Liquidity Risk and Funding Cost

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2nd Short-Term Funding Markets Conference

March 29, 2019

University of St.Gallen

Motivation

Funding liquidity risk channel: We present and test a new channel showing that **funding liquidity risk** is priced in short-term **interest rates**

- Banks with high funding liquidity risk are willing to pay higher rates to lock in their funding

Funding liquidity risk: Risk that a solvent but illiquid borrower is unable to obtain refinancing (Diamond, 1991)

- At the heart of banking: maturity transformation and bank runs (Bryant, 1980; Diamond and Dybvig, 1983)

Short term interest rates: Short end of the yield curve, interbank interest rates

- Prone to funding liquidity risk due to short-term nature
- Vivid example: Global Financial Crisis 2007/08 (Gorton and Metrick, 2012; Perignon, Thesmar, and Vuillemey, 2018)



Literature and contribution

- **Yield spreads** in fixed-income markets because **lenders** demand compensation for **default and non-default risk**
  - Corporate and government bond markets (e.g., Chen, Lesmond, and Wei, 2007; Krishnamurthy and Vissing-Jorgensen, 2012)
  - Interbank market (e.g., Afonso, Kovner, and Schoar, 2011; Acharya and Skeie, 2011; Filipovic and Trolle, 2013)
- **Funding liquidity risk** important component of banks' default risk, but difficult to measure (e.g., Michaud and Upper, 2008; Imbierowicz and Rauch, 2014; Morris and Shin, 2016)
- **Main contribution**
  - Funding liquidity risk is priced in short-term interest rates through a borrower markup
  - Borrowers are willing to pay a higher rate if they need liquidity urgently



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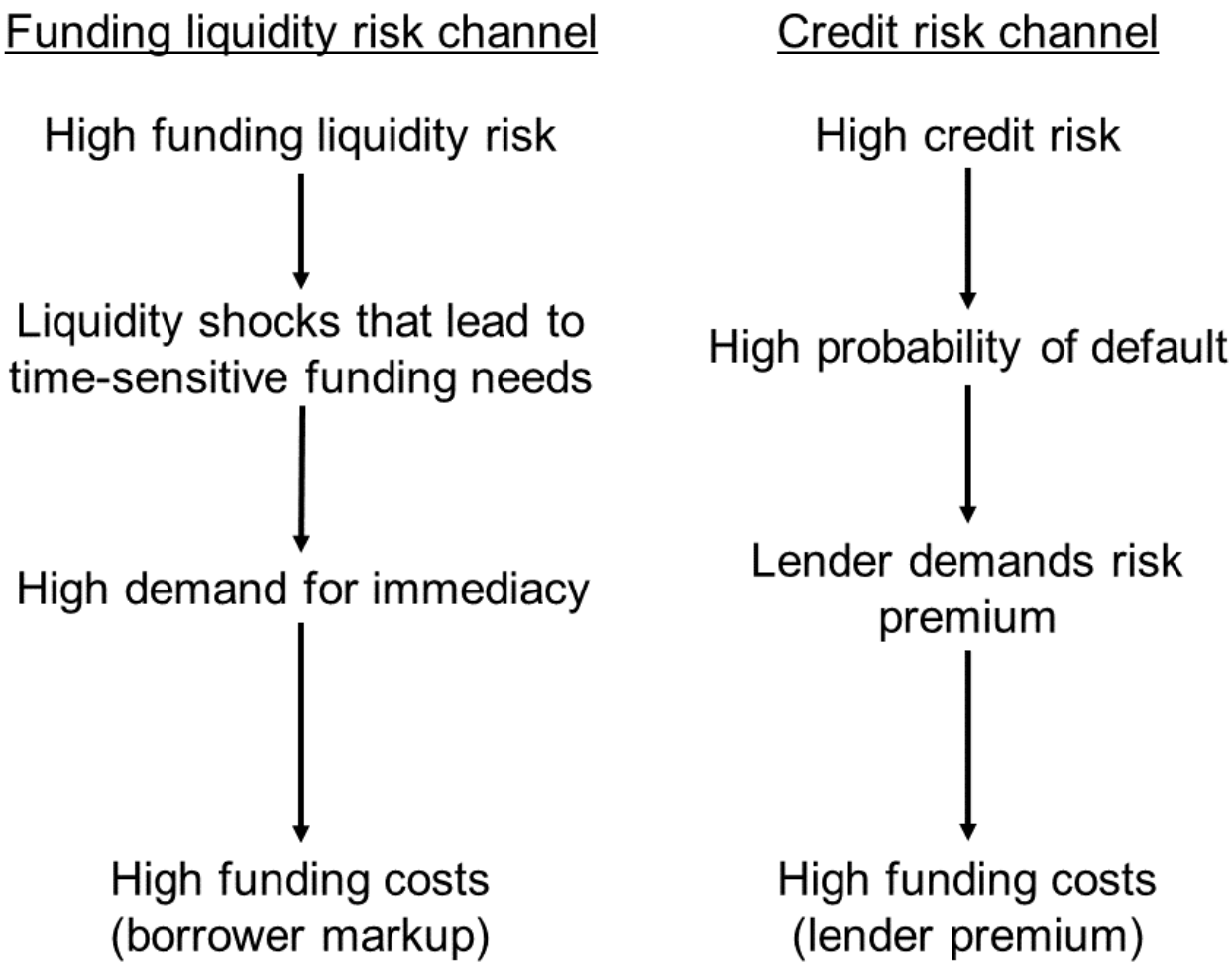


