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Financial Contagion during Lehman Default and Sovereign Debt Crisis

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Introduction

- After the stability that characterized the first 10 years of the European Economic and Monetary Union…from August 2007 onwards, **yield spreads of Euro area government bonds spiraled** in parallel with the rise in global financial instability that led to "flight-to-quality", resulting in:
  - a transfer of funds towards assets with a lower risk (German bunds)
  - an increase of the risk premium in the other EMU countries

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Introduction

Role of "fundamentals"

"Contagion" became the catchword for such phenomena and is now widely being used to describe the events around the crisis

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The research question

- Do these **periods of highly correlated market movements** provide evidence of contagion?
- The largest body of theoretical definitions hinges on the idea that:
  - **contagion is the amount of co-movement among asset prices which exceeds what is explained by fundamentals**
- Our paper defines contagion as (Forbes and Rigobon, 2002):
  - a **significant increase in the co-movement between assets during a period of crisis, compared with a tranquil period**; while if there is a high level of market co-movement in all periods it is the case **for interdependence**»

The research question

Contagion or Interdependence?

It is contagion **only if** cross-market movements **increase significantly after the shock**

Any continued high level of market correlation suggests **strong linkages** between the two economies that **exist in all state of the world**

- Comparing co-movements between two markets during a relatively stable period with co-movements immediately after a shock or crises:
  - contagion is **a significant increase in cross-market co-movements** (whatever these connections are measured) **after the shock**

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The research question

- **Investigate whether or not channels and intensities of shock propagation across countries are changed** in certain crises periods
- Four major strategies have been employed in the literature to identify contagion:
  - i) **correlation among asset prices**;
  - ii) conditional probability of crises;
  - iii) volatility changes;
  - iv) co-movements of capital flows

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The research question

Asset prices → sovereign bond spreads and stock indexes

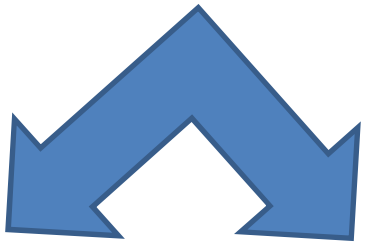
Significant increase → three step Granger causality/Vector error correction model (VECM) methodology

Crisis periods → we establish a periodization for contagion effects by looking directly into data, without making *a priori* conjecture on the time periods during which the contagion process could have started to spread out

The research question

- The analysis relates to a **sample of Euro area countries** over the period **January 2003-September 2012**

Contagion is revealed by



the **number of co-integrating vectors**

the extent of **Granger causality that exists among countries**

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Transmission mechanism

- Intensification or **change in the transmission** of shocks between markets
- **Structural break** and the identification of a tranquil, pre-event period
- The presence of contagion assumes that the transmission of a shock is made possible **through investors' anticipation behaviour** and information asymmetry (Calvo, 1999)

Transmission mechanisms during a crisis are forcibly **different from those in a stable period**

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Policy implications

- Fundamentals-driven movements:
  - policymakers cannot expect the markets to recover unless **measures are taken to improve fundamentals**

- If markets are declining owing to contagion, then:
  - credible policy actions to **soothe the market sentiments** ought to be priority

Correct differentiation between these causes is a key to tackling financial market contagion

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Methodology

- We perform a **three-steps econometric analysis** to test for contagion in **two shocks episodes** occurred in the last decade for a sample of European countries
- The sample is made of **eight European countries** (France, Germany, Greece, Ireland, Italy, Portugal, Spain and United Kingdom)
- We test the co-movements across countries using **two type of assets (equities and sovereign bonds)**
- Time span of our time series goes from the first of January 2003 to the 30th of September 2012

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Methodology

- To individuate significant connections among couple of markets, we will apply two econometric techniques:
  - The **bivariate Johansen cointegration** test allows us to identify relations between couples of markets which lead to slow price adjustment processes (long-run connections)
  - The **Granger causality test**, instead, individuates relations which have a short-term influence in the price discovery process (short-run connections)
- In order to test for contagion we have to identify "crisis" and "tranquil" periods of time and we have to **make a comparison among the number of significant relations in the two detected windows**

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First step procedure: bivariate dynamic cointegration analysis

- We use **bivariate dynamic cointegration analysis** to test if, in the time period analyzed, there has been the creation of new long-run equilibrium conditions among countries **through the application of dynamic rolling cointegration analysis for each pair of countries**
- Any increase of the **percentage of co-integrated countries over the total number of possible pairs** signals a shift of the shock transmission channels and represents the first indicator of potential contagion
- We detect contagion windows **by looking directly into the data**, finding evidence which either confirms or rejects our a priori conjecture of the time periods during which the contagion process could have started to spread out

