The Term Structure of Interbank Risk

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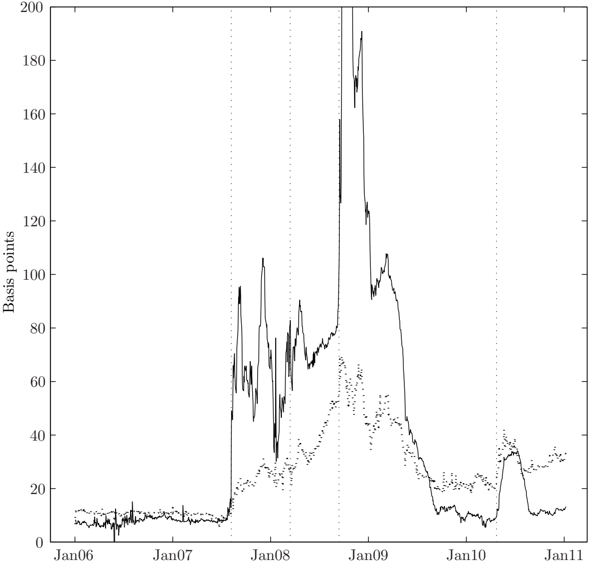
Objective

- The recent financial crisis has highlighted the central role of interbank risk for capital markets and economic growth.
- Existing studies have provided important insights on the determinants of short term interbank risk...
- ...we still know very little about the *term structure* of interbank risk
- Objective of the paper:
  - Provide a model for the term structure of interbank risk
  - Apply the model to study interbank risk since the onset of the financial crisis, decomposing the term structure of interbank risk into default and non-default components

Money market and swap spreads



Applications

- Monetary and regulatory policy
  - Provides market expectations about future stress in interbank markets
  - Decomposition into default and non-default (liquidity) components guides appropriate policy response (recapitalization of banks, termination/introduction of lending facilities, etc)
- Pricing, hedging, and risk-management in the interest rate swap market.
  - Swap dealers are exposed to *basis risk*: Swap cash flows are indexed to LIBOR but discounted using OIS rates
  - Typical swap portfolios are composed of swap contracts indexed to different LIBOR rates
  - Model provides a unified approach to risk-management

Related papers

- Collin-Dufresne and Solnik (2001, JF)
  - Study the term structure of spreads between AA corporate bonds and interest rate swaps
- Liu, Longstaff, and Mandell (2006, JB), Johannes and Sundaresan (2007, JF), and Feldhutter and Lando (2008, JFE)
  - Study the term structure of spreads between interest rate swaps and Treasuries
- Schwartz (2010), Taylor and Williams (2009), McAndrews, Sarkar, and Wang (2008), Michaud and Upper (2008), and Eisenschmidt and Tapking (2009)
  - Study money market spreads (typically 3M LIBOR-OIS)

LIBOR

- Many fixed income contracts are tied to an *interbank offered rate.*
- The main reference rate in the USD-denominated fixed income market is the USD London Interbank Offered Rate (LIBOR).
- A (trimmed) average of the rates at which banks believe they can obtain unsecured funding for a given term and in a given currency in the interbank market.
- LIBOR panel consists of 16 banks which are largely selected based on their credit quality
- Panel is reviewed and revised periodically.
- $L(t, T)$ denote the $(T - t)$-maturity LIBOR rate that fixes at time t.

Fed Funds

- An increasing number of fixed income contracts are tied to an *index of overnight rates.*
- In the USD market, the benchmark is the effective Fed Funds (FF) rate – a weighted average of the rates on overnight unsecured loans
- FF refers to unsecured lending but are widely regarded as the best available proxies for risk-free rates, since the credit risk in an overnight transaction is deemed negligible.
- FF is typically the contractual interest rates earned by cash collateral in USD-denominated contract

Collateralization of swap contracts

- Swap contracts between major financial institutions are virtually always collateralized.
- Best practice among major financial institutions is daily mark-to-market and adjustment of collateral.
- Cash collateral is the most popular form of collateral and typically earns the overnight rate.
- We take this market practice into account when pricing swap contracts
- We show

$$V(t) = E_t^Q\left[e^{-\int_t^T r_c(s)ds} X\right]. \tag{1}$$

- We assume that the collateral rate $r_c(t)$ is equal to an instantaneous proxy $L(t,t)$ of the overnight rate which we define as

$$r_c(t) = L(t,t) = \lim_{T \to t} L(t,T). \tag{2}$$

From RISK magazine

LCH.Clearnet re-values $218 trillion swap portfolio using OIS

Published online only

Author: Christopher Whittall

Source: Risk magazine | 17 Jun 2010

Categories: Risk Management, Interest Rate Derivatives

Interest rate swaps (IRS)