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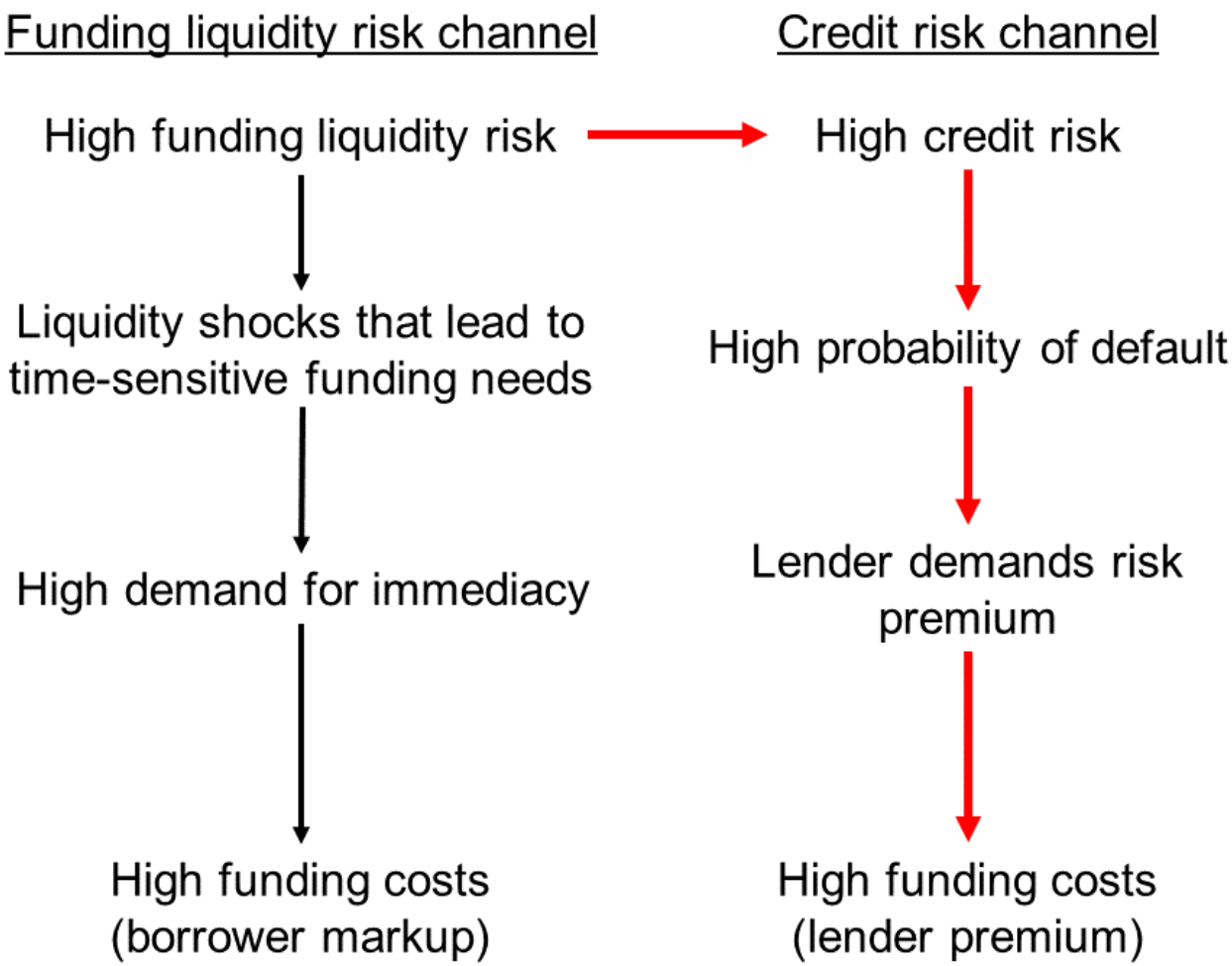
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Funding liquidity risk channel



