The Risk Sharing Benefit versus the Collateral Cost: The Formation of the Inter-Dealer Network in OTC Trading

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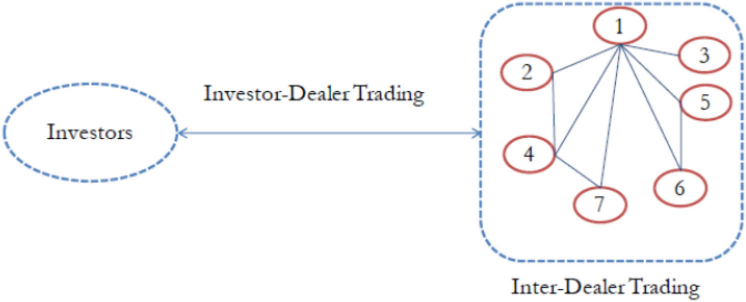
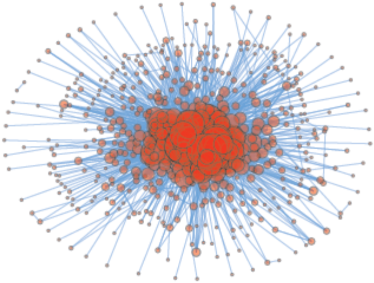
The Over-the-Counter Market

- Many financial assets are traded in the OTC market, e.g., asset backed securities, bank loans, CDS, corporate bonds, and municipal bonds.
- What is inter-dealer trading in an OTC market?



The Inter-Dealer Network in Empirical Studies

- Hollifield, Neklyudov, and Spatt (2015) document **the Core-Periphery Structure**.



- Prices and liquidity are related to this structure.
- In empirical studies, this network is treated exogenously.

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- How do dealers form the inter-dealer network?

- How does the inter-dealer network affect OTC trading?

- What explains the core-periphery inter-dealer network?

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  - capacity of providing liquidity.
  - order size from investors (work-in-progress).

Outline

- The Benchmark Model: Homogeneous Dealers.
- The Extended Model: Heterogeneous Dealers.
- Conclusion.

Benchmark Model

Assets.

- A risk free asset with a value 1.
- A risky asset which has a random value $v \sim N\left(\overline{v}, \sigma^2\right)$.

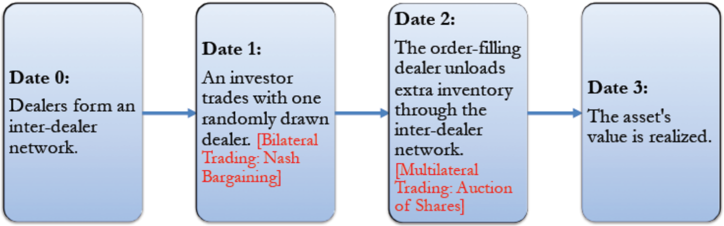
A set of dealers $\mathcal{N}$ with $|\mathcal{N}| = N \geq 3$.

- Mean-Variance preferences $u\left(W\right) = E\left[W\right] - \frac{\rho}{2} V\left[W\right]$.
- Each with I units of risky asset.

Matching technology

- Every dealer has the probability $\frac{1}{N}$ of trading with an investor.

Timeline



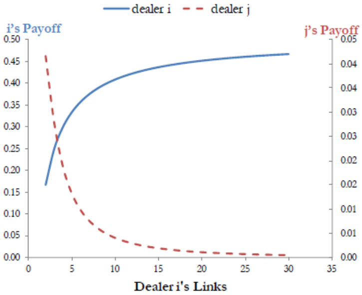
D0 Each dealer i forms his selling network $\mathcal{N}_i \subset \mathcal{N} \setminus \{i\}$.

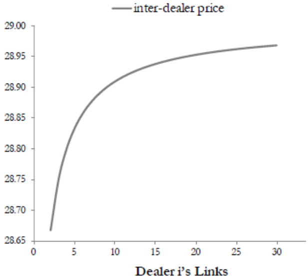
D1 An investor sells z units of risky asset to one dealer by Nash bargaining ($\rightarrow p_1$).

D2 The order-filling dealer unloads inventory by a share auction in his network ($\rightarrow$ inter-dealer price p_2 and volume).

Dealers' Gains from Risk Sharing

- Both the order-filling dealer (i) and his connected dealers (j) gain from inter-dealer trading.
- The number of i's links has an asymmetric effect on (i, j).
- Inter-dealer price increases with the number of links.





Network Formation

- In an auction $\mathcal{N}_i$ with $|\mathcal{N}_i| = n_i$, equilibrium volume is $\frac{n_i - 1}{n_i + 1} z$.
- The linking cost comes from the funding cost of collateral:

$$\underbrace{\Pr\left(\text{sell in inter-dealer trading}\right)}_{(1)} \times \underbrace{\sigma \frac{n_i - 1}{n_i + 1} z}_{(2)} \times \underbrace{m}_{(3)}.$$

(1) The probability that collateral is needed in inter-dealer trading (only the seller needs collateral).

