Liquidity Risk and Funding Cost

Alexander Bechtel
University of St. Gallen

Angelo Ranaldo
University of St. Gallen

Jan Wrampelmeyer
Vrije Universiteit Amsterdam
Tinbergen Institute

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Preview

- New **channel** that **links funding liquidity risk and short-term interest rates**
  - Borrowers with high liquidity risk are willing to pay a markup to lock in their short-term funding
  - Independent of credit and (market) liquidity risk premia demanded by lenders
- **Funding liquidity risk**: Risk that a solvent but illiquid borrower is unable to obtain refinancing in the market (Diamond, 1991)
  - At the heart of banking: customers withdraw deposits; borrowers draw on credit lines; investors do not roll-over funding ...
- **Short term interest rates:** short end of yield curve; interbank interest rates
  - Prone to funding liquidity risk
  - Vivid example: Global Financial Crisis 2007/09 (Gorton and Metrick, 2012; Perignon, Thesmar, and Vuillemey, 2018)

Relevance

1. Understanding funding liquidity risk is key for **financial stability**
   - Reinforces market liquidity risk (Brunnermeier and Pedersen, 2009)
   - Creates transmission channel between market liquidity and credit risk (He and Xiong, 2012)

2. Decomposing interest rates into premia demanded by lenders and markups from borrowers facilitates the distinction between **insolvent** and **illiquid** banks
   - Important for police response

3. Explanation for systematic and persistent heterogeneity in funding costs
   - Heterogeneity can undermine efficient liquidity allocation and **pass-through of monetary policy** (Duffie and Krishnamurthy, 2016)) Higher funding costs translate into less intermediation activity (Gambacorta and Shin, 2018)
   - Heterogeneity might spread outside the funding market because banks pass on funding costs to clients via liquidity transfer pricing or funding value adjustments (BCBS, 2008))

Outline

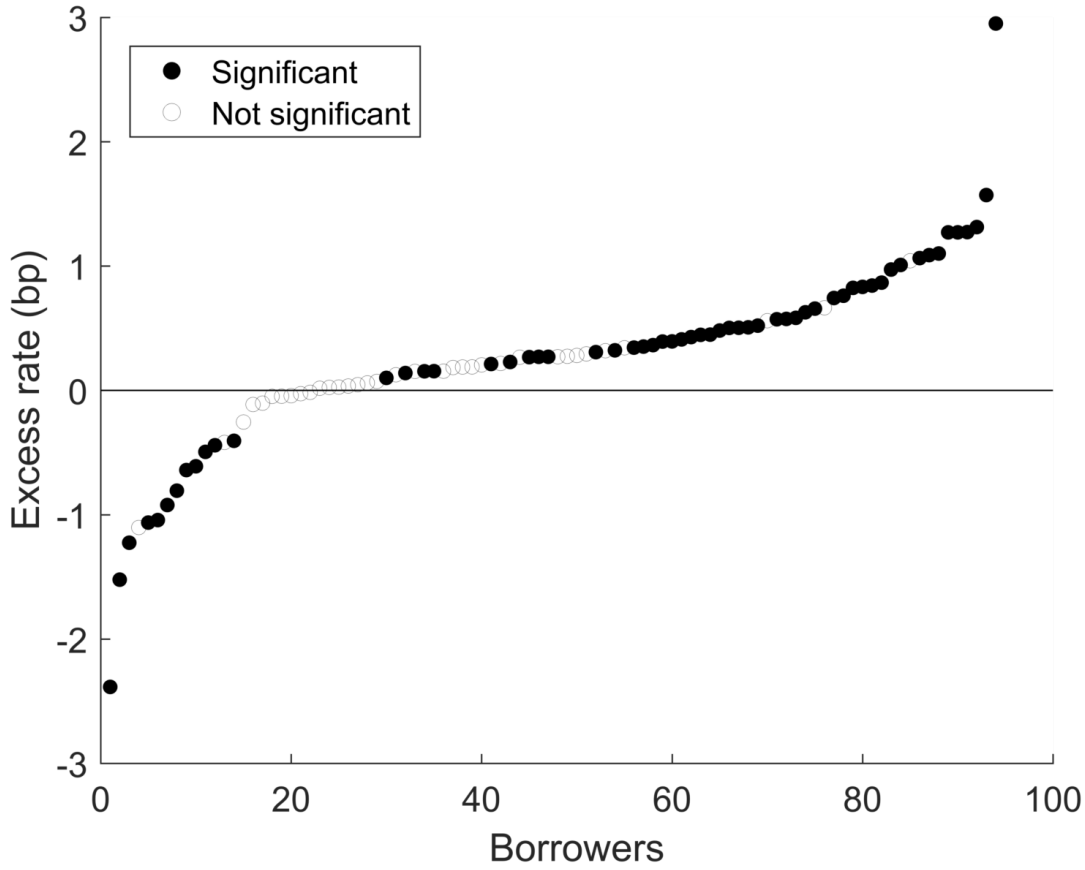
1. Funding liquidity risk channel

2. Empirical analysis
   - Identification strategy
   - Data
   - Results

3. Conclusion and implications

Motivation: Systematic heterogeneity in funding costs

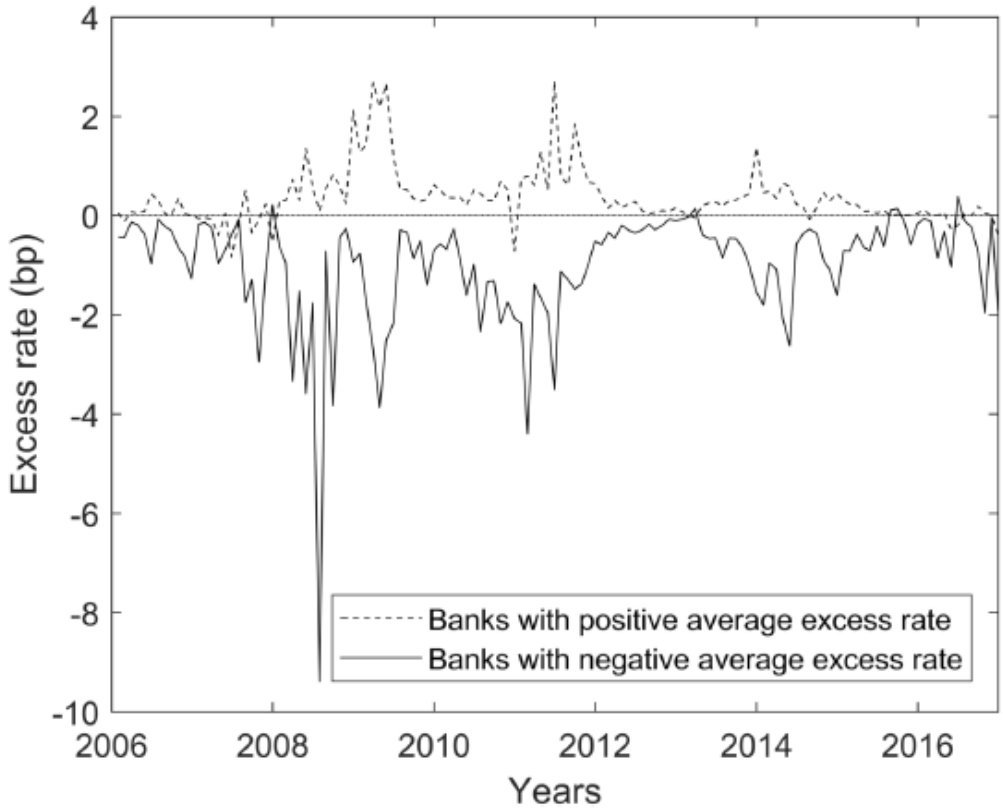
- **Average funding cost** of borrowers in main segment of the euro interbank funding market:



- **Unexpected heterogeneity**
  - Market is central counterparty-based, anonymous
  - Lenders cannot ask for risk premia specific to individual borrowers

