“Inventory Management, Dealers’ Connections and Prices in OTC Markets”

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Disclaimer: The views expressed are those of the presenter and do not necessarily reflect those of the ECB and/or the Eurosystem.
Roadmap

Introduction

Model

Equilibrium
  Core market
  Peripheral Market
  Closing the Model

Testable Implications

From DtD to DtC Spreads

Conclusion
Motivation

- Many assets trade over-the-counter (OTC)
  1. Corporate and Sovereign Bonds,
  2. Munis
  3. Bank reserves (interbank markets)
  4. Swaps, CDSs,
  5. etc.

- Liquidity provision in these markets critically rely on dealers’ willingness to absorb temporary order imbalances between final investors’ supply and demand.

- A key determinant of dealers’ quotes (liquidity supply) is their ability to manage their inventory holding costs (Stoll (1978)).
Interdealer Trading

- **Interdealer trading plays a central role for inventory management.** → Interdealer trades account for a significant fraction of trading volume in OTC markets
  1. 33% to 50% in U.S. corporate bonds (see Schultz (2017) and Friewald and Nagler (2019, JOF))
  2. 30% in U.S. munis (see Li and Schüroff (2017, JOF)).

- **Interdealer markets often have a “two-tiered" structure**
  1. A small number of dealers (**core dealers**) are highly interconnected with each other.
  2. Other dealers (**peripheral dealers**) have fewer relationships.

- “There is tremendous heterogeneity in dealer connectivity. 10 to 30 dealers are highly interconnected with more than 500 trading partners and trade heavily with one another. In contrast to these core dealers the remaining several hundred firms interact with a limited number of trading partners. The overall network is very sparse. Out of 5.1 million possible directed links, only 124000 (or 2.4%) exist over the 15 year period." (Li and Schüroff (2017)).
**Example: The European Interbank Market**

Heterogeneity in Connections in the Euro Area Overnight Interbank Market. The table shows the number of banks with “y” (blue) relationships to core banks to banks with “x” (red) relationships to core banks-2008 data-395 banks

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</tbody>
</table>
Introduction

Research Question

“Some of the key research and policy issues regarding OTC markets include: [...] (ii) the manner in which the price negotiated on a particular trade reflects the relative degree of connectedness of the buyer and seller with the rest of the market [...] (iv) the influence of market structure on the cross-sectional dispersion of prices negotiated at a particular time [...] (Duffie (2012) in “Dark Markets: Asset Pricing and Information Transmission in Over the Counter Markets”)

- **Our paper:** How does the level of connectedness among dealers affect:

  1. The distribution of prices in interdealer markets (e.g., price volatility)?
  2. The efficiency of interdealer markets in terms of inventory cost sharing?
  3. Trading costs for dealers’ clients.
Our Contribution

- We develop a new model of interdealer trading in OTC markets. Key features:
  1. **Two segments:** “Core” and “Peripheral” dealers
  2. **Heterogeneity:** Peripheral dealers are heterogeneous in their number of trading relationships (“connections”) with core dealers.
  3. **Cost sharing:** Dealers trade together to reduce/manage their inventory holding costs.
  4. **Endogenous market power** (depends on their connectedness and aggregate inventories)

- **Main result:** Distribution of equilibrium prices in the interdealer market depends on:
  1. Relative aggregate inventory positions of core and peripheral dealers
  2. Level of connectedness between peripheral dealers and core dealers.
  3. In particular, lower connectedness combined with inventory imbalances between core and peripheral dealers ⇒ Significant deviations of prices from walrasian prices.
Introduction

Literature

- **Search and matching models of OTC markets:** Duffie et al. (2005, 2007), Lagos & Rocheteau (2007, 2009), etc.
  1. **Main friction in these models:** time delays (search) for investors in finding a counterparty (if infinite speed, prices are walrassian).
  2. **Main frictions in our model:** Not cost of time but (i) heterogeneity in access to core dealers and (ii) rent seeking behavior (if all dealers are connected to core dealers, prices are walrassian).
  3. Most models of OTC markets (i) do not give a role to inventory costs (e.g., Duffie et al. (2005) assumes no inventory for dealers) and (ii) assumes frictionless interdealer markets (e.g., Duffie et al. (2005)).

