# How Much of Bank Credit Risk is Sovereign Risk?

## Evidence from the Eurozone

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# Motivation

- The tight sovereign/bank link is a key feature of the 2008-09 crisis, and, even more, of the recent sovereign debt crisis (e.g., Acharya et. al. 2013; Gennaioli el al., 2013.)
- Europe is a natural laboratory to assess such link:
  - In a number of countries, the crisis originates in the banking sector, spills over to the sovereign, and then feeds back to the banks. (e.g. Iceland, Ireland and Spain)
  - In other countries, sovereign public finances are the main initial source of fragility. (e.g. Greece and Italy)
  - But banks' exposures to the credit risk of the *domestic sovereign* are apparent from late 2008.
- Banks, however, are also exposed to the credit risk of the *non-domestic* sovereigns (Bolton and Jeanne, 2011; Korte and Steffen, 2014).

# This paper

- Estimate banks' sovereign exposures implied in CDSs (market based), by a multivariate credit risk model (Duffie and Singleton, 1999; Pan and Singleton, 2008; Ang and Longstaff, 2013; and Li and Zinna, 2014):
  1. Joint probability of default (systemic sovereign risk) for Germany, France, Italy and Spain, and idiosyncratic probability (country risk).
  2. Banks' individual exposures to systemic sovereign risk and country risk, as well as bank idiosyncratic credit risk.
- Relate the cross-section of estimated banks' exposures to standard measures of sovereign exposures, such as:
  - bank size
  - holdings of sovereign debt (and the associated subsidy)
  - expected government support.
- Investigate the term structure of the distress risk premia components.

# Pricing CDS

The present value of the premium leg is given by:

$$P(CDS, t, M) = CDS(t, M)E^{\mathbb{Q}}\Big[\int_t^{t+M} \exp\Big(-\int_t^s r_u + \lambda_u du\Big)ds\Big], \qquad (1)$$

The present value of the protection leg, given a constant risk-neutral fractional recovery $R^{\mathbb{Q}}$, is instead given by:

$$PR(R^{\mathbb{Q}}, t, M) = (1 - R^{\mathbb{Q}})E^{\mathbb{Q}}\Big[\int_t^{t+M} \lambda_s \exp\Big(-\int_t^s r_u + \lambda_u du\Big)ds\Big]. \qquad (2)$$

The fair value of $CDS(t, M)$ is then derived by equating the protection leg $PR(R^{\mathbb{Q}}, t, M)$ and the premium leg $P(CDS, t, M)$

The identification of the credit shocks stems from: i) the factor specification of $\lambda$; and, ii) the joint estimation across sovereigns.

# Stage 1: Sovereign credit risk

The intensity of default of sovereign $i$ is the sum of the country intensity ($C_{t,i}$) and the scaled systemic intensity ($\alpha_i \; S_t$):

$$\lambda_{t,i} = \alpha_i S_t + C_{t,i}, \tag{3}$$

where the intensities follow (independent) CIR processes:

$$dS_t = (\eta - \kappa^{\mathbb{Q}} S_t)dt + \sigma\sqrt{S_t}dB_t^{\mathbb{Q}}, \tag{4}$$

$$dC_{t,i} = (\eta_i - \kappa_i^{\mathbb{Q}} C_{t,i})dt + \sigma_i\sqrt{C_{t,i}}dW_{t,i}^{\mathbb{Q}}, \tag{5}$$

and $\alpha_i$ is sovereign's $i$ systemic exposure.

Identification: Germany has unit exposure to the systemic factor ( $\alpha_{GER} = 1$ ). Thus, other sovereign exposures are rescaled w.r.t. Germany.

# Stage 2: Bank credit risk

The (total) intensity of default of bank $j$ of country $i$ is:

$$\lambda_{t,i,j} = \alpha_{i,j} S_t + \gamma_{i,j} C_{t,i} + I_{t,i,j}, \tag{6}$$

- the scaled systemic ($\alpha_{i,j} S_t$)
- the scaled country intensity ($\gamma_{i,j} C_{t,i}$); and
- the idiosyncratic intensity ($I_{t,i,j}$), where

