Intermediary asset pricing: Capital constraints and market power

Jason Allen and Milena Wittwer

Bank of Canada and Boston College

November 3, 2022

Motivation

What moves asset prices?

- Intermediary asset pricing: equity capitalization of intermediaries (dealers)

  E.g., He and Krishnamurthy (2012, 2013); Brunnermeier and Sannikov (2014)

- Dealers are large banks, e.g., Bank of America, Deutsche Bank
  1. Face capital constraints
  2. Have market power

Motivation

What moves asset prices?

- Intermediary asset pricing: equity capitalization of intermediaries (dealers)

  E.g., He and Krishnamurthy (2012, 2013); Brunnermeier and Sannikov (2014)

- Dealers are large banks, e.g., Bank of America, Deutsche Bank

  1. Face **capital constraints**
  2. Have market power

Basel III leverage ratio (SLR)

- Imposed to reduce systematic risk
- Requires banks to hold sufficient equity capital, even when holding safe assets
- "Major constraint on bank activity" (Jerome Powell)

Leverage Ratio Runs Counter to Policy Objectives (Wall Street Journal, 2016)

Washington Wants to Weaken Bank Rules. Not Every Regulator Agrees. (New York Times, 2018)

US banks push Fed for extension of Covid capital relief (Financial Times, 2021)

Geithner stresses need for SLR reform (Risk.net, 2022)

Motivation

What moves asset prices?

- Intermediary asset pricing: equity capitalization of intermediaries (dealers)

  E.g., He and Krishnamurthy (2012, 2013); Brunnermeier and Sannikov (2014)

- In practice, dealers (Bank of America, TD, Deutsche Bank,...)

  1. Face capital constraints
  2. Have **market power**, e.g., Hortaçsu et al. (2018); Allen and Wittwer (2020); Brancaccio and Kang (2022); Huber (2022); Pinter and Üslü (2022); Wallen (2022)

This paper

Do capital constraints affect asset demand/prices when dealers have market power?

1) **Model**
- Capital-constrained dealers have market power à la Kyle (1989)

2) **Test and calibrate the model with data on Treasury auctions**
- Why? Dealers submit demand curves and balance sheet information
- How? Policy change of Basel III leverage ratio

Findings: Model predictions

Relax capital constraints

→ Price increases

→ Markups increase

Findings: Model predictions

Trade-off for primary market

$\rightarrow$ Benefit: Lower funding costs for the issuer

$\rightarrow$ Cost: Higher price distortion, which may reduce market efficiency

Findings: Model predictions

Trade-off for primary market

→ Benefit: Lower funding costs for the issuer

→ Cost: Higher price distortion, which may reduce market efficiency

Quantification

- Dealers face high (shadow) costs due to binding capital constraints
- If the shadow costs decrease by 1%

→ Market price and markups increase by $\approx 0.5\%$

Literature: Bird's eye view

Theories on intermediary asset pricing (macro)

- Following He and Krishnamurthy (2012, 2013); Brunnermeier and Sannikov (2014)

⇒ This paper allows for market power

Theories on market power in financial markets (micro)

- Following Wilson (1979); Kyle (1985, 1989)

⇒ This paper introduces capital constraints

more

Road ahead

1. Model

2. Descriptive evidence in favor or the model

3. Structural estimation

Model

Goods

- Asset of supply Q, pays per unit return $R \sim N(\mu, \sigma)$
- Cash (numeraire)

Players

- $N > 2$ dealers
- Initially, dealer i holds z_i of the asset, capital E_i, and *rest* on its balance sheet

Model

Goods

- Asset of supply $\boldsymbol{Q}$, pays per unit return $R \sim N(\mu, \sigma)$
- Cash (numeraire)

Players

- $N > 2$ dealers
- Initially, dealer i holds z_i of the asset, capital E_i, and *rest* on its balance sheet

Model

Goods

- Asset of supply Q, pays per unit return $R \sim N(\boldsymbol{\mu}, \sigma)$
- Cash (numeraire)

