



## Actuarial Research Centre

Institute and Faculty  
of Actuaries

# Actuarial Research Centre (ARC)

## PhD studentship output

The Actuarial Research Centre (ARC) is the Institute and Faculty of Actuaries' network of actuarial researchers around the world. The ARC seeks to deliver research programmes that bridge academic rigour with practitioner needs by working collaboratively with academics, industry and other actuarial bodies.

The ARC supports actuarial researchers around the world in the delivery of cutting-edge research programmes that aim to address some of the significant challenges in actuarial science.

# Modelling the Liquidity Risk Premium on Corporate Bonds

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Actuarial  
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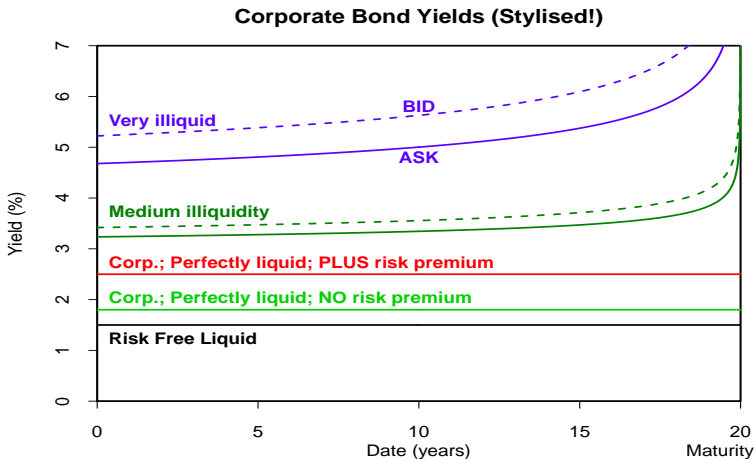
# Motivation

- Time of change in international insurance regulations
- Market consistent valuation: assets and liabilities
- What discount rate to value liabilities?
  - Risk free curve
  - Risk free curve plus an illiquidity premium
  - Risk free plus other margin
- Role of illiquidity premia in asset liability modelling

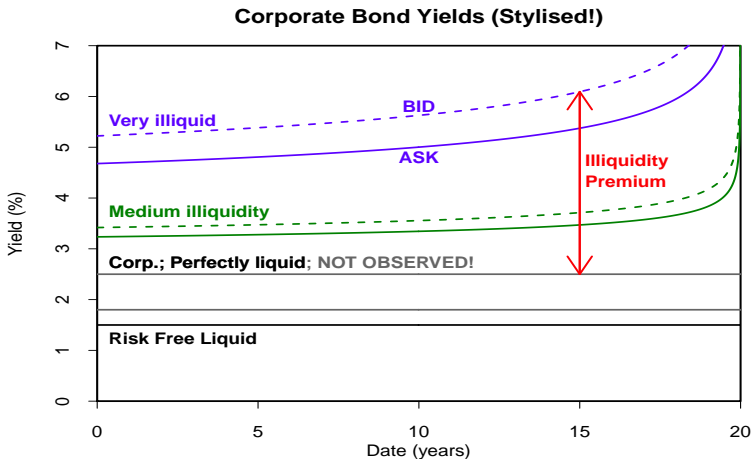
# Corporate Bond Investors

- **Long Term:** Hold to maturity
  - life insurer
  - annuity provider/ pension
- **Medium Term:** Sell before maturity
  - investment-grade-only mandate
  - investment strategy / risk management
- **Short Term**
  - e.g. convergence strategy, arbitrage

# Equivalent Bond Yields



# Illiquidity Premium



# Data

## Markit: GBP Investment Grade Corporate Bonds

- Daily from 2003 - 2014  
( $\approx 2500 \times 1000 \times 50 = 125\text{M}$  elements)
- Contractual:
  - Coupon rate
  - Maturity Date
  - Issuer
  - Seniority
  - etc.
- Time Dependent:
  - Bid- and Ask prices
  - Credit Rating
  - Credit Spread
  - etc.