- **Models of dealers’ inventory management** (Stoll (1978), Grossman and Miller (1988), Biais (1993), Hendershott and Menkveld (2014)):
  - Do not account for the fact trading in interdealer markets is decentralized.

- **Theories of network formation in OTC markets** (e.g., Nekludyov and Sambalaibat (2017), Hugonnier, Lester, and Weill (2016) etc.)
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Conclusion
An interdealer market for a risky asset with final payoff $\nu$ at date 3. Expected value: zero.

A continuum of risk neutral dealers

At date 0, the inventory position of dealer $i$ is $z_{i0} \in \{-1, 1\}$.

Two types of dealers:

1. Core dealers (mass $\kappa$). A fraction $\alpha_{0}^{co}$ of core dealers have a long position $\rightarrow$ Aggregate position of core dealers: $z_{0}^{co} = \kappa(2\alpha_{0}^{co} - 1)$.
2. Peripheral dealers (mass 1). A fraction $\alpha_{0}^{pe}$ of peripheral dealers have a long position $\rightarrow$ Aggregate position of peripheral dealers: $z_{0}^{pe} = (2\alpha_{0}^{pe} - 1)$.

Inventory costs: At date 3, dealers incur a (per unit) cost $C^s$ of holding a long position and a cost $C^b$ of holding a short position (in reality, short and long positions must be funded $\rightarrow$ costly).
Dealers’ Payoff

- Dealer $i$’s payoff when his final inventory position is $z_{i3}$ and his final cash position is $m_{i3}$:

$$\Pi_i = \begin{cases} 
    v \cdot z_{i3} - C^b |z_{i3}| + m_{i3} & \text{if } z_{i3} < 0 \\
    v \cdot z_{i3} - C^s |z_{i3}| + m_{i3} & \text{if } z_{i3} > 0,
\end{cases}$$ (1)

- **Gains from trade:** Consider dealers $i$ (short) and $j$ (long). If $i$ buys the asset from $j$ at $p \in [-C^s, C^b]$:
  1. Dealer $i$’s expected profit increases by $C^b - p > 0$.
  2. Dealer $j$’s expected profit increases by $p - C^s > 0$.
  3. Total gains from trade: $(C^b - p) + (p - C^s) = C^b + C^s > 0$

- **Interdealer trading serves to reduce inventory costs**
### Timing

- **Dealers trade sequentially in two stages.**
  1. **Date 1:** Peripheral dealers trade together.
  2. **Date 2:** Core dealers and peripheral dealers with access to core dealers trade together.

<table>
<thead>
<tr>
<th>Date 0</th>
<th>Date 1</th>
<th>Date 2</th>
<th>Date 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Initial inventories</strong></td>
<td><strong>Trade in the periphery</strong></td>
<td><strong>Trade in the core</strong></td>
<td><strong>Inventory shock ($\epsilon_i$)</strong></td>
</tr>
<tr>
<td>Type $z_{i0}$</td>
<td>Type $z_{i1}$</td>
<td>Type $z_{i2}$</td>
<td>Type $z_{i3}$</td>
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<tr>
<td>Buyers $-1$</td>
<td>Matched dealers $z_{i0} + q_{i1}$</td>
<td>Unconnected dealers $z_{i1}$</td>
<td>Unconnected dealers $z_{i2}$</td>
</tr>
<tr>
<td>Sellers $+1$</td>
<td>Unmatched dealers $z_{i0}$</td>
<td>Connected dealers $z_{i1} + q_{i2}$</td>
<td>Connected dealers $z_{i2}$</td>
</tr>
<tr>
<td>Core dealers $z_{i0}$</td>
<td>Core dealers $z_{i0}$</td>
<td>Core dealers $z_{i1} + q_{i2}$</td>
<td>Core dealers $z_{i2} + \epsilon_i$</td>
</tr>
</tbody>
</table>

- **Final inventory shock:** Just before date 3, dealers can get an additional inventory shock $\epsilon_i$. For peripheral dealers, $\epsilon_i = 0$. For core dealers, $\epsilon_i$ has a cumulative probability distribution $\Phi(.)$. This pins down uniquely the price in the core market (see below).
Connected vs. Unconnected dealers

- A mass $\lambda$ of peripheral dealers do not have access to core dealers (higher $\lambda \rightarrow$ Lower connectedness).
Trading Mechanisms

- The core market is similar to a centralized market because all dealers are connected
  1. ⇒ We assume that it operates like a walrassian market.