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First step procedure: bivariate dynamic cointegration analysis

We perform a pairwise countries rolling cointegration estimation for the selected asset prices time series

$$\Delta X_t = \eta_X + \sum_{i=1}^{k} \lambda_{X,i} \Delta X_{t-i} + \sum_{i=1}^{k} \gamma_{X,i} \Delta Y_{t-i} + \alpha_1 \beta' \begin{bmatrix} X_{t-1} \\ Y_{t-1} \end{bmatrix} + \varepsilon_{X,t}$$

$$\Delta Y_t = \xi_Y + \sum_{i=1}^{k} \lambda_{Y,i} \Delta Y_{t-i} + \sum_{i=1}^{k} \gamma_{Y,i} \Delta X_{t-i} + \alpha_2 \beta' \begin{bmatrix} X_{t-1} \\ Y_{t-1} \end{bmatrix} + \varepsilon_{Y,t}$$

We run regressions in order to determine the **number of cointegrating equations** in a vector error-correction model (VECM)

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First step procedure: bivariate dynamic cointegration analysis

- To detect possible contagion periods, we dynamically apply the above Johansen cointegration test between **all the possible couple of countries**
- With a rolling window of 1,000 days

$$Percentage\ of\ cross-country\ connections_t = \frac{Number\ of\ long-run\ relations_t}{Maximum\ number\ of\ long-run\ relations\ among\ all\ countries} * 100$$

- **Crisis periods** → above the 75th percentile of the distribution
- **Tranquil periods** → beneath the 15th percentile of the distribution

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Second step procedure: directionality of shock transmission

- **Granger/Gonzalo-Granger** analysis is performed to study the contagion effect by directly investigating **changes in the existence and the directions of causality connections** within EU countries
- This methodology allows to detect the **versus of these connections** and, consequently, to examine how shocks are transmitted through markets
- The conventional Granger test specifies a **bivariate vector autoregressive (VAR)** model with a lag length set as k

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Second step procedure: directionality of shock transmission

If the **series are found to be I(0)**, causality testing according to the following equations will be applied:

$$X_t = \alpha_X + \sum_{i=1}^{k} \beta_{X,i} X_{t-i} + \sum_{i=1}^{k} \gamma_{X,i} Y_{t-i} + \varepsilon_{X,t}$$

$$Y_t = \alpha_Y + \sum_{i=1}^{k} \beta_{Y,i} Y_{t-i} + \sum_{i=1}^{k} \gamma_{Y,i} X_{t-i} + \varepsilon_{Y,t}$$

If the **series are found to be I(1) and not co-integrated**, causality testing according to the following equations will be applied:

$$\Delta X_t = \alpha_X + \sum_{i=1}^{k} \beta_{X,i} \Delta X_{t-i} + \sum_{i=1}^{k} \gamma_{X,i} \Delta Y_{t-i} + \varepsilon_{X,t}$$

$$\Delta Y_t = \alpha_Y + \sum_{i=1}^{k} \beta_{Y,i} \Delta Y_{t-i} + \sum_{i=1}^{k} \gamma_{Y,i} \Delta X_{t-i} + \varepsilon_{Y,t}$$

Second step procedure: directionality of shock transmission

- Causality tests, which ignore the error correction term (ECT) derived from the cointegration relationship are misspecified

- If the **series are found to be I(1) and co-integrated**, causality will be tested based on these equations:

$$\Delta X_t = \alpha_X + \sum_{i=1}^{k} \beta_{X,i} \Delta X_{t-i} + \sum_{i=1}^{k} \gamma_{X,i} \Delta Y_{t-i} + \varphi_X ECT_{X,t-1} + \varepsilon_{X,t}$$

$$\Delta Y_t = \alpha_Y + \sum_{i=1}^{k} \beta_{Y,i} \Delta Y_{t-i} + \sum_{i=1}^{k} \gamma_{Y,i} \Delta X_{t-i} + \varphi_Y ECT_{Y,t-1} + \varepsilon_{Y,t}$$

Second step procedure: directionality of shock transmission

- The estimation is conducted separately for all sub-periods (the so-called **"contagion windows"**) identified in the first step

- If the series are co-integrated we can identify the **direction through which adjustment is applied**, i.e. who is the leader and who is the follower in the contagion transmission:

  ⇒ by applying the Gonzalo-Granger statistic in the context of a bivariate cointegration analysis (Engle and Granger, 1987)

Third step procedure: variance decomposition

- Forecast-error variance decomposition approach (FEVD): measures how much of the **movements in one country** can be **explained by shocks in other countries**

contagion occurs every time **the degree of vulnerability** of one country – measured as the fraction of his movements due to other country shocks – **increases after a crisis period**

