Decomposing Euro-Area Sovereign Spreads: Credit and Liquidity Risks

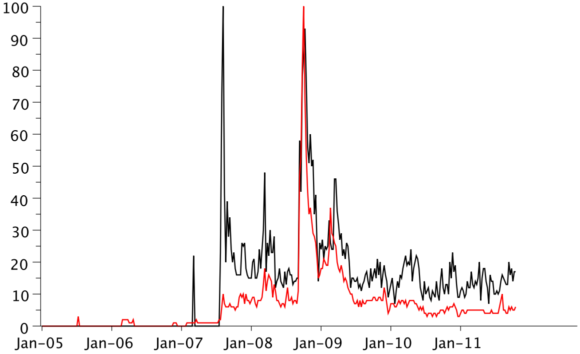
A. Monfort[1] and J.-P. Renne[2]

5th Volatility Institute Conference, NYU Stern, April 26th, 2013

[1]CREST, Banque de France and Maastricht University.

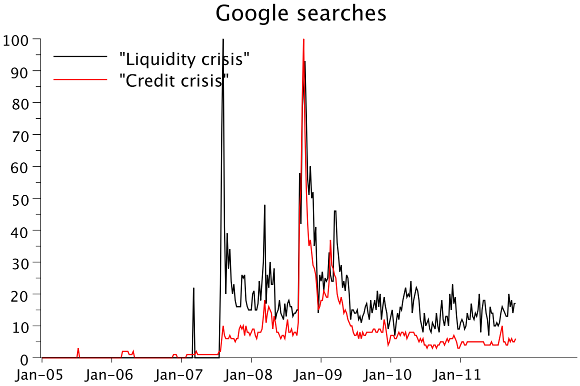
[2]Banque de France. The views expressed in the following are those of the authors and do not necessarily reflect those of the Banque de France.

Introduction
Credit and / vs Liquidity



Source: xxxxxxxxxxxxxxxxxxxxxxxx

Introduction
Credit and / vs Liquidity

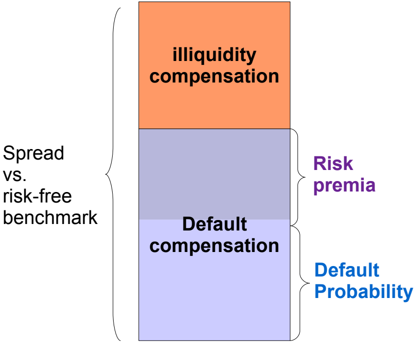


Source: Google Insights, www.google.com/insights/

Introduction

Motivations

1. Are euro-area sovereign yields affected by liquidity-pricing effects (and to what extent)?
2. Interactions between credit-related and liquidity-related risk factors?
3. How to extract probabilities of default (PDs) from bond prices?
4. Do the default compensations include risk premia? [*credit-spread puzzle*, Huang and Huang 2012, Chen et al. 2009]



Introduction

Disentangling credit and liquidity risks: what for?

- Policy implications of a rise in spreads depend on the source:
  - Liquidity problems ⇒ improve market functioning
  - Credit concerns ⇒ enhance the solvency of the debtors (Codogno, Favero and Missale, 2003)
- Investment decisions (Longstaff, 2009):
  - Buy-and-hold investors seek bonds whose price is low because of poor liquidity
  - Bond A and Bond B have the same credit quality but A is less liquid ⇒ buy-and-hold investors buy A because less expensive than B for the same final payoff distribution

Introduction

Overview of connected literature

- Disentangling credit/liquidity risks: (using spreads that are known to be liquidity-driven)
  Spreads between bonds of the same maturity but different ages (Fontaine and Garcia, 2012), between T-bill rates and repo rates (Liu, Longstaff and Mandel, 2006), between govies and swaps (Feldhütter and Lando, 2008)
- Credit affine term-structure models: Duffie and Singleton (1999), Geyer, Kossmeier and Pichler (2004), Longstaff, Mithal and Neis (2005), Mueller (2008)
- Regime-switching in ATSM: Ang, Bekaert and Wei (2008), Monfort and Pegoraro (2007), Dai, Singleton and Yang (2007), Monfort and Renne (2013), Gourieroux et al. (2013)
- Extraction of PDs from market prices: Litterman and Iben (1991)
- Sovereign risk premia: Borri and Verdelhan (2012), Longstaff et al. (2011), Ang and Longstaff (2011)