# Modelling Overview

## Stage 1:

- Modelling the Bid-Ask Spread  
→ Relative Bid-Ask Spread for each bond (RBAS)

## Stage 2:

- Modelling the Credit Spread

## Stage 3:

- Estimate Spread of perfectly liquid equivalent bonds  
→ Difference in yield = illiquidity premium

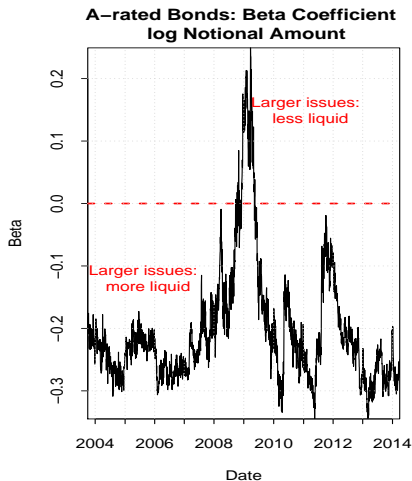
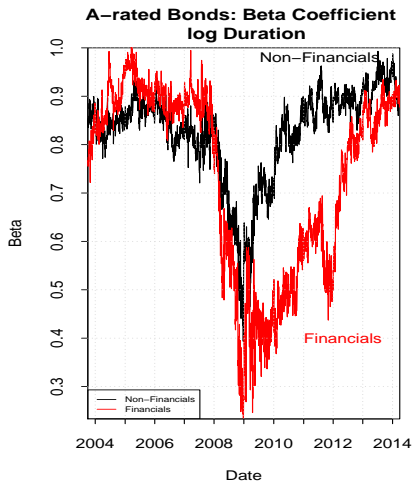
# Bid-Ask Spreads

$$BAS = (\text{Ask price} - \text{Bid price}) \quad / \quad \text{Bid price}$$

$$\begin{aligned} \log(BAS)(i, r, t) = & c(r, t) \\ & + \beta_{1,FIN}(r, t) \times \log \text{Duration}(i, t) \times I_{FIN}(i) \\ & + \beta_{1,NF}(r, t) \times \log \text{Duration}(i, t) \times I_{NF}(i) \\ & + \beta_2(r, t) \times \log \text{Notional}(i, t) \\ & + \sum_k \beta_k(r, t) \times I_k(i, t) \\ & + \log RBAS(i, t) \quad (\text{residual}) \end{aligned}$$

**Indicators:** Non-Financial, Sovereign, Seniority, Collateralised  
Time  $t$ , Bond  $i$ , Rating  $r \equiv r(i, t)$

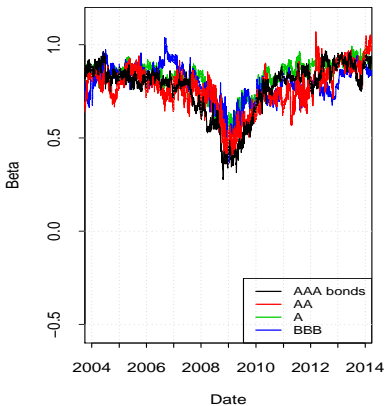
# Effect of Duration and Notional Amount



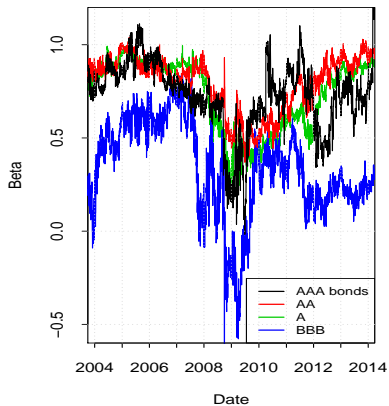
x-axis: e.g. "2008" means 1 January 2008

