Dealer Networks: Market Quality in OTC Markets

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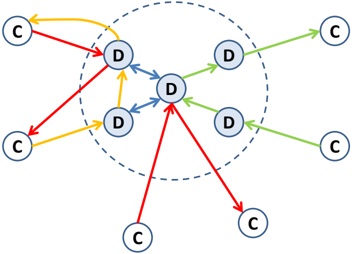
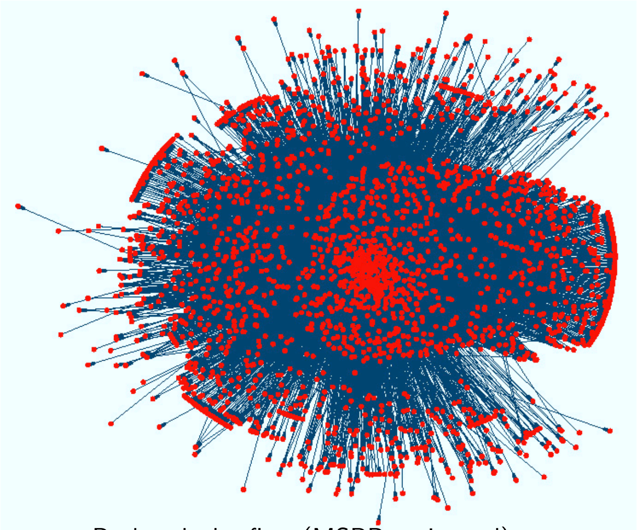
Over-The-Counter Markets

- 40% of U.S. financial assets OTC-traded: Muni, corp, agency + derivatives
- Regulatory & technological changes: MSRB, Dodd-Franck, MiFID I/II, RfQ
- Functioning of decentralized opaque OTC markets:
  - Opacity & fragmentation impose **search & matching frictions** on investors
  - Financial intermediation for matching buyers and sellers & price discovery
  - **Dealership networks** with long-term relations to facilitate liquidity provision



- What is impact of dealership networks on market quality & competition?

Dealership Network in U.S. Municipal Bonds



● = Broker-dealer firm (MSRB registered)

→ = Interdealer trading relation

Research Questions

- Characterize heterogeneity in dealer connections (central vs. peripheral)
  - Search frictions yield core-periphery structure
  - Dealer centrality is proxy for search efficiency
- Is dealer centrality an important determinant for execution quality, and why?
  - How do dealers provide liquidity & compete for order flow?
  - How do investors' liquidity preferences affect dealer choice?

1. Bertrand-type competition in execution cost

- Network allows central dealers to offer cheaper liquidity provision
- Liquidity increases & trading costs decline with dealer centrality

2. Liquidity-based differentiation in execution quality

- Network allows central dealers to differentiate liquidity & earn profits
- Liquidity increases & trading costs increase with dealer centrality

- Our data: MSRB trade surveillance tape for U.S. municipal bond market

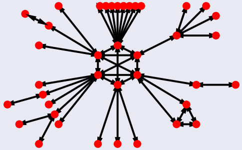
U.S. Municipal Bond Market is a Classic OTC Market

- **Important source of public financing**
  - Mostly tax-exempt fixed-income securities issued by state and local governments, governmental entities, and non-profits to fund capital projects (e.g., schools, universities, housing, roads, airports, sewage)
  - $4 trillion market cap, 55k issuers, >1.5m issues, 100-200k new cusips/year
- **Large and active OTC secondary market**
  - $10-20 bn daily volume & active inter-dealer trading
  - >2,000 registered broker-dealer firms, 700-800 active in a given month
- **Illiquid, fragmented & opaque**
  - Small issues (74% ≤$1m) & infrequent trade (70% w/o trade, 3 trades/year)
  - 50% individual investors due to state tax clienteles (local segmentation)
  - No central recording and dissemination of transaction prices until late 90s
- **Low adverse selection risk**
  - Most issues are insured: 75% AAA
  - Default rates low: 0.1% vs. 9.7% (corp)

Main Results

Topology in Bond Dealers' Trading Network

- Core-periphery structure:
  - Heterogeneity in dealer connections
  - Sparse hierarchical network with 20-30 highly connected core dealers
- Dealers form long-run relationships



Investors' Execution Costs and Dealer Centrality

- Systematic price dispersion across dealers (20-40% dealer-specific markups)
- Trading costs increase with dealer centrality (up to 80% higher at core)
- Dealers' loss & *DD* probabilities decline with centrality (search efficiency)

