Credit and Liquidity in Interbank Rates: A Quadratic Approach

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Contents

Introduction

- The interbank market risk is at the heart of the (on-going) financial crisis.
- The IBOR-OIS spreads are some of the most scrutinized indicators of interbank-market risks.

During the crisis, conventional and unconventional actions taken by the central banks include:

- drop in the central bank interest rates,
- new facilities for liquidity providing to financial institutions (e.g. TAF in the US, VLTRO in the Euro-zone).

$\Longrightarrow$ Have those unconventional actions been effective?

The Interbank Rates

- *EURIBOR rates*: unsecured interbank rates proxy. It contains:
  - *Credit risk*: default of the borrower before due date.
  - *Liquidity risk*: important liquidity need of the lender before due date $\Longrightarrow$ Additional cost.

- *Overnight Indexed Swaps (OIS)*: riskless interbank rates proxy.

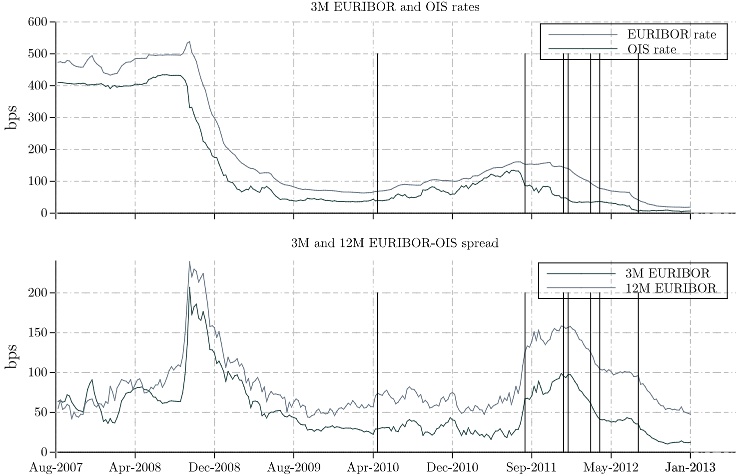
  Fixed leg $\rightleftarrows$ Floating leg indexed on EONIA.

  - Netting and credit-enhancement mechanisms (margin calls).
  - Nearly no immobilisation of capital.

    $\Longrightarrow$ Almost no credit and liquidity risk.

The Term Structure of Interbank Rates

Weekly data: EURIBOR-OIS spreads for four maturities (3M, 6M, 9M, 12M) from August 31, 2007 to January 4, 2013.



Motivations

- Separate bank credit risk from liquidity risk in the IBOR-OIS spread.
  $\longrightarrow$ *Observe the cause of fluctuations.*
- Extract the risk-premia linked to longer-term risk-bearing.
  $\longrightarrow$ *Necessitate no-arbitrage term structure model*.
- Generate strictly positive spreads under both measures.
  $\longrightarrow$ *Quadratic specification*.

Double decomposition to analyse monetary policy actions:

- Securities market program (May 2010, Aug. 2011).
- Very long-term refinancing operations (Dec. 2011 $\rightarrow$ Mar. 2012).
- Outright monetary transactions (late Aug. 2012).

Related literature

- *Quadratic term structure models*
  Ahn, Dittmar & Gallant (2001), Constantinides (1992), Gourieroux & Sufana (2002), Leippold & Wu (2002a, 2002b)
- *Interbank rates modelling*
  Michaud & Upper (2008), Taylor & Williams (2009), Schwarz (2009), Filipovic & Trolle (2011), Christensen, Lopez & Rudebusch (2009), Angelini *et al.* (2011)
- *Decomposition of interest rates*
  Liu, Longstaff & Mandell (2006), Feldhutter & Lando (2008), Longstaff, Mithal & Neis (2008), Monfort & Renne (2012)

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Pricing the Interbank Risk-Free Rate

We denote:

r_t the short-term risk-free interest rate,

$R_{t,h}^{OIS}$ the OIS rate at time t of maturity h.

$\Longrightarrow R_{t,1}^{OIS} = r_t$.

Under the absence of arbitrage opportunities:

- existence of both a historical ($\mathbb{P}$) and a risk-neutral measure ($\mathbb{Q}$).

Pricing formula of secured rates under risk-neutral measure:

$$R_{t,h}^{OIS} = -\frac{1}{h} \log\left(\mathbb{E}_t^{\mathbb{Q}}\left[\exp\left\{-\sum_{k=0}^{h-1} r_{t+k}\right\}\right]\right)$$

Pricing the Unsecured Interbank Rates

We denote:

d_t a dummy variable indicating either a default or an illiquidity event.

