Sovereign Credit Risk Co-movements in the Eurozone: Simple Interdependence or Contagion?

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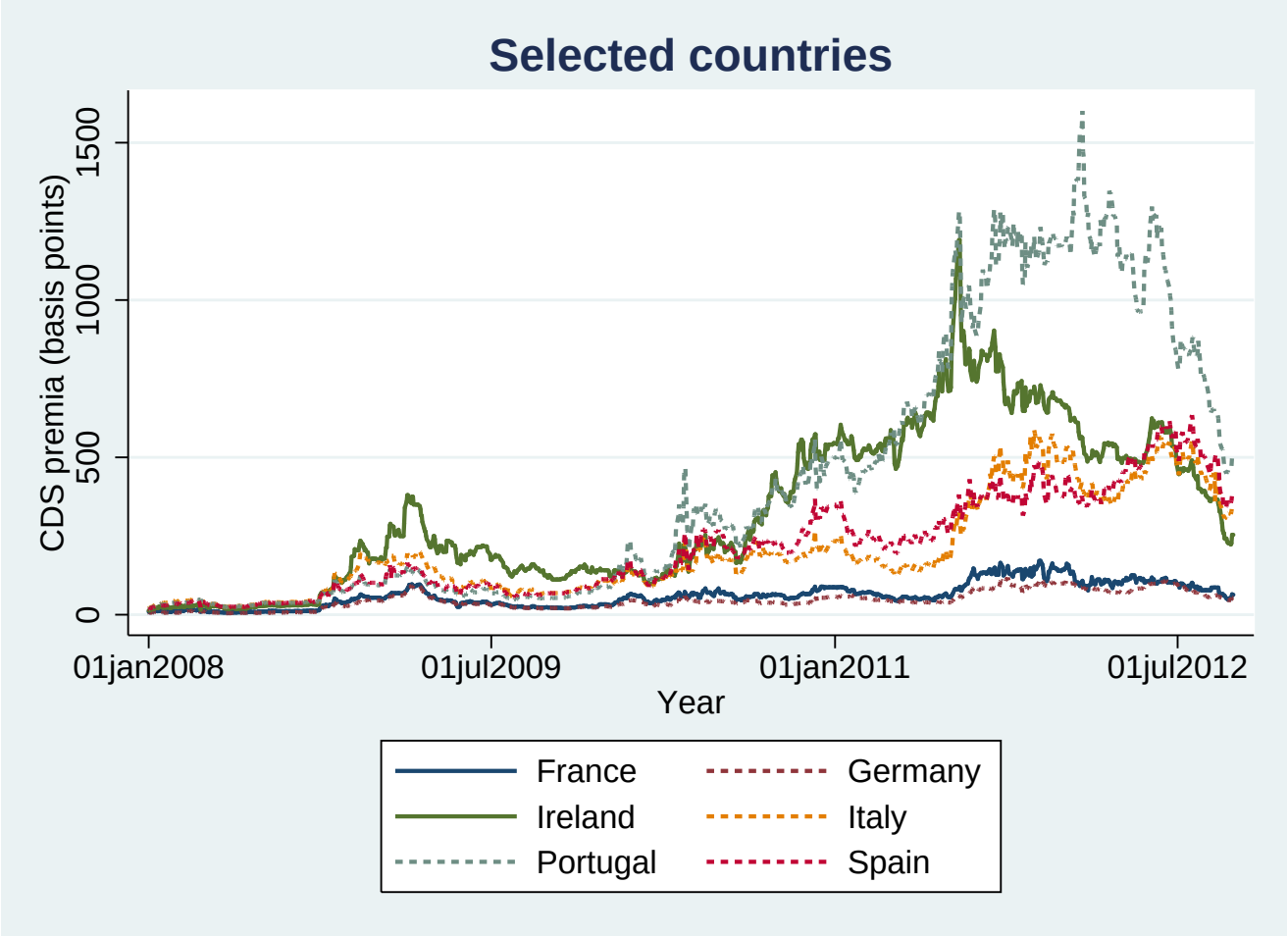
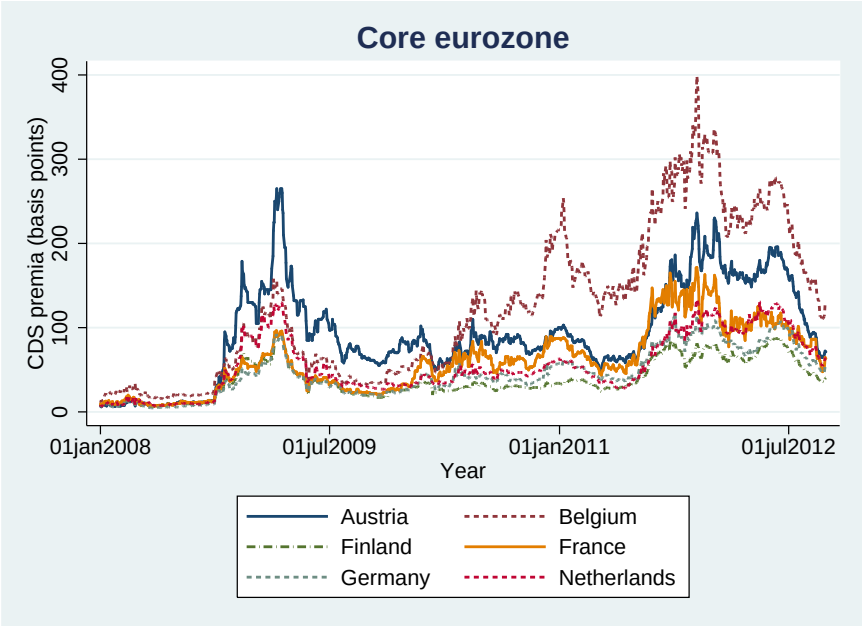
IWH/INFER Workshop
Halle, March 18, 2014