Liquidity Provision and Dealer Centrality

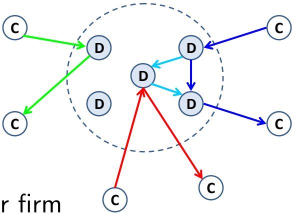
- Central dealers provide more liquidity (faster execution, less complexity)
  - More inventory risks (fewer pre-arranged, longer duration) & informational efficiency
  - Central (peripheral) dealers cater to high (low) liquidity willingness-to-pay
- Central dealers act as liquidity providers of last resort

Data from MSRB Transaction Reporting System

- Trade surveillance data collected by Municipal Securities Rulemaking Board
  - Comprehensive data from Feb 1998 to Dec 2012
  - Every transaction, issue, broker-dealer in secondary market
  - $>$60m transactions in 1.4m issues by 2,078 dealer firms
- Unique features:
  - Dealer identities: Dealer in customer trades (CD, DC) and dealers in DD
  - Trade identifier: Purchase from customer, Sale to customer, Inter-dealer
  - Limitation: Does not identify individual customers C
- Data filters:
  - Require reference data from SDC/Mergent, fixed coupon, 90d after issuance
  - Issuer, maturity, coupon, issue size, callability, taxability, rating, GO/revenue
- Round-trip transactions: 2-4 trades on avg. $\Rightarrow$ 'buy wholesale, sell retail'
- Transparency regimes: Initially published with substantial lag
  - 2000: 1 month delay (next day if $\geq$4 trades)
  - 2003: next day (only 24 subscribers as of June 2003)
  - 2005: 15min reporting & dissemination (`www.investingbonds.com`)

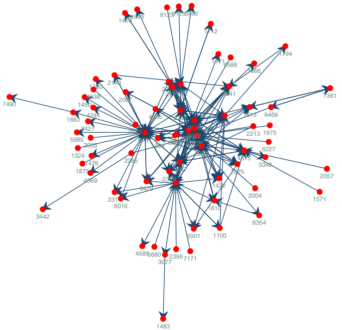
Tracing Order Flow through the Dealer Network

1. Trace time- & dealer-stamped **round-trip transaction** chains *CD...DC*
2. Use **interdealer trades** (*DD*) to construct dealer network
3. Examine market quality in **customer trades** (*CD*, *DC*)

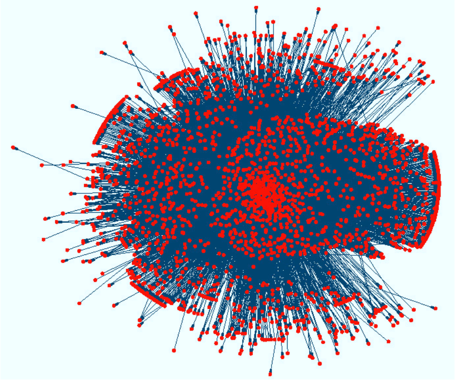


- *D* Node = Broker-dealer firm
- *D* → *D* Arrow = Directed trading relation ("From Dealer" → "To Dealer")
- Aggregate all interdealer trades between pairs of dealers
  - For topology analysis: all interdealer trades (16 million)
  - For empirical analysis: rolling window of interdealer trades in last 30 days
- Weighted by 0-1 (EW) or by par volume or no. trades (VW)

The core:



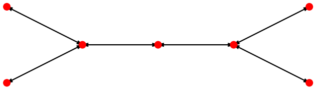
The entire network:



- Artificial map: The more trade links, the closer location on map
- Small group of densely connected core dealers, many peripheral w/o links
  - 20-30 highly active dealers with no. trades>10,000 out of 2,078
  - Only 44k out of 2.8m (1.5%) directed links ⇒ very sparse
- Dealer "centrality" matters ⇒ Needs statistical characterization

