Funding Liquidity, Market Liquidity, and TED Spread

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2 December 2011

Liquidity

- Liquidity: "ability to trade what we want when we want it."
- May want securities or money (perhaps backed by securities).
- *Funding liquidity*: ability to get funds (for investing).
- What if a loan is collateralized by risky securities?
  - Value of collateral will fluctuate, may affect loan terms.
  - But loan terms may affect margin buys, short sales.
  - $\Rightarrow$ endogeneity between market and funding liquidity.
- There is some theory about this; we look at the data.

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Brunnermeier and Pedersen (2009)

- Theory from Brunnermeier and Pedersen (2009).
- If financiers think extra volatility/illiquidity is temporary:
  - They will lower rates to encourage speculation.
  - Higher funding liquidity $\Rightarrow \sigma \downarrow$, market liquidity $\uparrow$.
  - This may justify increased funding liquidity (lower rates).
- If financiers think extra volatility/illiquidity will last:
  - They raise rates to account for more risky collateral.
  - Lower funding liquidity $\Rightarrow \sigma \uparrow$, market liquidity $\downarrow$.
  - This may justify decreased funding liquidity (higher rates).
- *N.B.* Equilibria imply virtuous, vicious cycles of liquidity.

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Results Preview

- Find empirical support for Brunnermeier and Pedersen (2009).
- First support of 2 regimes for market liq. $\Rightarrow$ funding liq.
  - Contradicts earlier study which did not find support.
- Compliments studies of funding liq. affecting market liq.
- TED spread[1] identifies stable vs unstable markets.
  - TED spread < 151 bp $\Rightarrow$ stable markets:
  - TED spread > 151 bp $\Rightarrow$ unstable markets:
- Policy makers should watch TED spread, esp. near 150 bp.

[1] Yield of Eurodollars − yield of T-bills.

Prior Work

Previous studies have examined this theory from other angles:

- Drehmann and Nikolau (2009): funding vs. market liquidity.
  - Funding liq. negatively related to market liq. (Aug–Dec 07).
- Hameed *et al* (2010): market liquidity vs. equity values.
  - Market liquidity affected by changes in equity values.
  - Indicates less funding liquidity when equity values fall.
  - Economic value to providing stabilizing market liquidity.
- Mancini-Griffoli and Ranaldo (2011): secured borrowing.
  - Use unsecured borrowing, financial crisis as controls.
  - Confirm funding liquidity affects market liquidity.

Balke (2000): market regimes may change due to credit conditions.

Hypotheses $H1$ and $H2$

We examine four hypotheses:

$H1$: *The rate on a collateralized loan is set given the expected future value of equity collateral. This expectation is influenced by (i) market liquidity, (ii) volatility of collateral value, and (iii) TED spread (indicating market stability).*

$H2$: *We can identify two regimes, tranquil and jittery, which occur when the TED spread is below or above some threshold.*

$H1$ is mostly just mean-variance utility and is a sanity check.
$H2$ (and $H1$): new idea; applies Balke (2000) to identify regimes.

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Hypotheses $H3$ and $H4$

$H3$: *In tranquil markets, brokers' loan rates decrease in market illiquidity. This is stabilizing for market liquidity.*

$H4$: *In jittery markets, brokers' loan rates increase in market illiquidity. This is destabilizing for market liquidity.*

$H3$ and $H4$ follow from Brunnermeier and Pedersen (2009).

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Model Implications

These hypotheses have implications for our modeling process:

- Include a liquidity measure, volatility, and TED spread.
  - Also: test if these belong in the model.
- Compare a single regime model to a two-regime model.
- Test for +/- market liquidity betas in these regimes.
- Handle endogeneity of funding and market liquidity.

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Data

Daily data on seven variables; Mar 1998–Oct 2010 (N=3182).

1. *fundilliq*: Broker collateralized loan rate − T-bills.[2]
2. *mktilliq*: Average bid-ask spread for S&P 500 (from CBOE).
3. *vol*: CBOE volatility index (VIX).
4. *ted*: Yields of Eurodollars (3MUSDLIBOR) vs T-bills.
5. *decdummy*: IV, indicates post-decimalization (29 Jan 2001).
6. *durtrend*: IV, trend: monthly mean time b/w Nasdaq trades.
7. *aaaliq*: IV, Δ short-term AAA bond yields vs 3MUSDLIBOR.