- The peripheral market is decentralized
  1. Peripheral dealers are matched together and negotiate bilaterally.
  2. Connected peripheral dealers have the outside option of trading in the core market at date 2 (connected dealers = liquidity suppliers of last resort for peripheral dealers).
Peripheral market - Trading protocol

- **{b, C}**

  - **Offer** \( p_b^C \)
    - \( 1 - \pi_s \)
    - \( \pi_s \lambda \)
    - \( \pi_s (1 - \lambda) \)

- **{b, i}**
  - Buyer rejects
  - \{b, C\} goes to the core
  - **Offer** \( p_b^i \)
    - New trader makes an offer
    - **Offer** \( p_b^C \)
      - \{b, C\} goes to the core

- **{s, U}**
  - Unconnected seller
  - Accepts
  - \{b, C\} and \{s, U\} trade

- **{s, C}**
  - Connected seller rejects
  - \{b, C\} goes to the core
  - **Offer** \( p_s^C \)
    - **Offer** \( p_s^U \)
      - \{b, C\} goes to the core

- **New trader makes an offer**
  - **Offers**
Peripheral market - Matching Technology

\[ \pi_b: \text{Probability that a peripheral buyer finds a seller} \]

\[ \pi_s: \text{Probability that a peripheral seller finds a buyer} \]

\[ \alpha^{pe} \text{: Fraction of Sellers} \]

![Graph showing the relationship between the fraction of sellers and the likelihood of finding a counterparty.]
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Core market equilibrium

Consider a core dealer with demand $q_{i2}$ who trades at price $p^{co}$. His expected profit is:

$$
E(\Pi_i) = E[z_{i3}|z_{i3} < 0]C^b - E[z_{i3}|z_{i3} > 0]C^s - q_{i2}p^{co}.
$$

(2)

where $z_{i3} = z_{i0} + q_{i2} + \epsilon_i$.

The optimal demand solves:

$$
C^b Pr(z_{i0} + q^*_{i2} + \epsilon_i < 0) = C^s Pr(z_{i0} + q^*_{i2} + \epsilon_i > 0) + p^{co}.
$$

Core dealers’ aggregate demand is therefore:

$$
q^{co*}(p^{co}, z^{co}) = -z^{co}_0 - \kappa \Phi^{-1} \left( \frac{p^{co} + C^s}{C^s + C^b} \right), \text{ for } p^{co} \in [-C^s, C^b].
$$

Decreases with core dealers’ aggregate inventory and the core market price.
Core market equilibrium

- **Connected peripheral dealers’ demand.** We can proceed in the same way, except that the peripheral dealer knows with certainty his final position given his trade ⇒:

\[ q_{i2}^{pe*}(p^{co}, z_{i0}) = -z_{i0}, \text{ for } p^{co} \in [-C^{s}, C^{b}]. \]  
(3)

- Thus, connected peripheral dealers’ aggregate demand in the core market is:

\[ q^{pe*} = -\Delta^{*} \]

\[ \Delta^{*} = \text{Diff. Mass of connected peripheral sellers and buyers in the core} \]

- **\( \Delta^{*} \) is endogenous:** It depends on connected peripheral dealers’ strategy in the peripheral market.
Core market equilibrium

Figure 1: Assumptions: $C^b = C^s$ and $z^c_0 > 0$. 