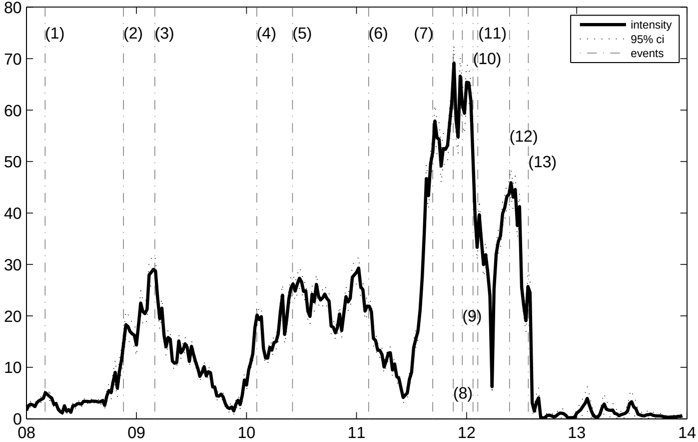
$$dI_{t,i,j} = (\eta_{i,j} - \kappa^{\mathbb{Q}}_{i,j} I_{t,i,j})dt + \sigma_{i,j}\sqrt{I_{t,i,j}}dZ^{\mathbb{Q}}_{t,i,j}, \tag{7}$$

Second stage: bank-by-bank estimation, whereby the systemic ($S_t$) and country ($C_{t,i}$) intensities, as well as the parameters driving their dynamics $\Theta^{\mathbb{Q}} = [\eta, \kappa^{\mathbb{Q}}, \sigma]$ and $\Theta^{\mathbb{Q}}_i = [\eta_i, \kappa^{Q}_i, \sigma_i]$, are fixed at the values estimated in the first stage.

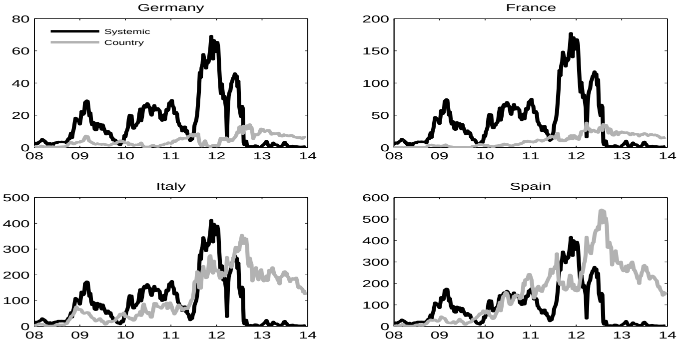
# Data and econometric methodology

- Bid-, mid- and ask-CDS premia for the 1-, 3-, 5-, 7- and 10-yr maturities. Senior CDS contracts; USD (EUR) denominated CDS contracts for sovereigns (banks). Source: CMA.
- Weekly frequency (Wednesdays), period from Jan-2008 to Dec-2013.
- We focus on a sample of 21 large European banks:
  - 4 French, and 5 Italian banks (as in FSAP and EBA exercise).
  - 7 German, and 5 Spanish banks; more fragmented banking systems; Selection criterion: Parent banks; assets exceed \$100 billion; liquid TS of CDSs available.
- Estimation:
  - Discretized with Euler; state-space representation; pricing error variance is a function of (il)liquidity, e.g., bank $i,j$ $\sigma_{\epsilon,i,j} \left| Bid_{t,i,j}(M) - Ask_{t,i,j}(M) \right|$.
  - single move algorithm (to tackle non-linearity of pricing and non-Gaussian intensity factors); slice sampling of Neal (2003); 40.000 reps, of which 20.000 burned-in

# Systemic sovereign intensity ($S_t$)



# Country ($C_{t,i}$) and scaled systemic ($\alpha_i S_t$)




| | $\alpha_i$ [ci] | SIW=$\alpha_i S_t/(\alpha_i S_t + C_{t,i})$ Mean | Med. | SDev. | Min | Max |
|---|---|---|---|---|---|---|
| GER | 1 | 66.2 | 83.1 | 33.0 | 1.4 | 99.4 |
| FRA | 2.56 [2.50;2.63] | 69.7 | 87.7 | 34.3 | 1.6 | 99.1 |
| ITA | 5.96 [5.75;6.18] | 48.5 | 58.9 | 28.8 | 0.4 | 93.2 |
| ESP | 6.01 [5.79;6.23] | 44.4 | 47.0 | 30.1 | 0.3 | 94.8 |

