) (1.179) (1.910)

$\overline{R}^2 = 0.926$; $SE = 0.042$; $DW = 1.735$; $FE = 0.353$

Crisis period: 2008Q1 2012Q2

$$is_t = 0.412 + 1.045 is_{t-1} + 0.632 dsr_t + 0.000 dfs_t - 0.100 liq_t + 0.003 cbs_t$$

(0.367) (24.753) (1.990) (0.074) (0.638) (0.893)

$\overline{R}^2 = 0.962$; $SE = 0.937$; $DW = 1.661$; $FE = 0.275$

Estimation Results

A) The euro break-up risk and macro indicators

- The high degree of persistency in sovereign spreads data led us to check for the order of integration and for a long-run or cointegrating equation among the variables of interest.
- The stationarity and cointegration properties of the data set are shown in tables 7 and 8.
- The estimated long-run or cointegrated relationships are shown in Table 9 below.

Table 7 Panel Unit Root Tests (p-value)						
Sample period: 2000Q1 2012Q2						
	Level			1st difference		
	LLC	F-ADF	F-PP	LLC	F-ADF	F-PP
is	1.000	1.000	1.000	0.000	0.003	0.000
dsr	0.975	0.203	0.258	0.000	0.000	0.000
dfs	1.000	0.998	0.437	0.004	0.002	0.000
liq	0.945	0.992	0.918	0.005	0.016	0.000
cbs	0.918	0.923	0.905	0.000	0.000	0.000

Note: Null hypothesis= unit root. LLC= Levin, Lin, and Chu test (common unit root process); F-ADF and F-PP= Fisher-ADF and Fisher-PP tests (individual unit root process). The test on the level includes individual fixed effects (intercepts and trends); the test on 1st difference includes no deterministic component. Maximum number of lags fixed at 3.

Table 8	Panel cointegration tests (p-value)				
Sample period: 2000Q1 2012Q2					
No. CE	None	At most 1	At most 2	At most 3	At most 4
J-F test	0.000	0.000	0.013	0.274	0.125
Kao test	0.001				
Note: None, At most 1, 2, 3 and 4 denote the number of cointegrated equations (No. CE) under the J-F test. J-F test= Johansen-Fisher cointegration test. Null hypothesis for Kao cointegration test= No cointegration. Maximum number of lags fixed at 3.					

Estimation Results

A) The euro break-up risk and macro indicators

Table 9 Long-run equilibrium relationship
Sample period: 2000Q1 2012Q2
$is_t = 14.120 dsr_t - 0.001 dfs_t + 0.061 liq_t - 0.001 cbs_t$
(7.045) (0.107) (0.883) (0.268)
Pre-crisis period: 2000Q1 2007Q4
$is_t = 0.123 dsr_t + 0.001 dfs_t + 0.003 liq_t + 0.001 cbs_t$
(1.562) (3.531) (1.884) (11.410)
Crisis period: 2008Q1 2012Q2
$is_t = 12.350 dsr_t + 0.030 dfs_t - 0.195 liq_t + 0.029 cbs_t$
(7.873) (3.891) (2.175) (5.394)

- *dsr* = Shadow devaluation rate differential over Germany; *dfs* = Fiscal space differential over Germany; *liq* = Ratio of government debt to euro-area-wide total; *cbs* = US corporate bond spread; *t* statistics in parentheses.

The main points are as follows.

- A long-run solution between bond yield spreads and the variables appearing in the vector of regressors $\mathbf{X}_t$ exists.
- The relationship is not stable but split in two distinct sub-periods: the period preceding the global financial crisis (2000-2007), when all the explanatory variables played a marginal or no role; the period following the crisis (2008-2012), when the chosen variables acquired a prominent relevance.
- The relevance of markets expectations of countries' exit from the European Monetary Union and hence of expectations of a euro break-up.

To understand the role played by each factor during the crisis period, we computed the relative contribution of each regressor to the changes in sovereign yield spreads (see Table 10).
The table shows that, for the whole panel and all countries, global risk aversion made up the majority of the sovereign yield spread during the financial turbulence period of 2009-2012. Yet, when we split the crisis phase in the two sub-period (2009-2010) and (2011-2012) we find that both risk aversion and expectations of countries exit from the monetary union played the major role, with the latter being the most relevant in the case of Greece. Hence, the perceived risk of a break-up of the euro area by private agents do appear to have been **a key driver of spreads** during the phase of exceptionally high volatility in financial markets.