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Identification strategy

- **Goal:** Provide empirical evidence for funding liquidity risk channel
  - Show that higher idiosyncratic funding liquidity risk leads to higher funding costs via borrower markups

- Two main **identification challenges**
  1. Construct a measure for idiosyncratic funding liquidity risk
     - Funding liquidity risk is not directly observable
  2. Isolate effect of borrower markup on interest rates
     - Funding liquidity risk affects interest rates through the borrower markup and lender risk premium $\rightarrow$ Disentangle the two
     - Control for other drivers of interest rates that are correlated with funding liquidity risk

- Solution
  - **Exploit unique market design** of a major short-term fixed income market and main segment of the euro money market: general collateral repo market



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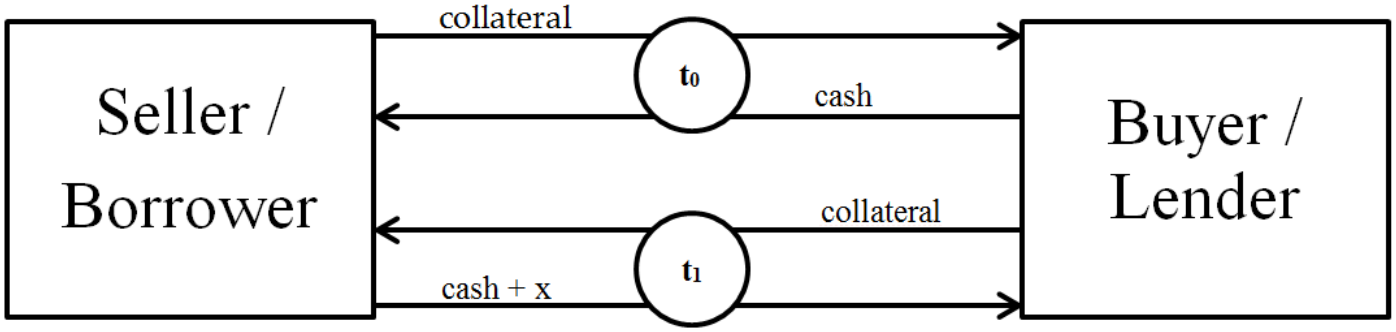
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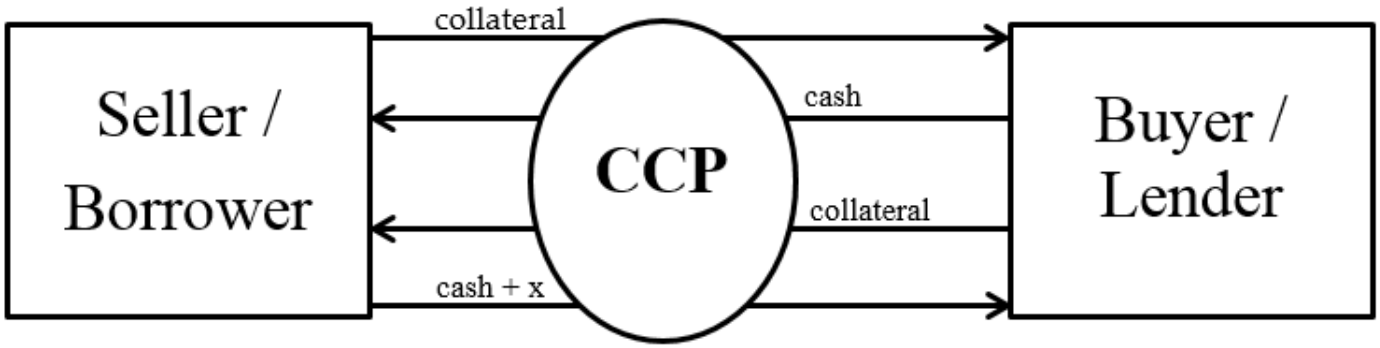
Identification strategy: GC repo market