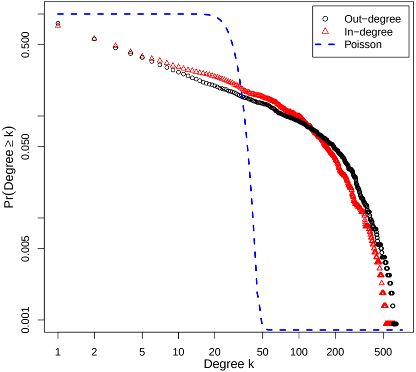
Measures for Dealer Centrality

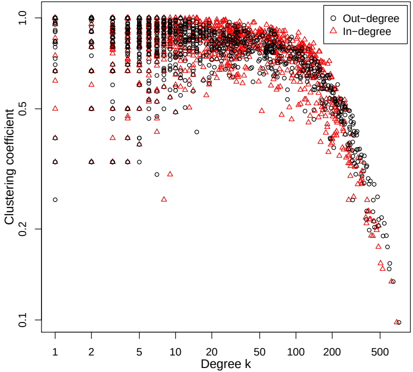
1. Local and global centrality measures
   1. Degree *dg* (*dgin*/ *dgout*): number of trading relationships
   2. Betweenness *bt*: number of shortest paths linking two dealers in the network that pass through a dealer
   3. Closeness *cl*: how close a dealer is to all other dealers
   4. Eigenvector centrality *ev*: importance of dealer in network (connections to high-scoring nodes)



2. Equal-weighted (0-1) and value-weighted (by par volume and no. trades)
   - Par-weighted dg and ev: dginwpar, dgoutwpar, evwpar
   - No. trade-weighted dg and ev: dginwntrade, dgoutwntrade, evwntrade
3. Aggregation: Extract first principle component
   - Equal-weighted (*pca1*)
   - Value-weighted (*pca1wt*)
4. Standardization: Apply rank transformation between 0 and 1

Market Connectedness & Hierarchy





- **Trading relations are not random**
- Locally segmented submarkets (hubs, hierarchy): $corr(cc, dg) < 0$

$\Rightarrow$ Hierarchical heavy-tailed dealer network (WWW, social networks)

Persistence in Trading Relationships & Dealer Ranks

Table : **Persistence in trading relationships**

Order flow this month	Order flow next month $= 0$	Order flow next month > 0	Order flow in same direction next month $= 0$	Order flow in same direction next month > 0
$= 0$	85.11%	14.89%	85.90%	14.10%
> 0	34.72%	65.28%	37.58%	62.42%

Table : **Persistence in dealer ranks**

	Rank month $t+1$							
	Top 10	11-20	21-50	51-100	101-200	>200	Pr(Up)	Pr(Down)
Rank month t								
Top 10	0.93	0.07	0.00	0.00	0.00	0.00	0.00	0.07
11-20	0.07	0.78	0.14	0.00	0.00	0.00	0.07	0.15
21-50	0.00	0.05	0.81	0.14	0.00	0.00	0.05	0.14
51-100	0.00	0.00	0.08	0.79	0.13	0.00	0.08	0.13
101-200	0.00	0.00	0.00	0.06	0.79	0.15	0.06	0.15
>200	0.00	0.00	0.00	0.00	0.03	0.97	0.03	0.00

⇒ **Dealers form long-run relations**

Search frictions: How do bonds flow through network?

Centrality: *Net* = 1 (most central dealer), *Net* = 0 (most peripheral dealer)

	Dealer #1	Dealer #2	Dealer #3	Dealer #4	Dealer #5	Dealer #6
CDC	0.949	.	.	.	.	.
CDDC	0.880	0.919	.	.	.	.
CDDDC	0.880	0.977	0.901	.	.	.
CDDDDC	0.813	0.972	0.949	0.884	.	.
CDDDDDC	0.845	0.975	0.934	0.959	0.875	.
CDDDDDDC	0.862	0.972	0.946	0.929	0.948	0.883

- Centrality measure is rank-transformed first PC of unweighted centralities
- **Bonds flow from periphery to center and back**
  - Dealers in the middle of the chain are more central, peak at second dealer
  - Tail dealers are more central than head dealers

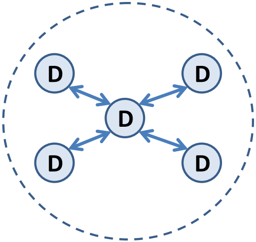
$\Rightarrow$ Central dealers act like "hubs"; transparency likely to diminish $CD^{(n)}Cs$

Search frictions: Length of dealer chains

	Pr(*DC* Trade | Trade)		No. dealers in round-trip chain			
			OLS		Poisson	
	EW	VW	EW	VW	EW	VW
Net	0.63***	0.55***	-1.41***	-1.09***	-0.51***	-0.40***
Controls	Yes	Yes	Yes	Yes	Yes	Yes
N	25,975,358	25,975,358	10,558,555	10,558,555	10,558,555	10,558,555