Motivation: Heterogeneity is persistent

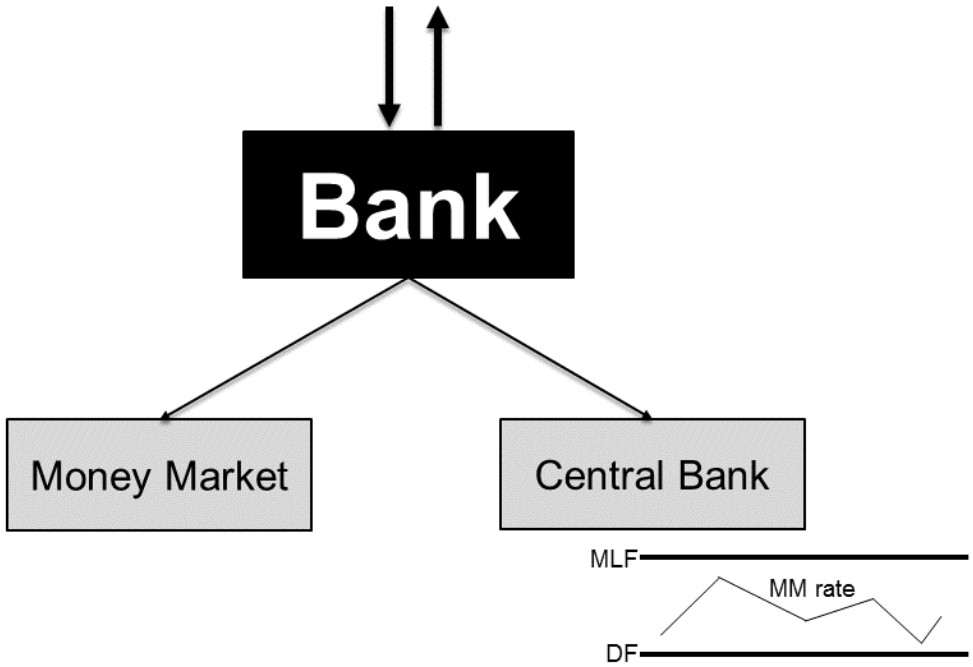
- Differences in funding cost are persistent



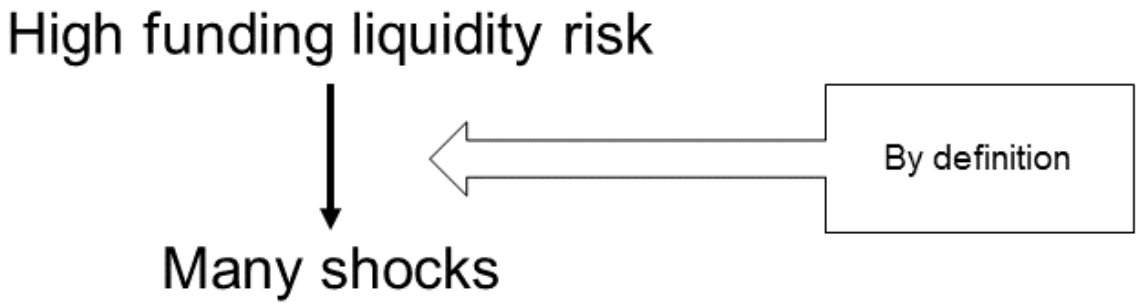
- We show that systematic and persistent **heterogeneity in funding costs** is driven by systematic and persistent **heterogeneity in funding liquidity risk**

Funding liquidity risk channel: Setting

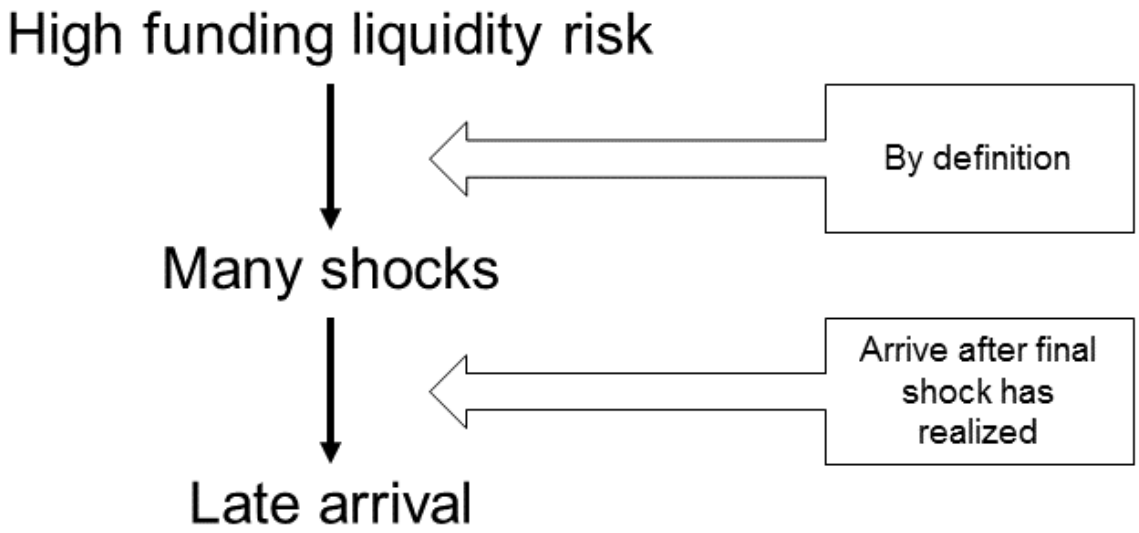
- Banks receive funding **shocks** during the day $\rightarrow$ deficit or surplus
- After realization of shocks: balance liquidity position in interbank market
  - Otherwise need to resort to costly central bank lending facility
- **FLRC:** Borrowers with high **funding liquidity risk** have high **funding costs**



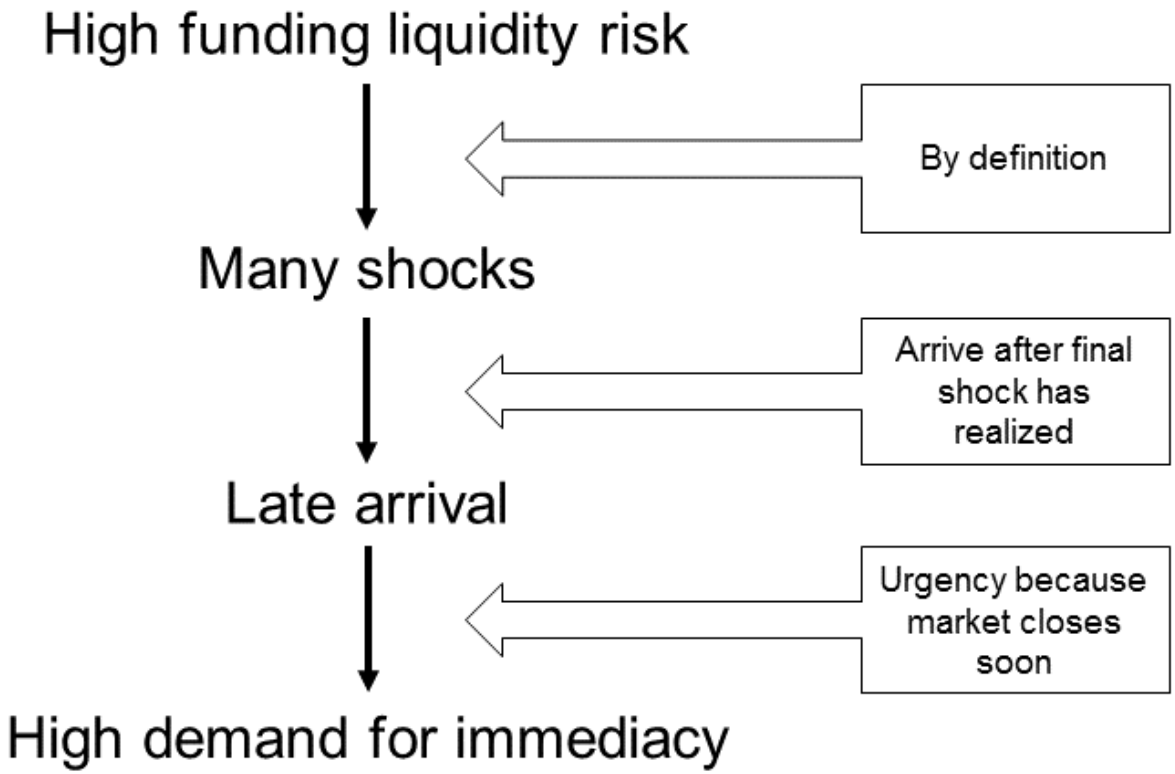
Funding liquidity risk channel: Intuition



