Improving the Efficiency of Over-the-Counter Financial Markets

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Drawing from recent work with Piotr Dworczak, Chaojun Wang, and Haoxiang Zhu

Disclosure of potential conflicts of interest at www.darrellduffie.com
Market design concerns: the role of search, bargaining, and network structure.

Entry, search, and matching: the welfare role of price transparency and benchmarks (with Dworczak and Zhu).

Bilateral contracting efficiency in network bargaining markets (with Wang).
Search and bargain over trades
Or request a quote from a dealer
With the outside option to search

Duffie, Gărleanu, Pedersen (2007)
Request quotes from several dealers
But only one at a time in bilateral OTC markets

Zhu (2013)
Dealers lay off risk with other clients and dealers

Dealers also transact via inter-dealer platforms
Dealers are increasingly agents, not principals
Some dealers sell more immediacy, for a price

Li and Schürhoff (2013)
Request quotes at a multilateral trading platform
Fragmenting trade across platforms

Babus and Parlatore (2015)
Reducing fragmentation improves competition
Corporate bond platform
More dealers lower buyside trade costs

Source: Hendershott and Madhavan (2014)
Two-tiered OTC markets

Diagram showing connections between different nodes and markets (MTP1, MTP2, MTP3, IDB) with labeled points (c1, c2, d1, d2, d3, c3, c5, c6, c7).
All-to-all central-limit-order-book platforms
Emergence of all-to-all treasuries trade platforms
Significant disintermediation of dealers

Source: Fleming (2014) (BrokerTec data)
At treasury all-to-all trade platforms
Bid-ask spreads are narrow and stable

Source: Adrian, Fleming, Stackman, and Vogt (2015) (BrokerTec data)
At treasury all-to-all trade platforms
Trade size has declined over time

Source: Adrian, Fleming, Stackman, and Vogt (2015) (BrokerTec data)
FX all-to-all platforms bring in non-dealer trade

![Daily trade volume (billions of USD)](chart)

Source: Rime and Schrimpf (2014) (BIS data)
Combined use of exchange and OTC markets

Default risk treated by central counterparties
Welfare Roles of OTC Price Transparency
(from research with Dworczak and Zhu)

1. Increasing the volume of beneficial trade through:
   - Signaling when there are high gains from trade.
   - Improving the share of gains offered to non-dealers.

2. Reducing total search costs.

3. Facilitating more efficient trade matching between dealers and non-dealers, through:
   - Improving the ability of non-dealers to detect when quotes are from high-cost dealers.
   - Strategic transparency commitment by lower-cost dealers.
Popular over-the-counter price benchmarks

- LIBOR, EURIBOR, TIBOR, ...
- WM/Reuters foreign exchange fixings.
- Gold, Silver, Palladium, Platinum, ...
- Oil (Brent, WTI), Natural Gas, Iron Ore (IODEX), ...
- Pharmaceuticals (Average Wholesale Price).
Key benchmark functions

1. Contractibility for price-contingent claims.


3. Pre-trade price transparency: allowing easier comparison shopping in OTC markets.
### Selected LIBOR and EURIBOR dependencies

(amounts in billions of USD equivalent notional)

<table>
<thead>
<tr>
<th></th>
<th>U.S.</th>
<th>LIBOR fraction</th>
<th>Eurozone</th>
<th>EURIBOR fraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syndicated loans</td>
<td>3400</td>
<td>97%</td>
<td>535</td>
<td>90%</td>
</tr>
<tr>
<td>Bilateral corporate loans</td>
<td>1650</td>
<td>≈40%</td>
<td>4322</td>
<td>60%</td>
</tr>
<tr>
<td>Retail mortgages</td>
<td>9608</td>
<td>15%</td>
<td>5073</td>
<td>28%</td>
</tr>
<tr>
<td>Floating rate notes</td>
<td>1470</td>
<td>84%</td>
<td>2645</td>
<td>70%</td>
</tr>
<tr>
<td>Interest rate swaps</td>
<td>106700</td>
<td>65%</td>
<td>137553</td>
<td>high</td>
</tr>
<tr>
<td>Exchange-traded derivatives</td>
<td>32900</td>
<td>93%</td>
<td>17300</td>
<td>100%</td>
</tr>
</tbody>
</table>

A sample of research on OTC price transparency


Price benchmark transparency

The cost of dealer $i$ is $c_i = c + \epsilon_i$, where $c$ is common, $\epsilon_i$ is idiosyncratic.