Introduction
Outline

1. Model
2. Data and estimation
3. Results
    1. Credit/liquidity decomposition
    2. Probabilities of default
4. Concluding remarks

Model
Variables

- N debtors (countries) that issue defaultable and illiquid bonds
- Credit risk: Debtors may default
  - Default variable: $d_t^{(n)} = 1$ if in debtor n in default at t (0 otherwise)
  - Default intensity: $\lambda_{c,t}^{(n)}$
  - Fractional loss given default (LGD): $1 - \zeta$
- Liquidity risk: Bondholders may have to liquidate hastily [Ericsson and Renault (2006)]
  - Liquidity-shock variable: ℓ_t
  - Liquidity-shock intensity: $\lambda_{\ell,t}$
  - Fractional loss given liquidation (LGL): $1 - \theta^{(n)}$
- r_t: risk-free short-term rate
- z_t: crisis-regime variable

Model
Overview

- Credit risk: Fractional-loss credit intensity $\lambda^{(n)}_{fc,t}$:

$$\lambda^{(n)}_{fc,t} = \underbrace{(1-\zeta)}_{\text{fractional LGD}} \times \underbrace{\lambda^{(n)}_{c,t}}_{\text{default intensity}}$$

- Liquidity risk: Fractional-loss liquidity intensity $\lambda^{(n)}_{f\ell,t}$:

$$\lambda^{(n)}_{f\ell,t} = \underbrace{(1-\theta^{(n)})}_{\text{fractional loss}} \times \underbrace{\lambda_{\ell,t}}_{\text{liq.-shock intensity}}$$

Model

Historical dynamics of the regimes

- Liquidity-related stress: $z_{\ell,t}$
- Credit-related stress: $z_{c,t}$
- For i in $\{\ell, c\}$, three stress levels:

$$z_{i,t} = \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} : \text{ low stress} \quad z_{i,t} = \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix} : \text{ distress} \quad z_{i,t} = \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} : \text{ severe stress}$$

- 9 unobserved regimes $z_t = z_{\ell,t} \otimes z_{c,t}$
- The two chains ($z_{\ell,t}$ and $z_{c,t}$) cause each other:

$$\begin{cases} \mathbb{P}(z_{\ell,t} | z_{\ell,t-1}) \neq \mathbb{P}(z_{\ell,t} | z_{\ell,t-1}, z_{c,t-1}) \\ \mathbb{P}(z_{c,t} | z_{c,t-1}) \neq \mathbb{P}(z_{c,t} | z_{\ell,t-1}, z_{c,t-1}) \end{cases}$$

Model

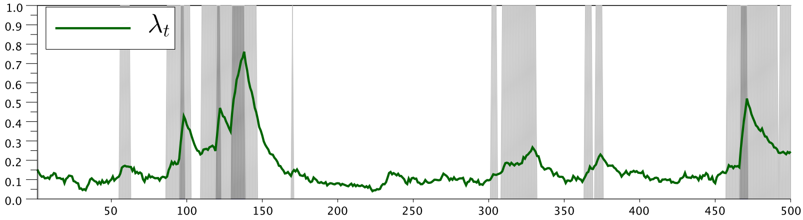
Historical dynamics of the intensities

Generic process followed by the intensities (the $\lambda_{c,t}^{(n)}$'s and $\lambda_{\ell,t}$):

$$\boxed{\lambda_t = \mu' z_t + \rho\lambda_{t-1} + \sigma\varepsilon_t}$$

Simulated example:

with $\mu = [\ 0.01 \quad 0.03 \quad 0.10\ ]$, $\quad P = \begin{bmatrix} 0.98 & 0.02 & 0 \\ 0.05 & 0.90 & 0.05 \\ 0 & 0.30 & 0.70 \end{bmatrix}$. and $\varepsilon_t \sim$ i.i.d. $\mathcal{N}(0, 0.01^2)$



Light grey: crisis regime ($z_t = [0, 1, 0]'$), Dark grey: severe crisis regime ($z_t = [0, 0, 1]'$)

Model
S.D.F.