- In a regular interest rate swap (IRS), counterparties exchange a stream of fixed-rate payments for a stream of floating-rate payments indexed to a LIBOR rate of a particular maturity.
- More specifically, consider two discrete tenor structures

$$t = t_0 < t_1 < \cdots < t_N = T \tag{3}$$

and

$$t = T_0 < T_1 < \cdots < T_n = T, \tag{4}$$

and let $\delta = t_i - t_{i-1}$ and $\Delta = T_i - T_{i-1}$ denote the lengths between tenor dates, with $\delta < \Delta$.
- At every time t_i, $i = 1, ..., N$, one party pays $\delta L(t_{i-1}, t_i)$, while at every time T_i, $i = 1, ..., n$, the other party pays ΔK, where K denotes the fixed rate on the swap.
- The swap rate, $IRS_{\delta,\Delta}(t, T)$, is the value of K that makes the IRS value equal to zero at inception and is given by

$$IRS_{\delta,\Delta}(t, T) = \frac{\sum_{i=1}^{N} E_t^Q \left[e^{-\int_t^{t_i} r_c(s)ds} \delta L(t_{i-1}, t_i) \right]}{\sum_{i=1}^{n} \Delta P_c(t, T_i)}. \tag{5}$$

Overnight indexed swaps (OIS)

- In an overnight indexed swaps (OIS), counterparties exchange a stream of fixed-rate payments for a stream of floating-rate payments indexed to the compounded FF rate.
- Specifically, consider the tenor structure (4) with $\Delta = T_i - T_{i-1}$.
- At every time T_i, $i = 1, ..., N$, one party pays ΔK, while the other party pays $\Delta \overline{L}(T_{i-1}, T_i)$, where $\overline{L}(T_{i-1}, T_i)$ is the compounded overnight rate for the period $[T_{i-1}, T_i]$
- The compounded overnight rate is given by

$$\overline{L}(T_{i-1}, T_i) = \frac{1}{\Delta}\left(\prod_{j=1}^{K_i}(1 + (t_j - t_{j-1})L(t_{j-1}, t_j)) - 1\right) \qquad (6)$$

where $T_{i-1} = t_0 < t_1 < \cdots < t_{K_i} = T_i$ denotes the partition of the period $[T_{i-1}, T_i]$ into K_i business days, and $L(t_{j-1}, t_j)$ denotes the respective overnight rate.

Overnight indexed swaps (OIS) (cont.)

- Approximate the overnight rate by the instantaneous rate $L(t,t)$ given in (2), in which case $\overline{L}(T_{i-1},T_i)$ becomes

$$\overline{L}(T_{i-1},T_i) = \frac{1}{\Delta}\left(e^{\int_{T_{i-1}}^{T_i} r_c(s)ds} - 1\right). \tag{7}$$

- The OIS rate is the value of K that makes the OIS value equal to zero at inception and is given by

$$OIS(t,T) = \frac{\sum_{i=1}^{n} E_t^Q\left[e^{-\int_t^{T_i} r_c(s)ds}\Delta\overline{L}(T_{i-1},T_i)\right]}{\sum_{i=1}^{n}\Delta P_c(t,T_i)} = \frac{1-P_c(t,T_n)}{\sum_{i=1}^{n}\Delta P_c(t,T_i)} \tag{8}$$

IRS-OIS swap spread

- Combining (5) and (8), we have

$$IRS_{\delta,\Delta}(t,T) - OIS(t,T) = \frac{\sum_{i=1}^{N} E_t^Q \left[e^{-\int_t^{t_{i-1}} r_c(s)ds} P_c(t_{i-1},t_i)\delta\big(L(t_{i-1},t_i) - OIS(t_{i-1},t_i)\big) \right]}{\sum_{i=1}^{n} \Delta P_c(t,T_i)}. \quad (9)$$

- I.e., the spread between the fixed rates on an IRS indexed to δ-maturity LIBOR and an OIS reflects (risk-neutral) expectations about future δ-maturity LIBOR-OIS spreads

Default risk component of LIBOR-OIS spread

- Rather than modeling the funding costs of individual panel banks, we assume a sequence of banks, each of which represents the panel at a given point in time.
- Current LIBOR reflects the expected future default risk of the bank that represents the current panel.
- The FF rate reflects the default risk of the bank that represents the current panel
- The fixed OIS rate reflects the expected default risks of the respective banks that represent the *future* panels.
- Less than the expected future default risk of the bank that represents the *current* panel (because of "refreshment" of LIBOR panel)
- Induces LIBOR-OIS spread