Players

- $N > 2$ dealers
- Initially, dealer i holds z_i of the asset, capital E_i, and *rest* on its balance sheet

Model

Goods

- Asset of supply Q, pays per unit return $R \sim N(\mu, \sigma)$
- Cash (numeraire)

Players

- $N > 2$ dealers
- Initially, dealer i holds $\boldsymbol{z_i}$ of the asset, capital E_i, and *rest* on its balance sheet

Model

Goods

- Asset of supply Q, pays per unit return $R \sim N(\mu, \sigma)$
- Cash (numeraire)

Players

- $N > 2$ dealers
- Initially, dealer i holds z_i of the asset, capital $\boldsymbol{E_i}$, and *rest* on its balance sheet

Model: Simplest case

Aggregate uncertainty about $\boldsymbol{Q}$, no private information/signals

Goods

- Asset of supply $\boldsymbol{Q} \sim \mathcal{F}$, pays per unit return $R \sim N(\mu, \sigma)$ with $\mu \in \mathbb{R}^+, \sigma \in \mathbb{R}^+$
- Numeraire

Players

- $N > 2$ dealers
- Initially, dealer i holds $z_i = 0$ of the asset, capital $E_i \in \mathbb{R}^+$ and $rest \in \mathbb{R}^+$

Model

Uniform price auction with a capital constraint

Period 1:

- Each dealer submits demand schedule $q_i(\cdot) : \mathbb{R} \to \mathbb{R}$ s.t. capital constraint
- Market clears at p^* such that $\sum_i q_i(p^*) = Q$

Period 2: Asset pays out return and all transactions take place

Model

Dealers maximize expected CARA utility from wealth s.t. capital constraint:

$$\mathbb{E}\left[1 - \exp^{-\rho\omega_i(q_i,p)}\right] \text{ with } \omega_i(q_i,p) = q_i(R-p)\ ,\ \rho > 0$$

$$\text{subject to: } \kappa \leq \frac{\text{equity capital}}{\text{total exposure}}$$

Model

Dealers maximize expected CARA utility from wealth s.t. capital constraint:

$$\mathbb{E}\left[1 - \exp^{-\rho\omega_i(q_i,p)}\right] \text{ with } \omega_i(q_i,p) = q_i(R-p)\ ,\ \rho > 0$$

$$\text{subject to: } \kappa \leq \frac{E_i}{pq_i + rest} \Rightarrow \text{Lagrange multiplier: } \lambda_i$$

Model: Equilibrium

There exists a unique linear equilibrium in which dealer i chooses $q_i(p)$ at p is s.t.:

$$\text{marginal utility} \;=\; \text{marginal disutility}$$

No capital constraint & perfect competition:

$$\mu - \sigma\rho q_i(p) = p$$

Model: Equilibrium

There exists a unique linear equilibrium in which dealer i chooses $q_i(p)$ at p is s.t.:

$$\text{marginal utility} \;=\; \text{marginal disutility}$$

With capital constraint & perfect competition

$$\mu - \rho\sigma q_i(p) = (1 + \lambda_i \kappa)p$$

Model: Equilibrium

There exists a unique linear equilibrium in which dealer i chooses $q_i(p)$ at p is s.t.:

$$\text{marginal utility} \;=\; \text{marginal disutility}$$

With capital constraint & market power

$$\mu - \rho\sigma q_i(p) = (1 + \lambda_i \kappa)[p + \Lambda_i(\vec{\lambda}) q_i(p)]$$