- Stochastic discount factor (s.d.f.) between $t-1$ and t:

$$M_{t-1,t} = \exp\left[-r_{t-1} - \frac{1}{2}\nu_t^{'}\nu_t + \nu_t^{'}\varepsilon_t + (\delta z_{t-1})' z_t\right]$$

- The risk-sensitivity matrix δ and the vectors ν_t respectively price the regimes z_t and the (standardized) Gaussian innovations ε_t of λ_t.
- Under $\mathbb{Q}$:
  - z_t follows a time-homogenous Markovian chain whose dynamics is described by transition probabilities π^*_{ij} (given by $\pi_{ij}\exp\delta_{ij}$)
  - The intensities follow:

$$\lambda_{i,t} = \mu_i^{*'} z_t + \rho_i^* \lambda_{i,t-1} + \sigma_i \varepsilon^*_{i,t}$$

where $\varepsilon^*_{i,t} \sim \mathcal{N}^{\mathbb{Q}}(0,1)$, $\mu_i^* = \mu_i + \sigma_i \nu'_{z,i}$ and $\rho_i^* = \rho_i + \sigma_i \nu_{\lambda,i}$ $(\nu_{i,t} = \nu_{\lambda,i}\lambda_{i,t-1} + \nu'_{z,i} z_t)$

Model

Risk-neutral dynamics of d_t and ℓ_t

$\mathbb{P}$ and $\mathbb{Q}$ intensities in this framework

- The conditional distributions of d_t and ℓ_t, given $(\lambda_{c,t}, \lambda_{\ell,t}, \underline{W}_{t-1})$, are the same functions of $\lambda_{c,t}$ and $\lambda_{\ell,t}$ under $\mathbb{P}$ and $\mathbb{Q}$
- The default and liquidity intensities are the same process in both worlds

- This stems from the fact that the variables d_t and ℓ_t do not enter the s.d.f.

Model

Risk-neutral dynamics of d_t and ℓ_t

$\mathbb{P}$ and $\mathbb{Q}$ intensities in this framework

- The conditional distributions of d_t and ℓ_t, given $(\lambda_{c,t}, \lambda_{\ell,t}, \underline{W}_{t-1})$, are the same functions of $\lambda_{c,t}$ and $\lambda_{\ell,t}$ under $\mathbb{P}$ and $\mathbb{Q}$
- The default and liquidity intensities are the same process in both worlds

- This stems from the fact that the variables d_t and ℓ_t do not enter the s.d.f.
- The intensities are the same processes under both measures **but their $\mathbb{Q}$- and $\mathbb{P}$-dynamics are different.** (Hence $\mathbb{Q}$- and $\mathbb{P}$-PDs are different.)

Model

Markov-switching State-space model

Bond spreads formulas

$$\begin{aligned} y_{t,h}^{(n)} - r_{t,h} &= -\frac{1}{h} \ln E_t^{\mathbb{Q}} \exp\left(-\lambda_{fc,t+1}^{(n)} - \ldots - \lambda_{fc,t+h}^{(n)} - \lambda_{f\ell,t+1}^{(n)} - \ldots - \lambda_{f\ell,t+h}^{(n)}\right) \\ &= a_h^{(n)'} z_t + b_h^{(n)'} \lambda_t \end{aligned}$$

where the $a_h^{(n)}$'s and the $b_h^{(n)}$'s are computed recursively.

- Model in state-space form (S_t: vector of spreads):

$$\begin{cases} \lambda_t = & \mu' z_t + \Phi \lambda_{t-1} + \Sigma \varepsilon_t \\ S_t = & A z_t + B \lambda_t + \xi_{S,t} \end{cases}$$

Model
Markov-switching State-space model

Bond spreads formulas

$$
\begin{aligned}
y_{t,h}^{(n)} - r_{t,h} &= -\frac{1}{h} \ln E_t^{\mathbb{Q}} \exp\left(-\lambda_{fc,t+1}^{(n)} - \ldots - \lambda_{fc,t+h}^{(n)} - \lambda_{f\ell,t+1}^{(n)} - \ldots - \lambda_{f\ell,t+h}^{(n)}\right) \\
&= a_h^{(n)'} z_t + b_h^{(n)'} \lambda_t
\end{aligned}
$$

where the $a_h^{(n)}$'s and the $b_h^{(n)}$'s are computed recursively.