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Third step procedure: variance decomposition

- Forecast-error variance decomposition model (FEVD) measures **the fraction of the forecast-error variance of an endogenous variable that can be attributed to orthogonalized shocks to itself or to another endogenous variable**
- The starting point of this indicator is given by the moving-average representation of the VECM:

$$R_t = \sum_{s=0}^{\infty} C(s)\, u(t-s)$$

- The variance of the *n-step* ahead forecast variance of the i-*th* return time series is:

$$\sigma_i(n)^2 = \sum_{j=1}^{n} C_{i,1}(j)^2 + \cdots + \sum_{j=1}^{n} C_{i,N}(j)^2$$

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Third step procedure: variance decomposition

- As a consequence, for each country stock market *i* the ratio

$$W_i(k) = \frac{\sum_{j=1}^{n} C_{i,k}(j)^2}{\sigma_i(n)^2}$$

represents the **portion of movements in country *i* due to shocks from country *k***, on the time horizon n

As a consequence, its complement to one measures **the degree of vulnerability of country *i***, because it is **the percentage of the variance of country *i* explained by innovations in other countries**

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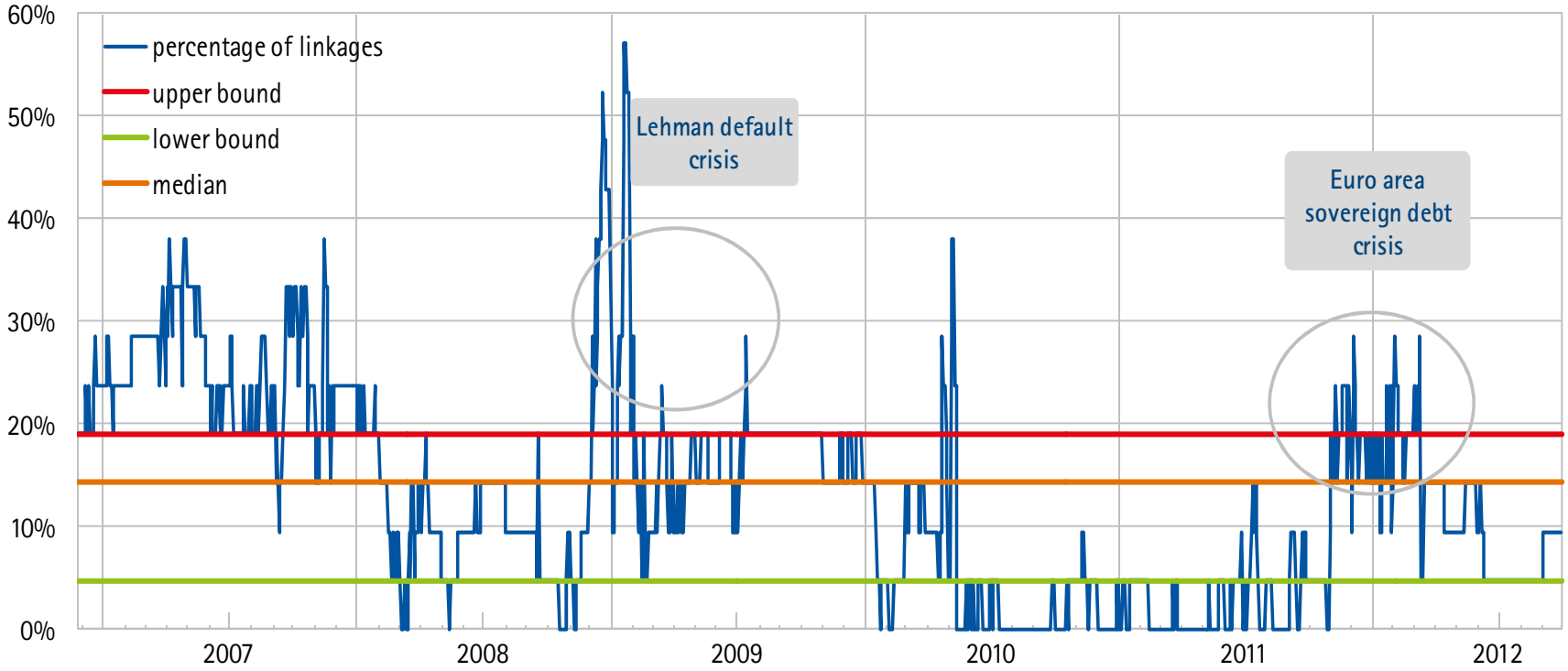
Results: identification of contagion windows