Sovereign credit risk - diverging with the debt crisis?

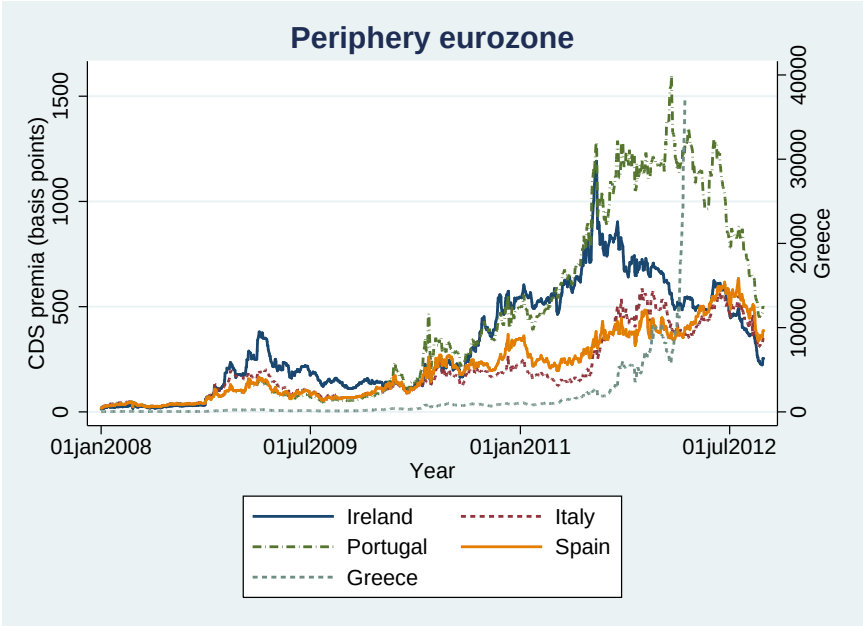


5-year sovereign CDS spreads

Sovereign credit risk - or rather co-moving?



5-year sovereign CDS spreads



5-year sovereign CDS spreads

This paper

- Explain why - despite well-known divergence in sovereign credit risk across countries - there are stronger ***co-movements*** within certain country groups.
  - Are these patterns due to simple interdependence arising from usual cross-country linkages? Or, is it the outcome of contagion?
  - And if so, which are the channels causing contagion?

- Answer these questions using a ***three-step approach***:
  - Correlation analysis: obtain time-varying co-movements in sovereign credit risk.
  - Measurement of contagion: detect significant increases in these time-varying co-movements (= contagion).
  - Regression analysis: separate factors that cause simple interdependence from contagion channels.

Contribution to the literature

- Determinants of sovereign bond yield spreads/CDS spreads.
  Attinasi et al. 2009, Haugh et al. 2009, De Grauwe and Ji 2012...
  $\Rightarrow$ Our paper: focus on bilateral co-movements and not on individual countries' risk spreads.

- Two-way feedback between the banking sector and the sovereign.
  Acharya et al. 2011, Bolton and Jeanne 2011, Dieckmann and Plank 2011, Alter and Schüler 2012...
  $\Rightarrow$ Our paper: evaluate the role of cross-border banking exposures for sovereign credit risk co-movements.