There is a benchmark if the common cost component $c$ is published.

The quote $p_i$ of dealer $i$ has an equilibrium probability distribution $F$ that depends on $c$ and $\epsilon_i$, and whether there is a benchmark.

The payoff of dealer $i$ is $(p_i - c_i)Q_i$, where $Q_i$ is the total volume of trades.
All traders value the asset at some constant value $v$.

A fraction $\mu$ of traders are “fast,” that is, have no search cost.

In this example, the payoff of the fast trader is $v - 1.7$. 
A feasible search path of an entering slow trader

Slow traders visit dealer trade platforms in random order, facing a Pandora Problem, solved by Weitzman (1979).

enter \( (s) \) \[ \rightarrow \] 2.1 \[ \overset{s}{\rightarrow} \] 1.9 \[ \overset{s}{\rightarrow} \] 2.2 \[ \overset{s}{\leftarrow} \] 1.7 \[ \rightarrow \] 2.3

The net payoff of this path is \( v - 1.9 - 3s \)
Equilibrium search with a benchmark

Enter with a probability $\lambda_c$ that depends on the observed benchmark $c$.

Immediately accept the first offer below an optimal reservation price $r_c$.

The net payoff of this path is $v - 1.9 - 2s$.

In equilibrium, dealer quotes are mixed-strategy and all below $r_c$, so the first dealer’s offer is accepted.
Equilibrium search with no benchmark

Enter with probability $\lambda$.

Accept the offer on the first platform visited if it is below $v$.

Then exit.

Because $v < 2.1$, this path has net payoff $-s$. 
Welfare effect of pre-trade benchmark transparency

Under conditions given in Duffie, Dworczak, and Zhu (2015):

▶ Adding a benchmark generates a greater quantity of beneficial trades. (Dealers may or may not prefer this.)

▶ Adding a benchmark improves matching efficiency.

▶ Lower-cost dealers will introduce a benchmark to gain market share.
Bilateral Contracting Efficiency in OTC Markets
(from research with Chaojun Wang)

Firm 1

\( s_1 \in C_1(s_2) \)

\( s_2 \in S_2 \)

Firm 2

\( s_2 \in S_2 \)

\( s_3 \in C_3(s_2) \)

Firm 3

Utilities

\( f_1(s_1, s_2) + y_1 \)

\( f_2(s_1, s_2, s_3) - y_1 - y_3 \)

\( f_3(s_2, s_3) + y_3 \)
Example: Selection of Creditor Seniority

Firm 1  $s_1 \equiv 0$

Firm 2  $s_2 \in \{1, 3, b\}$

Firm 3  $s_3 \equiv 0$

\[
\begin{align*}
  f_1(0, b, 0) &= -3 & f_2(0, b, 0) &= 0 & f_3(0, b, 0) &= 0 \\
  f_1(0, 1, 0) &= 6 & f_2(0, 1, 0) &= 0 & f_3(0, 1, 0) &= -3 \\
  f_1(0, 3, 0) &= -6 & f_2(0, 3, 0) &= 0 & f_3(0, 3, 0) &= 3
\end{align*}
\]
Example: Selection of Creditor Seniority

\[ s_1 \equiv 0 \quad y_1 \quad s_2 \in \{1, 3, b\} \quad y_3 \quad s_3 \equiv 0 \]

\[ f_1(0, b, 0) = -3 \quad f_2(0, b, 0) = 0 \quad f_3(0, b, 0) = 0 \]
\[ f_1(0, 1, 0) = 6 \quad f_2(0, 1, 0) = 0 \quad f_3(0, 1, 0) = -3 \]
\[ f_1(0, 3, 0) = -6 \quad f_2(0, 3, 0) = 0 \quad f_3(0, 3, 0) = 3 \]

Equilibrium solution: \( s_2^* = 1, \quad y_1 = -5, \quad y_3 = 4. \)
Outside and Breakdown Options

- A given status quo \((s^0, y^0)\) has zero utilities.