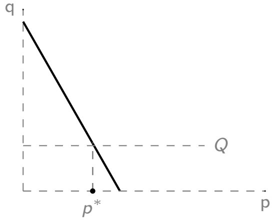
more

Model: Proposition

When the capital constraint is relaxed, e.g., $\kappa \downarrow$

(1) demand $q_i(\cdot)$ becomes flatter, and market price p^* increases

Figure: $q_i(p)$

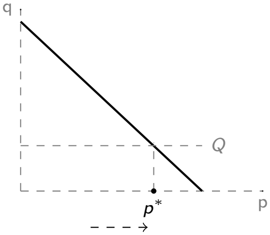


Model: Proposition

When the capital constraint is relaxed, e.g., $\kappa \downarrow$

(1) demand $q_i(\cdot)$ becomes flatter, and market price p^* increases

Figure: $q_i(p)$



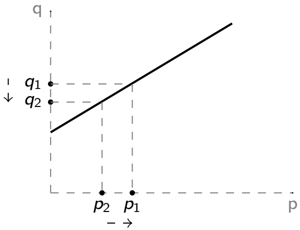
Model: Proposition

When the capital constraint is relaxed, e.g., $\kappa \downarrow$

(1) demand $q_i(\cdot)$ becomes flatter, and market price p^* increases

(2) price impact $\Lambda_i(\vec{\lambda})$ increases for all dealers i.

Figure: Residual $\text{Supply}_i(p)$



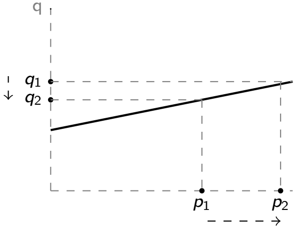
Model: Proposition

When the capital constraint is relaxed, e.g., $\kappa \downarrow$

(1) demand $q_i(\cdot)$ becomes flatter, and market price p^* increases

(2) price impact $\Lambda_i(\vec{\lambda})$ increases for all dealers i.

Figure: Residual Supply$_i(p)$



Model: IPV environment

IPV environment

- Dealers are ex-ante identical
- Have iid private information about their inventory positions or the asset's return

There exists a symmetric equilibrium with analogous properties

- In uniform price auction more
- In discriminatory price auction under additional assumptions more

Empirical application

Environment: Canada's Primary Market for Government Bonds

Attractive market features

- Dealers submit entire demand curves
- Dealer demand can be linked to balance sheet infos

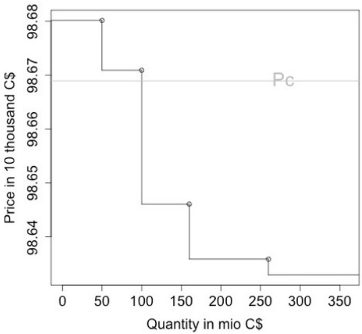
Challenges

- Auction format is discriminatory price
- Demand is a step-function as in Kastl (2011)
- There are different types of bidders, not only dealers
- Bids may be updated until auction closure as in Hortaçsu and Kastl (2012)

Data

Bidding data of all regular Treasury auctions (01/01/2015–02/01/2021)

- Who bids (ID), winning and losing bids



Data

Bidding data of all regular Treasury auctions (01/01/2015–02/01/2021)

- Who bids (ID), winning and losing bids

Balance sheet information of 8 dealers at bank level

- Quarterly Basel III Leverage Ratio (LR) $= \frac{\text{Tier 1 capital}}{\text{Total leverage exposure}} \geq 3\%$
- Quarterly institution-specific capital threshold

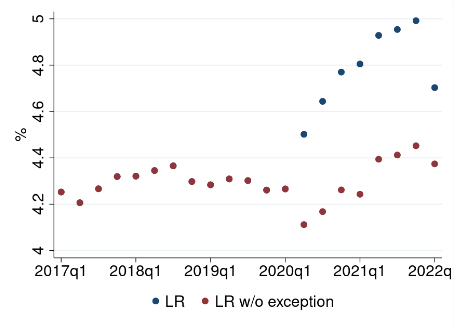
Volatility and price data

- Market Volatility Index
- Trade prices of the secondary market

Testing model predictions: Demand effect

- 04/2020–12/2021: Treasuries exempted from LR constraint
- Some banks i faced stricter capital $\textit{threshold}_{ik}$ than others

Figure: Time series of LR for an average bank



Testing model predictions: Demand effect

- 04/2020–12/2021: Treasuries exempted from LR constraint
- Some banks i faced stricter capital $threshold_i$ than others