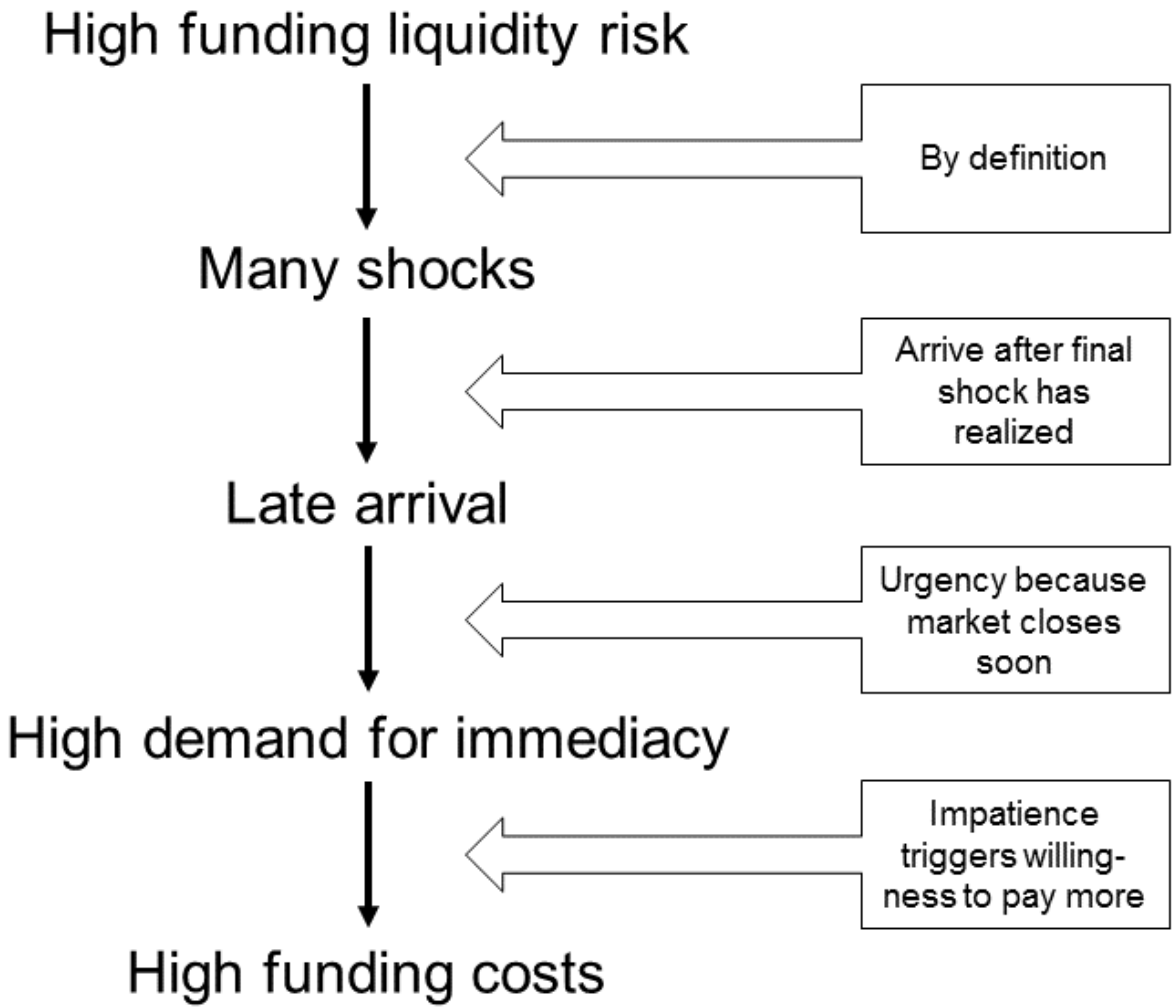
Funding liquidity risk channel: Intuition



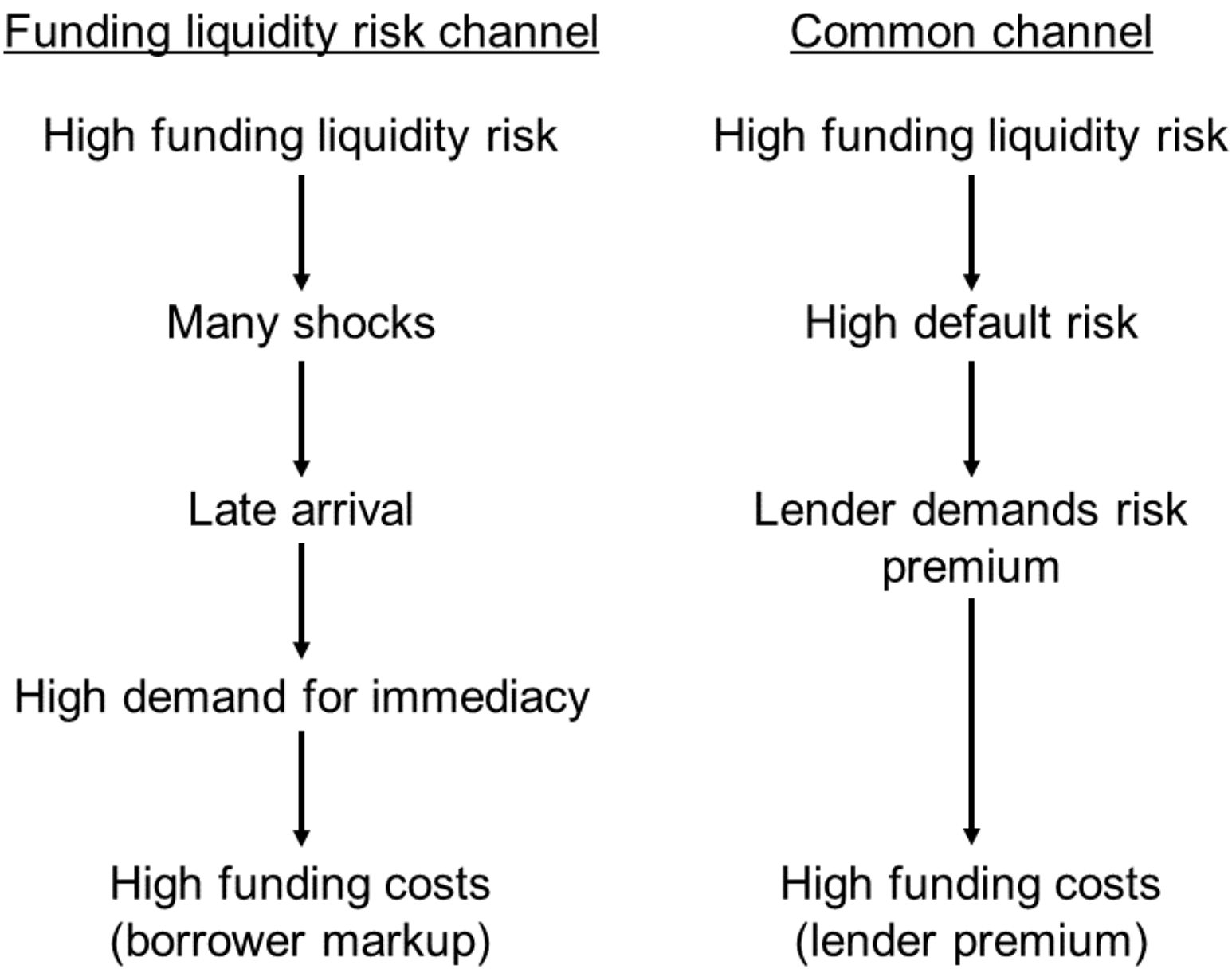
Funding liquidity risk channel: Intuition



Funding liquidity risk channel: Intuition



Borrower markup vs. lender premium



Outline

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Identification strategy

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

- Three **challenges**
  1. Isolate funding transactions
     - Other intentions: market making, speculation, sourcing a specific security
  2. How to measure idiosyncratic liquidity risk?
     - Not directly observable
  3. 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 main segment of euro money market: general collateral repo market