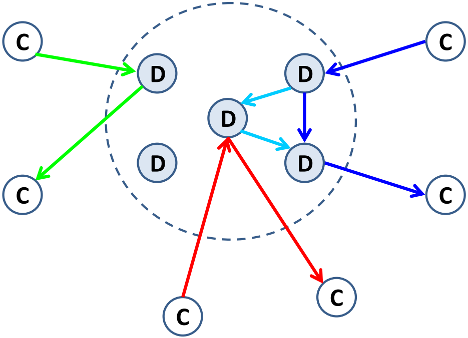
- Central dealers more likely to find customer than peripheral dealers
- Head dealer's centrality determines length of dealer chain

Execution Quality and Dealer Centrality



- Markups on round-trip transactions
  - CDC: Customer sale to dealer, followed by dealer sale to customer
    - Nonsplit: Dealer resells original bond lot
    - Split: Dealer splits bond lot and resells pieces
  - CDDC, CDDDC, ..., $CD^{(n)}C$: Multiple interdealer trades

Execution Quality and Dealer Centrality



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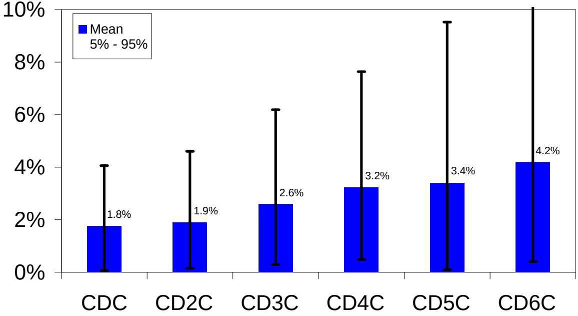
1. Are the blue trades more/less expensive than the green & red trades?
2. Are the green trades more/less expensive than the red trades?

Trading Costs, Trade Complexity & Price Dispersion

$$\text{Markup on round-trip transaction} = \frac{\bar{P}_{sell} - P_{purchase}}{P_{purchase}} * 100$$



1. **Trading costs are large**
   – Consistent with Green, Hollifield and Schürhoff (2007)
2. **Total costs larger the more dealers involved in roundtrip**
   – Consistent with Schultz' (2012) result on newly issued bonds
3. **Cross-sectional variation in markups** is substantial (trades size, dealer?)

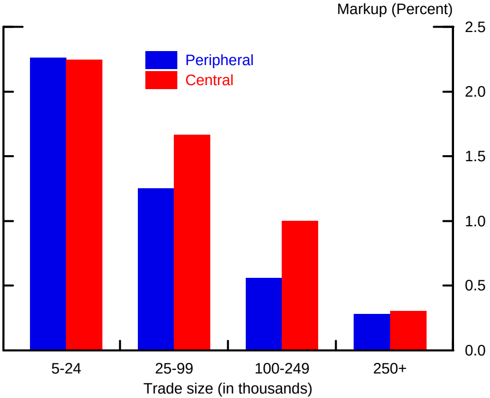
How do dealers split markups?

$$\text{Markup on round-trip transaction} = \frac{\bar{P}_{sell} - P_{purchase}}{P_{purchase}} * 100$$

	Total markup	Dealer 1	Dealer 2	Dealer 3	Dealer 4	Dealer 5	Dealer 6
CDC	1.769	1.769	.	.	.	.	.
		(100%)					
CD^2C	1.896	0.752	1.144	.	.	.	.
		(40%)	(60%)				
CD^3C	2.601	0.654	0.652	1.295	.	.	.
		(25%)	(25%)	(50%)			
CD^4C	3.242	0.606	0.532	0.857	1.247	.	.
		(19%)	(16%)	(26%)	(38%)		
CD^5C	3.408	0.603	0.362	0.861	0.425	1.158	.
		(18%)	(11%)	(25%)	(12%)	(34%)	
CD^6C	4.194	0.545	0.463	0.820	0.706	0.511	0.511
		(13%)	(11%)	(20%)	(17%)	(12%)	(12%)

- Central dealers tend to be tail dealer
- Tail dealer (closest to buyer) tends to earn largest share of profit

Trading Costs by Dealer Centrality



	Top 10	11-20	21-50	51-100	101-200
Avg. excess markup	17%	3%	-8%	-10%	-11%
Market share	26%	34%	20%	11%	7%

- **Central dealers charge larger markups than peripheral dealers**
- Excess markup largest for medium sized trades