(2) The risk (standard deviation) of the value of shares sold.

(3) The margin requirement m.

- The overall expected payoff for i in the network $\{\mathcal{N}_i\}_{i=1}^N$:

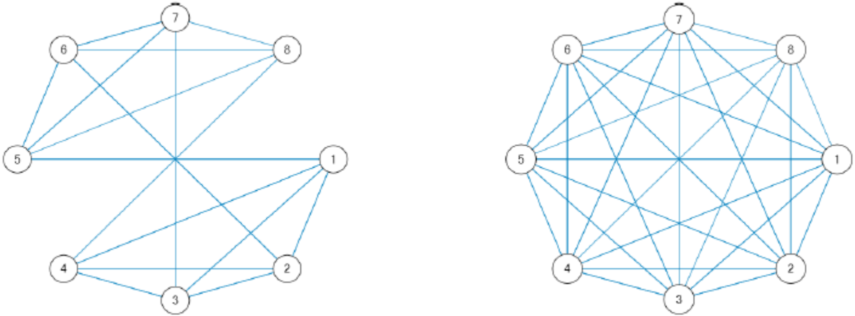
$$U_i\left(\{\mathcal{N}_i\}_{i=1}^N\right) = \overbrace{\frac{1}{N}u\left(v\left(I+\frac{2z}{n_i+1}\right)+f-p_2^i x_i\left(p_2^i\right)-zp_1^i\right)}^{i\text{ fills the order}}$$

$$+ \overbrace{\frac{1}{N}\sum_{j:i\in\mathcal{N}_j}u\left(v\left(I+\frac{n_j-1}{n_j\left(n_j+1\right)}z\right)+f-p_2^j x_i\left(p_2^j\right)\right)}^{i\text{'s connected dealers fill the order}}$$

$$+ \overbrace{\left(1-\frac{1}{N}-\frac{1}{N}\sum_{j:i\in\mathcal{N}_j}\right)u\left(vI+f\right)}^{\text{neither } i \text{ nor his connected dealers fill the order}}$$

$$- \overbrace{\frac{1}{N}\sigma\frac{n_i-1}{n_i+1}zm}^{\text{total cost of links}}$$

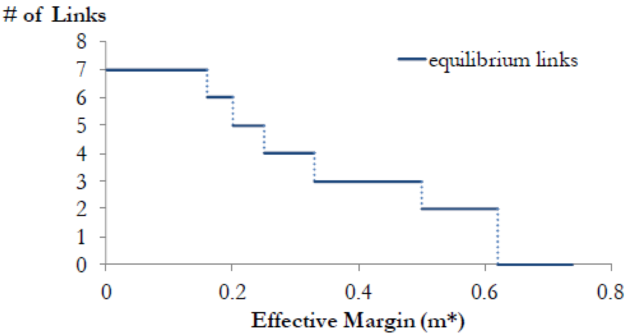
Proposition 1 *A strongly stable network is symmetric.*



4 Links 7 Links

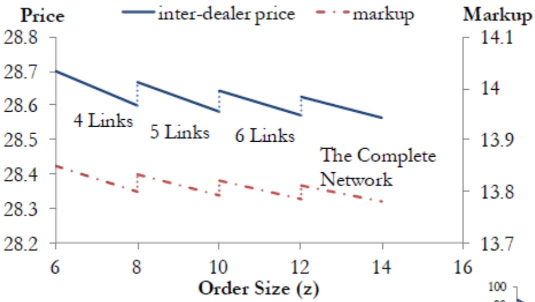
- In the benchmark, all dealers have the same number of links.

Comparative Statics of Equilibrium Network



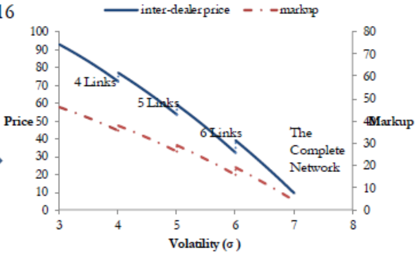
- The effective margin is defined as $m^* \equiv \frac{2}{\rho\sigma z} m$.
- Equilibrium number of links $n_i^* = n^*$ increases in:
  (i) order size z, and (ii) volatility σ or risk aversion ρ.

Asset Pricing Implications



Price-Order Size Relation

Price-Volatility Relation



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- **The Extended Model: Heterogeneous Dealers.**
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Limit of the Benchmark Model

- A symmetric network is counter-factual.
- Only one auction is used. No order splitting across multiple auctions.

The current draft:

- Three types of dealers with **heterogeneous capacity** of providing liquidity.
- Dealers with large (small) capacity stay at the core (periphery).