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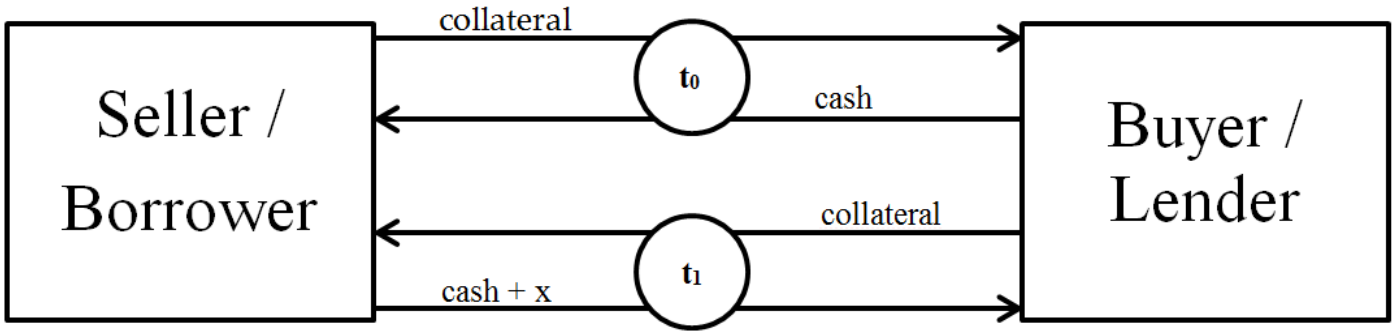
Solving challenge 1: Isolate funding-driven trades

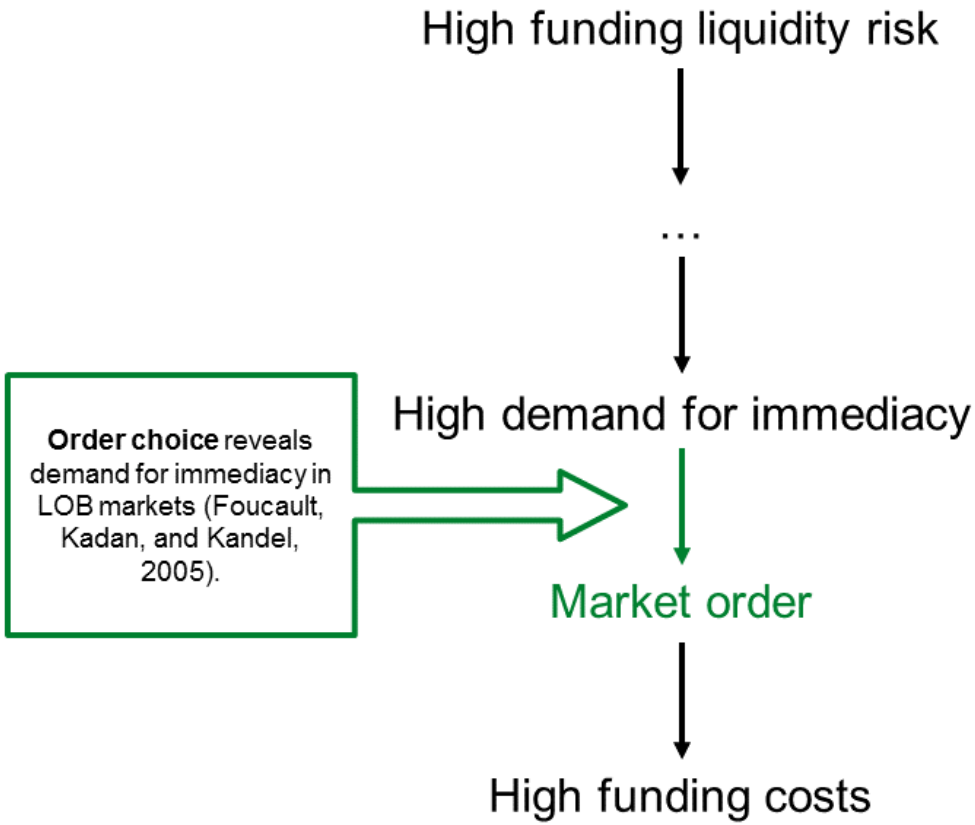


- Repo rate: $r = \frac{x}{cash} \frac{360}{t_1 - t_0}$
- Maturity: around 90% one day
- Collateral: general collateral (GC) or special
- Special repos are security-driven (demand for specific security)
- GC is organized in baskets
  - Eurex GC Pooling ECB Basket: Borrowers are free to supply any of 3000 securities as collateral

$\Rightarrow$ **GC repo market is funding-driven**

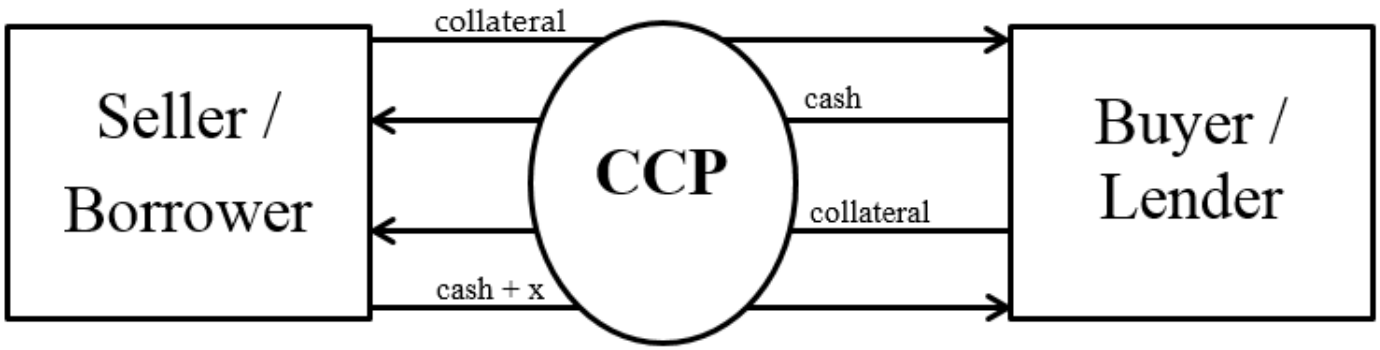
Solving challenge 2: Measure funding liquidity risk

- Majority of interbank repos traded in electronic limit order book



⇒ **Use volume-weighted share of market orders as proxy**

Solving challenge 3: Isolate borrower markup



- CCP manages risk and determines haircuts
- Trading via CCP and LOB is anonymous
- No asymmetric information, search costs, trading relationships, etc.

⇒ **Anonymous CCP-based market controls for lender risk premia and other common determinants of interest rates**

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 over 2,405 trading days
- Time stamp, repo rate, volume, collateral, term, anonymous identifier for repo traders, flag for market order
- Measure **funding cost** by excess rate (aggregate to daily frequency)