Equilibrium Price: Decreases with
(i) Core dealers inventories
(ii) Peripheral dealers' supply ($\Delta$)

Core dealers' aggregate inventory per capita 

Peripheral Dealers' Supply (goes to zero when $\kappa \rightarrow \infty$)
Peripheral market - Reminder

- **{b, C}**
  - Offer $p^C_b$
    - $1 - \pi_s$
      - Buyer rejects
        - $\{b, C\}$ goes to the core
          - Offer $p^i_b$
            - New trader makes an offer
              - ...$\ldots$
    - $\pi_s \lambda$
      - Connected seller rejects
        - $\{b, C\}$ goes to the core
          - Offer $p^C_s$
            - ...$\ldots$
    - $\pi_s (1 - \lambda)$
      - Unconnected seller
        - Accepts $\{b, C\}$ and $\{s, U\}$ trade
          - Offer $p^U_s$
            - ...$\ldots$

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Peripheral market

- We must solve for the equilibrium of bilateral bargaining games between different types of dealers.

- 4 types: \((i, k) \in \{C, U\} \times \{b, s\}\)
  1. Connected buyer ("Cb")
  2. Unconnected buyer ("Ub")
  3. Connected seller ("Cs")
  4. Unconnected seller ("Us")

- A dealer’s connectedness to the core is private information to the dealer.

- A dealer’s strategy specifies (i) whether he accepts an offer at price \(p\) or not and (ii) the price at which he makes an offer.
Bargaining among peripheral dealers

- Consider an unconnected buyer (wants to trade with a seller)
- Gains from trade with unconnected seller are $C^b + C^s$
Bargaining among peripheral dealers

- Consider an unconnected buyer (wants to trade with a seller)
- Gains from trade with unconnected seller are $C^b + C^s$

\[
p_b^U = -C^s
\]

- $p_b^U = -C^s$ would extract entire surplus
Bargaining among peripheral dealers

- Consider an unconnected buyer (wants to trade with a seller)
- Gains from trade with unconnected seller are $C^b + C^s$

\[ p^U_b = -C^s \] would extract entire surplus
- But: Seller can reject and make an offer to the next dealer
Bargaining among peripheral dealers

- Consider an *unconnected* buyer (wants to trade with a seller)
- Gains from trade with *unconnected* seller are $C^b + C^s$

$$p^U_b = -C^s$$ would extract entire surplus

- But: Seller can reject and make an offer to the next dealer
- Let $V^U_s$ denote the seller’s “continuation value”
Bargaining among peripheral dealers

- Consider an **unconnected** buyer (wants to trade with a seller)
- Gains from trade with **unconnected** seller are $C^b + C^s$

\[ p_b^U = -C^s \text{ would extract entire surplus} \]

- But: Seller can reject and make an offer to the next dealer
- Let $V_s^U$ denote the seller’s “continuation value”
- $p_b^U = V_s^U$ makes the seller just indifferent
Bargaining among peripheral dealers

- Consider an \textit{unconnected} buyer (wants to trade with a seller)
- Gains from trade with \textit{connected} seller are $C^b - p^{co}$
Bargaining among peripheral dealers

- Consider an **unconnected** buyer (wants to trade with a seller)
- Gains from trade with **connected** seller are $C^b - p^{co}$

\[ -C^s \quad V^U_s \quad p^{co} \quad C^b \]

- Connected dealers can resort to the core: $p^{co} > -C^s$
Bargaining among peripheral dealers

- Consider an unconnected buyer (wants to trade with a seller)
- Gains from trade with connected seller are $C^b - p^{co}$

\[ \begin{align*}
- C^s & \quad V_s^U & \quad p^{co} & \quad V_s^C & \quad C^b
\end{align*} \]

- Connected dealers can resort to the core.
- This implies a higher “continuation value”
- They require $p_b^U = V_s^C > V_s^U$
Bargaining among peripheral dealers

- Consider an unconnected buyer (wants to trade with a seller)
- Gains from trade with connected seller are $C^b - p^{co}$

\[ V_s^U \quad p^{co} \quad V_s^C \quad C^b \]

- Connected dealers can resort to the core.
- This implies a higher “continuation value”
- They require $p_b^U = V_s^C > V_s^U$
- Note: will also be accepted by unconnected sellers
Bargaining among peripheral dealers

- Consider an connected buyer (wants to trade with a seller)
- Gains from trade with unconnected seller are $p^{co} + C^s$
Bargaining among peripheral dealers

- Consider an connected buyer (wants to trade with a seller)
- Gains from trade with unconnected seller are $p^{co} + C^s$