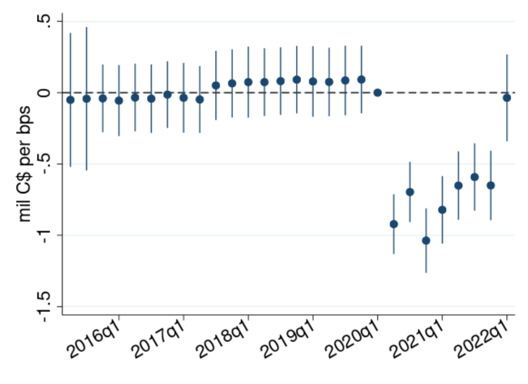
→ **Test if their demand became flatter relative to others**:

$$slope_{iqs} = \alpha + \sum_{k=-K}^{K} \gamma_k D_k \, threshold_i + \zeta_{qs} + \epsilon_{iqs}$$

– $slope_{iqs}$ is the avg. slope in i's demand for security s in quarter q
– D_k is an indicator for quarter k, ζ_{qs} is a quarter-security fixed effect

measure

Figure: Change in the slope of demand



Take away: Demands of banks s.t. stricter capital thresholds were flatter

Testing model predictions: Price effect

Quantifying effect on market price is difficult

correlation

- Must use variation across time instead of banks
- Endogeneity concern

$\Rightarrow$ Leverage structural model

Model calibration

Parameters

- Shadow cost of capital $\lambda_t \kappa$
- Risk aversion ρ_t

Identifying assumptions per auction t

- Dealer i draws private info $\zeta_{ti} \overset{iid}{\sim} \mathcal{H}_t$ about her true $value_{ti}(q)$ for amount q
- $value_{ti}(q) = \zeta_{ti} - \beta_t q$ with $\beta_t = \frac{\rho_t \sigma_t}{1+\lambda_t \kappa}$
- Everyone bids as in equilibrium of Hortaçsu and Kastl (2012)'s auction game

Model calibration

Estimation procedure

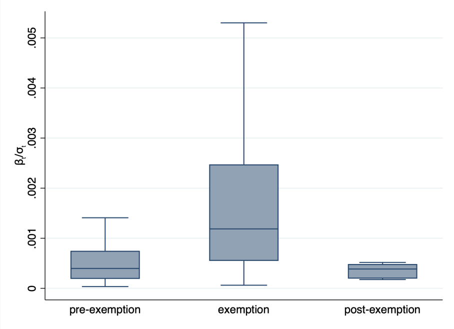
1) Back out $\hat{v}alue_{tik}$ at each submitted step k as in Allen et al. (2022)

2) Fixed-effect regression using bids of dealers who submit more than 1 step:

$$\hat{v}alue_{tik} = \zeta_{ti} - \beta_t q_{tik} + \epsilon_{ti}$$

Model calibration: Warm up

Figure: Distribution of $\frac{\hat{\beta}_t}{\sigma_t}$ with volatility σ_t volatility index



$$\frac{\hat{\beta}_t}{\sigma_t} = \rho_t \text{ during exemption; } \frac{\hat{\beta}_t}{\sigma_t} = \frac{\rho_t}{1 + \lambda_t \kappa} \text{ otherwise}$$

Point estimates: Policy change 1

- Assume $\rho_t = \rho$ and $\lambda_t \kappa = \lambda\kappa$ during a quarter
- Compare $\frac{\hat{\beta}_t}{\sigma_t}$ in auctions in 2020q1 and 2020q2 around exemption

	2020q1-2020q2		
ρ	$+1.52/10^4$	$(0.033/10^4)$	
$\lambda\kappa$	$+0.965$	(0.168)	
N	23,074		

Estimate of $\hat{v}alue_{tik} = \zeta_{ti} + \rho \times exempt_t \sigma_t q_{tik} + \frac{\rho}{1+\lambda\kappa} \times (1 - exempt_t)\sigma_t q_{tik} + \epsilon_{tik}$,
values are in yields to maturity in %, quantities in million C$, standard errors in parentheses