# Effect of Duration across Ratings

**Beta Coefficient: log Duration  
Non-Financials**



**Beta Coefficient: log Duration  
Financials**

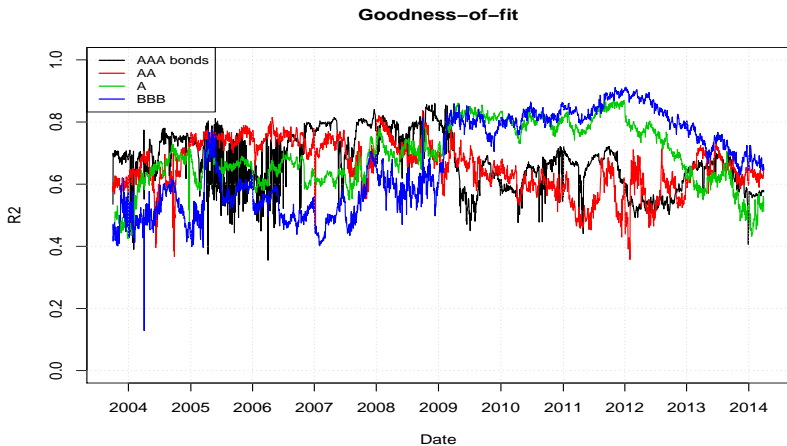


# Credit Spreads

$$\begin{aligned}\log(CS)(i, r, t) = & c(r, t) \\ & + \gamma_{1,FIN}(r, t) \times \log \text{Duration}(i, t) \times I_{FIN}(i) \\ & + \gamma_{1,NF}(r, t) \times \log \text{Duration}(i, t) \times I_{NF}(i) \\ & + \gamma_2(r, t) \times \log \text{Notional}(i, t) \\ & + \gamma_3(r, t) \times \text{Coupon}(i, t) \\ & + \gamma_4(r, t) \times \text{RBAS}(i, t) \\ & + \sum_k \gamma_k(r, t) \times I_k(i, t) \\ & + \epsilon(i, t) \quad (\text{residual})\end{aligned}$$

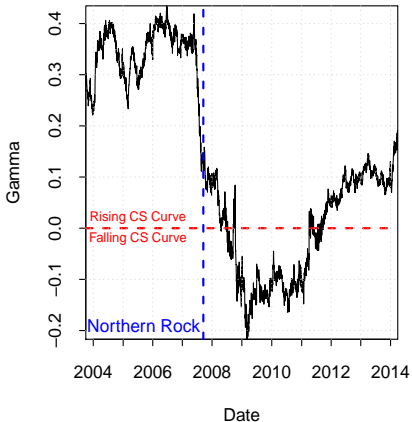
**Indicators:** Non-Financial, Sovereign, Seniority, Collateralised, Debt Tier

# $R^2$ as Goodness of Fit

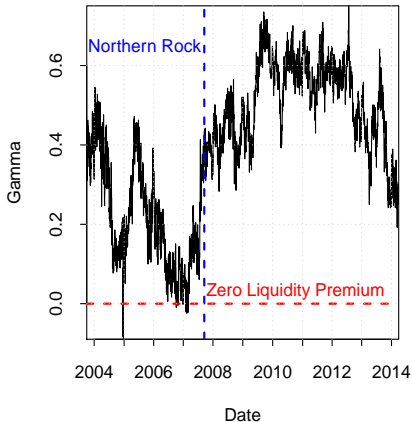


# Effect of Duration and RBAS

A-rated Bonds: Gamma Coefficient  
log Duration (Non-Financials)

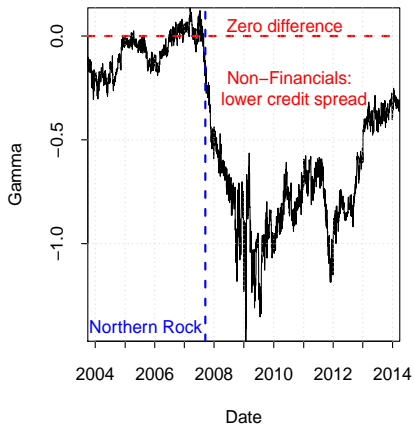


A-rated Bonds: Gamma Coefficient  
Relative Bid-Ask Spread (RBAS)