# Banks' exposures to sovereign risk

- Exposure to sovereign **systemic** risk ($S_t$)
  - $\alpha_{i,j}$ is the prob. that bank $j$ located in country $i$ defaults, relative to the prob. that Germany defaults, in the event that a sovereign systemic credit shock hits.
  - Systemic intensity weight (the fraction of bank credit risk that is due to systemic sovereign risk).

$$SIW = \alpha_{i,j} S_t / (\alpha_{i,j} S_t + \gamma_{i,j} C_{t,i} + I_{t,i,j})$$

- Exposure to sovereign **country** risk ($C_{t,i}$)
  - $\gamma_{i,j}$ is the prob. that bank j located in country i defaults, relative to the prob. that country i defaults, in the event that a country credit shock hits.
  - Country intensity weight (the fraction of bank credit risk that is due to domestic country credit risk).

$$CIW = \gamma_{i,j} S_t / (\alpha_{i,j} S_t + \gamma_{i,j} C_{t,i} + I_{t,i,j})$$

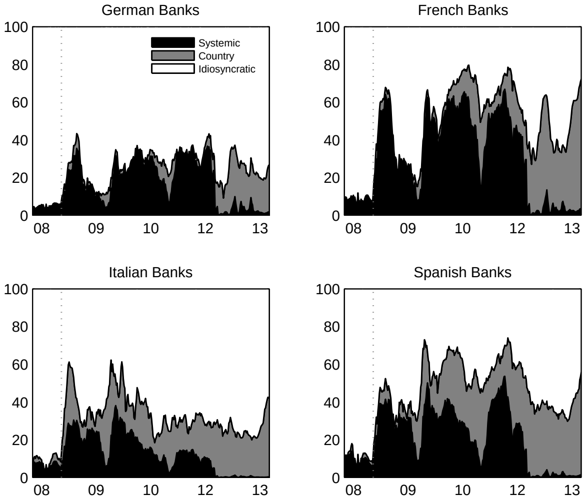
# Banks' sovereign exposures (core countries)

| | Panel A: German Banks | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | SIW | | | | | CIW | | | |
| | $\alpha_{i,j}$ | Mean | SDev | Min | Max | $\gamma_{i,j}$ | Mean | SDev | Min | Max |
| DB | 1.20 | 17.3 | 13.1 | 0.1 | 67.2 | 1.83 | 12.3 | 6.1 | 0.2 | 87.2 |
| CB | 2.32 | 26.1 | 23.7 | 0.2 | 72.9 | 2.38 | 7.9 | 6.7 | 0.3 | 25.8 |
| DZ | 1.42 | 17.3 | 9.9 | 0.3 | 63.5 | 1.77 | 9.3 | 4.2 | 0.3 | 39.1 |
| LBW | 2.47 | 20.3 | 16.0 | 0.5 | 61.3 | 1.96 | 9.2 | 3.9 | 0.2 | 39.9 |
| BYLAN | 1.57 | 13.0 | 11.0 | 0.2 | 50.4 | 1.42 | 8.7 | 2.8 | 0.1 | 52.6 |
| NDB | 1.18 | 9.5 | 8.4 | 0.1 | 23.2 | 0.03 | 0.1 | 0.0 | 0.0 | 0.2 |
| HSH | 1.24 | 8.0 | 3.0 | 0.1 | 41.1 | 1.85 | 2.9 | 1.8 | 0.2 | 13.4 |
| Avg | 1.63 | 15.9 | 12.2 | 0.2 | 54.2 | 1.60 | 7.2 | 3.6 | 0.2 | 36.9 |
| | Panel B: French Banks | | | | | | | | | |
| | | SIW | | | | | CIW | | | |
| | $\alpha_{i,j}$ | Mean | SDev | Min | Max | $\gamma_{i,j}$ | Mean | SDev | Min | Max |
| BNP | 2.37 | 34.2 | 36.3 | 0.4 | 80.9 | 1.57 | 20.3 | 11.0 | 0.3 | 71.3 |
| CA | 2.70 | 30.3 | 26.6 | 0.3 | 83.6 | 1.99 | 19.8 | 12.2 | 0.3 | 82.1 |
| SG | 3.08 | 31.9 | 32.7 | 0.3 | 79.8 | 1.91 | 17.7 | 9.0 | 0.3 | 79.9 |
| NTX | 3.23 | 22.9 | 12.6 | 0.3 | 80.1 | 1.51 | 10.2 | 6.8 | 0.1 | 58.1 |
| Avg | 2.84 | 29.8 | 27.0 | 0.3 | 81.1 | 1.74 | 17.0 | 9.8 | 0.3 | 72.9 |