- Risk aversion per unit of the asset, ρ, is small ≈ 0
- The shadow cost of capital, $\lambda\kappa$, is large

sanity check

Point estimates: Policy change 2

- Assume $\rho_t = \rho$ and $\lambda_t \kappa = \lambda\kappa$ during a quarter
- Compare $\frac{\hat{\beta}_t}{\sigma_t}$ in auctions in 2021q4 and 2022q1 around reintroduction

	2020q1-2020q2		2021q4-2022q1	
ρ	$+1.52/10^4$	$(0.033/10^4)$	$+3.96/10^4$	$(0.155/10^4)$
$\lambda\kappa$	$+0.965$	(0.168)	$+0.302$	(0.115)
N	23,074		12,894	

Estimate of $\hat{v}alue_{tik} = \zeta_{ti} + \rho \times exempt_t \sigma_t q_{tik} + \frac{\rho}{1+\lambda\kappa} \times (1 - exempt_t)\sigma_t q_{tik} + \epsilon_{tik}$,
values are in yields to maturity in %, quantities in million C$, standard errors in parentheses

- Risk aversion per unit of the asset, ρ, is small ≈ 0
- The shadow cost of capital, $\lambda\kappa$, is large

sanity check

Model calibration: Trade off

When demand functions are linear

- Decreasing the capital cost $\lambda\kappa$ by 1%,
  - Increases the market price
  - Increases markups

    I.e., difference btw. price that would arise if dealers were price takers and actual price
- Both by $\eta = \left(\frac{1}{1+\lambda\kappa} - 1\right)\%$

Model calibration: Trade off

In the data, demand functions are not linear, but approximately linear here

→ We can approximate the trade off

	2020q1-2020q2	2021q4-2022q1
η	0.49%	0.23%

Implication

- Exempting Treasuries from the Basel III leverage ratio ≈ capital cost ↓ by 100%

→ Reduces bond yields, but increases markups by ≈ 49%

Conclusion

This paper

- Shows that dealer capitalization affects asset prices and market power—trade-off!
- Quantifies the effects with data on Treasury auctions

→ Helps inform ongoing policy debate about Basel III

→ Contributes to intermediary asset pricing literature thanks to micro-level data

E.g., Adrian et al. (2014); He et al. (2017); Gospodinov and Robotti (2021)

Thank you!

References I

Adrian, T., Etula, E., and Muir, T. (2014). Financial intermediaries and the cross-section of asset returns. *Journal of Finance*, 69(6):2557–2596.

Allen, J., Hortaçsu, A., Richert, E., and Wittwer, M. (2022). Entry and exit in Treasury auctions. Working paper.

Allen, J. and Wittwer, M. (2020). Centralizing over-the-counter markets? Working paper.

Brancaccio, G. and Kang, K. (2022). Search frictions and product design in the municipal bond market. Working paper.

Brunnermeier, M. K. and Sannikov, Y. (2014). A macroeconomic model with a financial sector. *American Economic Review*, 104(2):379–421.

Cassola, N., Horaçsu, A., and Kastl, J. (2012). The 2007 subprime market crisis through the lens of european central bankauctions for short-term funds. *Econometrica*, 81(4):1309–1345.

Chang, B. and Feunou, B. (2014). Measuring uncertainty in monetary policy using implied volatility and realized volatility. *Bank of Canada Review*, pages 32–41.

Du, W., Tepper, A., and Verdelhan, A. (2018). Deviations from covered interest rate parity. *The Journal of Finance*, 73(3):915–957.

Gospodinov, N. and Robotti, C. (2021). Common pricing across asset classes: Empirical evidence revisited. *Journal of Financial Economics*, 140:292–324.

He, Z., Kelly, B., and Manela, A. (2017). Intermediary asset pricing: New evidence from many asset classes. *Journal of Financial Economics*, 126(1):1–35.