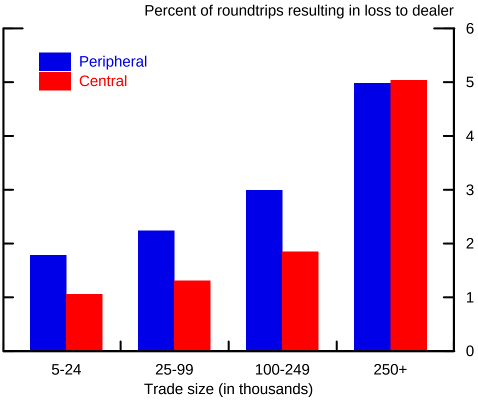
Transaction Costs and Dealer Centrality

$$Markup_{ijt} = \beta_0 + \beta_1 Net_{jt-1} + \beta_2 X_{it} + \epsilon_{ijt} \quad \forall(\text{dealer } j, \text{bond } i)$$

	CDC-Nonsplit		All CDC	
	EW	VW	EW	VW
Net	0.62***	0.54***	0.95***	0.87***
logpar_retail	-0.42***	-0.42***	-0.29***	-0.29***
logpar_medsize	-0.44***	-0.44***	-0.30***	-0.30***
logpar_lgsize	-0.37***	-0.37***	-0.29***	-0.29***
isgo	-0.03*	-0.03*	-0.04*	-0.04*
taxable	0.01	0.01	0.01	0.01
amt	0.21***	0.21***	0.24***	0.23***
Rating	0.00**	0.00**	0.00	0.00
logamt	0.14***	0.14***	0.17***	0.17***
callable	0.32***	0.32***	0.40***	0.40***
cons	2.00***	2.08***	1.30***	1.37***
N	2,933,867	2,933,867	4,023,515	4,023,515

- Regression with issuer fixed effects & robust standard errors
- Centrality: $Net = 1$ (most central dealer), $Net = 0$ (most peripheral dealer)
- **Markups increase by 62 bp from least to most connected dealer**
- Similar results if use individual network measures (dg, bt, cl, ev)

Dealer Loss Probability and Centrality



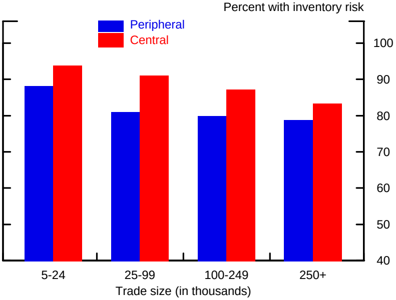
- Dealers lose money on only two percent of round-trips
- Robust to Probit/Logit: $P(Markup_{ijt} < 0) = f(\beta_0 + \beta_1 Net_{jt-1} + \beta_2 X_{it} + \epsilon_{ijt})$
- **Central dealers are less likely to suffer capital loss**

⇒ Larger bid-ask spreads are not compensation for price-risk taking

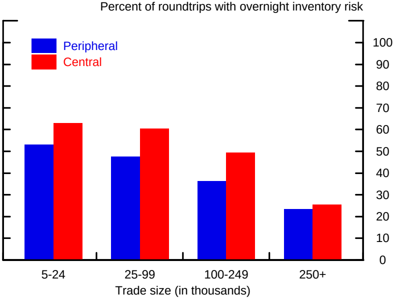
- Why do investors trade with central dealers? Liquidity supply

Liquidity Supply and Dealer Centrality

- Dealer's choices upon receiving sell order
  1. Wait until matching buyer is found. No inventory risk.
  2. Take the bond into inventory
- The more immediacy to customers, the more inventory risk dealers take
- Measure immediacy by time elapsed between dealer buy & sale



Note: We infer that dealer took bond into inventory if dealer-buy and dealer-sell trades are at least 10 seconds apart.



Note: A roundtrip has "overnight risk" if dealer-buy and dealer-sell trades are on different days.