- Measurement of contagion across countries and markets focusing on tail events and excess correlations.
  Forbes and Rigobon 2002, Bae et al. 2003, Forbes 2012, Caporin et al. 2013...
  $\Rightarrow$ Our paper: separate interdependence due to e.g. usual cross-country links from contagion on a country pair basis and explain reasons behind.

Contagion

Contagion: Definition

- *Controversial points*: Do global shocks qualify as contagion? Does the transmission of shocks due to fundamental links in trade and finance constitute contagion? Or is contagion only related to non-fundamentals reflected by panics or (ir)rational herding behavior?

- ***Our definition***: Significant increase in (volatility-adjusted) cross-country co-movements (Forbes and Rigobon 2002).

- *Advantages*: Separate co-movements existing in all states of the world from significant increase in co-movements, i.e. interdependence from contagion.
  - Like this, we do not limit our analysis to extreme events or...
  - ...impose ex ante restrictions on possible contagion channels.

Contagion channels

Common (macroeconomic) shocks or similarities in economic fundamentals.

- shocks affecting all countries at the same time might affect the pattern of co-movements (global volatility index, interest rate spreads).
- similarities in fundamentals relevant for pricing of sovereign risk might impact co-movements (public debt, banking sector) – "wake-up call" contagion.

Direct linkages causing interdependence and fundamentals based contagion.

- direct links existing in all states of the world cause simple interdependence (cross-border banking, trade).
- contagion can arise due to changes in the strength, e.g. portfolio reallocations, or in the nature of direct links, e.g. risk-sharing to channeling contagion.

Indirect linkages leading to non-fundamentals based contagion.

- e.g. think of herding behavior or irrational market sentiments.
- variables are not observable: use proxies like stock market volatilities.

Empirical Approach

Data and Sample

- Daily data on 5-year sovereign CDS spreads
- Sample period: Jan 2008 to Aug 2012
- 17 countries (of which 11 eurozone (EZ) countries)
- $17 \times 16/2 = 136$ country pairs
- Classification into country groups:

Core EZ	Periphery EZ	EU, non EZ	Non EU
Austria	Greece	Denmark	Japan
Belgium	Ireland	Sweden	Norway
Finland	Italy	United Kingdom	United States
France	Portugal		
Germany	Spain		
Netherlands			

Empirical approach

Step I: Dynamic conditional correlations (DCCs) for *daily* CDS spreads (Engle 2002).

- Use DCCs to get volatility-adjusted time-varying credit risk co-movements.

Step II: Measurement of contagion based on *weekly* averaged co-movements.

- Detect episodes with significant increase in weekly averaged co-movements.
- Construct contagion indicator varying across time and country pairs:
  $\Rightarrow$ analyze WHEN contagion takes place.

Step III: Regression analysis for *monthly* averaged DCCs.

- Analyze drivers behind simple interdependence in contrast to contagion.
- Exploit contagion indicator to learn more about the transmission channels:
  $\Rightarrow$ analyze THROUGH WHICH CHANNELS contagion takes place.

Step I: Correlation analysis

- DCC Model (Engle, 2002) based on multivariate GARCH processes.
- allows estimating time-varying credit risk co-movements $\rho_{ij,t}$ DCC
- Advantage: The DCCs are time-varying, based on the full sample period and adjusted for the underlying volatility.
- Hence, we can interpret a significant increase in the DCCs as contagion (Forbes and Rigobon 2002, Chiang et al. 2007).

Step II: Measurement of contagion

- Now: Measure contagion defined as significant increase in volatility-adjusted correlations, i.e. significant increase in DCCs.
- To do so, we aggregate the DCCs to weekly frequency ρ_{ijw} and run sequential time-series regressions for each country pair ij as follows:

$$\rho_{ijw} = d_0 + \sum_{k=1}^{K} d_k \rho_{ijw-k} + q_w dummy_w + \epsilon_{ijw}$$

- with $dummy_w$ being an indicator variable taking a value of one for a given week w and zero otherwise.
- Contagion indicator (CI_{ijw}):

$$CI_{ijw} = \begin{cases} 1 & \text{if } q_w \geq 0 \text{ and } p - value_{q_w} \leq 0.1, \\ 0 & \text{otherwise.} \end{cases}$$