He, Z. and Krishnamurthy, A. (2012). A model of capital and crises. *The Review of Economic Studies*, 79(2):735–777.

He, Z. and Krishnamurthy, A. (2013). Intermediary asset pricing. *American Economic Review*, 103(2):732–70.

References II

He, Z., Nagel, S., and Song, Z. (2022). Treasury inconvenience yields during the COVID-19 crisis. *Journal of Financial Economics*, 143(1):57–79.

Hortaçsu, A. (2002). Bidding behavior in divisible good auctions: Theory and evidence from the Turkish Treasury auction market. Working paper.

Hortaçsu, A. and Kastl, J. (2012). Valuing dealers' informational advantage: A study of Canadian Treasury auctions. *Econometrica*, 80(6):2511–2542.

Hortaçsu, A., Kastl, J., and Zhang, A. (2018). Bid shading and bidder surplus in the U.S. Treasury auction. *American Economic Review*, 108(1):147–169.

Huber, A. W. (2022). Market power in wholesale funding: A structural perspective from the triparty repo market. Working paper.

Kastl, J. (2011). Discrete bids and empirical inference in divisible good auctions. *Review of Economic Studies*, 78:974–1014.

Kyle, A. S. (1985). Continuous auctions and insider trading. *Econometrica*, 53(6):1315–1335.

Kyle, A. S. (1989). Informed speculation with imperfect competition. *The Review of Economic Studies*, 56(3):317–355.

Pinter, G. and Üslü, S. (2022). Comparing search and intermediation frictions across markets. Working paper.

Wallen, J. (2022). Markups to financial intermediation in foreign exchange markets. Working paper.

Wilson, R. (1979). Auctions of shares. *The Quarterly Journal of Economics*, 93(4):675–689.

Appendix

Empirical literature

Empirical intermediary asset pricing (macro)

- He et al. (2017); Du et al. (2018); Gospodinov and Robotti (2021); He et al. (2022)...

$\Rightarrow$ This paper uses micro-level to observe the link btw. demand and capitalization

Empirical studies on market power in Treasury auctions (micro)

- Hortaçsu (2002); Cassola et al. (2012); Hortaçsu and Kastl (2012); Hortaçsu et al. (2018)...

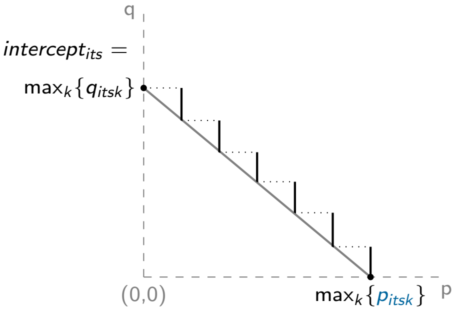
$\Rightarrow$ This paper introduces capital constraints

back

Data: Slope measure

Conventions: Draw demand curves with quantity on y-axis

Day t, security s, dealer i: $\boldsymbol{slope_{its}} = -\frac{\max_k \{q_{itsk}\}}{\max_k \{p_{itsk}\}}$ in quantity-price space

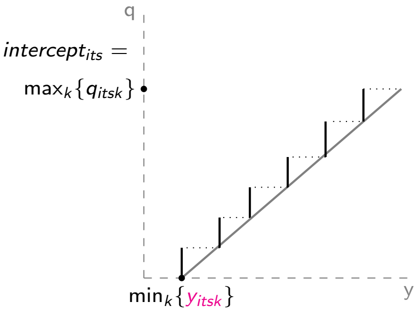


back

Data: Slope measure

Conventions: Draw demand curves with quantity on y-axis

Day t, security s, dealer i: $\boldsymbol{slope_{its}} = +\frac{\max_k\{q_{itsk}\}}{\min_k\{y_{itsk}\}}$ in quantity-yield space