[2] This is the "Call Money Rate" published in the *WSJ*.

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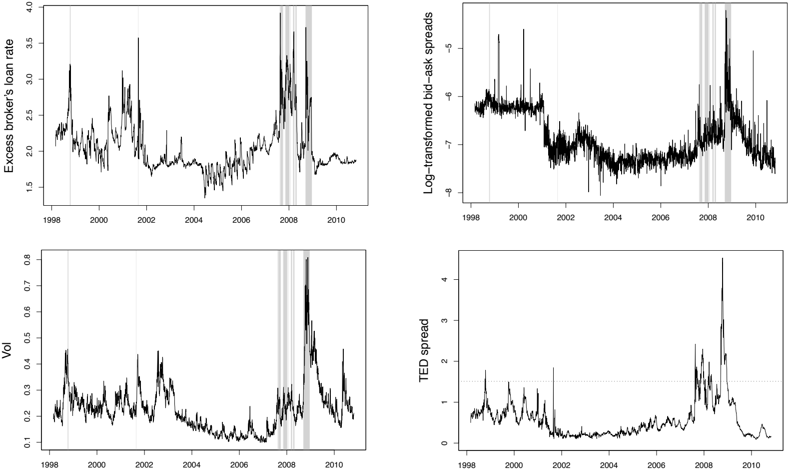
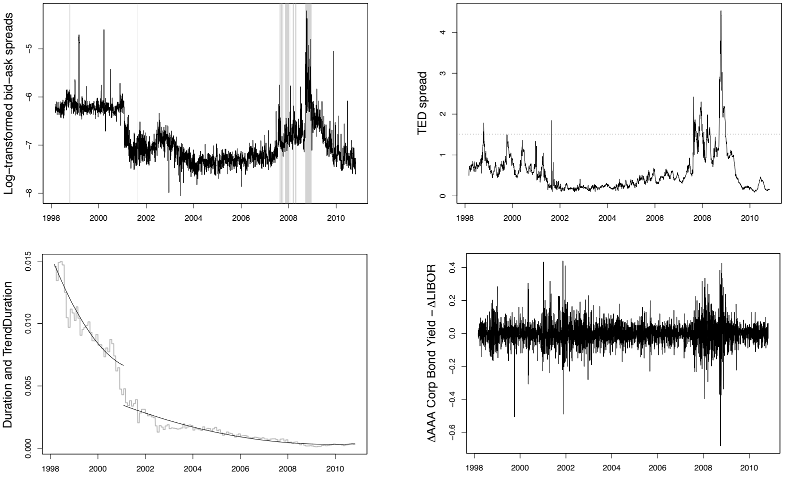
Data Plots


Excess broker's loan rate
1.5
2.0
2.5
3.0
3.5
4.0
1998
2000
2002
2004
2006
2008
2010
Log−transformed bid−ask spreads
−8
−7
−6
−5
Vol
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
TED spread
0
1
2
3
4

Instrument Plots



mktilliq and *ted* plots repeated for comparison.

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Data Summary

	Full sample		TED spread $\leq$ 151 bp				TED spread $>$ 151 bp			
	med	mean	min	med	mean	max	min	med	mean	max
fundilliq	1.94	2.05	1.35	1.92	2.01	3.30	1.95	2.91	2.90	3.92
mktilliq	-7.02	-6.87	-8.06	-7.04	-6.89	-4.60	-7.32	-6.48	-6.34	-4.21
vol	0.22	0.23	0.10	0.21	0.22	0.57	0.17	0.30	0.38	0.81
ted	0.44	0.58	0.09	0.42	0.50	1.51	1.51	1.98	2.14	4.53
durtrend	1	3	0.3	1	3	15	4	4	8	12
aaaliq	0.00	0.00	-0.51	0.00	0.00	0.44	-0.68	0.02	0.02	0.43

- Yield spreads (*ted*, *aaaliq*) in percent, so $0.5 = 0.5\%$.
- *durtrend* in years/1000; "1" $= 0.001$ years.
- Mean/median significantly differ b/w regimes at 0.1% level.
- *fundilliq*, *mktilliq*, *vol* higher in crisis.
- *durtrend* $\Rightarrow$ trading less frequent in crisis.
- *aaaliq* $\Rightarrow$ bonds (less liquid) diverge from LIBOR in crisis.