- Model in state-space form (S_t: vector of spreads):

$$
\begin{cases}
\lambda_t = & \mu' z_t + \Phi \lambda_{t-1} + \Sigma \varepsilon_t \\
CF_t = & A_{CF} z_t + B_{CF} \lambda_t + \xi_{CF,t} \\
S_t = & A z_t + B \lambda_t + \xi_{S,t}
\end{cases}
$$

⇒ Small-sample persistence bias problem: survey-based forecast are introduced [Kim and Orphanides, 2012]

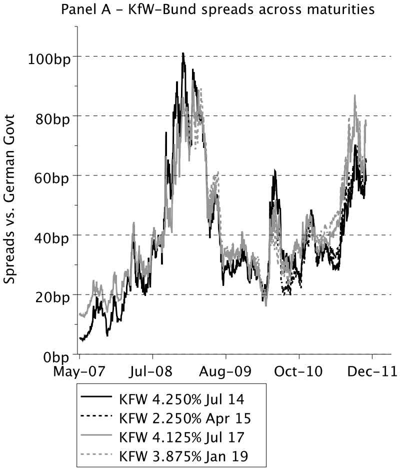
Data and estimation
Data

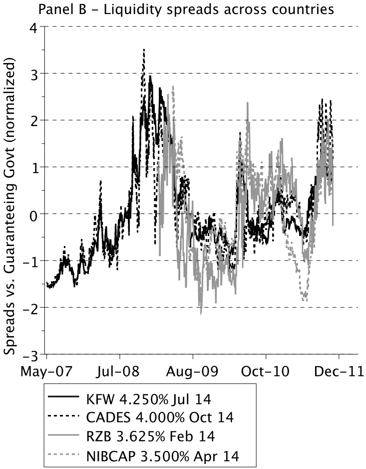
- Weekly data July 2006 – February 2013
- Eight euro-area countries: Austria, Belgium, Finland, France, Germany, Italy, the Netherlands and Spain
- Riskfree yields $r_{t,h}$:

$$r_{t,h} = \underbrace{\text{German yields}}_{\text{riskfree yd } + \text{German credit risk}} - \underbrace{\text{German CDS}}_{\text{German credit risk}}$$

- 12-month-ahead forecasts of 10-year sovereign yields (France, Germany, Italy, Netherlands and Spain) are exploited
- MLE estimation: Log-likelihood of the Markov-Switching State-Space model computed by means of Kim's (1994) algorithm
- Liquidity-factor identification: KfW bonds feature the same credit quality as Germany but are less liquid

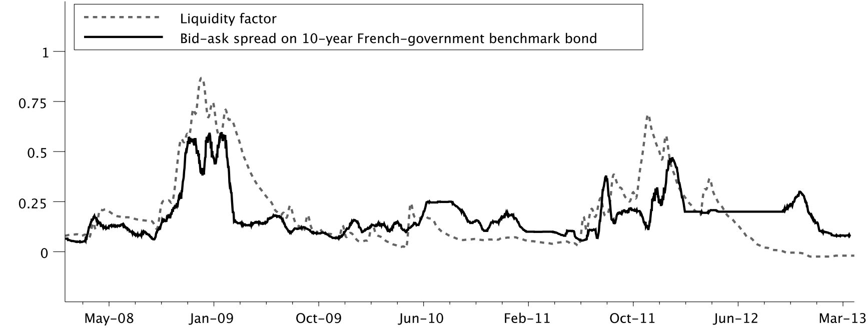
Data and estimation
Liquidity factor: sprds between gov-guaranteed bonds and govies