➢We identify "crisis" ("tranquil") windows by detecting periods during which **for an high percentage of times the indicator is above (under) the upper (lower) bound**

Contagion windows estimation using sovereign spreads



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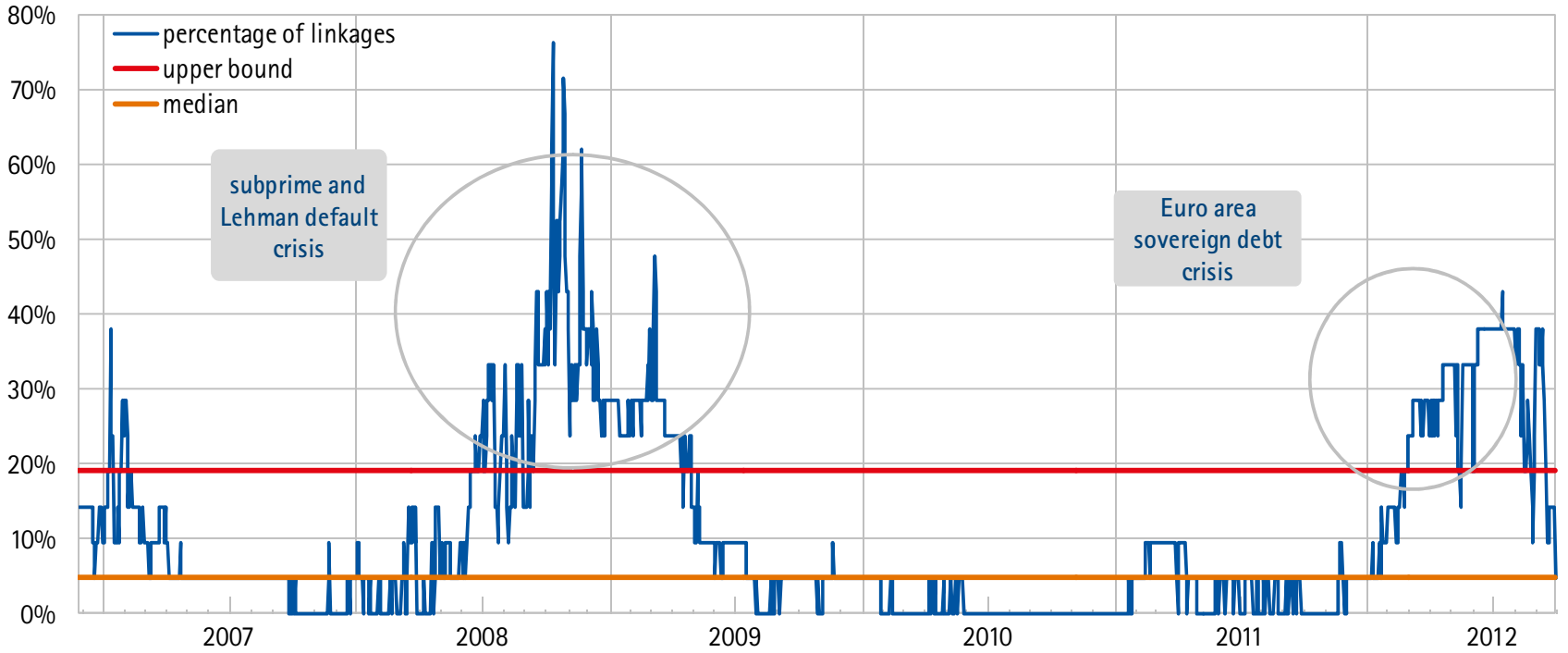
Results: identification of contagion windows

➢We identify "crisis" ("tranquil") windows by detecting periods during which **for an high percentage of times the indicator is above (under) the upper (lower) bound**