- If bargaining between Nodes 1 and 2 break down, the action of Node 1 is \(s^0_1\). Nodes 2 and 3 choose from \(S_{2,3}^B\).

- Likewise, if Nodes 2 and 3 break down, the action of Node 3 is \(s^0_3\). Nodes 1 and 2 choose from \(S_{1,2}^B\).

- Conditions on \(S_{2,3}^B\) and \(S_{1,2}^B\).
The Efficient Outcome $s^{**}$

$$(s_1^{**}, s_2^{**}, s_3^{**}) = \arg\max_{s_2 \in S_2} U(s_1, s_2, s_3),$$

where

$$U(s_1, s_2, s_3) = f_1(s_1, s_2) + f_2(s_1, s_2, s_3) + f_3(s_2, s_3).$$
Some prior work on non-cooperative bilateral bargaining in network markets

- Stole and Zwiebel (1996) de Fontenay and Gans (2013) provide equilibrium models of bilateral, non-enforceable, non-contingent contracts, with Myerson-Shapley outcome values.

- Björnerstedt and Stennek (2007) show bilateral efficiency in upstream-downstream goods markets, with Walrasian allocations under substitution assumptions.

Network bargaining problems

A network bargaining problem \((G, S, C, f, u)\) consists of:

- A finite undirected graph \(G = (V, E)\).
- For each agent \(i\) in \(V\), a finite set \(S_i\) of actions.
- For each edge \((i, j)\), a set \(C_{ij} \subset S_i \times S_j\) of pairwise-compatible actions.
- For each agent \(i\), a utility \(f_i : S \rightarrow \mathbb{R}\) that depends only on \(s_i\) and on \(s_j\) for directly connected \(j\).
- For each agent \(i\), an outside option value \(u_i\).
Network Bargaining Solutions

- An outcome of a network bargaining problem \((G, S, C, f, u)\) consists of a compatible action vector \(s\) and a payment function \(y : E \rightarrow \mathbb{R}\) with \(y_{ij} = -y_{ji}\).

- The total utility of node \(i\) for outcome \((s, y)\) is

\[
    u_i(s, y) = f_i(s) + \sum_{\{j : (i, j) \in E\}} y_{ji}.
\]

- A solution of network bargaining problems is a function that maps each problem \((G, S, C, f, u)\) to an outcome \((s, y)\).

- We propose a set of solution axioms motivated by bilateral bargaining behavior (e.g. Nash) implying a unique solution, which is efficient.
Rubinstein non-cooperative bilateral bargaining

firm 1 proposes $s$.

firm 2 accepts $s$ if $s > s^0$.

firm 2 rejects $s$.

nature proposes $s'$.

firm 2 proposes $s'$ if $s' > s^0$.

firm 1 accepts $s'$ if $s' > s^0$.

firm 1 rejects $s'$.
Final result

\[
(s_1(s_{2,3}), s_{2,3}; y_1(s_{2,3}), y_3)
\]

absent breakdown

breakdown treatments and payments

Nodes 1 and 2 in Stage $a'$
bargain over payment $y_1$
contingent on Stage $b$ outcome

Nodes 2 and 3 in Stage $b'$
bargain over payment $y_3$

Nodes 1 and 2 in Stage $a$
bargain over treatment $s_1$
contingent on Stage $b$ outcome

Nodes 2 and 3 in Stage $b$
bargain over treatments $s_{2,3} = (s_2, s_3)$
Equilibrium Solution Concept

We adjust the notion of trembling hand perfect equilibria by requiring:

- Minimum tremble probabilities do not depend on strategically irrelevant information.

- Any costly deviation by a player is less likely than a lower-cost deviation by the same or another player [Milgrom and Mollner (2014)].
Efficiency of contingent bilateral bargaining

**Theorem.** For each sufficiently small breakdown probability $\eta$:

- The network bargaining game $(\eta, S, C, f, s^0)$ has a unique strategy profile that is extensive-form trembling-hand perfect in behavioral strategies.

- This equilibrium is in pure strategies.

- The unique associated actions are the efficient actions $s^{**}$.

- As $\eta \rightarrow 0$, these equilibrium utilities and payments converge to the associated axiomatic solution $(s^{**}, y^a)$. 