Step III: Regression analysis

- Now: What are the *determinants* of co-movements in general and the *channels* of contagion in particular?
- To answer this, we aggregate the DCCs to monthly frequency ρ_{ijm} and use them as dependent variable...
  - ...to analyze the determinants of co-movements:

$$\rho_{ijm} = \mathbf{x}'_{ijm}\,\boldsymbol{\beta} + u_{ijm}$$

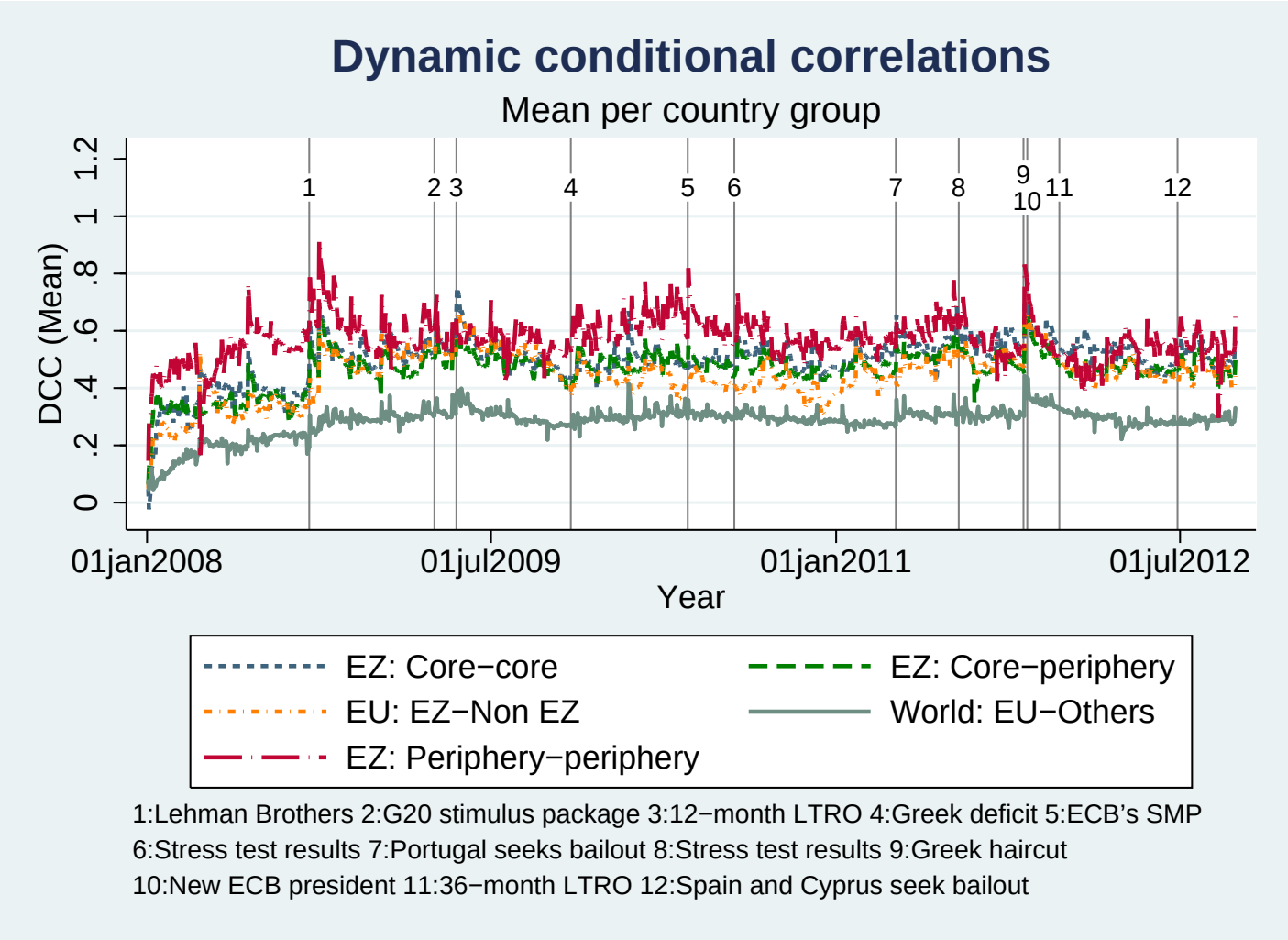
  - ...to identify the channels of contagion:

$$\rho_{ijm} = \mathbf{x}'_{ijm}\,\boldsymbol{\beta} + \tilde{\mathbf{x}}'_{ijm}\,\boldsymbol{\delta} * CI_{ijm} + u_{ijm}$$

- Robust SE, clustered by country pair, augmented by ij and m fixed effects.
- Contagious episode: The contagion indicator CI_{ijm} takes a value of one if at least one weekly dummy in month m is positive and significant.