# Banks' sovereign exposures (periphery countries)

| | Panel C: Italian Banks | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | SIW | | | | | CIW | | | |
| | $\alpha_{i,j}$ | Mean | SDev | Min | Max | $\gamma_{i,j}$ | Mean | SDev | Min | Max |
| ISP | 0.00 | 0.0 | 0.0 | 0.0 | 0.0 | 0.77 | 34.1 | 35.5 | 1.4 | 90.9 |
| UI | 0.00 | 0.0 | 0.0 | 0.0 | 0.0 | 0.91 | 31.9 | 31.0 | 1.2 | 95.5 |
| MPS | 3.41 | 22.6 | 17.3 | 0.1 | 66.9 | 0.48 | 13.7 | 13.7 | 0.5 | 38.9 |
| BP | 3.36 | 14.1 | 11.8 | 0.1 | 60.3 | 0.51 | 11.0 | 11.3 | 0.4 | 28.0 |
| UBI | 2.98 | 21.7 | 20.5 | 0.1 | 69.9 | 0.04 | 1.6 | 1.5 | 0.1 | 5.2 |
| Avg | 1.95 | 11.7 | 9.9 | 0.0 | 39.4 | 0.54 | 18.4 | 18.6 | 0.7 | 51.7 |
| | Panel D: Spanish Banks | | | | | | | | | |
| | | SIW | | | | | CIW | | | |
| | $\alpha_{i,j}$ | Mean | SDev | Min | Max | $\gamma_{i,j}$ | Mean | SDev | Min | Max |
| BST | 3.98 | 27.6 | 25.5 | 0.2 | 63.4 | 0.54 | 32.6 | 38.1 | 0.4 | 69.2 |
| BBVA | 4.31 | 28.9 | 26.8 | 0.2 | 69.4 | 0.64 | 36.6 | 38.9 | 0.6 | 84.0 |
| BCXA | 2.42 | 12.5 | 9.1 | 0.1 | 68.0 | 0.11 | 5.3 | 5.0 | 0.1 | 20.3 |
| BPE | 5.96 | 16.8 | 18.1 | 0.1 | 46.2 | 0.74 | 20.3 | 24.1 | 0.3 | 42.4 |
| BSB | 6.32 | 17.8 | 18.4 | 0.1 | 55.9 | 0.79 | 23.4 | 27.0 | 0.5 | 65.5 |
| Avg | 4.60 | 20.7 | 19.6 | 0.1 | 60.6 | 0.56 | 23.6 | 26.6 | 0.4 | 56.3 |

# Bank credit risk components (% of total risk)



# Summary of results credit risk model

Stage 1 estimates:

- Market perception of systemic sovereign risk reaches its peak in late 2011, and following Draghi's "whatever it takes" speech vanishes.
- Pivotal role of Spain and Italy: their exposures are similar, and roughly 6 (2.5) times higher than Germany (France).
- But Germany and France's credit risk is largely systemic.

Stage 2 estimates:

- Sovereign risk accounts for 45% of French and Spanish banks' credit risk, then 30% and 23% of Italian and German banks.
  - However, Italian (and Spanish) banks' sovereign risk is largely due to country risk.
  - Moreover, Italian and Spanish banks' show lower exposures than the domestic sovereign to both types of sovereign risk, revealing the sovereign nature of the crisis.
- $I_{i,j}$ display strong comovement; consistent with sovereign risk not being the only source of comovement across banks' credit risk (private sector, repo market, liquidity shocks and regulation)

# Determinants of banks' sovereign exposures

- Systemic risk indicators generally combine PDs with **bank size**, whereas we only use information on PDs. Do larger banks display larger sovereign exposures?
- Bank **holdings of sovereign debt** is a standard measure of banks' direct exposures to sovereign risk. (source: EBA 2011 stress test)
- 'Zero risk weight' *de facto* applied to holdings of EA government debt, which is an **implicit subsidy** to banks $\rightarrow$ When sovereign credit risk deteriorates, banks face a shortfall in bank capital.