- Repo rate: $r = \frac{x}{cash}\frac{360}{t_1 - t_0} = \frac{P(repurchase) - P(purchase)}{P(purchase)}\frac{360}{t_1 - t_0}$
- Maturity: around 90% one day
- Collateral: general collateral (GC)
- GC is organized in baskets
  - Eurex GC Pooling ECB Basket: Borrowers are free to supply any of 3000 securities as collateral



First identification challenge: Measuring funding liquidity risk



- Exploit **limit order book** structure to measure funding liquidity risk
  - Limit order vs market order
  - Market order is a revealed preference for the demand for immediacy

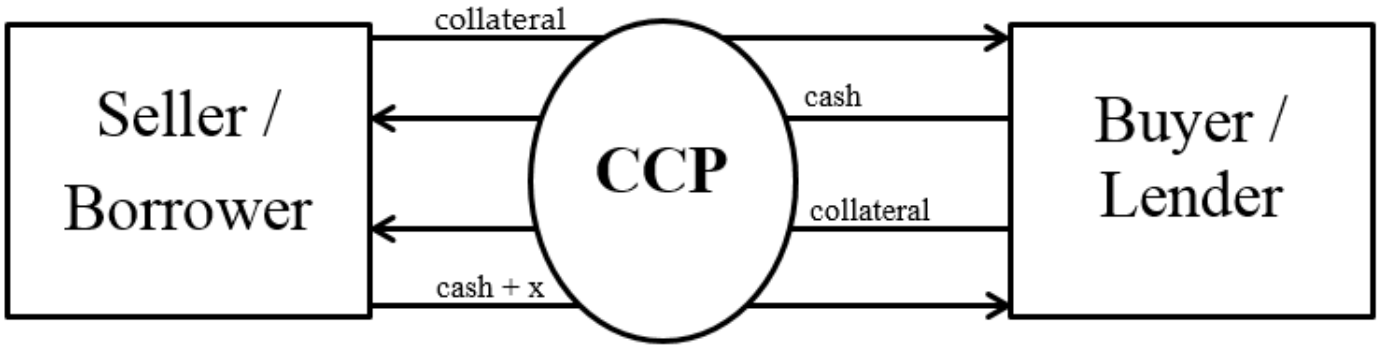
  → Construct measure for funding liquidity risk based on banks' intensity of using market orders

$$MOS_{i,t} = X_{i,t}\,\beta + \eta_i + \lambda_t + u_{i,t}$$

$$\hat{u}_{i,t} = LiquidityRisk_{i,t}$$



Second identification challenge: Disentangling borrower markup and lender premium



- Exploit **central counterparty** (CCP) to disentangle borrower markup and lender premium
  - Centralized and anonymous trading without counterparty risk
  - No direct exposure between borrowers and lenders due to CCP

  $\rightarrow$ No lender premia specific to individual borrowers

$$r^{e}_{i,t} = \alpha LiquidityRisk_{i,t} + X_{i,t}\beta + \eta_i + \lambda_t + \varepsilon_{i,t},$$

Empirical analysis: Data

- All EUR-denominated **GC repo transactions** from Jan 2006 to Dec 2016 at Eurex Repo GmbH
- Focus on overnight repos from the GC Pooling ECB basket
  - 95,496 transactions with total volume of EUR 23 trillion
  - 95 banks from 10 countries, 2,405 trading days
- Time stamp, repo rate, volume, collateral, term, anonymous identifier for repo traders, flag for market order
- Measure **yield spread (funding cost)** by excess rate (aggregate to daily frequency)

$$r^e_{i,t} = r_{i,t} - \bar{r}_t.$$

  - $r_{i,t}$: volume-weighted average repo rate paid by bank i on day t,
  - $\bar{r}_t$: daily volume-weighted average of all overnight transactions from the GC Pooling ECB basket



Empirical analysis: Testing validity of measure (1/2)

- Proxy liquidity shocks with intraday changes from lending to borrowing
- $LiquidityRisk$ correctly captures increased liquidity risk from shocks
- Odds of having positive liquidity risk double if liquidity shock hits

Table: Switching trades contingency table

	$Switch = 0$	$Switch = 1$	Total
$LiquidityRisk \leq 0$	20,855	316	21,171
$LiquidityRisk > 0$	16,272	560	16,832
Total	37,127	876	38,003



Empirical analysis: Testing validity of measure (2/2)