Models Forms

- We believe two modeling corrections are needed:
  - Must allow for two regimes of behavior; and,
  - Use IV regression to handle endogeneity of *mktilliq*.
- Thus we consider four model forms in our analysis:
  - OLS without/with a threshold interaction (one/two regimes).
  - 2SLS without/with a threshold interaction (one/two regimes).
- Threshold estimated via Hansen (2000), Caner and Hansen (2004).

Model 1: OLS

The first model is just straight OLS:

$$fundilliq_t = \beta_0 + \beta_1 mktilliq_t + \beta_2 vol_t + \beta_3 vol_t^2 + \beta_4 ted_t + \varepsilon_t \quad (1)$$

This is the model of Drehmann and Nikolau (2009).

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Model 2: IV

The second model adds instrumental variables to the first model:

$$fundilliq_t = \beta_0 + \beta_1 mktilliq_t + \beta_2 vol_t + \beta_3 volsq_t + \beta_4 ted_t + \varepsilon_t.$$

$$\begin{aligned} mktilliq_t &= \alpha_0 + \alpha_1 vol_t + \alpha_2 volsq_t + \alpha_3 ted_t \\ &+ \alpha_4 decdummy_t + \alpha_5 durtrend_t + \alpha_6 aaaliq_t + \eta_t \end{aligned} \tag{2}$$

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Model 3: OLS×threshold

The third model uses OLS and a threshold:

$$\begin{aligned} fundilliq_t = & \beta_0 + \beta_1 mktilliq_t + \beta_2 vol_t + \beta_3 volsq_t + \beta_4 ted_t \\ & + \beta_5 stressmktilliq_t + \beta_6 stressvol_t + \beta_7 stressted_t \\ & + \varepsilon_t \end{aligned} \quad (3)$$

where *stress* variables are interacted with threshold indicator.

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Model 4: IV×threshold

The fourth model adds instrumental variables to the second model:

$$\begin{aligned} fundilliq_t &= \beta_0 + \beta_1 mktilliq_t + \beta_2 vol_t + \beta_3 volsq_t + \beta_4 ted_t \\ &\quad + \beta_5 stressmktilliq_t + \beta_6 stressvol_t + \beta_7 stressted_t + \varepsilon_t \end{aligned}$$

$$\begin{aligned} mktilliq_t &= \alpha_0 + \alpha_1 vol_t + \alpha_2 volsq_t + \alpha_2 ted_t \\ &\quad + \alpha_4 stressvol_t + \alpha_5 stressted_t \\ &\quad + \alpha_6 decdummy_t + \alpha_7 durtrend_t + \alpha_8 aaaliq_t + \eta_t \end{aligned} \tag{4}$$

$$\begin{aligned} stressmktilliq_t &= \alpha_0^s + \alpha_1^s vol_t + \alpha_2^s volsq_t + \alpha_3^s ted_t \\ &\quad + \alpha_4^s stressvol_t + \alpha_5^s stressted_t \\ &\quad + \alpha_6^s decdummy_t + \alpha_7^s durtrend_t + \alpha_8^s aaaliq_t + \eta_t^s \end{aligned} \tag{5}$$

stress variables interacted with threshold indicator.
Currently: looking at instrumenting TED spread as well.