Non-default (liquidity) risk component of LIBOR-OIS spread

- *Precautionary* hoarding of liquidity: Banks may be reluctant to provide term loans in the interbank market because they fear that they may not themselves be able to raise funds if they are hit by an adverse liquidity shock; see Allen, Carletti, and Gale (2009) and Acharya and Skeie (2010)
- *Strategic* hoarding of liquidity: Banks may not provide term loans in anticipation of possible fire-sales of assets by other troubled financial institutions; see Acharya, Gromb, Yorulmazer (2007), Acharya, Shin, Yorulmazer (2009), and Diamond and Rajan (2010)
- Whatever the motivation, hoarding of liquidity will reduce the volume of longer term loans and increase the rates on such loans.
- Posit a "residual" factor that captures the component of the LIBOR-OIS spread that is not due to default risk.

Preferred specification

- Model is set within a general affine framework
- Analyze various specifications. The preferred specification has
  - Two factors driving the OIS term structure
  - Two factors driving the default component of LIBOR-OIS spreads (i.e. the risk of credit quality deterioration of current LIBOR panel banks)
  - One factor driving the non-default component of LIBOR-OIS spreads
- Highly tractable with analytical expressions for LIBOR, OIS, IRS, and CDS.
- Maximum-likelihood in conjunction with Kalman filtering.

Interest rate data

- The sample period is August 09, 2007 to January 12, 2011 – a total of 895 daily observations
- OIS rates with maturities 3M, 6M, 1Y, 2Y, 3Y, 4Y, 5Y, 7Y, and 10Y
- IRS rates indexed to 3M and 6M LIBOR with maturities 1Y, 2Y, 3Y, 4Y, 5Y, 7Y, and 10Y
- Source: Bloomberg.

CDS data

- CDS data is from Markit
- For each bank in the LIBOR panel, we collect daily spread term structures for CDS contracts written on senior obligations. The term structures consists of 6M, 1Y, 2Y, 3Y, 4Y, 5Y, 7Y, and 10Y maturities.
- Construct a composite CDS spread term structure for the panel based on the CDS spread term structures of the panel constituents.

CDS data (cont.)

- Trimmed mean, CDS_{TrMean}
  - Inspired by the definition LIBOR, in which each panel bank submits the rate at which it believes it can obtain unsecured funding.
  - Therefore, it seems likely that LIBOR reflects a trimmed mean of the credit risk in the panel.
- Liquidity-adjusted mean I, CDS_{LIQ1}
  - Default risk constitute 90 percent of the quoted CDS spreads; based on results by Buhler and Trapp (2010)
- Liquidity-adjusted mean II, CDS_{LIQ2}
  - Composite CDS spreads are constructed solely from the banks with the most liquid CDS contracts (average daily trading volume from the DTCC)

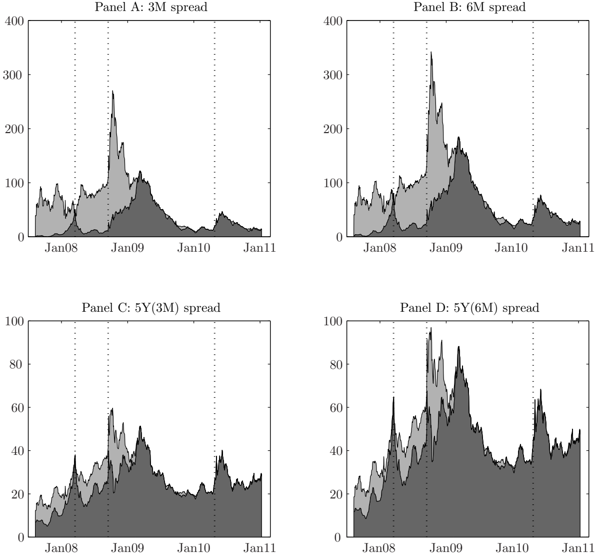
Summary statistics

	Maturity								
	3M	6M	1Y	2Y	3Y	4Y	5Y	7Y	10Y
				Panel A: USD market					
OIS	1.17 (1.48)	1.17 (1.43)	1.26 (1.35)	1.63 (1.21)	2.06 (1.12)	2.42 (1.03)	2.72 (0.96)		3.17† (0.55)
$SPREAD_{3M}$	58.7 (57.5)		51.2 (34.6)	43.8 (23.2)	39.0 (17.2)	35.4 (14.0)	32.5 (11.9)		28.7† (8.2)
$SPREAD_{6M}$		79.1 (57.4)	70.0 (42.7)	58.0 (28.2)	50.8 (20.8)	45.8 (16.9)	41.9 (14.2)		38.1† (7.7)
CDS_{TrMean}		67.8 (46.5)	70.2 (44.9)	78.7 (41.2)	85.3 (37.9)	93.4 (37.0)	99.1 (35.9)	102.1 (34.5)	104.8 (33.3)
CDS_{LIQ1}		61.1 (41.9)	63.2 (40.4)	70.9 (37.1)	76.8 (34.1)	84.1 (33.3)	89.2 (32.3)	91.9 (31.0)	94.3 (30.0)
CDS_{LIQ2}		78.7 (55.1)	82.9 (53.4)	91.2 (48.4)	98.8 (45.0)	106.2 (43.0)	113.1 (42.0)	114.6 (40.7)	116.6 (39.2)