$$r^e_{i,t} = r_{i,t} - \bar{r}_t. \tag{1}$$

  - $r_{i,t}$: 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

Descriptive statistics: High vs. low funding cost

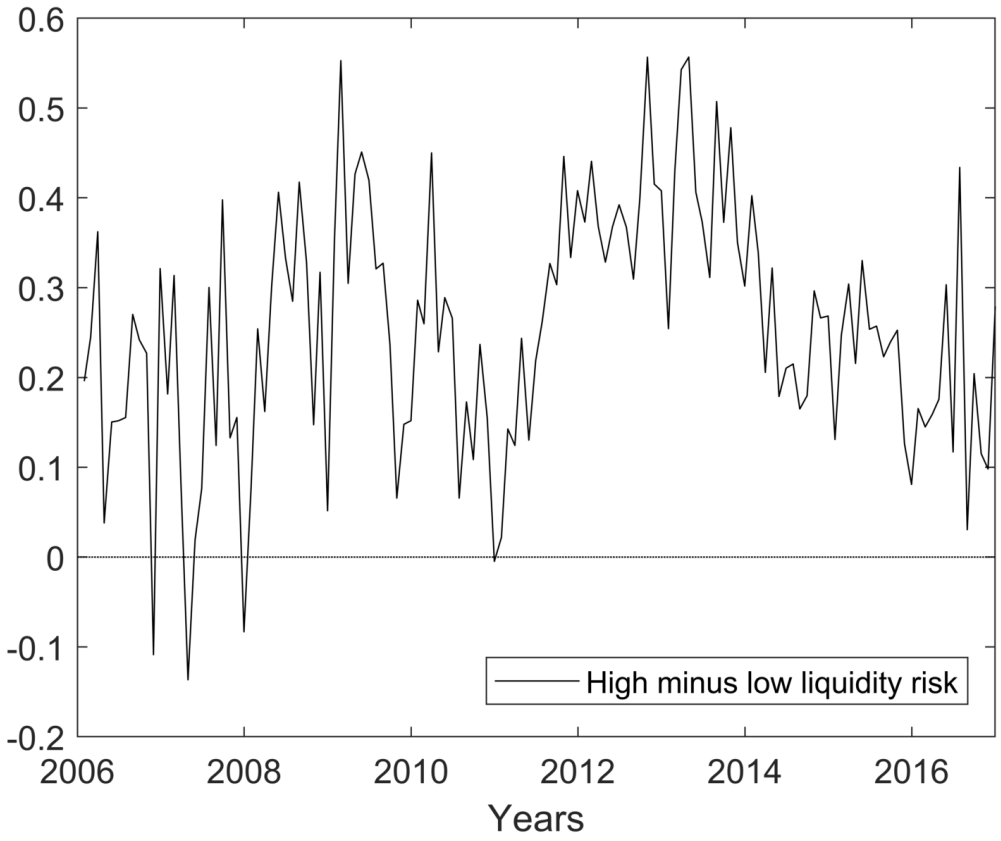
- Repo data

	High funding cost			Low funding cost			Difference	
	Mean	NT	N	Mean	NT	N	High−low	t-value
Excess rate (bp)	0.28	25,593	73	−0.77	11,729	23	1.05	27.83
Relative frequency (RF)	0.59	25,593	73	0.40	11,729	23	0.19	38.55
Market order share	0.61	25,593	73	0.37	11,729	23	0.24	49.14
Volume	553	25,593	73	758	11,729	23	−205	−21.72
Trade time	12.12	25,593	73	12.97	11,729	23	−0.85	−32.97
Number of trades	2.49	25,593	73	2.71	11,729	23	−0.23	−8.53
Experience	635	61,913	73	835	29,042	23	−200	−47.49

- Balance sheet data

Systematic heterogeneity

- Some banks have consistently higher liquidity risk than others



- Difference in liquidity risk between banks with high and low average liquidity risk (defined as market order volume share above/below 50%)

Cross-sectional regression

- Examine effect of funding liquidity risk on funding costs
- **Cross-sectional regression** framework

$$r_i^e = \alpha \; LiquityRisk_i + X_i \; \beta + \varepsilon_i$$

- $LiquityRisk_i$: Volume-weighted market order share
- X_i: Control variables
  - Variables that (1) determine funding costs and (2) are correlated with funding liquidity risk

Cross-sectional regression results

- Liquidity risk **positively** impacts borrowing cost
- Banks with higher liquidity risk pay higher interest rates than banks with low liquidity risk

	(1)	(2)	(3)	(4)
LiquidityRisk	1.788***	1.394***	1.967***	2.224***
	(6.00)	(5.72)	(7.12)	(3.50)
Volume		-0.235***	-0.0869	-0.452*
		(-3.55)	(-0.91)	(-2.06)
Trade time		-0.142***	-0.200***	-0.248*
		(-3.56)	(-4.49)	(-1.77)
Experience			-0.171	-0.421**
			(-1.54)	(-2.42)
Size			0.0211	0.0978
			(0.52)	(1.43)
ROAA			-0.145	0.176
			(-1.28)	(0.74)
Leverage			-0.0327	0.0303
			(-1.54)	(0.82)
CDS				0.369
				(1.56)
Constant	-0.929***	2.308***	3.325***	5.374**
	(-4.32)	(3.50)	(3.66)	(2.37)
N	95	95	58	24
R^2	0.320	0.435	0.608	0.743
Adj. R^2	0.312	0.416	0.554	0.606

Panel regression

- Quantify the markup borrowers are willing to pay due to their exposure to funding liquidity risk
- **Panel regression** framework

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

- $LiquityRisk_{i,t}$: Volume-weighted market order share
- Include control variables $X_{i,t}$, bank fixed effects η_i, and day fixed effects λ_t
  - Other variables that drive funding costs and are correlated with (our proxy of) funding liquidity risk

Panel regression results

- Overall **similar** to cross-sectional results
- Liquidity risk positively affects funding cost

	(1)	(2)	(3)	(4)	(5)
DFI	1.235***	1.169***	1.272***	1.379***	2.004***
	(8.29)	(10.42)	(10.95)	(10.51)	(10.03)
Volume			0.132***	0.128***	0.253***
			(3.30)	(2.86)	(3.58)
Trade time			−0.175***	−0.187***	−0.305***
			(-6.56)	(-6.16)	(-10.83)
Experience				−0.0703	−0.279
				(-0.51)	(-1.24)
Size				0.746*	1.306
				(1.80)	(1.10)
ROAA				0.0999	0.222
				(1.31)	(1.58)
Leverage				0.0260	0.0236
				(1.21)	(0.83)
CDS					−0.0453
					(-0.71)
Constant	−0.711***	−0.723**	0.573	−2.802*	−8.901
	(-4.90)	(-2.08)	(1.02)	(-1.91)	(-1.17)
Bank/Day FE	no/no	yes/yes	yes/yes	yes/yes	yes/yes
NT	37346	37346	37346	27801	11486
R^2	0.0352	0.156	0.172	0.197	0.271
Adj. R^2	0.0351	0.0845	0.102	0.105	0.0454

Economic significance

- Trading volume is large
  - Average high bank borrows 543m 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 rate spreads
- Measure **lower bound** of effect?
  - GC repo one of the most liquid and sophisticated debt markets

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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 risk premia $\rightarrow$ avoid bias and misinterpretation of the origin of interest rate spreads
  - Banks' liquidity management
  - Supervisors and CCPs can rely on funding liquidity risk markup as high-frequency proxy for liquidity risk of individual banks
  - Heterogeneity affects pass-through efficiency of monetary policy

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Appendix

Related literature

- **Interest rates** in fixed-income markets deviate from risk-free rate because **investors** require **risk premia** for default risk (credit risk) and non-default risks (market liquidity risk)
  - Corporate bond markets (e.g., Longstaff, Mithal, and Neis (2005))
  - Government bond markets (e.g., Krishnamurthy and Vissing-Jorgensen (2012))
  - **Interbank markets** (e.g., Taylor and Williams (2009), Filipovic and Trolle (2013), Schwarz (2018))
- Less attention on the role of funding liquidity risk for interest rate spreads (e.g., Imbierowicz and Rauch (2014), Morris and Shin (2016))
- Some evidence that borrowers behave differently depending on liquidity risk
  - Bidding behavior in central bank auctions (e.g., Bindseil, Nyborg, and Strebulaev (2009), Fecht, Nyborg, and Rocholl (2011), Cassola, Hortacsu, and Kastl (2013), Drehmann and Nikolaou (2013))
  - Pricing of deposits (Ben-David, Palvia, and Spatt, 2015)

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Related literature

- How do short-term funding markets **function**?
  - Wide range of empirical and theoretical research in recent years
    - Why are money markets fragile? What is the best infrastructure? What role does collateral play? How are markets affected by (unconventional) monetary policy and new regulation? ...
  - Mostly **aggregate** data, specific market segments, distressed periods