Table 10	Relative contributions			
	2009Q1 2012Q2			
Country	*dsr*	*dfs*	*liq*	*cbs*
Italy	1.73	5.88	17.52	74.86
Spain	8.98	20.29	3.39	67.34
Ireland	20.95	16.88	3.45	58.70
Portugal	8.43	42.06	5.17	44.33
Greece	7.45	41.43	5.89	45.23
Panel Average	7.25	21.94	13.19	57.61

Table 10	Relative contributions			
	2009Q1 2010Q4			
Country	*dsr*	*dfs*	*liq*	*cbs*
Italy	3.68	20.44	31.40	44.48
Spain	21.46	8.70	12.65	57.19
Ireland	29.94	5.83	2.79	61.44
Portugal	44.48	9.24	2.46	43.82
Greece	42.36	26.14	3.37	28.13
Panel Average	31.07	13.83	10.29	44.81

Table 10	Relative contributions			
	2011Q1 2012Q2			
Country	*dsr*	*dfs*	*liq*	*cbs*
Italy	7.86	18.85	29.01	44.28
Spain	30.54	1.12	13.73	54.60
Ireland	17.35	29.25	2.88	50.51
Portugal	27.00	19.98	1.95	51.07
Greece	43.66	23.32	3.04	26.99
Panel Average	27.21	20.40	9.72	42.66

Contagion effects were investigated using a simple empirical specification of (2) such as:

$$\widetilde{dsr}_t = a_0 + a_1 dsr_t^{GRE},$$

where $\widetilde{dsr}_t$ excludes the Greek shadow devaluation rate differential $\left(dsr_t^{GRE}\right)$ used as regressor to measure contagion.
The estimated long-run relationship over the period 2008Q1-2012Q2 is:

$$\begin{aligned} \widetilde{dsr}_t &= 0.001 + 0.198 dsr_t^{GRE} \\ & \quad (0.006)\ (2.295) \quad . \end{aligned} \tag{4}$$

(unit root and cointegration tests are in Table 11).

Estimation Results

B) Contagion and systemic risk

Table 11	Panel Tests (*p*-value)					
	Sample period: 2008Q1 2012Q2					
	Unit root					
	Level			1st difference		
	LLC	F-ADF	F-PP	LLC	F-ADF	F-PP
$\widetilde{dsr}$	0.821	0.933	0.959	0.000	0.002	0.000
dsr^{GRE}	0.057	0.702	0.984	0.000	0.021	0.000

Cointegration		
No. CE	None	1
J-F test	0.028	0.913
Kao Test	0.003	

Note: 1= At most 1. Maximun number of lags fixed at 2. Analogous results are obtained if the tests are carried out over the period 2000Q1-2012Q2.

Estimation Results

B) Contagion and systemic risk

The estimates show that:

- contagion from the Greek financial crisis and expected exit from the euro area have occurred in the other countries;
- the relative impact of dsr^{GRE} on the variation in the shadow devaluation rates of the other peripheral EU countries ranges from a worthy 34% over the period 2009-2012 to an impressive 61% or even 78% over the periods 2009-2010 and 2011-2012, respectively;
- empirical evidence for a long-run equilibrium relationship between each non-core country and the other four countries was not found.

Conclusion

The main conclusions are as follows:

- We found that even controlling for country-specific and global risk factors, fears of a reversibility of the euro and contagion from Greece were fundamentals drivers of sovereign risk premia in non-core countries.
- This provides strong empirical support to the view that the debt crisis in the Euro Zone is mainly due to the rise of a systemic risk fuelled by expectations of a fundamental change in the monetary union set-up.
- These results are strongly consistent with the main implication of our theoretical model, which predicts that in a monetary union financial instability can be transmitted through changes in exit expectations and devaluations of its member countries, thus foreshadowing the occurrence of a union break-up eventually.

Relative contribution

For example, the relative contribution of the *dsr* variable (C_{dsr}) is computed as

$$C_{dsr} = \frac{\mid \hat{\beta}_1 \left(\overline{dsr_t}\right) \mid}{\mid \hat{\beta}_1 \left(\overline{dsr_t}\right) \mid + \mid \hat{\beta}_2 \left(\overline{dfs_t}\right) \mid + \mid \hat{\beta}_3 \left(\overline{liq_t}\right) \mid + \mid \hat{\beta}_4 \left(\overline{cbs_t}\right) \mid},$$

where $\hat{\beta}_i$ $(i = 1, 2, 3, 4)$ is the coefficient estimate from table I (e.g., 12.350 for *dsr*) and $(\overline{x}_t)$ is the average value over time of the (generic) regressor x.

A Model of Exit and Contagion

The model uses a multi-country setting consisting of an asymmetric three-country monetary union (with two 'non-core' countries and one 'core' country) and the rest of the world. Under fixed price and a zero inflation rate, the macroeconomic structure is summarized by the following set of equations:

$$L_t^i = \left(y_t^i - \bar{y}^i\right)^2 + \theta^i \left(s_t^i - \bar{s}^i\right)^2 + \delta \mathbb{C}^i \quad \text{(M.1)}$$

$$y_t^i = \gamma_i (s_t^i - \bar{s}^i) + y_t^{i,F} \quad \text{(M.2)}$$

$$y_t^{i,F} \equiv D + \gamma_i (\bar{s}^i - \phi s_t^j - \alpha s^W) - u_t^i \quad i,j \in \{A, B\} \quad i \neq j \text{ ,(M.3)}$$

where all variables are country-specific and measured in logs , $L =$ welfare loss, $\mathbb{C} =$ opting out cost, $y =$ real output, $\bar{y} =$ output target, $s =$ nominal (shadow) exchange rate, $\bar{s} =$ entry currency parity, $s^W =$ world exchange rate, $D =$ autonomous component of aggregate demand, $u =$ random shock.