- Urgent liquidity need at the end of the maintenance period for banks that have not yet fulfilled reserve requirements
- Due to high volatility, borrowers usually try to avoid entering the market on these days
- Liquidity shock might force them to enter anyway
- $LiquidityRisk$ correctly captures increased liquidity risk for borrowers on these days

Table: End-of-maintenance period

	t	$t-1$	$t-2$
ON	**0.033*****	-0.023^{***}	-0.041^{***}
TN	0.032^{**}	**0.123*****	-0.001
SN	0.004	0.063^{***}	**0.112*****



Empirical analysis: Regression results

- Liquidity risk **positively** impacts funding cost
- Banks with high funding liquidity risk willing to pay about 2 bp more
- Additional specifications:
  - Subperiods
  - Dynamic panel
  - Alternative tenors and baskets
  - Relative frequencies

	(1)	(2)	(3)	(4)	(5)
LiquidityRisk	1.649***	2.047***	2.001***	2.004***	2.005***
	(6.87)	(8.92)	(10.68)	(10.19)	(10.10)
Volume			0.150*	0.124	0.124
			(1.77)	(1.58)	(1.59)
TradeTime			-0.325***	-0.326***	-0.327***
			(-11.71)	(-11.24)	(-11.37)
Experience			-0.0605	-0.0685	-0.0683
			(-0.30)	(-0.32)	(-0.32)
TotalAssets				1.505	1.493
				(1.30)	(1.25)
ROAA				0.158	0.158
				(1.12)	(1.12)
Leverage				0.0180	0.0182
				(0.62)	(0.64)
CDS					0.00631
					(0.11)
Constant	-0.185	-0.524***	1.284	-8.324	-8.276
	(-1.34)	(-3.14)	(1.48)	(-1.12)	(-1.09)
Bank/Day FE	no/no	yes/yes	yes/yes	yes/yes	yes/yes
NT	11,486	11,486	11,486	11,486	11,486
R^2	0.0402	0.244	0.269	0.271	0.271
Adj. R^2	0.0401	0.0106	0.0437	0.0454	0.0452



Economic significance

- **Trading volume** is large
  - Banks borrow EUR 617m on average per day
  - One standard deviation increase in liquidity risk increases funding cost by 2.5% on a given day
- **Similar magnitude** as the impact of **credit risk** in unsecured markets as documented by Angelini, Nobili, and Picillo (2011)
  - Downgrade in individual rating from A (best) to C (middle of the range) corresponds to a 0 to 5 basis points increase in yield spreads
- Measure **lower bound** of effect?
  - GC repo one of the most liquid and sophisticated debt markets



Conclusion

- Propose **funding liquidity risk channel**
  - Borrowers with high liquidity risk are willing to pay a markup to lock in funding
  - Complements the existing literature on short-term interest rates that emphasizes the role of lenders (demanding risk premia)
- **Test** channel and **quantify** effect
  - Exploit market design of euro repo market
  - Likely that results have external validity $\rightarrow$ future research
- **Implications**
  - Need to account for funding liquidity risk channel when analyzing interest rate spreads $\rightarrow$ avoid bias and misinterpretation
  - Supervisors and CCPs can rely on funding liquidity risk markup as high-frequency proxy for liquidity risk of individual banks