  Note: the subsidy is measured by weighting each holding of sovereign debt by the risk weights which apply to corporate debt of comparable credit risk (source: Korte and Steffen, 2014).

# Determinants of banks' sovereign exposures (cont'd)

| | Panel A: SIW | | | | | Panel B: CIW | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (1) | (2) | (3) | (4) | (5) |
| Size | **0.179**[b] | | | | | **0.278**[a] | | | | |
| (in %) | (0.0646) | | | | | (0.0696) | | | | |
| For.Exp. | | **0.158**[a] | | | | | 0.0745 | | | |
| (in €bn) | | (0.0414) | | | | | (0.0470) | | | |
| For. Sub. | | | **0.602**[a] | | | | | 0.289 | | |
| (in €bn) | | | (0.166) | | | | | (0.192) | | |
| Dom. Exp. | | | | -0.0977 | | | | | **0.262** | |
| (in €bn) | | | | (0.154) | | | | | (0.162) | |
| Dom. Sub. | | | | | -1.134[c] | | | | | **1.472**[a] |
| (in €bn) | | | | | (0.567) | | | | | (0.459) |
| Con. | 14.11[a] | 16.04[a] | 15.74[a] | 21.96[a] | 25.10[a] | 8.621[a] | 14.67[a] | 14.51[a] | 7757 | 7.945[b] |
| | (1.930) | (1.996) | (2.033) | (4.594) | (3.685) | (2.465) | (2.915) | (2.983) | (4.718) | (3.270) |
| $R^2$ | 0.195 | 0.204 | 0.201 | 0.027 | 0.185 | 0.367 | 0.036 | 0.036 | 0.153 | 0.244 |

# Expected government support

- Active literature investigating the link between implicit guarantees and asset prices (e.g., Correa et, 2013).
- *Our hypothesis*: The expected government support increases the probability that a bank defaults in the event of a country credit event ($\gamma_{i,j}$).
- The expected government support (so-called 'uplift') can be measured as the difference between:
  - All-in-all credit rating (bank's ability to repay its deposit obligations);
  - Stand-alone rating (bank's intrinsic safety and soundness). Note: We map

    ratings to a numerical scale from 1 (C) to 13 (Aaa) (source: Moody's).

# Expected government support (cont'd)

| | Panel A: $\gamma_{i,j}$ | | | | Panel B: CIW | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (1) | (2) | (3) | (4) |
| All-in-all CR | **0.215**[c] | | | | 2.243 | | | |
| | (0.116) | | | | (1.378) | | | |
| Stand-alone CR | | -0.0227 | | 0.172 | | **4.615**[a] | | **3.626**[b] |
| | | (0.0818) | | (0.102) | | (0.970) | | (1.492) |
| Uplift | | | **0.203**[b] | **0.339**[b] | | | -4.604[a] | -1.724 |
| | | | (0.093) | (0.149) | | | (1.584) | (2.099) |
| Con. | -0.719 | 1.337[b] | 0.767[a] | -0.680 | -3.290 | -14.80[b] | 25.99[a] | -4.551 |
| | (1.069) | (0.594) | (0.225) | (0.978) | (12.24) | (6.347) | (4.909) | (14.39) |
| $R^2$ | 0.145 | 0.003 | 0.162 | 0.249 | 0.066 | 0.488 | 0.351 | 0.515 |

## Summary of cross-sectional results

- Sovereign exposures extracted from asset prices relate to standard measures of sovereign exposures.
  - Larger banks display higher CIW and SIW.
  - SIW (CIW) increase with the holdings of EA (domestic) sovereign debt and the associated subsidy.
  - The higher the 'uplift' the higher the $\gamma_{i,j}$; the higher the bank financial strength the higher the CIW.
- But, taken together, standard measures only explain roughly half of banks' credit risk.
- Thus, asset prices might contain additional information relative to these standard measures of sovereign exposure
  $\rightarrow$ *indirect* sovereign exposures also matter!