A Model of Exit and Contagion

Model solution yields the optimal switching conditions

$$s_t^i - \bar{s}^i = -\frac{\gamma_i}{\gamma_i^2 + \theta^i}\left(y_t^{i,F} - \bar{y}^i\right), \tag{M.4}$$

$$\bar{u}_t^i = \frac{\left(\gamma_i^2 + \theta^i\right)\bar{\mathbb{C}}^i}{\gamma_i} + D + \gamma_i\left(\bar{s}^i - \phi s_t^j - \alpha s^W\right) - \bar{y}^i, \quad i,j \in \{A, B\} \;\; i \neq j. \tag{M.5}$$

(M.4) gives the theoretical relationship for modelling market's concern about the risk of a euro break up. (M.5) computes the threshold value of the shock $\left(\bar{u}_t^i\right)$ at which the policymaker is indifferent between opting out and remaining in the union.

A Model of Exit and Contagion

Under rational expectations and mutual interdependence of private agents' expectations in different countries, equilibrium requires

$$\pi_t^i = \pi_t^j \left[1 - G\left(\bar{u}_{t+1}^i \middle| s_{t+1}^j = s_t^j + \xi^j\right)\right] + \left(1 - \pi_t^j\right)\left[1 - G\left(\bar{u}_{t+1}^i \middle| s_{t+1}^j = s_t^j\right)\right] \equiv \Psi\left(\pi_t^i, \pi_t^j; f_t\right) \quad \text{(M.6)}$$

where π_t^i and π_t^j denote the exit probability (formed at time t for period $t+1$) for country i and for contry j, respectively, $G(\cdot)$ is the cumulative distribution function of u_t^i, ξ^i and ξ^j the expected devaluation rate in each country following the opting out decision, and f_t the state of fundamentals at time t.

Equation (M.6) shows that private agents compute π_t^i as a weighted average of two conditional probabilities: the probability that country j exits and devalues and the probability that j continues to remain in the union next period. As both sides of (M.6) are increasing with π_t^i multiple equilibria can arise as in the second generation models of currency crises.

A Model of Exit and Contagion

Equation (M.6) shows the main channels for contagion of the shocks. '**Monsoonal effects**' result from changes in s^W, or D; '**spillover effects**' from changes in π_t^j; '**pure contagion**' from self-fulfilling expectations of an exit of country i. The possibility of contagion is also related to **changes in exit expectations** for country j. This follows from

$$\frac{\partial \pi_t^i}{\partial \pi_t^j} = G\left(\bar{u}_{t+1}^i \middle| s_{t+1}^j = s_t^j\right) - G\left(\bar{u}_{t+1}^i \middle| s_{t+1}^j = s_t^j + \xi^j\right) > 0 \,, \qquad \text{(M.7)}$$

which is the equation we used to estimate contagion effects. It states that a rise in π_t^j can push the exit probability in country i high enough that an opting out choice can hardly be avoided. Fear of a crisis and exit in one country can spread in the other country, making the opting out choice more likely to occur

Equation (1) estimates

- Using quarterly data of some key European countries over 1980-2010 period, the estimates for γ were obtained by the following long-run or cointegration equation:

$$\ln\left(\frac{EX_{i,t}}{IM_{i,t}}\right) = a_0 + \gamma \ln(REER_{i,t}) + \epsilon_{i,t}, \tag{M.8}$$

- where (EX_i / IM_i) is a measure of trade balance for country i, and $REER_i$ is country's i real effective exchange rate.
- Estimates of output gaps $\left(y_t^{i,F} - \bar{y}^i\right)$ for individual countries were obtained using the Hodrick-Prescott filter.
- The inflation aversion coefficients θ^i were fixed taking logs from a scale of tens $[1, 10, 20, ...100]$, where 100 and 1 denote the maximum and the minimum inflation aversion value, respectively.
- the nominal fixed parities $\bar{s}^i$ were given by Euro official fixed conversion rates for each country

Equation (1) estimates

- Advantages of using equation (M.8) as a model specification are :
  a) the definition of the trade balance is unit-free, and insensitive to nominal-real distinction
  b) the (long-run) effect of changes in *REER* is read immediately from the γ value
  c) it is a close substitute for testing the Marshall-Lerner condition

Estimated values

Table 1		
Country	γ	θ
France	–5.384	$\log(50) = 3.9$
Germany	-3.478	$\log(100) = 4.6$
Greece	-4.973	$\log(10) = 2.3$
Ireland	-0.384	$\log(40) = 3.7$
Portugal	-0.449	$\log(40) = 3.7$
Italy	-1.220	$\log(40) = 3.7$
Spain	-2.874	$\log(40) = 3.7$