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Appendix



Logit regression

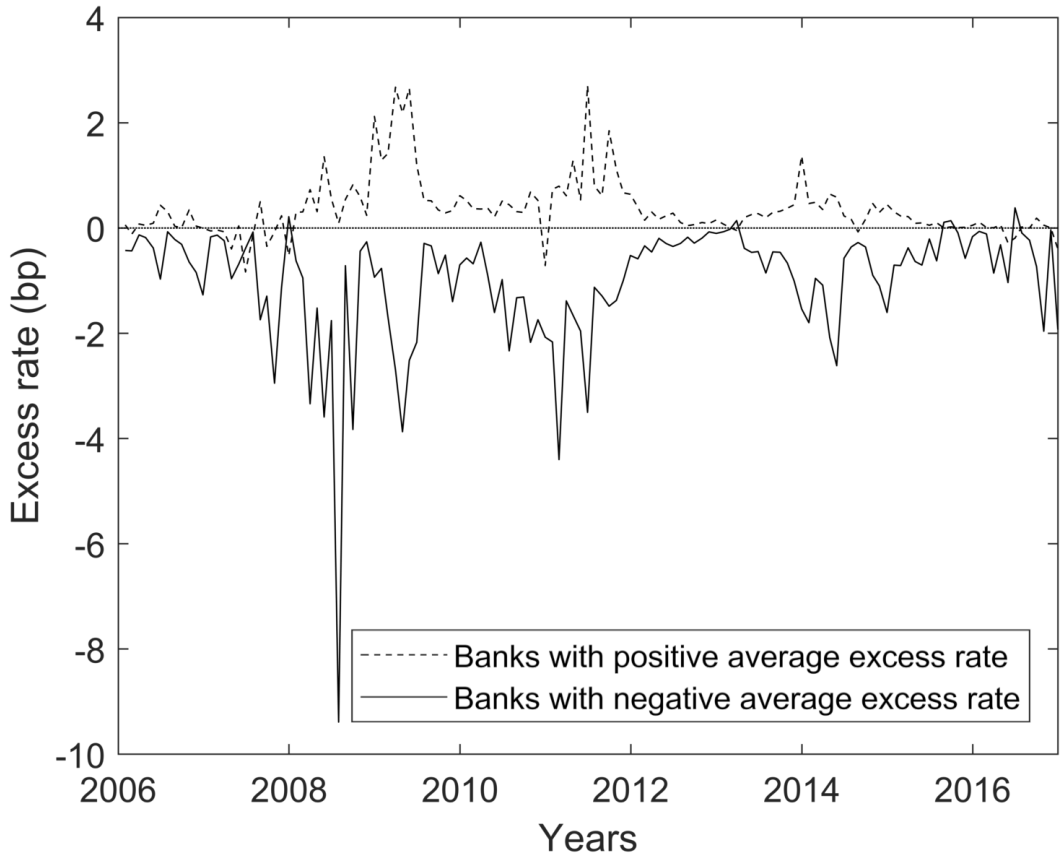
- Estimate probability of using a market order when switching the direction of trading
- **Odds** of using market order **increase** by more than twofold when being hit by liquidity shock

Table: Validity test of $LiquidityRisk$: Logistic regression

	$LiquidityRisk > 0$	Odds Ratio
$Switch$	0.820***	2.271***
	(11.53)	(11.53)
Constant	−0.248***	
	(-23.72)	
N	38,003	38,003



Systematic heterogeneity: time variation



Back

Order choice

- Demand of immediacy **observable** in limit order book markets
- Choice between limit and market order:

Market order	**Limit order**
Execution guaranteed	Execution not guaranteed
Execution immediately	Execution later or never
Best price upon arrival	Guaranteed price

- A bank with high liquidity risk is more likely to use **market orders**

back



Descriptive statistics

- Repo data

	Mean	Median	Std	Min	Max	NT	N
Excess rate (bp)	−0.05	0.04	2.96	−69.07	75.41	37,314	95
Excess rate (rel. frequency)	0.53	0.59	0.45	0.00	1.00	37,314	95
Market order share	0.53	0.59	0.45	0.00	1.00	37,314	95
Volume	617	320	817	1	12,425	37,314	95
Trade time	12.38	12.28	2.33	5.91	17.00	37,314	95
Number of trades	2.56	2.00	2.43	1	42	37,314	95
Experience	699	554	566	1	2,703	90,955	95

- Balance sheet data

	Mean	Median	Std	Min	Max	NT	N
Total assets (EURbn)	329	87	583	1	3544	590	63
ROAA	0.20	0.21	0.65	−6.44	3.15	560	63
Leverage	6.13	4.31	6.21	0.00	40.51	538	58
Short/total funding	0.66	0.69	0.25	0.04	1.00	421	41
Short/long funding	54	2	556	0	8535	421	41
Non-liquid/total assets	0.55	0.57	0.21	0.02	1.00	425	47
CDS	136	115	110	1	679	216	25



Subperiods: Financial crisis and floor system

- Liquidity risk has **larger** impact on funding cost in **crises** periods

	Financial crisis			Floor system		
	(1)	(2)	(3)	(4)	(5)	(6)
$LiquidityRisk$	2.806***	2.727***	2.709***	0.998***	1.002***	1.005***
	(8.51)	(10.15)	(10.26)	(7.33)	(7.30)	(7.32)
Controls	no	yes	yes, incl. CDS	no	yes	yes, incl. CDS
Bank/Day FE	yes/yes	yes/yes	yes/yes	yes/yes	yes/yes	yes/yes
NT	2,216	2,216	2,216	4,800	4,800	4,800
R^2	0.243	0.287	0.288	0.446	0.449	0.449
Adj. R^2	-0.00130	0.0532	0.0540	0.263	0.266	0.266