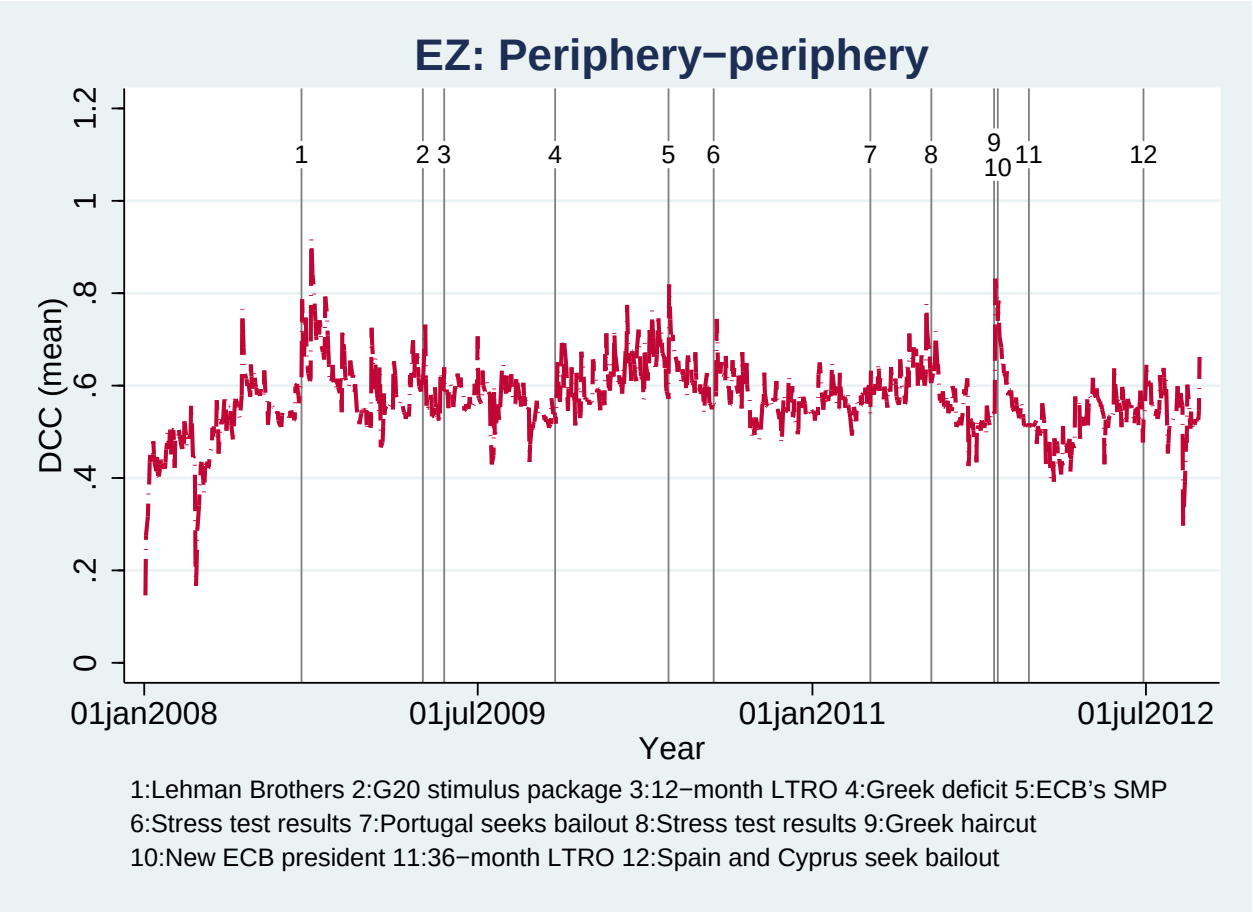
Results

Results: Correlation analysis



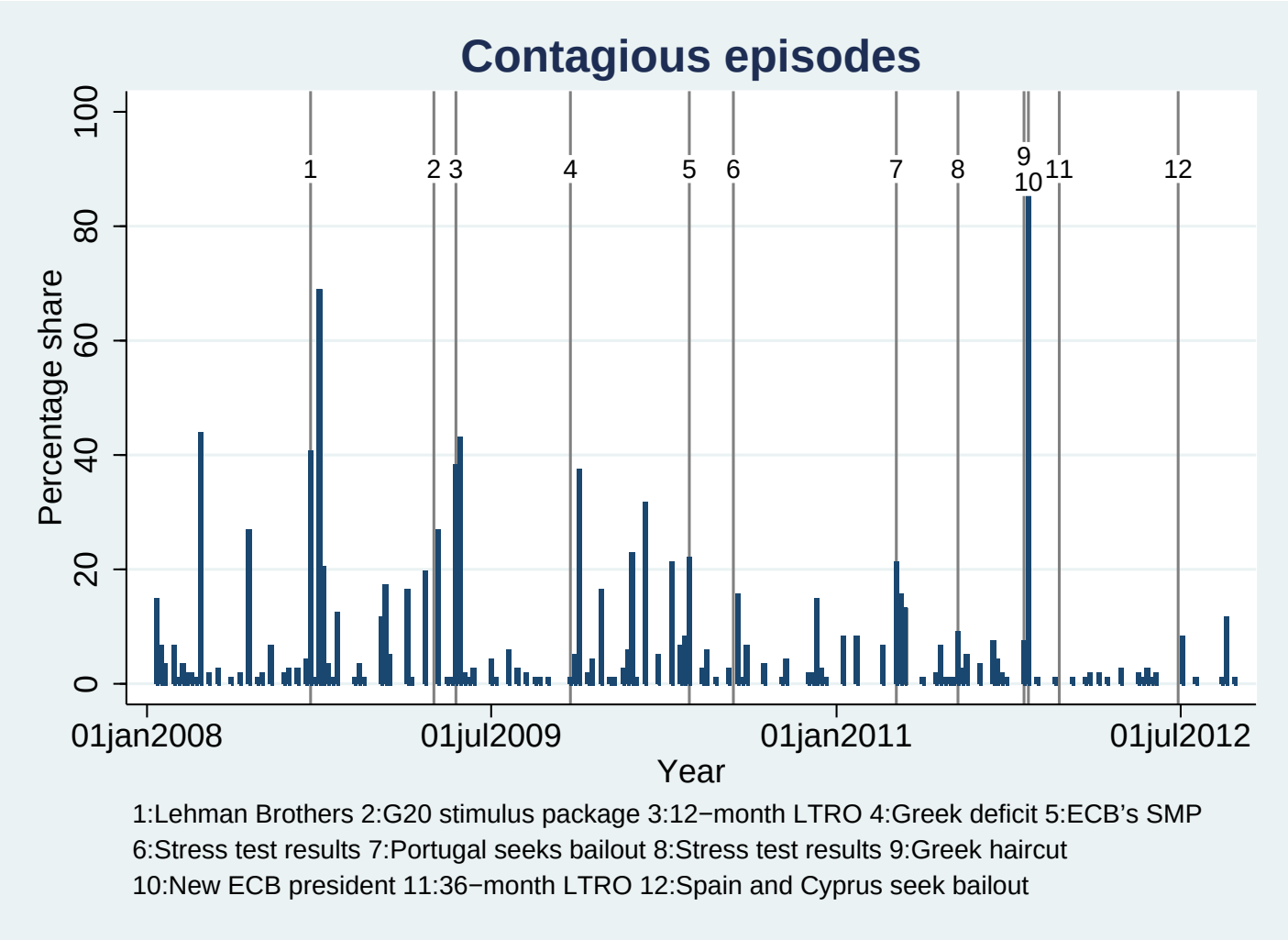
- DCC $\rho_{ij,t}$ show increase after Sept 2008; peaks correspond to key events.
- Divergence with sovereign crisis: eurozone effect; high DCCs in EZ periphery.