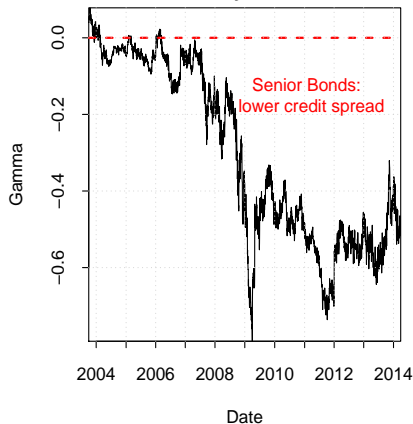


# Effect of Financial Indicator and Seniority

**A-rated Bonds: Gamma Coefficient  
Non-Financial Indicator**

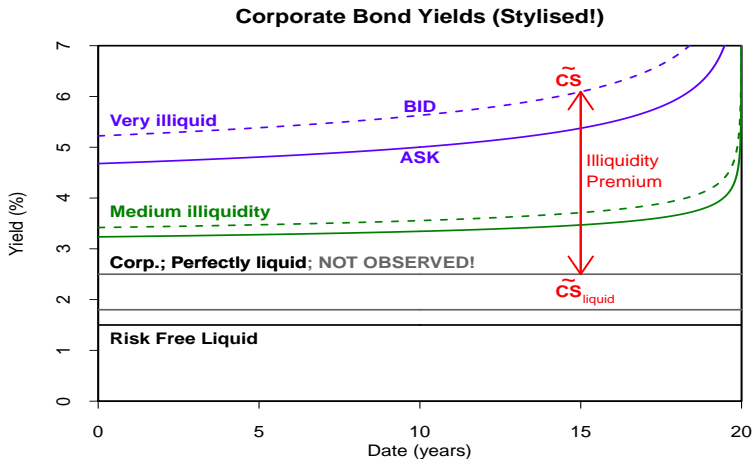


**A-rated Bonds: Gamma Coefficient  
Seniority Indicator**





# Perfectly Liquid Equivalent



# Perfectly Liquid Equivalent II

## Perfectly liquid equivalent

$C\tilde{S}_{liq}(i, r, t) \leftarrow$  RBAS set to zero

## Liquidity Premium

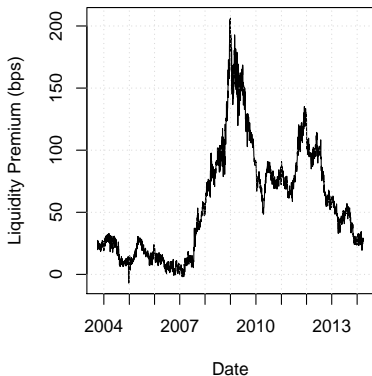
$$\text{Liquidity Premium}_{bps}(i, r, t) = \tilde{C}S(i, r, t) - C\tilde{S}_{liq}(i, r, t)$$

$$\text{Liquidity Premium}_{\%}(i, r, t) = \frac{\tilde{C}S(i, r, t) - C\tilde{S}_{liq}(i, r, t)}{\tilde{C}S(i, r, t)}$$

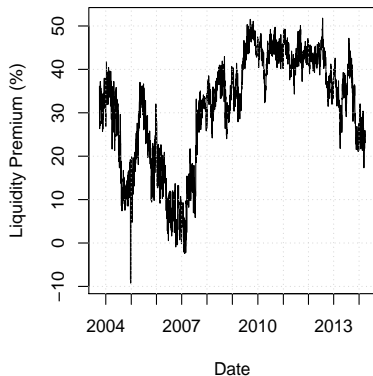
- $\tilde{C}S(i, r, t)$  is the estimated Credit Spread
- $C\tilde{S}_{liq}(i, r, t)$  is the estimated Credit Spread of the perfectly liquid equivalent