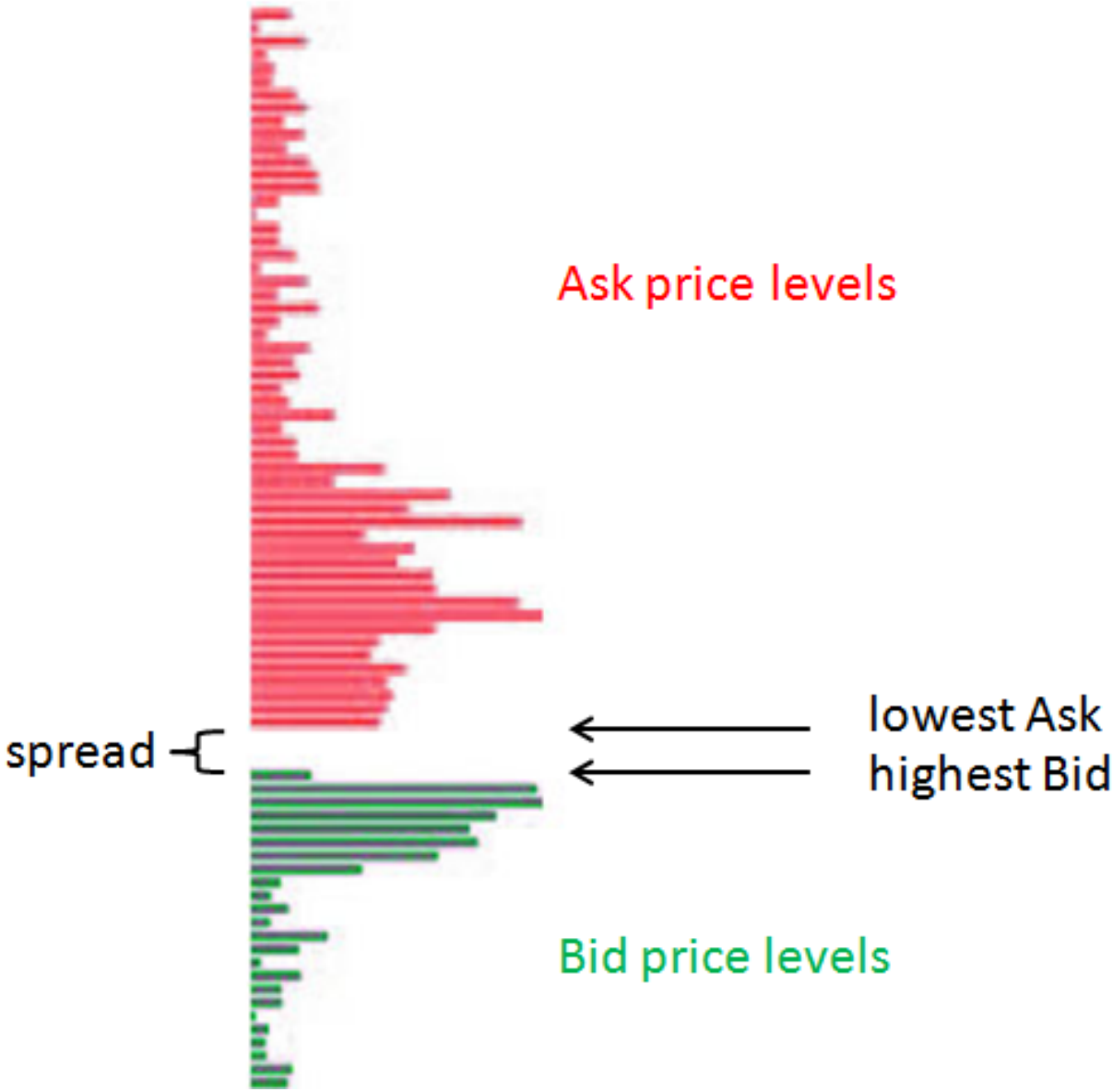
    (E.g., Afonso, Kovner, and Schoar (2011), Gorton and Metrick (2012), Krishnamurthy, Nagel, and Orlov (2014), Mancini, Ranaldo, and Wrampelmeyer (2016), Boissel, Derrien, Ors, and Thesmar (2017))

- **Measuring** funding liquidity risk
  - Aggregate measures, such as LIBOR-OIS $\Rightarrow$ suffer from being affected by other risk factors (e.g., Gyntelberg and Wooldridge (2008))
  - Measures based on balance sheet data (e.g., Cornett, McNutt, Strahan, and Tehranian (2011)) $\Rightarrow$ only available at low frequency
  - Measure based on banks' bidding behavior at central bank auctions (Drehmann and Nikolaou (2013)) $\Rightarrow$ does not work in full allotment regime

Interbank market

- **Major source of funding** for financial institutions
- **Borrowers** need short-term funding liquidity to satisfy reserve requirements, allow for depositor withdrawals, or to trade with customers
  - Banks with liquidity deficit
- **Lenders** use money market for short-term, liquid investments (relatively safe)
  - Banks with excess reserves
- **Functions** of the interbank market
  - Efficient allocation of liquidity in the financial system
  - Managing and sharing of liquidity risk
  - Price-discovery for funding liquidity
  - Benchmark interest rates
  - Central bank policy implementation

Limit order book



http://randomfx.net/forexinnerworkings.html

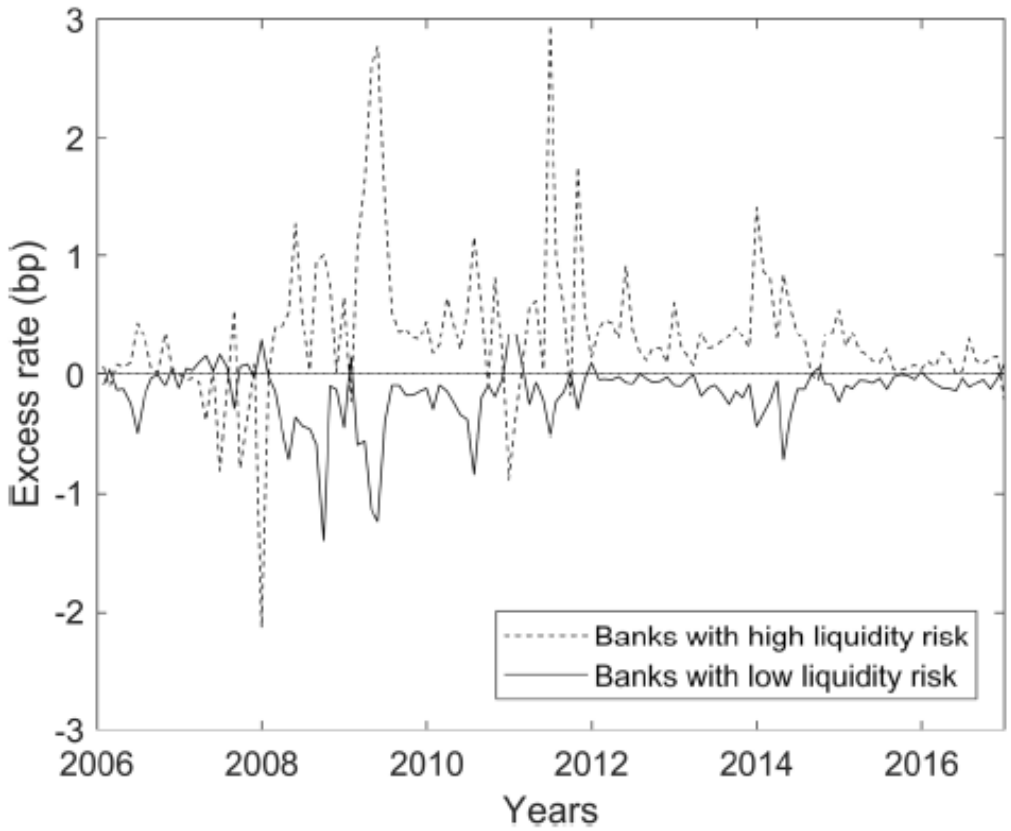
Descriptive statistics: High vs. low funding cost

- Balance sheet data

	High funding costs			Low funding costs			Difference	
	Mean	NT	N	Mean	NT	N	High−low	t-value
Total assets (EURmn)	375	432	47	204	158	16	171	4.82
ROAA	0.21	408	47	0.17	152	16	0.04	0.91
Leverage	5.54	399	44	7.85	139	14	−2.32	−3.18
Short/total funding	0.70	299	29	0.58	122	12	0.11	4.08
Short/long funding	74	299	29	5	122	12	69	1.82
Non-liquid/total assets	0.57	305	36	0.49	120	11	0.08	3.67
CDS	150	163	47	91	53	16	59	4.98

Systematic heterogeneity

- Banks with higher liquidity risk have higher funding cost



(b) Funding costs of banks with high and low liquidity risk

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	2.646***	2.666***	2.712***	0.725***	0.827***	1.006***
	(6.04)	(7.32)	(10.19)	(13.32)	(11.13)	(9.17)
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	3203	2827	2216	21113	15454	6333
R^2	0.206	0.247	0.288	0.233	0.267	0.317
Adj. R^2	0.0387	0.0628	0.0544	0.174	0.190	0.132