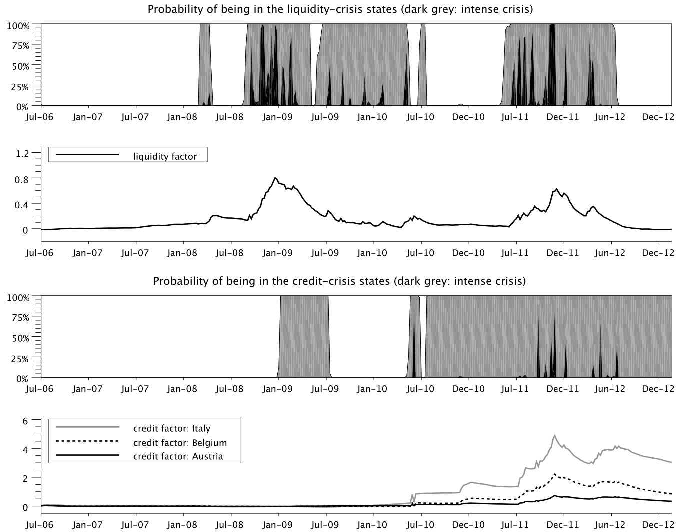


Data and estimation

Liquidity factor $\lambda_{\ell,t}$



Data and estimation
Estimated crisis regimes

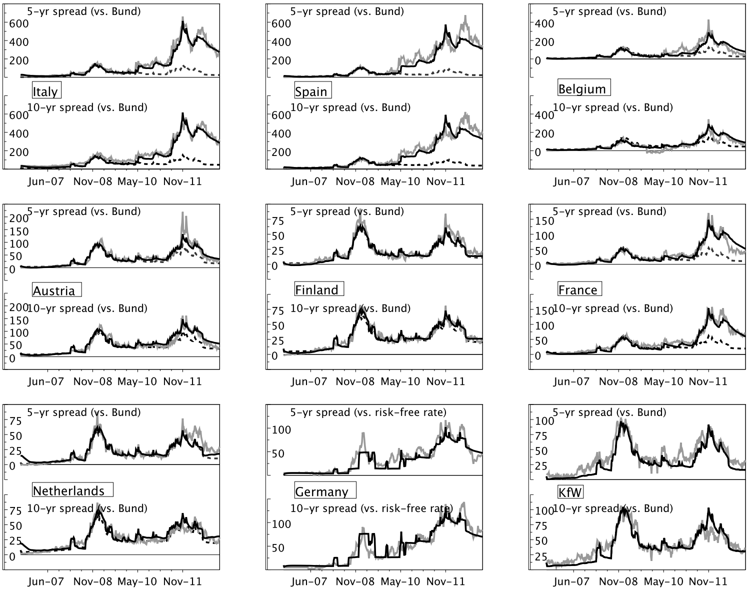


Data and estimation
Transition probabilities

Under $\mathbb{P}$				
		NL_{t+1}	L_{t+1}	LL_{t+1}
NL_t	NC_t	0.999***	0.00106	-
		(0.0011)	(0.0011)	-
	C/CC_t	0.96***	0.043***	-
		(0.012)	(0.012)	-
L_t	NC_t	0.037***	0.85***	0.109***
		(0.002)	(0.042)	(0.042)
	C/CC_t	0.0061	0.89***	0.105***
		(0.0055)	(0.034)	(0.034)
LL_t		-	0.69***	0.31***
		-	(0.092)	(0.092)

Data and estimation
Transition probabilities

Under $\mathbb{Q}$				
		NL_{t+1}	L_{t+1}	LL_{t+1}
NL_t	NC_t	0.999***	0.0015***	-
		(0.00035)	(0.00035)	-
	C/CC_t	0.98***	0.021***	-
		(0.0056)	(0.0056)	-
L_t	NC_t	0.019***	0.000049	0.98***
		(0.004)	(0.12)	(0.11)
	C/CC_t	0.000048	0.00004	0.9999***
		(0.0046)	(0.13)	(0.13)
LL_t		-	1***	0.000049
		-	(0.088)	(0.088)

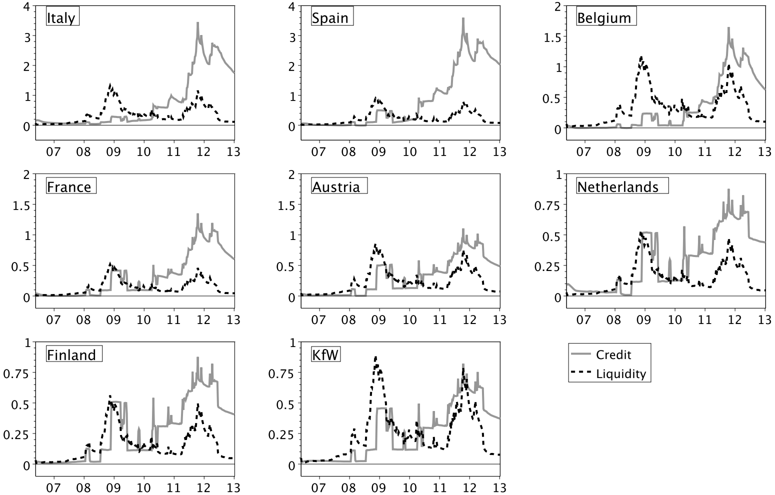

5-yr spread (vs. Bund)
Italy
10-yr spread (vs. Bund)
5-yr spread (vs. Bund)
Spain
10-yr spread (vs. Bund)
5-yr spread (vs. Bund)
Belgium
10-yr spread (vs. Bund)
5-yr spread (vs. Bund)
Austria
10-yr spread (vs. Bund)
5-yr spread (vs. Bund)
Finland
10-yr spread (vs. Bund)
5-yr spread (vs. Bund)
France
10-yr spread (vs. Bund)
5-yr spread (vs. Bund)
Netherlands
10-yr spread (vs. Bund)
5-yr spread (vs. risk-free rate)
Germany
10-yr spread (vs. risk-free rate)
5-yr spread (vs. Bund)
KfW
10-yr spread (vs. Bund)
Jun-07 Nov-08 May-10 Nov-11