⇒ **Central dealers more likely to take bonds into inventory**

⇒ **Central dealers take more overnight inventory risk**

Inventory Risk Taking and Dealer Centrality

	Inventory Duration		Pr(Immediate Match)		Pr(Same Day Match)	
	EW	VW	EW	VW	EW	VW
Net	0.56***	0.33***	-1.58***	-1.64***	-1.58***	-1.47***
logpar_retail	-0.29***	-0.29***	0.16***	0.16***	0.04***	0.04***
logpar_medsize	-0.35***	-0.35***	0.15***	0.15***	0.10***	0.10***
logpar_lgsize	-0.26***	-0.27***	0.10***	0.11***	0.12***	0.13***
isgo	-0.03	-0.03	-0.00*	-0.00	-0.00	-0.00
taxable	-0.56***	-0.56***	0.26***	0.26***	0.29***	0.29***
amt	-0.34***	-0.34***	0.05***	0.05***	0.26***	0.26***
Rating	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***
logamt	-0.37***	-0.37***	0.06***	0.06***	0.10***	0.11***
callable	-0.09***	-0.09***	-0.08***	-0.08***	0.01***	0.01***
cons	3.37***	3.59***	-0.59***	-0.55***	0.60***	0.50***
N	2,929,570	2,929,570	2,917,162	2,917,162	2,917,162	2,917,162

- **Central dealers take on more inventory risk & provide more immediacy**
  - Central dealer trades are comparable to a "market order"
  - Peripheral dealer trades are comparable to a "limit order"
- Why & when do investors trade with central dealers? Liquidity preferences

Liquidity-Based Differentiation

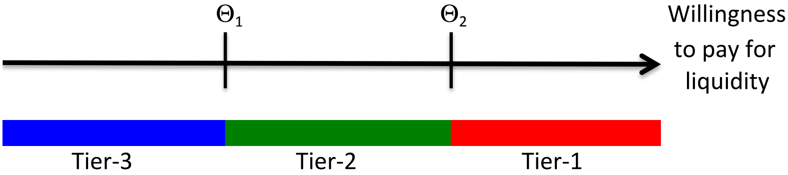
- Dealers offer bundle of execution cost & liquidity quality (M_j, L_j)
- Investors with high (low) WTP for liquidity select central (peripheral) dealers
  - Gains from trade for investor i:

$$v_i = u(M, L; \theta_i) = \theta_i L - M$$

  - Investors and dealers matched as follows:

$$D_i = j \iff \Theta_j < v_i \leq \Theta_{j+1}$$

where Θ_j is indifference WTP between dealer j-1 to j



Liquidity-Based Differentiation

- Observed liquidity at chosen dealer j (solid):

$$E[L_{ij}|D_i = j] = \underbrace{X_i\gamma_j}_{\text{Expected liquidity supply}} + \underbrace{\rho_j\sigma_j\lambda_{ij}}_{\text{Liquidity prefs}} \quad \text{with } \lambda_{ij} = E[e_i|D_i = j]$$

- Unobserved "quoted" liquidity at non-chosen dealer (shaded counterfactual):

$$E[L_{ij}|D_i] = X_i\gamma_j + \rho_j\sigma_j\lambda_{iD_i}$$

- Expected markup & liquidity supply by dealer j:
  $E[M_{ij}] = X_i\beta_j, \qquad E[L_{ij}] = X_i\gamma_j$

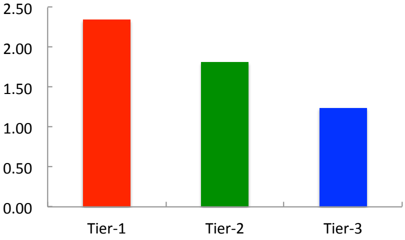
- Actual markup & liquidity supply by dealer j:
  $M_{ij} = X_i\beta_j + \varepsilon_{ij} \qquad L_{ij} = X_i\gamma_j + \eta_{ij}$

- Observed markup & liquidity (D_i is dealer choice by investor i):
  $M_i = \sum_{j=1}^{J} M_{ij}(D_i = j), \qquad L_i = \sum_{j=1}^{J} L_{ij}(D_i = j)$

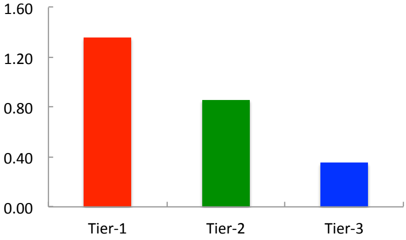
Liquidity supply across the network

- Expected markup: $E[M_{ij}] = X_i\beta_j$
- Expected liquidity: $E[L_{ij}] = X_i\gamma_j$