# Distress risk premia

- Estimation method exploits both time series ($\mathbb{P}$; objective) and cross-sectional ($\mathbb{Q}$; pricing) information in the CDS term structure $\rightarrow$ Quantify distress risk premia.
- Essentially affine market price of risk specification (e.g. Duffee 2002).
  - Market prices of risk ($\pi$, $\pi_i$, $\pi_{i,j}$): systemic $\kappa^{\mathbb{P}} = \kappa^{\mathbb{Q}} - \pi\sigma$; country $\kappa_i^{\mathbb{P}} = \kappa_i^{\mathbb{Q}} - \pi_i\sigma_i$; and, bank idiosyncratic. $\kappa_{i,j}^{\mathbb{P}} = \kappa_{i,j}^{\mathbb{Q}} - \pi_{i,j}\sigma_{i,j}$.
- The resulting 'distress risk premia' remunerate investors for unexpected changes in the default intensities (Driessen, 2005; Pan and Singleton, 2008; Longstaff, Pan, Pedersen and Singleton, 2011; and, Li and Zinna, 2014) .
- Take for example sovereign $i$ , the contribution of the risk premium to the spread is measured as $CRP_i(M) = (CDS_i(M) - CDS_i(M)^{\mathbb{P}})/CDS_i(M)$.

# TS of sovereign risk premium components

| Panel A: Germany | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total | | | | Systemic | | | | Country | | | |
| | 1yr | 3yr | 5yr | 10yr | 1yr | 3yr | 5yr | 10yr | 1yr | 3yr | 5yr | 10yr |
| Mean | 68 | 92 | 97 | 99 | 42 | 54 | 51 | 43 | 26 | 38 | 46 | 56 |
| Sdev | 2 | 1 | 1 | 0 | 22 | 29 | 30 | 28 | 24 | 31 | 31 | 29 |
| Panel B: France | | | | | | | | | | | | |
| | Total | | | | Systemic | | | | Country | | | |
| | 1yr | 3yr | 5yr | 10yr | 1yr | 3yr | 5yr | 10yr | 1yr | 3yr | 5yr | 10yr |
| Mean | 65 | 90 | 95 | 98 | 44 | 56 | 50 | 34 | 20 | 34 | 45 | 64 |
| Sdev | 1 | 1 | 1 | 1 | 22 | 30 | 30 | 23 | 22 | 31 | 31 | 24 |
| Panel C: Italy | | | | | | | | | | | | |
| | Total | | | | Systemic | | | | Country | | | |
| | 1yr | 3yr | 5yr | 10yr | 1yr | 3yr | 5yr | 10yr | 1yr | 3yr | 5yr | 10yr |
| Mean | 52 | 78 | 86 | 91 | 30 | 35 | 28 | 17 | 22 | 43 | 58 | 75 |
| Sdev | 6 | 3 | 2 | 1 | 17 | 21 | 17 | 12 | 12 | 18 | 17 | 11 |
| Panel D: Spain | | | | | | | | | | | | |
| | Total | | | | Systemic | | | | Country | | | |
| | 1yr | 3yr | 5yr | 10yr | 1yr | 3yr | 5yr | 10yr | 1yr | 3yr | 5yr | 10yr |
| Mean | 47 | 72 | 80 | 87 | 28 | 33 | 28 | 17 | 19 | 38 | 52 | 70 |
| Sdev | 8 | 5 | 3 | 2 | 18 | 22 | 19 | 13 | 10 | 17 | 17 | 12 |

# Summary of distress risk premium results

- Default risk is largely priced in short- to medium-term CDS, whereas long-term CDS largely reflect investors' risk aversion.
- Safer sovereigns display: i) higher contribution of the risk premium to the spread (CRP), ii) less upward sloping CRP term structures .
  - Recall safer sovereigns display higher SIW; in fact, systemic risk premia (SCRP) are particularly large and show a hump-shaped term structure.
  - In contrast, country (bank-idiosyncratic) risk premia show an upward sloping term structure.
- Systemic sovereign risk is priced in short- to medium-term CDS contracts rather than in longer-term (SIW is an upper bound!)

  $\rightarrow$ take the Italian sovereign, the contribution of systemic risk to the one-, three-, five- and ten-year spreads is, respectively, 44, 37, 28 and 18 percent.
- *Policy*: our results lend support to the choice of the ECB to tackle Eurozone systemic risk, or the fears of reversibility of the euro, by focusing the OMT on government-issued bonds with short maturities.

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