# Observed Liquidity Premia

**Median Liquidity Premium  
in bps (A-rated)**

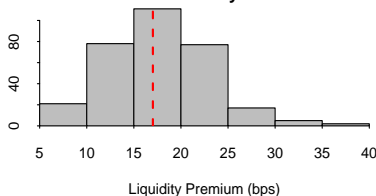


**Median Liquidity Premium  
in % (A-rated)**

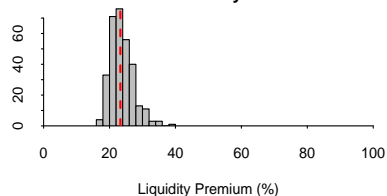


# From Point-Estimate to Distribution

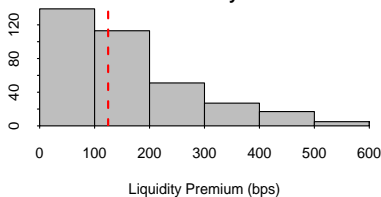
**A-rated Liquidity Premium (bps)  
on 1 January 2006**



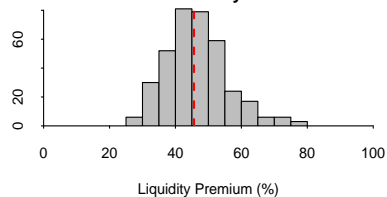
**A-rated Liquidity Premium (%)  
on 1 January 2006**



**A-rated Liquidity Premium (bps)  
on 1 January 2012**



**A-rated Liquidity Premium (%)  
on 1 January 2012**



# Ordering Liquidity Premia

	AAA	AA	A	BBB
Pre - Northern Rock	8.71%	19.47%	17.27%	22.28%
Post - Northern Rock	20.30%	25.32%	39.19%	42.72%

**Table:** Dividing the sample period into two very loosely defined 'regimes', with the Northern Rock event (14-09-2007) as cutoff, Table 1 shows an ordering in premia.

# Model Observations

- Method addresses liquidity on **individual bond level**
- Method requires **no subjective parameterisation**
- Parameter estimates are **robust**
- Parameter dynamics are **economically intuitive**

# Liquidity Premia

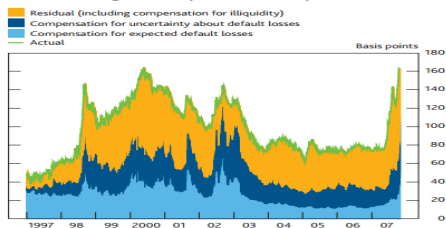
Liquidity Premium varies:

- over time
- by rating
- between bonds
  
- Generally ranges from 20% to 65%
- Exception: near 0% just before Northern Rock collapse

# Quick Comparison: Bank of England

- Structural model assesses **fair default spread** → **residual** is LP
- Restrictions wrt bond sample, calibration & aggregated results

**Chart 1** Decomposition of sterling-denominated investment-grade corporate bond spreads



Taken from: *Webber, L. (2007). Decomposing corporate bond spreads. Bank of England Quarterly Bulletin, 47(4)*

BoE: all IG-bonds; approx. 45% - 50% LP during 2003-2007.

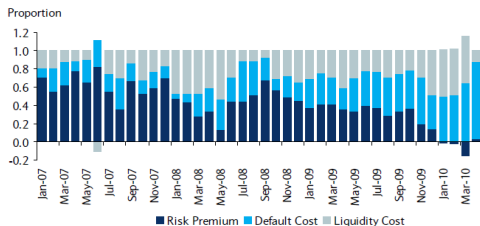
Our estimates: IG (e.g. 'A') are between 5% - 30%.



# Quick Comparison: Barclays

- Regression model, based on Barclays dealer data,
- Proprietary measure LCS (Liquidity Cost Score) as proxy, similar to BAS

Figure 10: Share of OAS (as a % of OAS) of Market, Default, and Liquidity Components (Equally Weighted Portfolio of the Bonds in Our Sample), January 2007-April 2010



Source: Barclays Capital

Taken from: *Dastidar, S. G., & Phelps, B. D. (2010). Credit spread decomposition: decomposing bond-level credit OAS into default and liquidity components. Barclays Capital: Cross Asset Strategy, 08 July 2010*

Liquidity component accounts for approx. 20% - 45% of spread.