- **Lower** dispersion when **central bank excess liquidity** is high

Back



Dynamic panel regression and relative frequencies regression results

- Dynamic panel regression:

$$r^e_{i,t} = \gamma r^e_{i,t-1} + \alpha LiquidityRisk_{i,t} + X_{i,t}\beta + \eta_i + \epsilon_{i,t}$$

	(1) r^e	(2) r^e	(3) r^e	(4) RF	(5) RF	(6) RF
$LiquidityRisk$	1.102***	1.202***	1.611***	0.329***	0.355***	0.381***
	(6.62)	(8.06)	(7.13)	(17.67)	(20.38)	(16.20)
r^e_{t-1}	0.110***	0.0945***	0.0777**			
	(3.20)	(3.13)	(2.03)			
Volume		0.0662	0.105		0.0127*	0.0111
		(1.25)	(1.13)		(1.91)	(1.49)
TradeTime		−0.126***	−0.270***		−0.00488	−0.0245***
		(-3.23)	(-5.47)		(-1.16)	(-7.36)
Experience		0.104	0.103		−0.0210	−0.000915
		(0.89)	(0.43)		(-1.54)	(-0.03)
TotalAssets		2.072***	0.643		0.0313	0.168
		(2.63)	(0.35)		(0.49)	(1.10)
ROAA		0.346	0.135		0.00690	0.0230
		(1.61)	(0.48)		(0.49)	(1.21)
Leverage		−0.0408	−0.0177		0.00162	0.00284
		(-1.42)	(-0.25)		(0.61)	(0.77)
CDS			0.191			0.00374
			(1.26)			(0.34)
Bank/Day FE	yes/yes	yes/yes	yes/yes	yes/yes	yes/yes	yes/yes
NT	27256	20836	8930	37346	27801	11486
N	94	56	17			
Instruments	10	40	18			
AR(1) p-value	0.0000441	0.000296	0.00603			
AR(2) p-value	0.820	0.934	0.981			
Hansen p-value	0.0147	0.325	0.320			
Adj. R^2				0.247	0.248	0.254

▶ Back



Alternative baskets and tenors regression results

	TN&SN ECB			ON ECB EXT		
	(1)	(2)	(3)	(4)	(5)	(6)
LiquidityRisk	0.664***	0.685***	0.870***	1.338***	1.402***	2.054***
	(12.87)	(10.96)	(7.62)	(8.35)	(7.87)	(6.96)
Volume		0.0484*	0.0669		0.0899*	0.0477
		(1.74)	(1.50)		(1.97)	(0.89)
TradeTime		0.00951	−0.0309*		−0.161***	−0.157***
		(0.68)	(-1.95)		(-4.58)	(-3.59)
Experience		−0.0388	0.0448		−0.00856	0.360
		(-0.37)	(0.12)		(-0.06)	(1.29)
TotalAssets		0.0846	0.106		0.382	0.731
		(0.31)	(0.28)		(0.68)	(0.56)
ROAA		0.0787	0.106		0.203	0.349
		(0.95)	(0.78)		(0.78)	(1.01)
Leverage		0.0257	0.0372		0.00254	0.158
		(1.35)	(1.26)		(0.06)	(1.00)
CDS			0.187*			−0.907
			(1.76)			(-1.59)
Constant	−1.263**	−1.832*	−2.796	−4.775**	−3.265	−1.862
	(-2.25)	(-1.88)	(-1.02)	(-2.62)	(-1.36)	(-0.22)
Bank/Day FE	yes/yes	yes/yes	yes/yes	yes/yes	yes/yes	yes/yes
N	21423	15652	8268	17017	12812	4034
R^2	0.135	0.208	0.258	0.203	0.191	0.472
Adj. R^2	0.00187	0.0396	−0.0845	0.0910	0.0372	0.168

▸ Back



Relative frequencies regression results

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▶ Back



Alternative explanation?