Decomposing the term structure of interbank risk

	Maturity								
	3M	6M	1Y	2Y	3Y	4Y	5Y	7Y	10Y
	Panel A1: $SPREAD_{3M}$, USD market								
Default	28.1 (26.8)		25.2 (17.2)	24.0 (12.5)	23.8 (10.7)	23.9 (9.8)	24.1 (9.2)		28.6† (5.8)
Non-default	33.4 (45.2)		20.4 (27.3)	10.6 (14.1)	7.2 (9.5)	5.5 (7.3)	4.5 (6.0)		1.8† (3.5)
	Panel A2: $SPREAD_{6M}$, USD market								
Default		45.9 (39.7)	43.1 (30.1)	40.9 (21.8)	40.5 (18.5)	40.7 (16.8)	41.0 (15.7)		48.6† (10.0)
Non-default		38.3 (53.2)	29.6 (40.5)	15.6 (21.2)	10.6 (14.3)	8.1 (10.9)	6.7 (8.9)		2.9† (5.4)

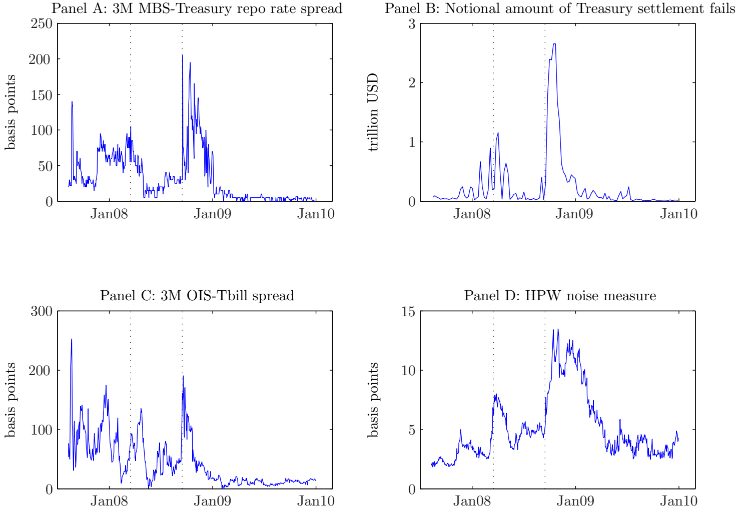
Decomposing the term structure of interbank risk (cont.)



Understanding non-default component

- The residual component captures the part of interbank risk that is orthogonal to default risk
- Does the residual factor capture liquidity risk? More specifically, the component of liquidity risk that is orthogonal to default risk
- Approach:
  - Regress the liquidity proxies on the first two principal components of the CDS term structure $\Rightarrow$ orthogonalized liquidity proxies
  - Regress residual factor on these orthogonalized liquidity proxies

Funding and market liquidity proxies



Understanding non-default component

MBS-Treasury repo	Fails	OIS-Tbill	HPW noise	adj. R^2
Panel A: USD market				
0.042*** (3.635)				0.289
	15.316*** (6.366)			0.296
		0.019* (1.910)		0.071
			0.934*** (7.291)	0.616
0.036* (1.942)	7.653* (1.673)			0.395
		0.006 (0.678)	0.910*** (6.864)	0.622
0.014 (1.111)	3.633 (0.790)	−0.003 (−0.347)	0.772*** (5.407)	0.654

Conclusion

- We study the *term structure* of interbank risk
- Provide a model for the term structure of interbank risk
- Apply the model to study interbank risk since the onset of the financial crisis
- We find:
  - On average, from August 2007 to January 2011, the fraction of total interbank risk due to default risk increases with maturity
  - At the short end of the term structure, the non-default component is important in the first half of the sample period...
  - ...and is correlated with various measures of funding liquidity and market liquidity.
  - Further out the term structure, the default component is the dominant driver of interbank risk throughout the sample period
  - Results hold true in both the USD and EUR markets and are robust to different model parameterizations and measures of interbank default risk