Contagion windows estimation using stock returns



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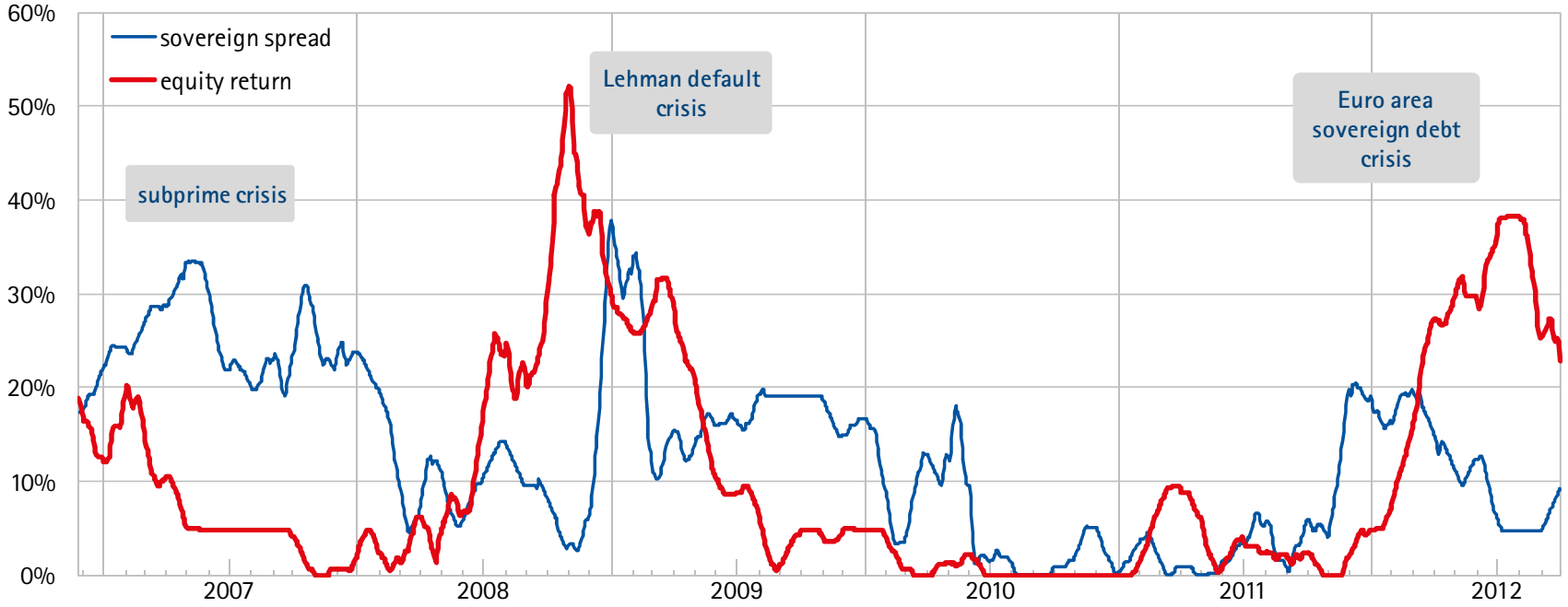
Results: identification of contagion windows

Comparing contagion windows using sovereign spreads and stock returns



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Results: identification of contagion windows

	Lehman default crisis	Euro area sovereign debt crisis
Sovereign spreads	01/12/2008 - 14/07/2009; 162 days; in 84% of the cases the indicator is above or equal to the median in 24% of the cases the indicator is strictly above the upper bound.	02/11/2011 - 05/06/2012; 155 days; in 79% of the cases the indicator is above or equal to the median; in 14% of the cases the indicator is strictly above the upper bound.
Stock returns	10/03/2008 – 16/07/2009; 354 days; in 88% of the cases the indicator is above or equal the median; in 52% if the cases the indicator is strictly above the upper bound.	09/01/2012 - 28/09/2012; 190 days; in 100% of the cases the indicator is above or equal to the median; in 67% of the cases the indicator is strictly above the upper bound.

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Results: connections among sovereign bond markets

APRIL 2008 – NOVEMBER 2008 – "TRANQUIL" PERIOD OF TIME

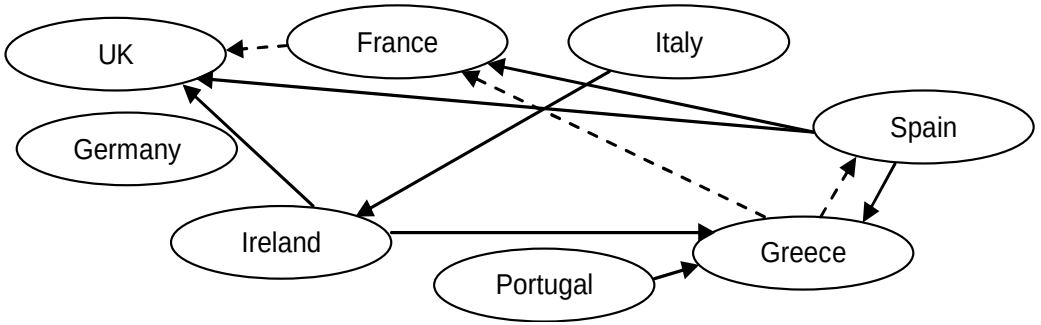
leading country / follower country	Germany		France		Italy		Spain		Greece		Portugal		Ireland		Uk		Tot
	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	
Germany	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
France	-	-	-	-	-	-	1.1**	-	-	4.0**	-	-	-	-	-	-	2
Italy	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
Spain	-	-	-	-	-	-	-	-	-	2.9*	-	-	-	-	-	-	1
Greece	-	-	-	-	-	-	0.04**	-	-	-	0.4**	-	0.4**	-	-	-	3
Portugal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
Ireland	-	-	-	-	3.5**	-	-	-	-	-	-	-	-	-	-	-	1
Uk	-	-	-	3.2*	-	-	1.5**	-	-	-	-	-	0.01**	-	-	-	3
Tot	0		1		1		3		2		1		2		0		10