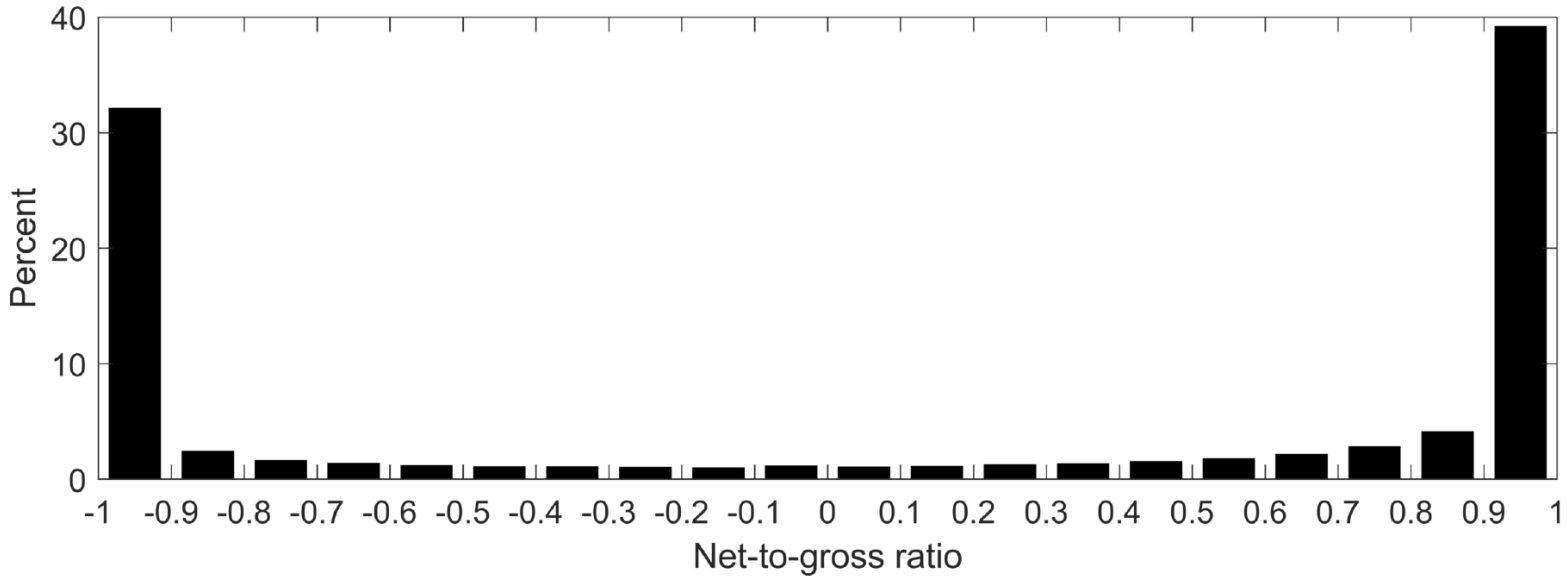
- **Lower** dispersion when **central bank excess liquidity** is high

Additional support for our measure of funding liquidity risk

- We rely on banks' **order choice as proxy for liquidity risk**
  - Provide more evidence for this relation
- Are banks more likely to use market orders when they are hit by a funding shock?
- **Identify funding shocks** by a change in direction of trading during the day
  - Funding market in which banks are usually either borrowing or lending on any given day
  - Change in direction of trading likely caused by liquidity shock

Net-to-gross ratio

- Net-to-gross ratio
  - $+1$: Only borrowing on given day
  - -1: Only lending on given day



Logit regression

- Focus on days when banks switch
- Estimate probability of using a market order when switching the direction of trading

- **Odds** of using market order **increase** by 79% when being hit by liquidity shock

	Market Order	Odds Ratio
Switch	0.582***	1.790***
	(13.73)	(13.73)
Constant	-0.278***	
	(-18.58)	
N	20,781	20,781

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

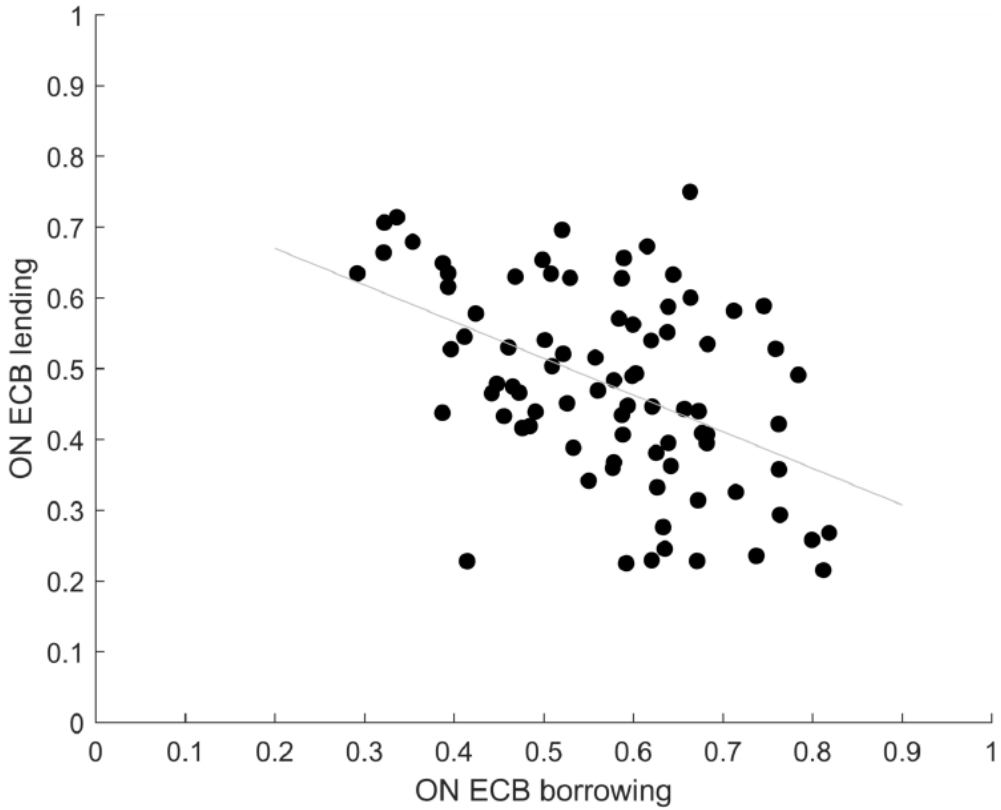
- **Lender** perspective
  - Repo rate is not a cost but a revenue
  - Demand for immediacy is urgent need to lend
- Our simple theory still applies
  - Banks with funding surplus have similar pressure to efficiently manage their liquidity
  - Banks have to resort to deposit facility if they do not lend 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

More evidence on liquidity risk

- **When** is liquidity risk most important?
  1. Consequences of missing funding are the largest
  2. Cost for alternative funding sources are high

- Investigate:
  1. End-of-maintenance periods
  2. Position of money market rates in ECB interest rate corridor

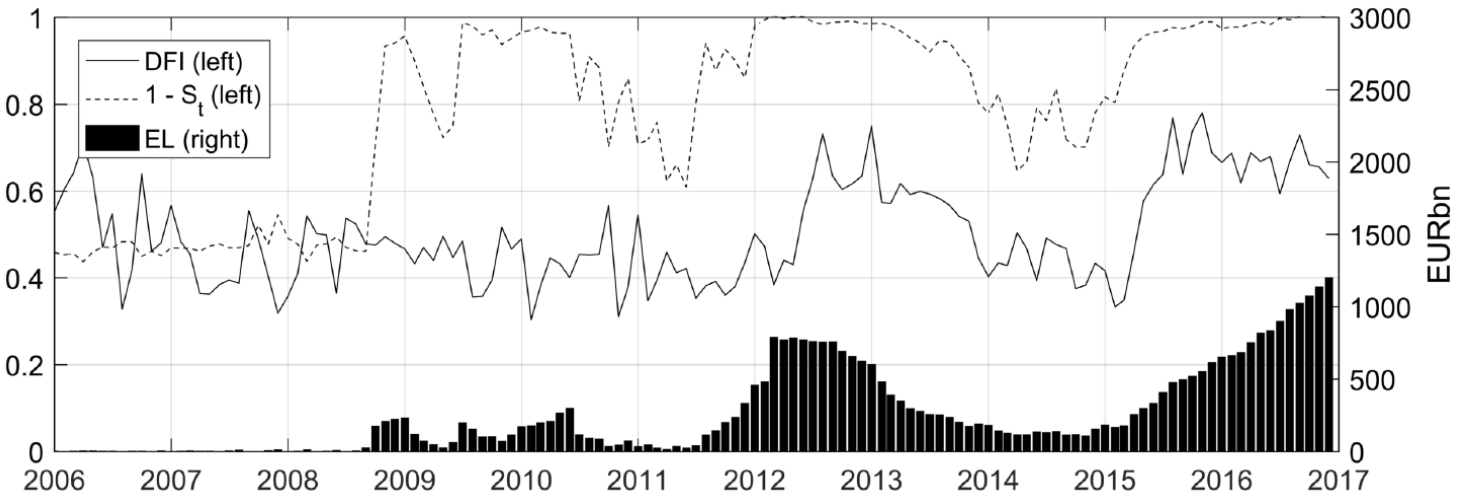
End-of-maintenance-period

- Expect **larger impact** of liquidity risk at end of reserve maintenance period (RMP)
- **End of maintenance period**
  - Banks need to hold an average amount of liquidity over the RMP
  - If banks have not yet fulfilled this requirement towards the end of the period, they are obliged to acquire the missing reserves to avoid fines
- Borrowers' share of market orders:

	t	$t-1$	$t-2$	other
ON	**50.0*****	47.0	45.0***	47.8
TN	52.7	**58.6*****	51.4	51.4
SN	51.7	56.0*	**55.8***	52.1

Position of money market rates in ECB interest rate corridor

- If banks do not have sufficient liquidity at the end of the day, they need to **borrow from the central bank** at r_{MLF}
- Liquidity shocks have larger consequences and the incentive to borrow in repo market is higher when r_{MLF} much higher than repo rate
  - Measured by relative repo spread (position in interest rate corridor)



- Our liquidity risk measure is correlated with relative repo spread

Robustness tests

- Dynamic panel regression:

  ▸ Dynamic panel

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

- Relative frequencies as dependent variables
  (empirical probability of having positive excess rate)

  ▸ Relative frequencies

- Alternative baskets and tenors

  ▸ Other repos

Robustness test: Dynamic panel regression and relative frequencies

- Dynamic panel regression:

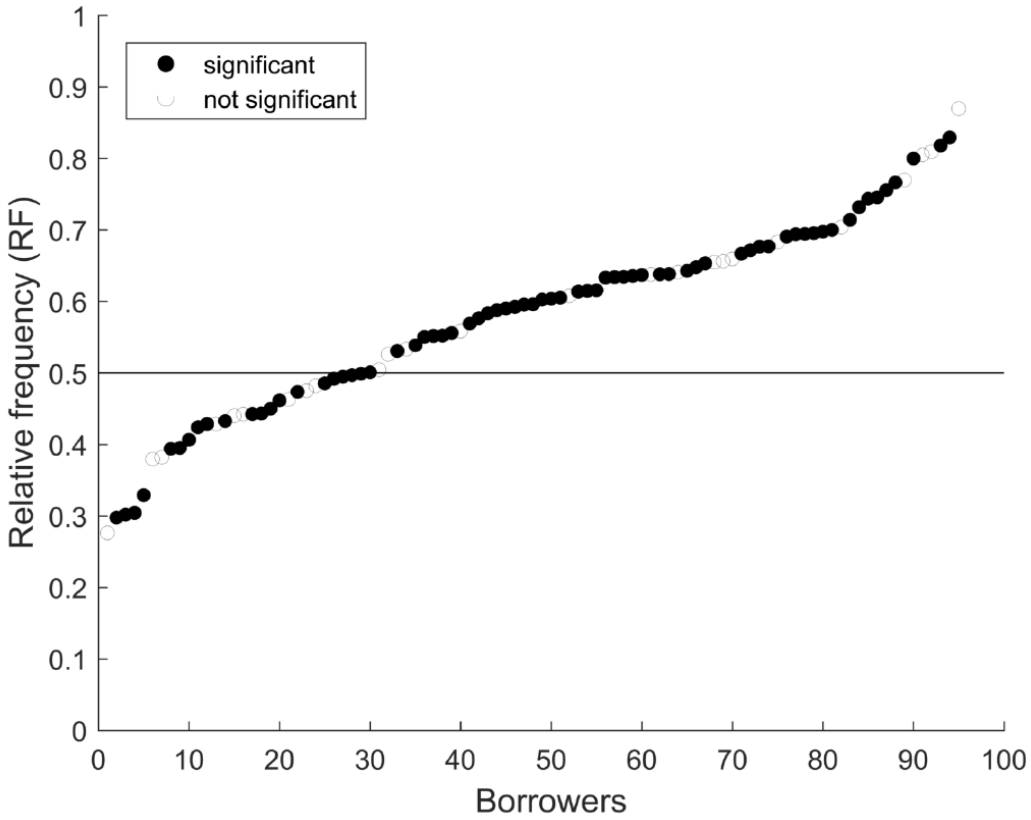
$$r^e_{i,t} = \gamma r^e_{i,t-1} + \alpha LiquidityRisk_{i,t} + X_{i,t}\beta + \eta_i + \epsilon_{i,t}$$

	(1) r^e	(2) r^e	(3) r^e	(4) RF	(5) RF	(6) RF
DFI	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)
Trade time		−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)
Size		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			66	0.247	0.248	0.254

Back

Robustness test: Relative frequencies

- Relative frequencies as dependent variables (empirical probability of having positive excess rate)



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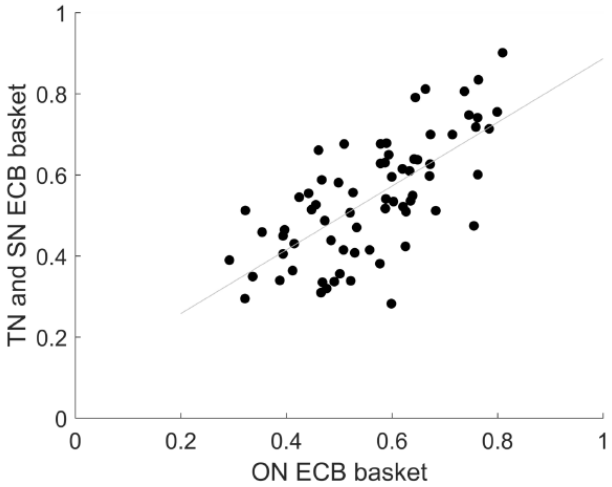
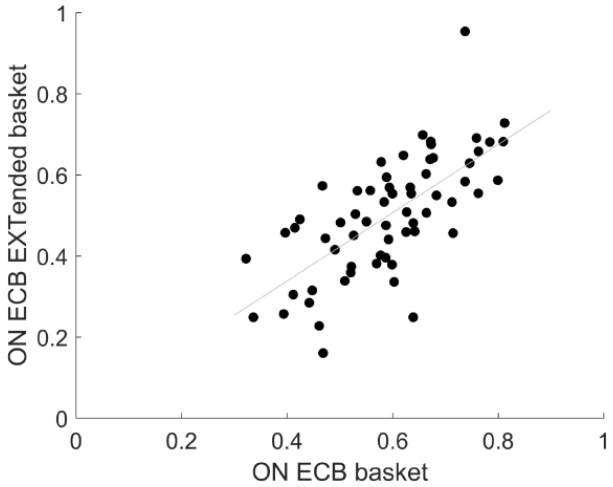
Alternative baskets and tenors

- Relative frequencies of paying more than the average for repos with different baskets and tenors



(a) Terms



(b) Baskets

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

Unsecured funding cost

- **Unsecured money market** as alternative funding source
- Other measure of banks funding liquidity risk (Acharya and Steffen, 2015)
  - Measure liquidity risk via a regression of banks' CDS prices on the Euribor-OIS spread:
    (1) Regress $CDS_{i,t}$ on $EuriborOIS_t$
    (2) Regress $LiquidityRisk_i$ on β_i from (1)

	(1)	(2)
Funding risk exposure	0.0209**	0.0238**
	(2.18)	(2.36)
Constant	0.476***	0.613***
	(44.00)	(4.06)
Bank/Year FE	yes/no	yes/yes
Observations	141	141
R^2	0.0569	0.288
Adj. R^2	0.0501	0.227

- Our liquidity risk measure is correlated with funding risk exposure in unsecured market