Crisis events and DCCs



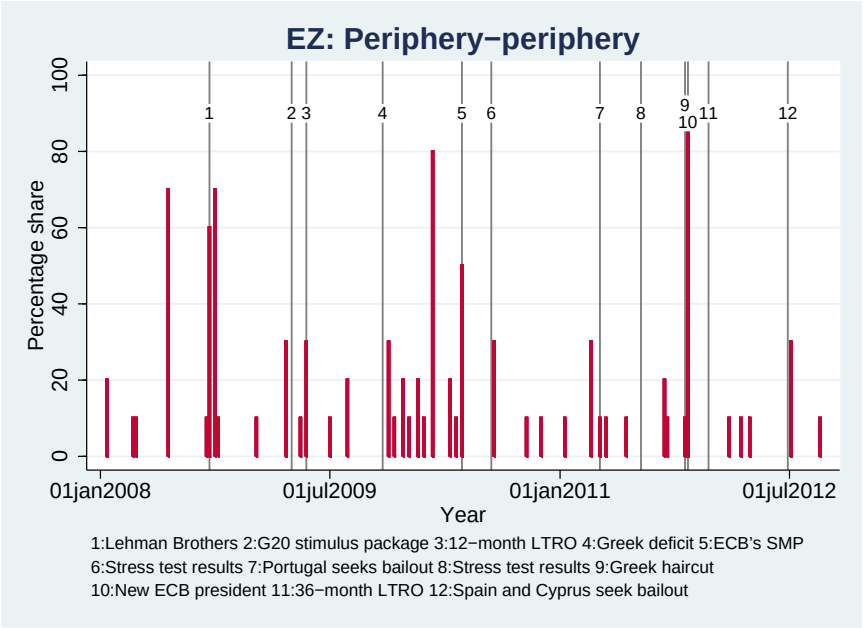
- 4:Increase after announcement of Greek deficit (Nov 2009).
- 5:Decline due to rescue packages (May 2010).
- 9:Sharp peak due to failure of Dexia and PSI rumors (Oct 2011).
- 10:Lower level since ECB interventions (Nov 2011).

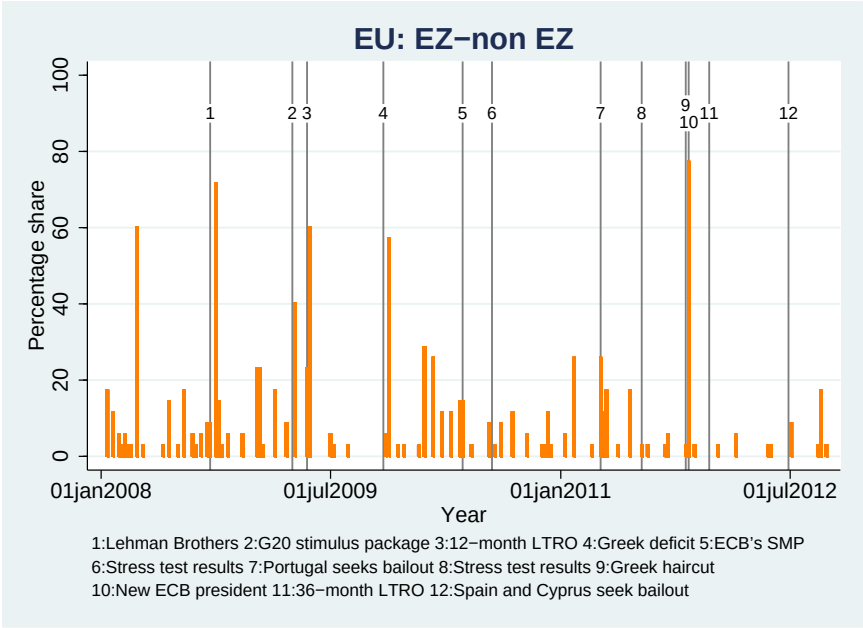
Results: Measurement of contagion



- Graph shows share of country pairs with contagious episode, i.e. $CI_{ijw} = 1$.
- Sovereign debt markets experienced various contagious episodes.

Similarities *and* discrepancies across country groups





- Graph shows share of country pairs with contagious episode per country group.
- Variation of contagion indicator not only across *time* but also across *groups*.
- Specifying arbitrary cut-off points held constant across countries would miss this!

			(I) No FE	(II) $ij + m$ FE	(III) No FE	(IV) $ij + m$ FE
Global controls		%ΔVDAX volatility	0.0165***		0.0150***	
			(0.0048)		(0.0047)	
		%ΔEuribor-Eonia	0.0044***		0.0043***	
			(0.0008)		(0.0008)	
Similarity in economic fundamentals		ΔGDP	0.1152***	0.1748***	0.1109***	0.1647***
			(0.0139)	(0.0413)	(0.0137)	(0.0396)
		Public debt	-0.0058	-0.0128	-0.0088	-0.0156*
			(0.0068)	(0.0081)	(0.0070)	(0.0082)
		Foreign reserves	-0.0220	-0.0312*	-0.0235	-0.0309
			(0.0164)	(0.0186)	(0.0169)	(0.0189)
		Bank assets	0.0002***	0.0001*	0.0002***	0.0001
			(0.0000)	(0.0001)	(0.0000)	(0.0001)
		Bank equity	0.0051**	0.0113***	0.0083**	0.0132***
			(0.0026)	(0.0031)	(0.0032)	(0.0034)
Links	non-fundamental financial	Stock market volatility	0.0459***	0.0204**	0.0178*	-0.0044
			(0.0087)	(0.0099)	(0.0091)	(0.0093)
		Bank's foreign claims	-0.0918**	-0.0526	-0.0922*	-0.0711
			(0.0463)	(0.0496)	(0.0517)	(0.0509)
	real	Trade	-0.0132	0.0284	-0.0018	0.0444*
			(0.0126)	(0.0253)	(0.0133)	(0.0265)
Interaction (× CI)		Public debt			0.0209**	0.0189**
					(0.0095)	(0.0084)
		Bank equity			-0.0156	-0.0135
					(0.0117)	(0.0089)
		Stock market volatility			0.0944***	0.0929***
					(0.0149)	(0.0191)
		Bank's foreign claims			-0.0589	0.1671**
					(0.0666)	(0.0757)
		Trade			-0.1395***	-0.0722***
					(0.0268)	(0.0247)
Observations			5,677	5,677	5,677	5,677
Country pairs			107	107	107	107
R-squared			0.05	0.27	0.05	0.28