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Fitted Models

Model	Linear models		Two-regime models	
Estimator	OLS, (1)	IV, (1)+(2)	OLS, (3)	IV, (3)+(4)+(5)
(*intercept*)	**1.304**	**1.481**	**1.456**	-2.651
	(0.092)	(0.113)	(0.099)	(1.759)
	[1.12;1.48]	[1.26;1.70]	[0.94;1.80]	[-7.00;0.89]
mktilliq	-0.010	0.012	0.013	**-0.299**
	(0.011)	(0.014)	(0.011)	(0.144)
	[-0.03;0.01]	[-0.01;0.04]	[-0.04;0.05]	[-0.64;-0.01]
vol	**2.939**	**2.796**	**3.151**	**20.861**
	(0.160)	(0.169)	(0.213)	(6.984)
	[2.27;3.25]	[2.47;3.13]	[2.20;3.98]	[6.54;39.01]
volsq	**-5.442**	**-5.275**	**-6.096**	**-42.546**
	(0.244)	(0.251)	(0.389)	(14.273)
	[-5.92;-4.97]	[-5.77;-4.78]	[-7.55;-4.25]	[-80.08;-13.25]
ted	**0.588**	**0.577**	**0.560**	**0.727**
	(0.011)	(0.011)	(0.015)	(0.094)
	[0.57;0.61]	[0.56;0.60]	[0.50;0.67]	[0.53;0.94]
stressmktilliq			**-0.112**	**1.517**
			(0.009)	(0.630)
			[-0.16;-0.07]	[0.24;3.06]
stressvol			**1.132**	**16.320**
			(0.189)	(5.940)
			[0.13;1.90]	[4.20;31.40]
stressted			**-0.435**	**2.018**
			(0.032)	(0.944)
			[-0.62;-0.22]	[-7.14;-6.97]
Threshold κ			**1.511**	**1.511**
			[1.40;2.00]	[1.47;1.55]

- Variables significant at a 95% level are bolded.
- 95% CIs may be asymmetric for two-regime models.

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Fitted Models Commentary: Model 1

Model	Linear models		Two-regime models	
Estimator	OLS, (1)	IV, (1)+(2)	OLS, (3)	IV, (3)+(4)+(5)
(*intercept*)	**1.304**	**1.481**	**1.456**	-2.651
	(0.092)	(0.113)	(0.099)	(1.759)
	[1.12;1.48]	[1.26;1.70]	[0.94;1.80]	[-7.00;0.89]
mktilliq	-0.010	0.012	0.013	**-0.299**
	(0.011)	(0.014)	(0.011)	(0.144)
	[-0.03;0.01]	[-0.01;0.04]	[-0.04;0.05]	[-0.64;-0.01]
vol	**2.939**	**2.796**	**3.151**	**20.861**
	(0.160)	(0.169)	(0.213)	(6.984)
	[2.27;3.25]	[2.47;3.13]	[2.20;3.98]	[6.54;39.01]
volsq	**-5.442**	**-5.275**	**-6.096**	**-42.546**
	(0.244)	(0.251)	(0.389)	(14.273)
	[-5.92;-4.97]	[-5.77;-4.78]	[-7.55;-4.25]	[-80.08;-13.25]
ted	**0.588**	**0.577**	**0.560**	**0.727**
	(0.011)	(0.011)	(0.015)	(0.094)
	[0.57;0.61]	[0.56;0.60]	[0.50;0.67]	[0.53;0.94]
stressmktilliq			**-0.112**	**1.517**
			(0.009)	(0.630)
			[-0.16;-0.07]	[0.24;3.06]
stressvol			**1.132**	**16.320**
			(0.189)	(5.940)
			[0.13;1.90]	[4.20;31.40]
stressted			**-0.435**	**2.018**
			(0.032)	(0.944)
			[-0.62;-0.22]	[-7.14;-6.97]
Threshold κ			**1.511**	**1.511**
			[1.40;2.00]	[1.47;1.55]

- Same negative relationship as Drehmann and Nikolau; but,
- Correcting for *vol*, *ted*: *mktilliq* is not significant.

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Fitted Models Commentary: Model 2