Credit/Liquidity

Risk Premia Analysis (5-year maturity)

	Expectation part of the spreads				Risk premiums			
	Credit		Liquidity		Credit		Liquidity	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Austria	0.06	0.09	0.08	0.04	0.31	0.29	0.23	0.20
Belgium	0.17	0.26	0.12	0.06	0.33	0.42	0.32	0.27
Finland	0.03	0.05	0.05	0.03	0.27	0.24	0.15	0.13
France	0.11	0.16	0.06	0.03	0.33	0.35	0.14	0.12
Germany	0.04	0.05	-	-	0.25	0.22	-	-
Italy	0.49	0.63	0.10	0.07	0.74	0.91	0.35	0.30
Netherlands	0.04	0.04	0.05	0.03	0.28	0.24	0.14	0.12
Spain	0.45	0.63	0.14	0.05	0.82	0.98	0.24	0.20

Credit/Liquidity
Risk Premia Analysis (5-year maturity)



Credit/Liquidity
Risk Premia Analysis (5-year maturity)

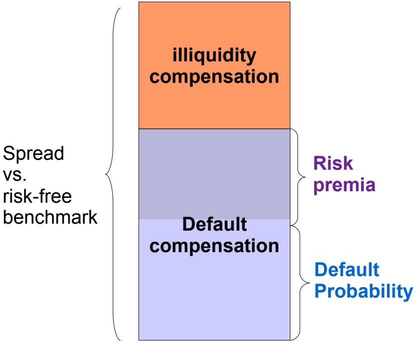
- Regression analysis suggests that the different parts of the spreads are related to macro-finance indicators:

	Expectation part	Risk premium
Credit	VSTOXX, IBOR-OIS, BVOL	VSTOXX, EUROSTOXX, BVOL
Liquidity	EUROSTOXX	IBOR-OIS, EUROSTOXX

Credit/Liquidity
Extracting default probabilities

- Once the model is estimated, one can derive implicit default probabilities
- In the spirit of Litterman and Iben (1991), various basic methodologies result in risk-neutral PDs (Chan-Lau, 2006)
- In our framework, we can compute both the risk-neutral and the actual (or real-world) PDs

⇒ Results: significant differences between actual and risk-neutral PDs



Credit/Liquidity
Extracting default probabilities

- The actual PD between time t and time $t+h$ is:

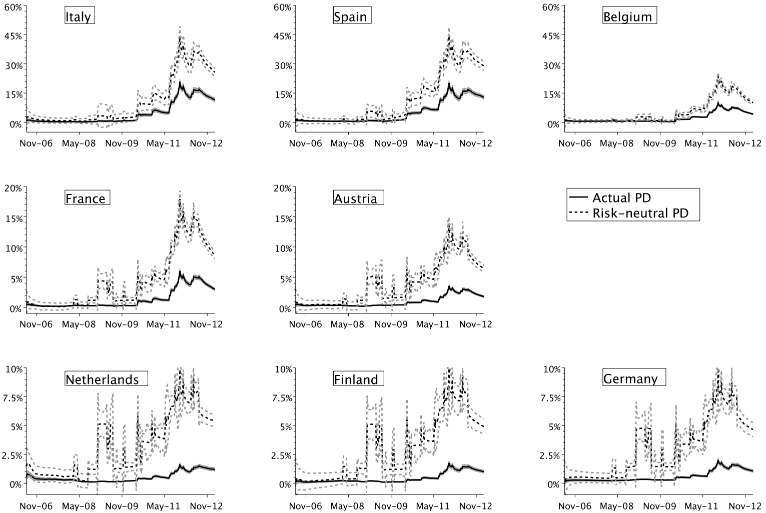
$$\mathbb{P}_t\left(d^{(n)}_{t+h} = 1 \middle| d^{(n)}_t = 0 \right),$$

that is:

$$1 - E^{\mathbb{P}}_t \left(\exp\left\{ \frac{1}{1-\zeta} (-\lambda^{(n)}_{fc,t+1} - \ldots - \lambda^{(n)}_{fc,t+h}) \right\} \right)$$