back

Model: Equilibrium

(i) There exists a unique equilibrium in which dealer i submits demand curve

$$q_i(p) = \big((1+\lambda_i\kappa)\Lambda_i + \sigma\rho\big)^{-1}\big(\mu - (1+\lambda_i\kappa)p\big),$$

where

$$\Lambda_i = \beta_i\alpha_i\sigma \text{ with } \beta_i = \frac{2}{\alpha_i b - 2 + \sqrt{(\alpha_i b)^2 + 4}} \text{ and } \alpha_i = \frac{\rho}{1+\lambda_i\kappa s},$$

with $b \in \mathbb{R}^+$ as unique positive solution to $1/2 = \sum_i (\alpha_i b + 2 + \sqrt{(a_i b)^2 + 4})^{-1}$.

(ii) When dealers are identical ($z_i = z, E_i = E$), the demand curve simplifies to

$$q_i(p) = \left(\frac{N-2}{N-1}\right)\frac{1}{\rho\sigma}\Big(\mu - \rho\sigma z - (1+\lambda\kappa)p\Big).$$

The price impact is $\Lambda = \frac{1}{N-2}\frac{\rho\sigma}{1+\lambda\kappa}$ with $\lambda \geq 0$ for sufficiently high κ.

back

IPV uniform price auction

Period 1:

- Each dealer observes $z_i \overset{iid}{\sim} \mathcal{H}$ and $\sum_i z_i$
- Each dealer submits demand schedule $q_i(\cdot) : \mathbb{R} \to \mathbb{R}$ s.t. capital constraint
- Market clears at p^* such that $\sum_i q_i(p^*) = Q$

Period 2:

- Dealer's balance out total exposure so that each carries $\alpha - \beta p^*$, $\alpha \in \mathbb{R}, \beta > 0$
- Asset pays out return and all transactions take place

IPV uniform price auction

In equilibrium dealer i submits

$$q_i(p) = (\Lambda + \sigma\rho)^{-1}\Big(\mu + \alpha\kappa\Lambda\lambda - \sigma\rho z_i - (1 + 2\beta\kappa\Lambda\lambda)p\Big)$$

$$\text{with } \Lambda = \frac{-(N-2) + \sqrt{(N-2)^2 + 8\beta\kappa\lambda(N-1)\rho\sigma}}{\sqrt{4\beta\kappa\lambda(N-1)}}.$$

The equilibrium exists if λ which solves $E - \kappa p^* \eta(p^*) = 0$ with $p^* : \sum_i a_i(p^*) = A$ is non-negative. This is the case when κ is sufficiently high given all other parameters.

Assume that the capital constraint is relaxed so that λ decreases.
Then demand becomes flatter, the market price and price impact increase.

back

IPV discriminatory price auction

Let dealer i have value $v_i(q) = \frac{\sigma\rho}{1+\lambda\kappa}[\mu - (z_i + q)]$ for amount q,
with z_i being drawn from iid across i from a distribution with support $[\underline{z}, \overline{z}]$.

If winning quantities are drawn from a distribution with CDF $F_i(q) = 1 - (\frac{\nu_i + \xi q}{\nu_i})^{-\frac{1}{\xi}}$ with $\xi \in (-\infty, -1], \nu_i = -\xi(\frac{N(1-\xi)-1}{N(1-\xi)})(\overline{z} - z_i) - \xi(\frac{Q}{N})$, there exists an equilibrium in which dealer i submits the demand curve

$$q_i(p) = \left(\frac{N(1-\xi)-1}{N-1}\right)\frac{1}{\sigma\rho}(\mu_i - (1+\lambda\kappa)p)$$

with $\mu_i = \mu + \frac{\rho\sigma}{1-\xi}(\overline{z} - z_i) + \frac{\rho\sigma A}{N(1-\xi)-1}$ as long as $\mathbb{E}[\mu_i] \geq \frac{\rho\sigma A(N-1)}{N(N(1-\xi)-1)}$.