Model	Linear models		Two-regime models	
Estimator	OLS, (1)	IV, (1)+(2)	OLS, (3)	IV, (3)+(4)+(5)
(*intercept*)	**1.304**	**1.481**	**1.456**	-2.651
	(0.092)	(0.113)	(0.099)	(1.759)
	[1.12;1.48]	[1.26;1.70]	[0.94;1.80]	[-7.00;0.89]
mktilliq	-0.010	0.012	0.013	**-0.299**
	(0.011)	(0.014)	(0.011)	(0.144)
	[-0.03;0.01]	[-0.01;0.04]	[-0.04;0.05]	[-0.64;-0.01]
vol	**2.939**	**2.796**	**3.151**	**20.861**
	(0.160)	(0.169)	(0.213)	(6.984)
	[2.27;3.25]	[2.47;3.13]	[2.20;3.98]	[6.54;39.01]
volsq	**-5.442**	**-5.275**	**-6.096**	**-42.546**
	(0.244)	(0.251)	(0.389)	(14.273)
	[-5.92;-4.97]	[-5.77;-4.78]	[-7.55;-4.25]	[-80.08;-13.25]
ted	**0.588**	**0.577**	**0.560**	**0.727**
	(0.011)	(0.011)	(0.015)	(0.094)
	[0.57;0.61]	[0.56;0.60]	[0.50;0.67]	[0.53;0.94]
stressmktilliq			**-0.112**	**1.517**
			(0.009)	(0.630)
			[-0.16;-0.07]	[0.24;3.06]
stressvol			**1.132**	**16.320**
			(0.189)	(5.940)
			[0.13;1.90]	[4.20;31.40]
stressted			**-0.435**	**2.018**
			(0.032)	(0.944)
			[-0.62;-0.22]	[-7.14;-6.97]
Threshold κ			**1.511**	**1.511**
			[1.40;2.00]	[1.47;1.55]

- IV regression suggests positive relationship (!); and again,
- Correcting for *vol*, *ted*: *mktilliq* is not significant.

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Fitted Models Commentary: Model 3

Model	Linear models		Two-regime models	
Estimator	OLS, (1)	IV, (1)+(2)	OLS, (3)	IV, (3)+(4)+(5)
(intercept)	**1.304**	**1.481**	**1.456**	-2.651
	(0.092)	(0.113)	(0.099)	(1.759)
	[1.12;1.48]	[1.26;1.70]	[0.94;1.80]	[-7.00;0.89]
mktilliq	-0.010	0.012	0.013	**-0.299**
	(0.011)	(0.014)	(0.011)	(0.144)
	[-0.03;0.01]	[-0.01;0.04]	[-0.04;0.05]	[-0.64;-0.01]
vol	**2.939**	**2.796**	**3.151**	**20.861**
	(0.160)	(0.169)	(0.213)	(6.984)
	[2.27;3.25]	[2.47;3.13]	[2.20;3.98]	[6.54;39.01]
volsq	**-5.442**	**-5.275**	**-6.096**	**-42.546**
	(0.244)	(0.251)	(0.389)	(14.273)
	[-5.92;-4.97]	[-5.77;-4.78]	[-7.55;-4.25]	[-80.08;-13.25]
ted	**0.588**	**0.577**	**0.560**	**0.727**
	(0.011)	(0.011)	(0.015)	(0.094)
	[0.57;0.61]	[0.56;0.60]	[0.50;0.67]	[0.53;0.94]
stressmktilliq			**-0.112**	**1.517**
			(0.009)	(0.630)
			[-0.16;-0.07]	[0.24;3.06]
stressvol			**1.132**	**16.320**
			(0.189)	(5.940)
			[0.13;1.90]	[4.20;31.40]
stressted			**-0.435**	**2.018**
			(0.032)	(0.944)
			[-0.62;-0.22]	[-7.14;-6.97]
Threshold κ			**1.511**	**1.511**
			[1.40;2.00]	[1.47;1.55]

- Two-regime model: +/- coeff for *mktilliq* in-/ex-crisis; but,
- Correcting for *vol*, *ted*: *mktilliq* is not significant.
- Non-sensical: lower rates in crisis for less liquid collateral?

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Fitted Models Commentary: Model 4