## Quick Comparison: Dick Nielsen et al.

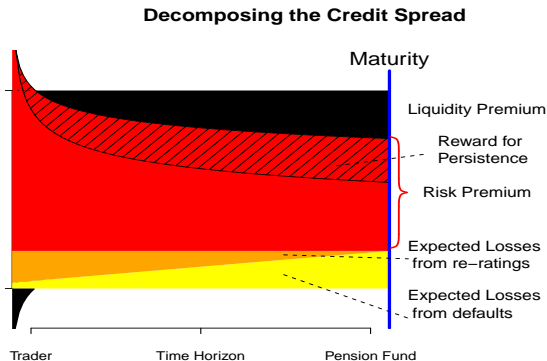
- Use PCA of nine different liquidity proxies, TRACE (US) transaction data
- Pooled regression (quarterly), controlling for credit risk (long term debt:assets, operating income:sales, level/slope swap curve, etc. )

	Dick-Nielsen et al. (US)	Our model (UK)
2005Q1:2007Q1	11% (5-18)	14% (5-25)
2007Q2:2009Q2	26% (14-39)	22% (15-30)

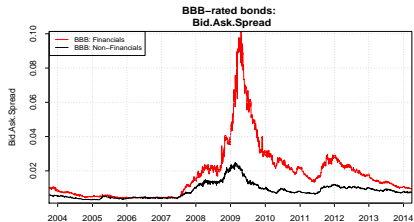
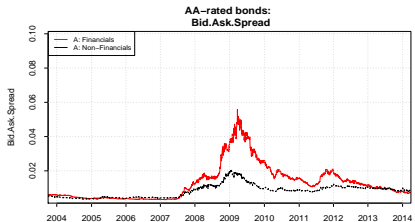
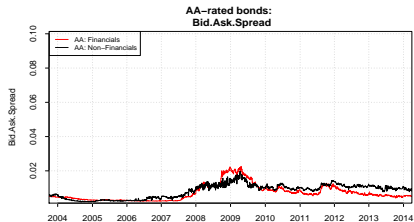
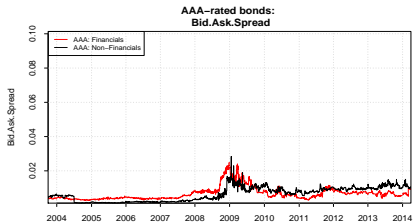
Liquidity premium in fraction of spread. Results are for A-rated bonds and approximate, figures taken from Table 5, Dick-Nielsen, J., Feldhuetter, P., & Lando, D. (2012). *Corporate bond liquidity before and after the onset of the subprime crisis*. *Journal of Financial Economics*, 103(3), 471-492.

# Ongoing work

- Liquidity term structure; interaction effects
- Compare *hold-to-maturity* with *sell-on-BBB-downgrade*:  
How much of the illiquidity premium do we sacrifice?

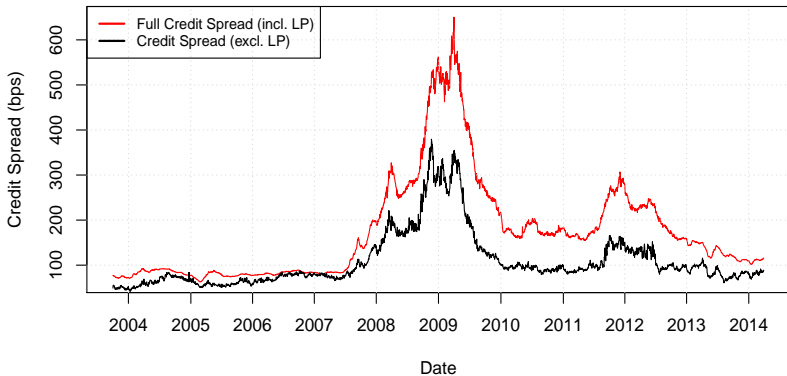


# Appendix: Observed BAS dynamics



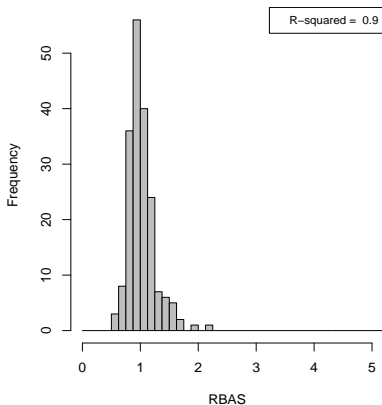
# Appendix: Credit Spread: Two Components, A-rated