DECEMBER 2008 – JULY 2009 - LEHMAN DEFAULT CRISIS

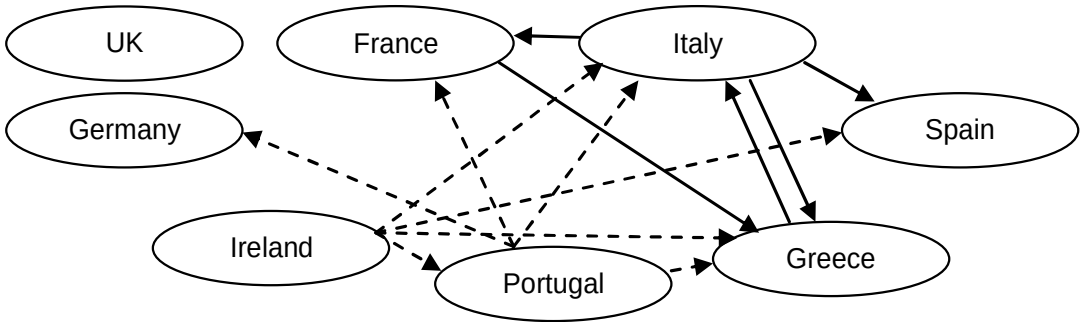
leading country / follower country	Germany		France		Italy		Spain		Greece		Portugal		Ireland		Uk		Tot
	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	
Germany	-	-	-	-	-	-	-	-	-	-	-	3.2*	-	-	-	-	1
France	-	-	-	-	0.6**	-	-	-	-	-	-	4.1**	-	-	-	-	2
Italy	-	-	-	-	-	-	-	-	0.7*	-	-	3.1*	-	4.2**	-	-	3
Spain	-	-	-	-	3.5**	-	-	-	-	-	-	-	-	2.8*	-	-	2
Greece	-	-	0.7**	-	2.1**	-	-	-	-	-	-	4.2**	-	10.0***	-	-	4
Portugal	-	-	-	-	-	-	-	-	-	-	-	-	-	6.7**	-	-	1
Ireland	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
Uk	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0
Tot	0		1		3		0		1		4		4		0		13

Results: connections among sovereign bond markets

"TRANQUIL PERIOD": APRIL 2008 – NOVEMBER 2008



LEHMAN DEFAULT CRISES: DECEMBER 2008 – JULY 2009



Results: connections among sovereign bond markets

MAY 2010 – DECEMBER 2010– "TRANQUIL" PERIOD OF TIME

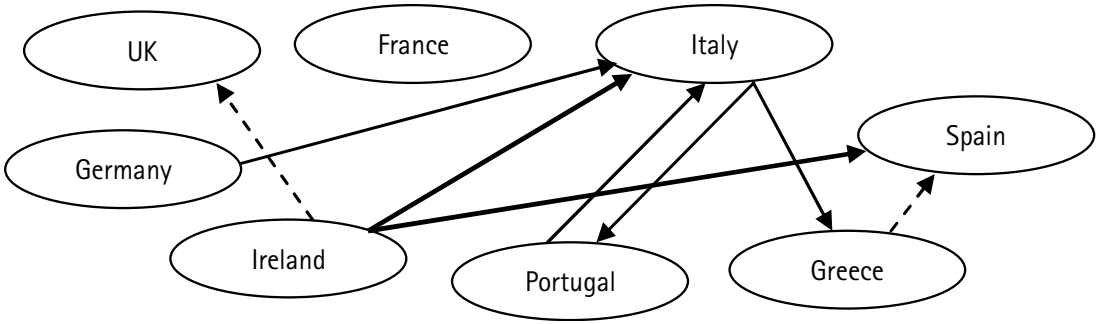
leading country / follower country	Germany		France		Italy		Spain		Greece		Portugal		Ireland		Uk		Tot
	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	
Germany	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
France	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Italy	3.4**	–	–	–	–	–	–	–	–	–	2.8**	–	0.5**	5.6***	–	–	3
Spain	–	–	–	–	–	–	–	–	–	3.7*	–	–	1.1**	5.5***	–	–	2
Greece	–	–	–	–	2.6**	–	–	–	–	–	–	–	–	–	–	–	1
Portugal	–	–	–	–	2.8**	–	–	–	–	–	–	–	–	–	–	–	1
Ireland	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Uk	–		–		–		–		–		–		–	4.0***	–	–	1
Tot	1		0		2		0		1		1		3		0		8