Model	Linear models		Two-regime models	
Estimator	OLS, (1)	IV, (1)+(2)	OLS, (3)	IV, (3)+(4)+(5)
(*intercept*)	**1.304**	**1.481**	**1.456**	-2.651
	(0.092)	(0.113)	(0.099)	(1.759)
	[1.12;1.48]	[1.26;1.70]	[0.94;1.80]	[-7.00;0.89]
mktilliq	-0.010	0.012	0.013	**-0.299**
	(0.011)	(0.014)	(0.011)	(0.144)
	[-0.03;0.01]	[-0.01;0.04]	[-0.04;0.05]	[-0.64;-0.01]
vol	**2.939**	**2.796**	**3.151**	**20.861**
	(0.160)	(0.169)	(0.213)	(6.984)
	[2.27;3.25]	[2.47;3.13]	[2.20;3.98]	[6.54;39.01]
volsq	**-5.442**	**-5.275**	**-6.096**	**-42.546**
	(0.244)	(0.251)	(0.389)	(14.273)
	[-5.92;-4.97]	[-5.77;-4.78]	[-7.55;-4.25]	[-80.08;-13.25]
ted	**0.588**	**0.577**	**0.560**	**0.727**
	(0.011)	(0.011)	(0.015)	(0.094)
	[0.57;0.61]	[0.56;0.60]	[0.50;0.67]	[0.53;0.94]
stressmktilliq			**-0.112**	**1.517**
			(0.009)	(0.630)
			[-0.16;-0.07]	[0.24;3.06]
stressvol			**1.132**	**16.320**
			(0.189)	(5.940)
			[0.13;1.90]	[4.20;31.40]
stressted			**-0.435**	**2.018**
			(0.032)	(0.944)
			[-0.62;-0.22]	[-7.14;-6.97]
Threshold κ			**1.511**	**1.511**
			[1.40;2.00]	[1.47;1.55]

- Two-regime model: -/+ coeff for *mktilliq* in-/ex-crisis; and,
- Correcting for *vol*, *ted*: *mktilliq* is significant.
- Confirms BP: stabilizing and destabilizing regimes vs *mktilliq*.

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First-Stage Regressions

	Linear Model	Two-regime Model	
Model	IV, (2)	IV, (4)	IV, (5)
Response	*mktilliq*	*mktilliq*	*mktilliq*
		($ted < \kappa$)	($ted \geq \kappa$)
(*intercept*)	**-7.065**	**-7.052**	**1.086**
	(0.035)	(0.040)	(0.081)
vol	**2.964**	**2.973**	**-10.451**
	(0.145)	(0.183)	(0.374)
volsq	**-1.710**	**-1.678**	**22.260**
	(0.309)	(0.336)	(0.687)
ted	**0.309**	**0.296**	-0.044
	(0.011)	(0.014)	(0.029)
stressvol		0.059	**-9.343**
		(0.173)	(0.353)
stressted		-0.024	**-1.501**
		(0.030)	(0.061)
decdummy	**-0.732**	**-0.728**	-0.051
	(0.026)	(0.027)	(0.055)
durtrend	1.621	1.569	**12.257**
	(2.774)	(2.791)	(5.709)
aaaliq	**0.057**	-0.053	*-0.190*
	(0.014)	(0.052)	(0.107)

- Variables significant at: **95% level**, *90% level*.
- All first-stages have significant instruments.

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Further Commentary

- Have a strong theoretical reason to prefer model 4.
- Data support model 4; do not support models 1–3.
- All models confirm *vol* and *ted* are informative ($H1$).
- Model 4 confirms *mktilliq* affects *fundilliq* ($H1$).
- Estimate 151 bp threshold; tighter bounds in model 4 ($H2$).
- Asymmetric financing response suggests crises are tail events.
- TED spread < 151 bp $\Rightarrow$ stable markets ($H3$):
  - Bid-ask spreads 1% $\uparrow \Rightarrow$ loan rates 0.3% $\downarrow$.
- TED spread > 151 bp $\Rightarrow$ unstable markets ($H4$):
  - Bid-ask spreads 1% $\uparrow \Rightarrow$ loan rates 1.5% $\uparrow$.
- Thus we cannot reject any of the four hypotheses.

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Conclusion

- Empirical support for Brunnermeier and Pedersen (2009).
  - Shows two regimes, market liquidity affects funding liquidity.
- Should correct for volatility, credit market conditions.
- Credit conditions (TED spread) help identify market regime.
- Find asymmetry in crisis response vs stabilizing response.
- Must instrument to account for endogeneity implicit in model.
- Useful instruments: decimalization, mean inter-trade duration.
- Likely useful: Δ AAA bond yields vs Δ LIBOR.
  - Should instrument TED spread to handle flights to quality.
- Traders, monetary policy makers should watch TED spread.
- BP also predict flights to quality. Model *aaaliq*?
- Is 151 bp right number? Krugman, others say 100 bp.
- Would we see similar behavior in Europe, esp. recently?