back

Yield effect

Table: Correlation between yield and LR

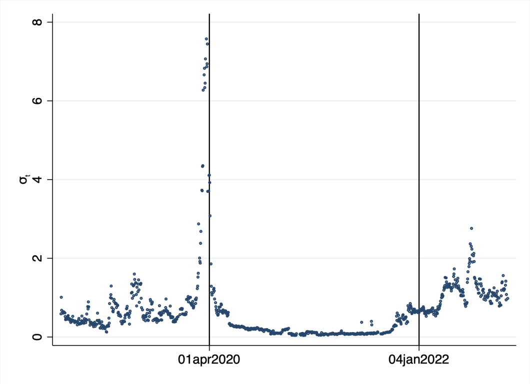
	(OLS)	(FE1)	(FE2)
LR	−0.360	−0.370	−0.245
	(0.0362)	(0.0411)	(0.0521)
controls	–	–	✓
fixed effects	–	✓	✓
Observations	2912	2912	2904
Adjusted R^2	0.032	0.679	0.789

This shows results of $yield_d = \alpha + \beta LR_{qi} + \epsilon_{ti}$ in (OLS). In (FE1) we add dealer and year fixed effects; in (FE2) other control variables. Yield and LR are in %. Standard errors are in parentheses, clustered at the dealer level in (FE1) and (FE2).

back

Implied volatility index

- Measures the expected volatility of Treasury yields (in % per year)
- Based on option prices on interest rate futures (Chang and Feunou (2014))
- Similar to MOVE for US Treasuries, VIX for stocks



back

Sanity check

Use observed bids instead of estimated values:

	2020q1-2020q2		2021q4-2022q1	
ρ	$+0.686/10^4$	$(0.010/10^4)$	$+2.050/10^4$	$(0.046/10^4)$
$\lambda\kappa$	$+0.844$	(0.169)	$+0.169$	(0.076)
N	23,074		12,894	

Tables shows the estimate of $bid_{tik} = \zeta_{ti} + \rho \times exempt_t \sigma_t q_{tik} + \frac{\rho}{1+\lambda\kappa} \times (1 - exempt_t)\sigma_t q_{tik} + \epsilon_{tik}$ with bids expressed as yields to maturity in %, quantities are in million C\$, standard errors are in parentheses

Findings

- Both parameters are downward biased due to shading

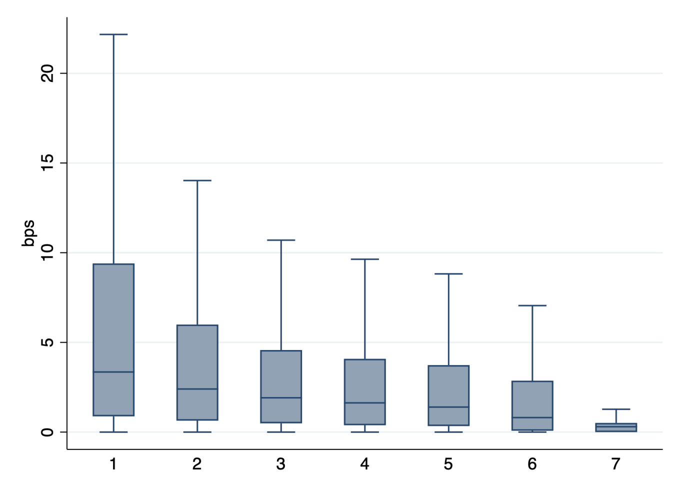
more

- But magnitudes are roughly similar

back

Shading

Figure: Distribution of bid shading per step k



back

Supporting descriptive evidence

Follow Hortaçsu (2002) and check R_t^2 of

$$b_{ti\tau k} = \zeta_{ti\tau} + \beta_t q_{ti\tau k} + \epsilon_{ti\tau k}$$

	mean	median	sd
β_t	0.20	0.17	0.11
R_t^2	0.82	0.83	0.16
Adj. R_t^2	0.77	0.77	0.21
Within R_t^2	0.53	0.54	0.15

Subsample: bidding-functions with at least 2 steps.
Bids are in yields (bps) and quantities in % of supply.

back