NOVEMBER 2011 – MAY 2012 - EURO AREA SOVEREIGN DEBT CRISIS

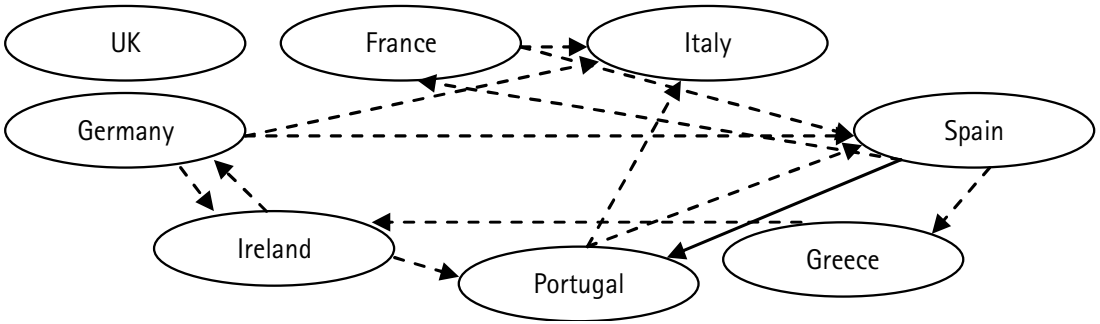
leading country / follower country	Germany		France		Italy		Spain		Greece		Portugal		Ireland		Uk		Tot
	L	S	L	S	L	S	L	S	L	S	L	S	L	S	L	S	
Germany	–	–	–	–	–	–	–	–	–	–	–	–	–	4.6**	–	–	1
France	–	–	–	–	–	–	–	3.1*	–	–	–	–	–	–	–	–	1
Italy	–	3.58*	–	11.5***	–	–	–	–	–	–	–	5.9***	–	–	–	–	3
Spain	–	10.3***	–	6.6***	–	–	–	–	–	–	–	10.4***	–	–	–	–	3
Greece	–	–	–	–	–	–	–	3.8*	–	–	–	–	–	–	–	–	1
Portugal	–	–	–	–	–	–	3.2**	–	–	–	–	–	–	3.0*	–	–	2
Ireland	–	3.3*	–	–	–	–	–	–	–	3.3*	–	–	–	–	–	–	2
Uk	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	0
Tot	3		2		0		3		1		2		2		0		13