Two possible drivers of systematic differences in the demand for funding immediacy

1. Exposure to liquidity risk
2. Investment opportunities: Better or more time-sensitive investment opportunities

Distinguish between (1) and (2) by looking at reverse repo trades (cash lending)

- Borrower: High demand for immediacy due to (1) and/or (2)
- Lender: High demand for immediacy due to (1), but not due to (2)



Lender perspective

- **Lender** perspective
  - Repo rate is not a cost but a revenue
  - Demand for immediacy is urgent need to lend
- Our simple theory still applies
  - Banks with funding surplus have similar pressure to efficiently manage their liquidity
  - Banks have to resort to deposit facility if they do not lend in the interbank market $\Rightarrow$ pays lower interest rates



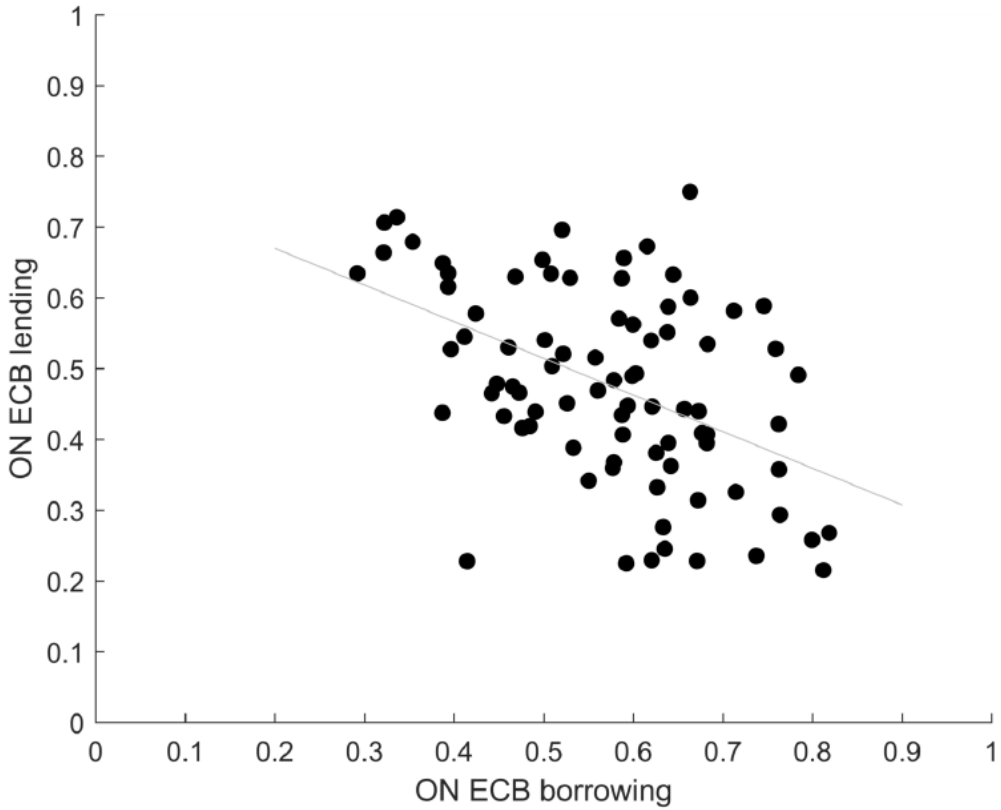
Lender regression results

	(1)	(2)	(3)	(4)	(5)
LiquidityRisk	−1.702***	−1.743***	−1.731***	−1.843***	−1.880***
	(-14.94)	(-16.93)	(-16.83)	(-12.45)	(-6.01)
Volume			−0.0888*	−0.0572	−0.00734
			(-1.78)	(-0.90)	(-0.08)
TradeTime			−0.234***	−0.242***	−0.279***
			(-8.65)	(-8.37)	(-4.85)
Experience				−0.229	−2.578
				(-1.52)	(-1.27)
TotalAssets				−0.0169	−0.287
				(-0.04)	(-0.18)
ROAA				−0.302	−0.560
				(-0.97)	(-0.98)
Leverage				−0.0148	−0.00958
				(-0.67)	(-0.17)
CDS					0.282
					(1.54)
Constant	0.921***	0.628**	3.796***	3.488**	0.153
	(9.51)	(2.11)	(9.68)	(2.41)	(0.01)
Bank/Day FE	no/no	yes/yes	yes/yes	yes/yes	yes/yes
NT	28643	28643	28643	17235	4861
R^2	0.0468	0.152	0.167	0.224	0.480
Adj. R^2	0.0467	0.0568	0.0724	0.0771	0.0408



Performance across borrowing and lending

- Banks with low cost when borrowing tend to have high revenue when lending



- Results for lenders support funding liquidity risk channel rather than investment channel