The unconnected seller will accept $p^C_b = V^U_s$
Bargaining among Peripheral Dealers

- Consider an connected buyer (wants to trade with a seller)
- Gains from trade with connected seller are zero

\[ -C^s \quad p^{co} \quad C^b \]

- Connected dealers never trade with each other bilaterally
Summing up

- **Connections are valuable** (connected dealers have a better outside option)
  - \( V_k^c \geq V_k^u \)

- **Unconnected dealers target either unconnected or both**
  - \( p_s^u \in \{-V_b^u, -V_b^c\} \) and \( p_b^u \in \{V_s^u, V_s^c\} \)

- **No mutual gains from trade between connected dealers**
  - \( p_s^c \in \{-V_b^u, \emptyset\} \) and \( p_b^c \in \{V_s^u, \emptyset\} \)
Optimization - unconnected dealers

Consider the possible offers for an unconnected buyer (symmetric for seller)

- Target connected seller: $p = V^C_s$
  Payoff: $-\pi^s p - (1 - \pi^s) C^b$

- Target unconnected sellers: $p' = V^U_s$
  Payoff: $-\pi^s \lambda p' - (1 - \pi^s \lambda) C^b$

Trade-off between

- rent extraction ($p' < p$)
- inventory risk ($\pi^s > \pi^s \lambda$)
Optimization - connected dealers

▶ Very simple!

1. Connected sellers target unconnected buyer if \(- V_b^U \geq p^{co}\)
2. Connected buyers target unconnected seller if \(V_s^U \leq p^{co}\)
3. Otherwise directly go to the core (or, make offers that are always rejected).

▶ This gives rise to 3 types of equilibria:

1. Connected buyers and sellers make offers that are accepted by unconnected dealers (ACD equilibrium).
2. Connected buyers only trade with core dealers (ICB equilibrium).
3. Connected sellers only trade with core dealers (ICS equilibrium).
Example: ACD equilibrium

- unconn. (conn.) dealers target both (unconn.) types
  - \( p_s^{C*} = -V_b^U, \ p_b^{C*} = V_s^U, \ p_s^{U*} = -V_b^C, \ p_b^{U*} = V_s^C \)

- yields the following system of equations
  - \( V_s^{C*} = \lambda \pi^b p_s^{C*} + (1 - \lambda \pi^b)p^{co*} \)
  - \( V_b^{C*} = -\lambda \pi^s p_b^{C*} - (1 - \lambda \pi^s)p^{co*} \)
  - \( V_s^{U*} = \pi^b p_s^{U*} - (1 - \pi^b)C^s \)
  - \( V_b^{U*} = -\pi^s p_b^{U*} - (1 - \pi^s)C^b \)

- Solving yields equilibrium prices and continuation values
- Equilibrium (no profitable deviations exist) for
  - \( \omega^s C^b - (1 - \omega^s)C^s < p^{co*} < (1 - \omega^b)C^b - \omega^b C^s \)
Closing the model

- **Equilibrium prices in core & periphery are jointly determined**
  1. Equilibrium strategies in periphery ($\Sigma^*$) depend on $p^{co*}$ (outside option for connected dealers)
  2. Core market price $p^{co*}$ depends on the net aggregate inventory of connected dealers who do not find a match in the peripheral market ($\Delta^*(\Sigma^*(p^{co*}))) \Rightarrow$ depends on equilibrium strategies in the peripheral market ($\Sigma^*$).

- **Equilibrium is a fixed point such that $p^{co*}$ and $\Sigma^*$ are consistent:**
  \[ p^{co*} = p^{co}(\Sigma^*(p^{co*})) \].
Equilibrium regimes (entries = “targets”)  

<table>
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<tr>
<th>Regime</th>
<th>Buyer</th>
<th>Seller</th>
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</thead>
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<tr>
<td></td>
<td>unconn.</td>
<td>conn.</td>
</tr>
<tr>
<td>ACD</td>
<td>U &amp; C</td>
<td>U</td>
</tr>
<tr>
<td>ICB (z_0^{pe} \ll 0 \ll z_0^{co})</td>
<td>U &amp; C</td>
<td>Core</td>
</tr>
<tr>
<td>ICS (z_0^{pe} \gg 0 \gg z_0^{co})</td>
<td>U</td>
<td>U</td>
</tr>
</tbody>
</table>