Results: connections among sovereign bond markets

"TRANQUIL PERIOD": MAY 2010 – DECEMBER 2010



SOVEREIGN DEBT CRISES: NOVEMBER 2011 – MAY 2012



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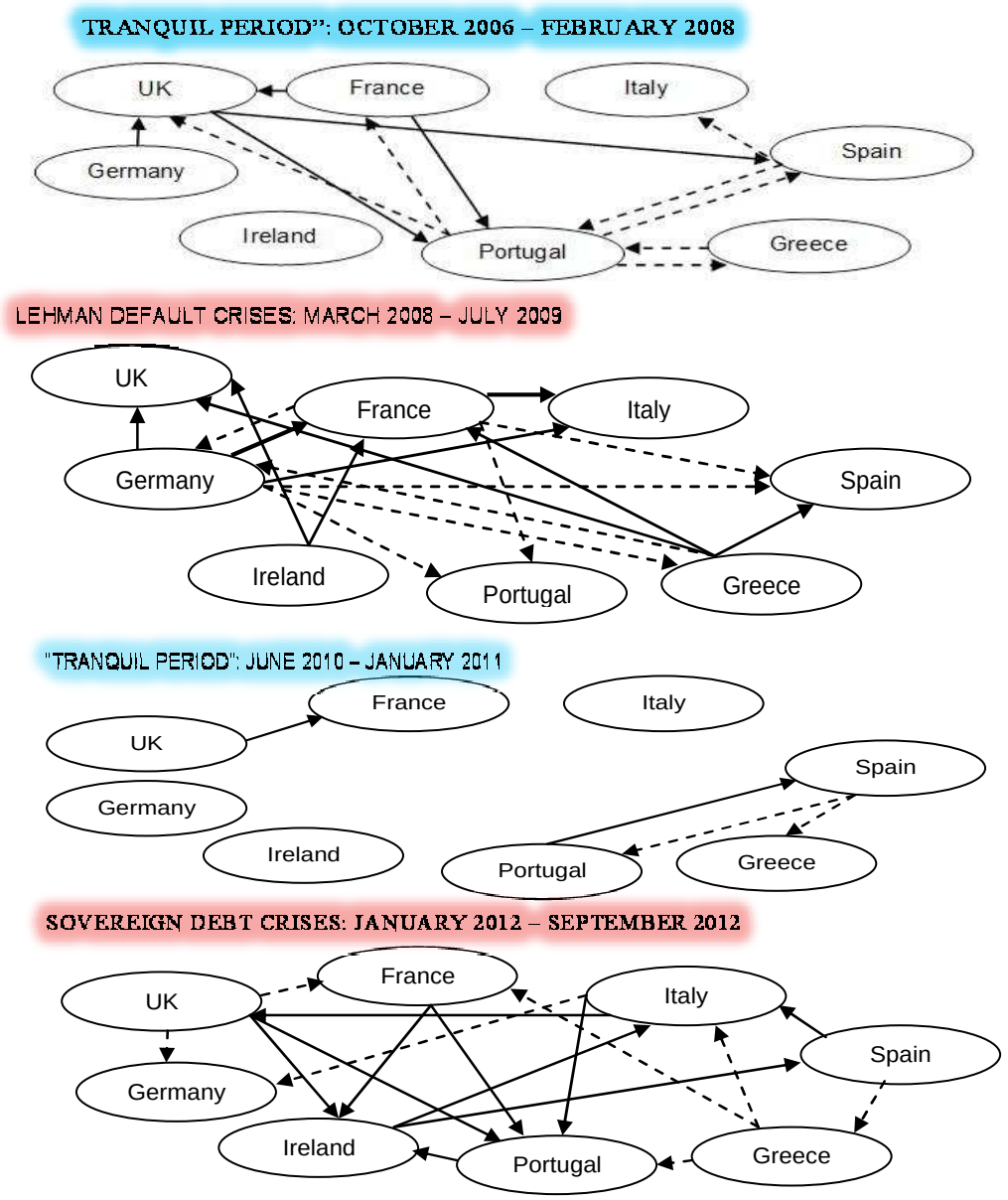
Results: connections among stock markets



Results: involvement in the contagion process

Table 1 – Rate of involvement in contagion process using sovereign spreads

	"tranquil" period before Lehman default	Lehman default crisis	"tranquil" period before sovereign debt crisis	sovereign debt crisis
Germany	6.42%	2.87%	4.42%	7.94%
France	3.60%	4.91%	2.06%	2.93%
Italy	2.55%	6.95%	7.20%	8.33%
Spain	3.76%	3.92%	6.89%	16.13%
Greece	2.24%	10.01%	4.77%	6.79%
Portugal	4.15%	8.45%	3.40%	3.71%
Ireland	6.61%	10.66%	2.62%	5.37%
Uk	5.94%	8.92%	8.01%	7.89%

Results: involvement in the contagion process

Table 1 – Rate of involvement in contagion process using stock returns

	"tranquil" period before Lehman default	Lehman default crisis	"tranquil" period before sovereign debt crisis	sovereign debt crisis
Germany	2.86%	2.81%	1.72%	4.08%
France	3.25%	7.35%	1.95%	2.04%
Italy	3.92%	7.98%	6.19%	6.25%
Spain	3.68%	8.82%	7.44%	6.88%
Greece	1.47%	3.89%	2.57%	4.07%
Portugal	4.48%	6.72%	11.24%	11.95%
Ireland	2.03%	2.90%	1.18%	2.81%
Uk	4.04%	5.08%	2.23%	5.29%

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Conclusions

- **There has been contagion both during Lehman crisis and sovereign debt crisis**, given that the number of cross-market connections has significantly increased after such crisis episodes and then has newly reduced
- **Different timings** of contagion for the two assets

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Conclusions

- **Equity market**:
  - **After the Lehman default**: the most contagion pulse over stock returns has been transmitted by «core» countries as Germany and France
  - **During the sovereign debt crisis:** the contagion phenomenon hit predominantly the peripherals countries as Italy, Greece and Portugal

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Conclusions

- **Sovereign spreads:**
  - **peripherals countries** (like Italy, Ireland, Portugal and Spain) **turn out to be the most involved** in both the contagion occurrences
  - Italy has shown to be the most vulnerable country as **it is the only one which does not spread any contagion link to the others** and, in turn, **reveals to be affected by the most large number of contagion links coming from other economies**
  - Moreover, Italy turns out to be more closely connected with peripheral countries during the Lehman default crisis and **more with the «core» countries (as Germany and France) during the last recent sovereign debt crisis**