Work-in-progress:

- Dealers with **heterogeneous amounts of risky asset** form auctions and submit orders to multiple auctions simultaneously.

Heterogeneous Endowments (work-in-progress)

- An auction among $n+1$ dealers, each with endowment I_i.
- Heterogeneous gains from trade:

$$G_i = \frac{\rho\sigma^2}{2}\frac{n^2-1}{n^2}\left(I_i - \bar{I}\right)^2, \qquad \bar{I} \equiv \frac{1}{n+1}\sum_{i=1}^{n+1} I_i.$$

- An additional trader affects G_i through two channels:

1. $\frac{n^2-1}{n^2}$ (liquidity effect); and
2. $\bar{I}$ (distributional effect).

Asymmetric Impact of Adding Another Dealer

$$G_i = \frac{\rho\sigma^2}{2} \times \overbrace{\frac{n^2-1}{n^2}}^{\text{Liquidity effect}} \times \overbrace{\left(I_i - \overline{I}\right)^2}^{\text{Distributional effect}} .$$

- Distributional effect can be **asymmetric**: positive (negative) if $\overline{I}$ moves away from (closer to) I_k.

Example (benchmark model):

- The order-filling dealer i and dealer j in i's network $\mathcal{N}_i$:

$$G_i = \frac{\rho\sigma^2}{2}\frac{n_i^2-1}{n_i^2}\left\{(I+z) - \left(I + \frac{z}{n_i+1}\right)\right\}^2,$$

$$G_j = \frac{\rho\sigma^2}{2}\frac{n_i^2-1}{n_i^2}\left\{I - \left(I + \frac{z}{n_i+1}\right)\right\}^2.$$

- $\left|I_i - \overline{I}\right|$ increases in n_i while $\left|I_j - \overline{I}\right|$ decreases in n_i.

Multiple Auctions

- $i = 1 \sim N$ dealers and $k = 1 \sim K$ auctions. Let $\mathcal{N}_k$ be a set of dealers who trade in auction k and $N_k \equiv |\mathcal{N}_k|$.
- Let $\mathcal{K}_i$ be a set of auctions in which dealer i trades.

Proposition *A vector of asset positions after trading, $Y = [Y_1, .., Y_N]^\intercal$, is linear in $I = [I_1, .., I_N]^\intercal$:*

$$Y = \Phi^{-1} I, \qquad \text{where } \Phi \equiv \begin{bmatrix} 1+\chi_1 & -\Gamma_{1,2} & \cdots & -\Gamma_{1,N} \\ -\Gamma_{2,1} & \ddots & & \vdots \\ \vdots & & \ddots & \\ -\Gamma_{N,1} & \cdots & & 1+\chi_N \end{bmatrix},$$

$$\chi_i \equiv \sum_{k \in \mathcal{K}_i} \frac{(N_k - 2)(N_k - 1)}{N_k} \text{ and } \Gamma_{i,j} \equiv \sum_{k \in \mathcal{K}_i} \frac{N_k - 2}{N_k} \mathbf{1}_{[j \in \mathcal{K}_i]} = \Gamma_{j,i}.$$

Incremental Value of Auctions

- Given $Y = [Y_1, .., Y_N]^\intercal$, gains from trade are $G(\mathcal{K}_i) =$

$$\rho\sigma^2 \left[\sum_{k \in \mathcal{K}_i} (N_k - 2) \left(\overline{Y}_k - Y_i\right)^2 + \frac{1}{2} \left\{ \sum_{k \in \mathcal{K}_i} (N_k - 2) \left(\overline{Y}_k - Y_i\right) \right\}^2 \right]$$

- The contribution of auction k is $V_{i,k} \equiv G_i(\mathcal{K}_i) - G_i(\mathcal{K}_i - k)$

$$= \rho\sigma^2 (N_k - 2) N_k \left(\overline{Y}_k - Y_i\right)^2 \left(\frac{1}{2} + \sum_{k' \in \mathcal{K}_i - k} \frac{N_{k'} - 2}{N_k} \frac{\overline{Y}_{k'} - Y_i}{\overline{Y}_k - Y_i} \right).$$

- Question: **Who benefits the most from each auction?**

Conclusion

- The first paper that endogenizes the inter-dealer network in OTC trading.
- Dealers form the inter-dealer network for risk sharing.
  - Assets with high volatility and traded in large order size have more connected networks.
  - When the collateral cost is high, the network is less connected.
- Empirical studies should take account of the network effect to avoid model misspecification.
  - The price-size relation and price-volatility relation may encounter structural breaks, since the order size or volatility can change the network structure.
- Heterogeneous capacity or endowment (work-in-progress) can explain the core-periphery network.
  - Dealers with large (small) capacity stay at the core (periphery).
  - (conjecture) dealers with extreme positions stay at the core.