λ_t the intensity representing the underlying risks in the economy.

$$\mathbb{P}(d_t = 1 | \underline{d_{t-1}}, \underline{r_t}, \underline{X_t}) = 1 - \exp(-\lambda_t)$$

Pricing formula of EURIBOR rates under risk-neutral measure:

$$R_{t,h}^{EUR} = -\frac{1}{h} \log \left(\mathbb{E}_t^{\mathbb{Q}} \left[\exp \left\{ -\sum_{k=0}^{h-1} r_{t+k} + \lambda_{t+k+1} \right\} \right] \right)$$

Standard Results in Term Structure Models

We denote:

X_t a vector of factors in the economy.

If for all t, r_t and λ_t are affine functions (resp. quadratic) of X_t,

- the secured and unsecured rates are affine functions (resp. quadratic) of X_t,
- these functions are available in closed-form for all maturities,
- the factor loadings are computable recursively.

General pricing formulae for QTSM

$$R_{t,h}^{OIS} = a_h^{OIS} + b_h'^{OIS} X_t + X_t' c_h^{OIS} X_t$$
$$R_{t,h}^{EUR} = a_h^{EUR} + b_h'^{EUR} X_t + X_t' c_h^{EUR} X_t$$

Modelling the EURIBOR-OIS Spread

- Implicitly, EURIBOR and OIS are considered as zero-coupons rates,
- We assume the short-term rate is independent from the intensity:

Spread formula

$$\begin{aligned} S(t,h) &= R_{t,h}^{EUR} - R_{t,h}^{OIS} \\ &= -\frac{1}{h}\log\left(\mathbb{E}_t^{\mathbb{Q}}\left[\exp\left\{-\sum_{k=1}^{h}\lambda_{t+k}\right\}\right]\right) \end{aligned}$$

$\Longrightarrow$ No need to express r_t for the spread modelling.

Remark: $\lambda_t \geqslant 0 \quad \Longrightarrow \quad S(t,h) \geqslant 0.$

What We Need

- Definition of factors with
  - $\mathbb{P}$-dynamics,
  - $\mathbb{Q}$-dynamics,
- Specification of intensity $\lambda_t = f(X_t)$,
- Identification constraints.

The Historical Dynamics

- Credit and liquidity latent risk factors: $X_t = (x_{c,t},\, x_{l,t})'$.
- $x_{c,t}$ and $x_{l,t}$ are not instantaneously correlated.
- VAR(1) representation with independent idiosyncratic shocks.

$$\begin{pmatrix} x_{c,t} \\ x_{l,t} \end{pmatrix} = \begin{pmatrix} \mu_c \\ \mu_l \end{pmatrix} + \begin{pmatrix} \varphi_{1,1} & \varphi_{1,2} \\ \varphi_{2,1} & \varphi_{2,2} \end{pmatrix} \begin{pmatrix} x_{c,t-1} \\ x_{l,t-1} \end{pmatrix} + \begin{pmatrix} \sigma_c & 0 \\ 0 & \sigma_l \end{pmatrix} \begin{pmatrix} \varepsilon_{c,t} \\ \varepsilon_{l,t} \end{pmatrix}$$

where $(\varepsilon_{c,t},\, \varepsilon_{l,t})' \sim \mathcal{IIN}^{\mathbb{P}}(0, I_2)$.

- For identification purposes, $\sigma_c^2 + \sigma_l^2 = 1$.
- We also define $x_t = x_{c,t} + x_{l,t}$.

Risk-Neutral Specification and Intensity Process

- Also VAR(1) dynamics under $\mathbb{Q}$-measure with constraints
  $\Longrightarrow$ AR(1) $\mathbb{Q}$-dynamics for x_t.

$$x_t = \mu^* + \varphi^* x_{t-1} + \varepsilon_t^* \quad \text{where} \quad \varepsilon_t^* \sim \mathcal{IIN}^{\mathbb{Q}}(0,1)$$

- Intensity is one-factor dependent:

$$\begin{aligned} \lambda_t &= \lambda_0 + \lambda_1 x_t + \lambda_2 x_t^2 \qquad \text{with:} \\ \lambda_0 &\geqslant \lambda_1^2/4\lambda_2 \quad \Longrightarrow \quad \lambda_t \geqslant 0 \end{aligned}$$

Reduced-form pricing formulas

$$S(t,h) = \theta_{0,h} + \theta_{1,h} x_t + \theta_{2,h} x_t^2$$

with $\theta_{i,h}$ functions of $(\lambda_0, \lambda_1, \lambda_2, \mu^*, \varphi^*)$ computable recursively.