Wake-up call contagion

Links	non-fundamental	Stock market volatility	0.0459***	0.0204**	0.0178*	-0.0044
			(0.0087)	(0.0099)	(0.0091)	(0.0093)
	financial	Banks' foreign claims	-0.0918**	-0.0526	-0.0922*	-0.0711
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- Similarity in public debt: Evidence for **"wake-up call" contagion**.

Fundamentals based contagion

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- Financial linkage seems to reduce sovereign credit risk co-movements in "normal times" but changes its role during "contagious times".
- Evidence for **fundamentals based contagion**.

Non-fundamentals based contagion

Links	non-fundamental	Stock market volatility	0.0459***	0.0204**	0.0178*	-0.0044
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	financial	Banks' foreign claims	-0.0918**	-0.0526	-0.0922*	-0.0711
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					(0.0268)	(0.0247)

- Indirect linkage proxied by stock market volatility: Evidence for **non-fundamentals based contagion**.

Concluding remarks

- Sovereign debt crisis characterized by sharp widening in sovereign credit risk spreads. Yet, EZ countries co-move despite diverging fundamentals. Why?
- *Our results suggest*:
  - Sovereign debt markets in the eurozone are tied together during the sovereign debt crisis (eurozone effect) with co-movements highest for periphery countries.
  - Contagion is not attributable to one moment in time or country pair.
  - Evidence for both fundamentals and non-fundamentals based contagion.
  - Similarities in economic fundamentals, cross-country linkages in banking and common market sentiments matter.
  - "Eurozone effect" – Adjustments at the national level sufficient?

DCC model (Engle 2002)

- **First Stage**: univariate GARCH model for each demeaned series.
- Mean equation for 2×1 vector of log differenced CDS spreads $y_t = (y_{i,t}, y_{j,t})'$:

$$y_t = \gamma_0 + \gamma_1 y_{t-1} + \xi_t$$

with $\xi_t | \Omega_{t-1} \sim N(0, H_t)$ and variance-covariance matrix $H_t = D_t R_t D_t$.

- D_t contains time-varying standard deviations $\sqrt{h_{i,t}}$, which follow a GARCH(1,1) process:

$$h_{i,t} = \omega_i + a_i \xi_{i,t-1}^2 + b_i h_{i,t-1}$$

- **Second stage**: use standardized residuals $v_{i,t} = \xi_{i,t} / \sqrt{h_{i,t}}$ to estimate the time-varying correlation of the DCC(1,1) process:

$$Q_t = (1 - \alpha - \beta)\overline{Q} + \alpha v_{t-1} v_{t-1}' + \beta Q_{t-1}$$

$\overline{Q}$: 2×2 time-invariant unconditional covariance matrix of $v_{i,t}$.
Q_{t-1}: 2×2 time-varying variance-covariance matrix of $v_{i,t}$.

DCC model (Engle 2002)

- The final correlation matrix R_t is given as:

$$R_t = (\text{diag}(Q_t))^{-1/2}\, Q_t\, (\text{diag}(Q_t))^{-1/2}$$

- The off-diagonal elements provide information on the DCCs between CDS spreads in country i and j:

$$\rho_{ij,t} = q_{ij,t} / \sqrt{q_{ii,t}\, q_{jj,t}}$$

- Advantage: The DCCs are time-varying, based on the full sample period and adjusted for the underlying volatility.
- Hence, we can interpret a significant increase in the DCCs as contagion (Forbes and Rigobon 2002, Chiang et al. 2007).