▶ **Intuition for ICB (“Inactive connected buyers”) regime**

1. \(z_0^{pe} \ll 0\): Large excess of buyers in the peripheral market →
2. \(z_0^{co} \gg 0\): \(p^{co*}\) is low (good for connected buyers)

▶ (1) and (2) → unconnected sellers choose offers that only attract unconnected buyers and reject any offer to trade at \(p^{co*}\) ⇒ Connected buyers prefer to trade only in the core market.
Peripheral market - equilibria

- Equilibria with high risk of rejection for unconnected dealers' offers become more likely as connectedness decreases ($\lambda$ increases).
Equilibrium prices

Periphery long: $\alpha^{pe} > 1/2$

\[
\Sigma = \sum^{ACD}
\]

\[p^c = p^c^s \quad p^u^b = p^c^s\]

\[
- C^s \quad p^c_b \quad p^u_s \quad p^u_b = p^c^s \quad C^b
\]

\[
\Sigma = \sum^{ICS}
\]

\[
- C^s \quad p^c_b = p^u_b \quad p^u^s \quad C^b
\]

Periphery short: $\alpha^{pe} < 1/2$

\[
\Sigma = \sum^{ACD}
\]

\[p^c^s \quad p^c_b = p^u_s \quad p^u_b \quad p^c_s \quad C^b
\]

\[
\Sigma = \sum^{ICB}
\]

\[p^c^s \quad p^u_b \quad p^c^s = p^u_s \quad C^b
\]
Bargaining power and connectedness

- If all dealers are connected ($\lambda = 0$) then all trades take place at the core market price $p^{co}$

- If there is heterogeneity in dealers’ connections ($\lambda > 0$).
  1. If there are more peripheral buyers than sellers ($z^{pe} < 0$) then all transaction in the peripheral markets take place at least at $p^{co}$ and some at a strictly higher price.
  2. If there are more peripheral sellers than buyers ($z^{pe} > 0$) then all transaction in the peripheral markets take place at most at $p^{co}$ and some at a strictly smaller price.
  3. In the two later cases, connected dealers on one side (say buyers) trade at better prices than unconnected dealers on the same side.

- $\iff$ Connectedness $\times$ Inventory Imbalance generates market power (connectedness alone is not sufficient).
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Markups and Connections

Let $\bar{p}^{i,j}$ be the average price between $i$ (seller) and $j$ (buyer) and $M^{i,j} = \bar{p}^{i,j} - p^{co*}$ (markup of peripheral prices relative to core dealers’ prices).

Implication.

$$M^{U,C} \leq M^{U,U} \leq M^{C,U} \leq 0 \quad \text{for} \quad z_0^{pe} > 0,$$

$$0 \leq M^{U,C} \leq M^{U,U} \leq M^{C,U} \quad \text{for} \quad z_0^{pe} < 0,$$

Thus

1. The sign of markups depends on $z_0^{pe}$ because it determines buyers’ market power relative to sellers.

2. Connectedness is another determinant of market power (consistent with DiMaggio et al. (2016)): Connected buyers (resp., sellers) obtain better prices than unconnected sellers (res., buyers).
Consider an increase in core dealers’ aggregate inventory \((z_{0}^{co} \uparrow)\) (e.g., a new treasury issue absorbed by primary dealers)

**Implication**

1. **Standard:** The core price declines: \(\frac{\partial p_{0}^{co}}{\partial z_{0}^{co}} < 0\).

2. **New:** The dispersion of prices in the peripheral market (measured by the difference between the highest and the lowest price observed in equilibrium):
   - Increase if \(z^{pe} < 0\)
   - Decrease if \(z^{pe} > 0\)

**Why?** Limited pass-through of change in prices in the core market to peripheral dealers’ prices.
Example

\begin{align*}
\alpha^c_0 & = -0.5 \\
0.5 & = p_{co}^* = p_s^U = p_b^C \\
1.0 & = p_{sp}^C \quad \text{or} \quad p_b^U
\end{align*}
Implication for Price Distributions

- Empiricists often collect prices over multiple days in OTC markets.
- Holding the fundamental value of the asset constant (0 in our model), price volatility of interdealer transaction prices reflects:
  1. Shocks to core and peripheral dealers’ positions.
  2. Dispersion in transaction prices due to heterogeneity in dealers’ connectedness.