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Identification Strategy

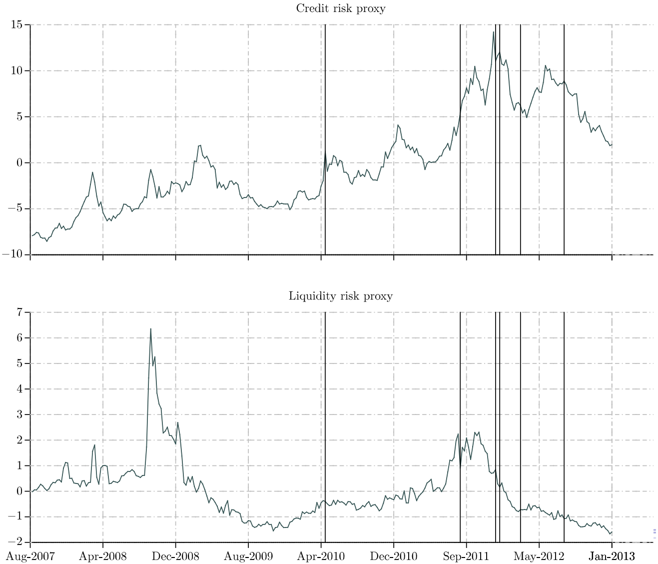
- Proxy for credit risk $P_{c,t} \rightarrow$ first PC of 36 Euro-zone bank CDS
- Proxy for liquidity risk $P_{l,t} \rightarrow$ first PC of
  - 5Y KfW-Bund spread
  - Spread of 3M general collateral *repo* rate versus 3M German treasury bill
  - Bank Lending Survey data (BLS): percentage of '−' and '−−' answers to the question *over the past three months, how has your bank's liquidity position affected the credit standards as applied to the approval of loans or credit lines to enterprises?*

Proxies equations

Proxies are assumed quadratic functions of the corresponding factor with measurement errors.

$$\begin{cases} P_{c,t} & = & \pi_{c,0} + \pi_{c,1} x_{c,t} + \pi_{c,2} x_{c,t}^2 + \sigma_{\nu_c} \nu_{c,t} \\ P_{l,t} & = & \pi_{l,0} + \pi_{l,1} x_{l,t} + \pi_{l,2} x_{l,t}^2 + \sigma_{\nu_l} \nu_{l,t} \end{cases}$$

Proxies


Credit risk proxy
15
10
5
0
−5
−10
Liquidity risk proxy
7
6
5
4
3
2
1
0
−1
−2
Aug-2007
Apr-2008
Dec-2008
Aug-2009
Apr-2010
Dec-2010
Sep-2011
May-2012
Jan-2013

The state-space representation

Transition and measurement equations :

Transition Two-factor $\mathbb{P}$-dynamics.

Measurement Spread pricing formulae and proxies specification.

$\Longrightarrow$ Maximum likelihood estimation with the Quadratic Kalman Filter (Monfort, Renne, & Roussellet (2013)).

Estimation constraints:

- Intensity and proxies functions are monotonously increasing *in most cases* in both factors.

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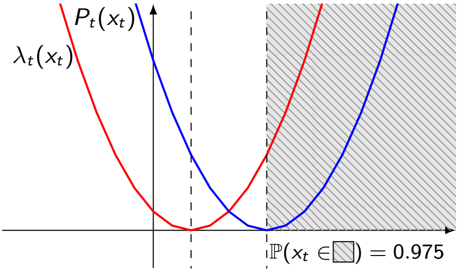

Results

Table : Risk-neutral and measurement parameter estimates

Equation		Estimate		Estimate		Estimate
x_t	μ^*	$0,2627^{***}$	φ^*	$0,9962^{***}$		
		$(0,0387)$		$(0,0019)$		
$P_{c,t}$	$\pi_{c,0}$	$-8,9650^{***}$	$\pi_{c,1}$	$-0,000006$	$\pi_{c,2}$	$0,4496^{***}$
		$(0,4296)$		$(3,0444)$		$(0,0594)$
$P_{l,t}$	$\pi_{l,0}$	$-1,3098^{**}$	$\pi_{l,1}$	$0,1382^{***}$	$\pi_{l,2}$	$0,0045^{***}$
		$(0,7577)$		$(0,0534)$		$(0,0006)$
λ_t	λ_0	$0,1015$	λ_1	$0,0003$	λ_2	$0,0023^{***}$
		$(0,0666)$		$(0,0261)$		$(0,0003)$
noise	$\sigma^2_{\nu_c}$	$0,0081$	$\sigma^2_{\nu_l}$	$0,1000$	σ^2_{η}	$0,0106^{***}$
		$(0,4206)$		—		$(0,0003)$