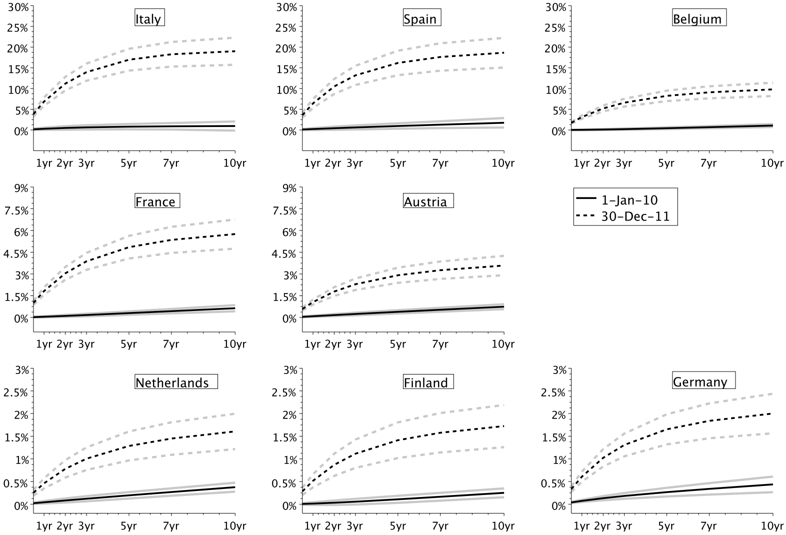
- We use a recovery rate of 50%

Credit/Liquidity
Extracting default probabilities (5-year PDs)

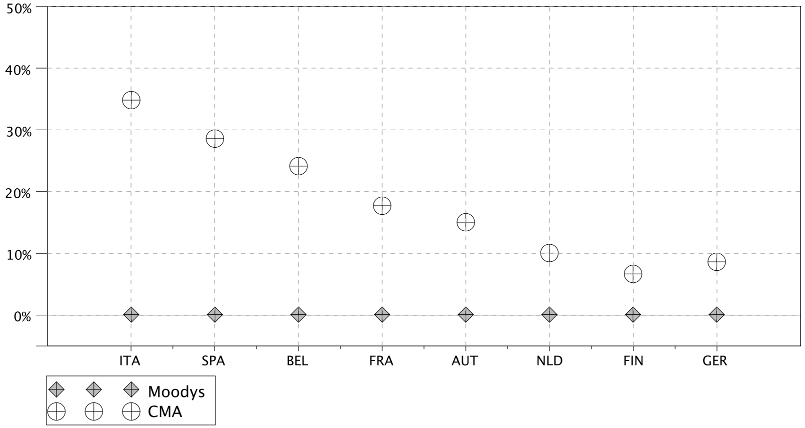


Credit/Liquidity

Extracting default probabilities (Term Structures of PDs)

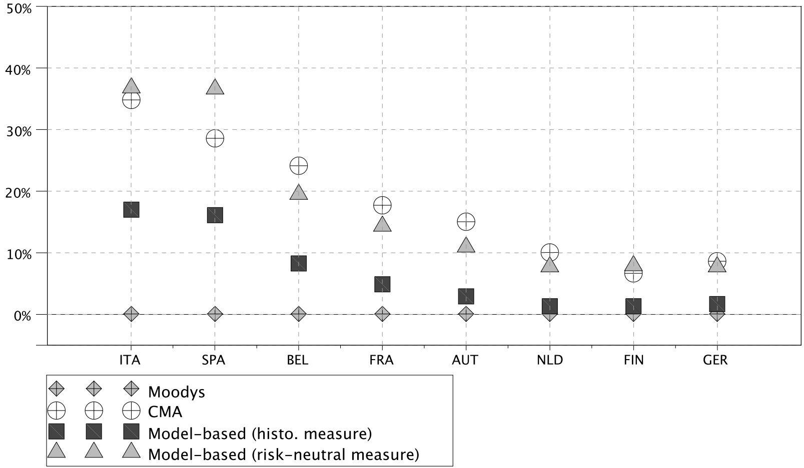


Credit/Liquidity
Extracting default probabilities (5-year PDs)



Credit/Liquidity

Extracting default probabilities (5-year PDs)