Markup



Liquidity

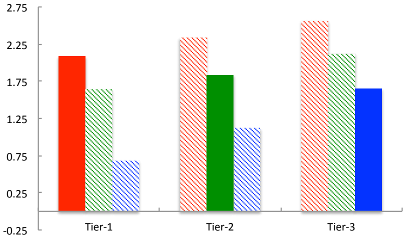


- Central dealers charge highest markups
- Central dealers provide most liquidity & immediacy

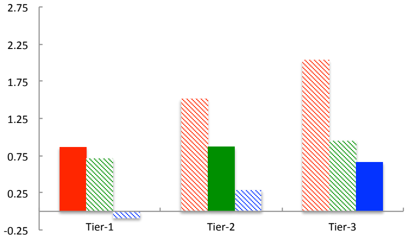
Central dealers as liquidity providers of last resort

- Liquidity at chosen dealer (bold): $E[L_{ij}|D_i = j] = X_i\gamma_j + \rho_j\sigma_j\lambda_{ij}$
- Liquidity at non-chosen dealer (shaded): $E[L_{ij}|D_i] = X_i\gamma_j + \rho_j\sigma_j\lambda_{iD_i}$

Markup



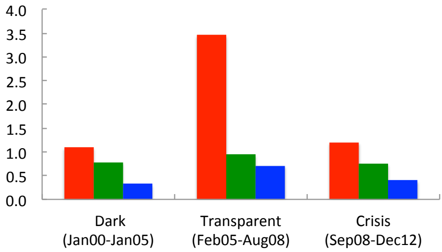
Liquidity



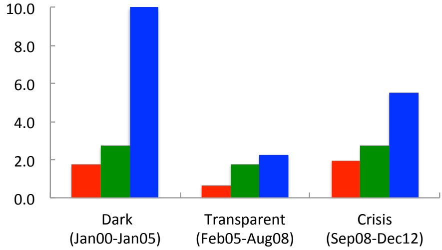
- Central dealers charge highest markups
- Central dealers provide most liquidity & immediacy
- Investors have preference for target liquidity level
- Investor trade with central dealers when others do not offer liquidity

Liquidity supply before and after financial crisis

Liquidity supply



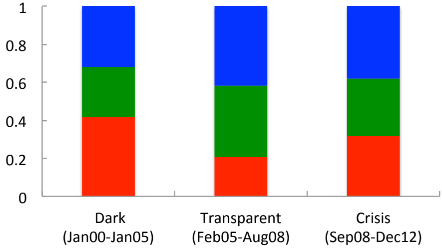
Price of Liquidity



- Peripheral dealers benefitted the most from transparency

Market shares before and after financial crisis

Market share



- Peripheral dealers benefitted the most from transparency
- Central dealers are liquidity suppliers of last resort

Do central dealers face larger costs or earn more profits?

- Stochastic frontier model as in Green, Hollifield and Schürhoff (2007)
- Decompose markups in fixed cost part and stochastic (non-negative) profit

$$Markup_i = \overbrace{\alpha + \beta Net_i + \gamma' X_i}^{\text{Cost}} + \overbrace{u_i}^{\text{Profit} \geq 0} + \overbrace{\epsilon_i}^{\text{Noise}} \quad \forall \text{ trades } i,$$

where $u_i \sim Exp(\lambda_i)$, $\epsilon_i \sim N(0, \sigma_i)$, $\lambda_i = e^{\alpha_\lambda + \beta_\lambda Net_i + \gamma'_\lambda Z_i}$, $\sigma_i = e^{\alpha_\sigma + \beta_\sigma Net_i + \gamma'_\sigma Z_i}$.

	CDC-Nonsplit		All CDC	
	EW	VW	EW	VW
Panel A: Intermediation cost function				
Net	0.39***	0.56***	0.11***	0.22***
Panel B: Dealer profit (One-sided error component)				
Net	0.50***	0.15***	2.64***	2.21***
Panel C: Resale price risk (Symmetric error component)				
Net	-0.24***	0.20***	-1.17***	-1.07***

$\Rightarrow$ **Central dealers face larger intermediation cost, but earn larger profits**

Summary & Conclusion

For dealers

- Connections are valuable by reducing search frictions
- Economies of scale in financial intermediation
  - Central dealers provide more liquidity & immediacy
  - Central dealers can charge more than periphery
- Dealers exposed to illiquidity spillovers

For investors

- Heterogeneous motives for trade across investors
- Dealership network serves different investor needs for immediacy

For regulators

- Regulation likely to impact dealers asymmetrically
- Regulation may have ambiguous effect on execution cost & liquidity