**Median Credit Spread (two components)  
in bps (A-rated)**

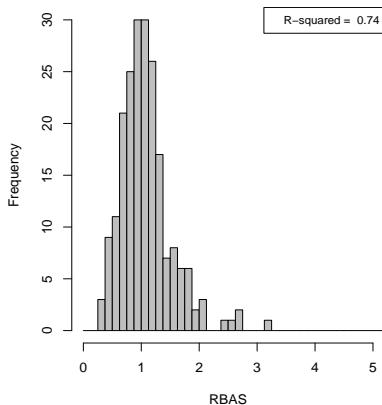


# Appendix: Distribution RBAS

Distribution of RBAS (A-rated) on  
2006-10-02

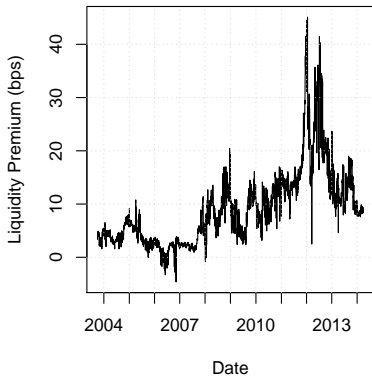


Distribution of RBAS (A-rated) on  
2009-08-04

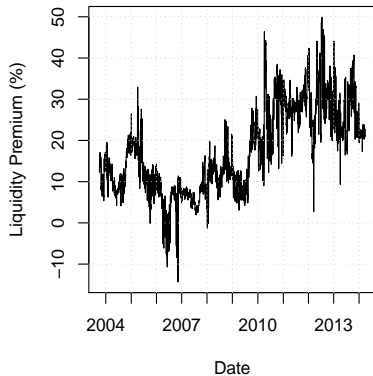


# Appendix: Liquidity Premia Estimates AAA

**Median Liquidity Premium  
in bps (AAA-rated)**

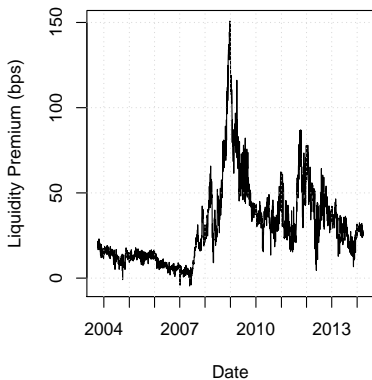


**Median Liquidity Premium  
in % (AAA-rated)**

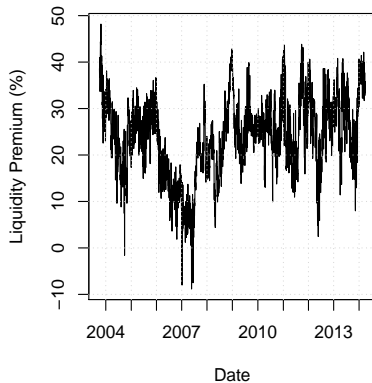


# Appendix: Liquidity Premia Estimates AA

**Median Liquidity Premium  
in bps (AA-rated)**



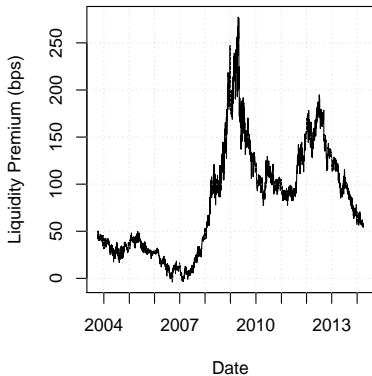
**Median Liquidity Premium  
in % (AA-rated)**





# Appendix: Liquidity Premia Estimates BBB

**Median Liquidity Premium  
in bps (BBB-rated)**



**Median Liquidity Premium  
in % (BBB-rated)**