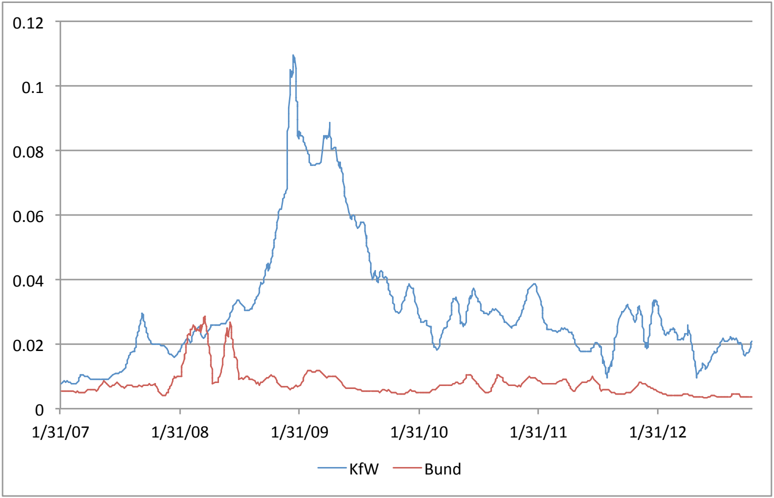


Concluding remarks

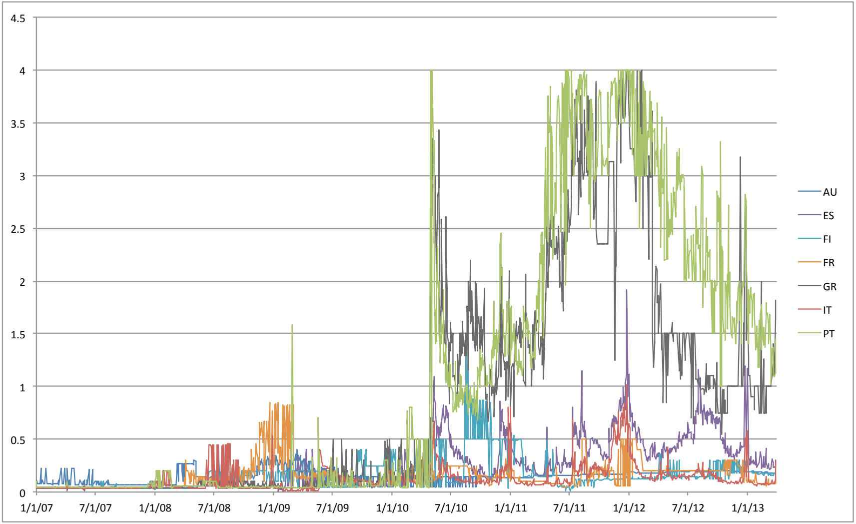
- One of the few attempts to model simultaneously sovereign EA spreads in a no-arbitrage framework
- Innovative use of regime-switching features to model interactions between credit and liquidity pricing effects
- Empirical results:
  - Liquidity effects account for a substantial part of EA-spreads fluctuations, but credit aspects have dominated over the last two years
  - The existence of risk premia results in significant differentials between risk-neutral and actual PDs

Thank you for your attention.

Bid-Ask spreads: KfW vs Bund



Bid-Ask spreads: Euro-area sovereigns



A structural interpretation of the liquidity intensities
Ericsson and Renault (2006)

- The liquidity-related fractional-cost intensity: $\lambda_{\ell,t}^{(n)} = (1-\theta^{(n)})\lambda_{\ell,t}$
- Fractional cost: $1-\theta^{(n)}$.
- $\ell_t = 1 \Rightarrow$ the investor has to exit by selling her bond holdings.
  - This liquidation has to be done in a limited period of time, between t and $t+\varepsilon$, say (where $\varepsilon << 1$).
  - Random number K of offers from traders, $K \sim \mathcal{P}(\gamma^{(n)})$,...
  - ... each offer is a random fraction ω_i ($i \in \{1,\ldots,K\}$) of $B_{t,h}^{(n)}$, $\omega_i \sim \mathcal{U}([0,1])$.
- The selling price is: $\max_{i\in\{1,\ldots,K\}}(\omega_i)B_{t,h}^{(n)} = \theta(\gamma^{(n)}) \times B_{t,h}^{(n)}$, where θ is monotonically increasing and valued in $[0,1]$.