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Decomposition method

Decomposition of the spread

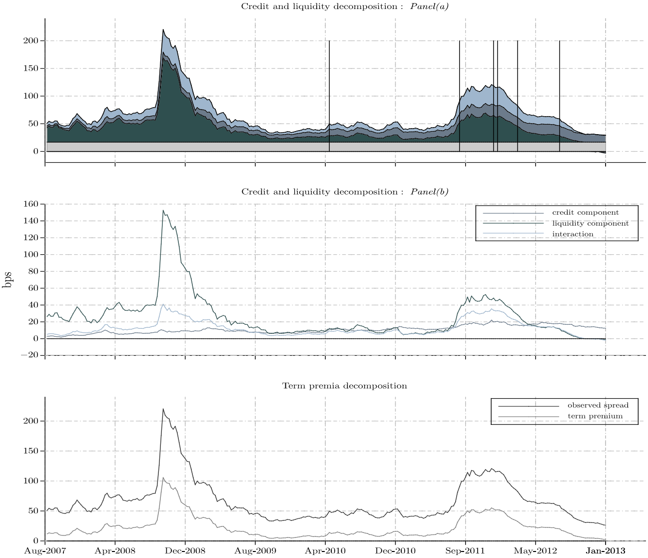
$$S(t,h) = \theta_{0,h} + \theta_{1,h}x_t + \theta_{2,h}x_t^2$$

$$= \underbrace{\theta_{1,h}x_{c,t} + \theta_{2,h}x_{c,t}^2}_{\text{credit spread}} + \underbrace{\theta_{1,h}x_{l,t} + \theta_{2,h}x_{l,t}^2}_{\text{liquidity spread}} + \underbrace{2\theta_{2,h}x_{c,t}x_{l,t}}_{\text{interaction}} + \theta_{0,h}$$

- credit risk part,
- liquidity risk part,
- interaction part: presence and comovement of both risks in the economy,
- constant effect $\theta_{0,h}$: not attributable to any of the previous effects.

⇒ Decomposition in credit/liquidity and expected hypothesis component/term premia.

Decomposition Results: 6M Spread



Time series decomposition

Liquidity component:

- High level on average and high-frequency fluctuations,
- represents most of the spread during Lehman crisis
- disappears at the end of the sample.

Credit component:

- Globally increasing and low-frequency fluctuations,
- represents more than 20 bps at the end of the sample.

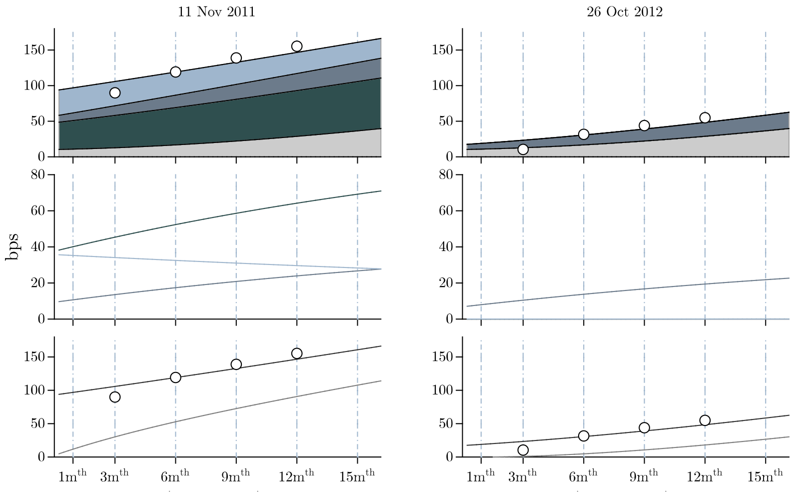
Interaction term:

- Represents between 0 and 40 bps for the 6-month spread,
- fades out at the end of the sample.

Term premia:

- Possess similar features as the observed spread,
- fluctuates between 0 and 60 bps for the 6-month spread.

Decomposition of the Term Structure



Efficiency of Unconventional Monetary Policies

SMP No clear drop or increase in any spread component.
$\Longrightarrow$ No effect.

VLTRO Significant drop after the announcement due mostly to liquidity and to a lesser extent to the interaction term. The two allotments do not change this trend.
$\Longrightarrow$ Nearly a 50 bps drop in 16 weeks.

OMT Disappearing of both liquidity and interaction terms 2 months after Mario Draghi's London Speech.
$\Longrightarrow$ Contributed to erase liquidity risk in the Euro Area.

Contents

Conclusion

In this paper,

- We use a quadratic no-arbitrage term structure model of EURIBOR-OIS spreads.
- We perform a decomposition of interbank spreads in credit and liquidity components.
- We extract the term premia from the observed spread.
- We show that the SMP program had no significant influence on interbank risk whereas the OMT contributed to erase the liquidity risk for all maturities.