- These two sources of variations for transaction prices induce deviations of the distribution of prices from the distribution of prices that would be obtained if trading was centralized.
Numerical Simulations

- We set:

\[ \alpha^{pe} = \bar{\alpha}^{pe} + \eta^{pe}, \]
\[ \alpha^{co} = \bar{\alpha}^{co} + \eta^{co}, \]

where \( \eta^{pe} \) and \( \eta^{co} \) have a normal distribution with zero mean and variance \( \sigma_{\eta}^2 \).

- We interpret \( \bar{\alpha}^{pe} \) and \( \bar{\alpha}^{co} \) as the structural positions of core and peripheral dealers.

  1. \( \eta^{pe} \) and \( \eta^{co} \) are daily shocks to these structural positions.
  2. We provide examples of markets in which \( \bar{\alpha}^{pe} \neq \bar{\alpha}^{co} \) (e.g., Treasury markets, FX, interest rates swaps, or central banks reserves in the euro area).

- We draw 1 million realizations of \( \eta^{pe} \) and \( \eta^{co} \) and report the histogram of prices at which transactions occur in the peripheral market across all simulations.
Parameter values: zero aggregate inventories in the peripheral and core markets; $\lambda = 0$ (Blue); $\lambda = 0.4$ (Red). ($\kappa = \infty$: core prices are identical when $\lambda = 0$ and $\lambda > 0$)

Panel A
Distribution of Equilibrium Prices

- **Parameter values:** Structural short position in the peripheral market ($\bar{\alpha}^{pe} < 0.5$)/ Long aggregate position in the core market ($\bar{\alpha}^{co} > 0.5$). $\lambda = 0$ (Blue); $\lambda = 0.4$ (Red). ($\kappa = \infty$: core prices are identical when $\lambda = 0$ and $\lambda > 0$)
## Connectedness and Price Volatility

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<th>λ</th>
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**Table 1:** This table reports the mean and the standard deviation of transaction prices in (a) the core market and (b) the peripheral market for different parameter values for (i) λ and (ii) \( \tilde{\alpha}^{pe} \) and \( \tilde{\alpha}^{co} \).
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We then consider the initial stage in which dealers trade with their clients in the DtC market. This endogenizes dealers’ initial position $z_{i0}$.

Extensions

1. Dealers are contacted by clients who buy or sell one unit of the asset. Clients have private valuations ($+L$ or $-L$) from holding the asset (with $L > Max\{C^s, C^b\}$ so that gains from trade with dealers exist).
2. Prices (bid and ask) between dealers and their clients are set by Nash bargaining. The value of a position for a dealer depends on his expected inventory holding cost, which is endogenous (ultimately depends on whether he can trade or not in the interdealer market).

Finding: Connected dealers charge smaller bid-ask spreads to their clients than unconnected dealers. Moreover, the difference in bid-ask spreads between the two types of dealers increase as the mass of dealers without connections increases.

Connections matter to understand trading costs in DtC markets.
Example

Bid-ask spread charged by unconnected dealers
Bid-ask spread charged by core dealers
Bid-ask spread charged by connected dealers
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Duffie (2012): “Some of the key research and policy issues regarding OTC markets include: [...] (ii) the manner in which the price negotiated on a particular trade reflects the relative degree of connectedness of the buyer and seller with the rest of the market [...] (iv) the influence of market structure on the cross-sectional dispersion of prices negotiated at a particular time [...] (in “Dark Markets: Asset Pricing and Information Transmission in Over the Counter Markets”)

- Our results show how relative connectedness:
  1. Matters in price negotiations (better connected dealers obtain better prices both with clients and other dealers)
  2. Affects the dispersion of prices beyond and above the dispersion coming from aggregate inventory shocks (is a cause of volatility even when trading is centralized).