Improving the Efficiency of Over-the-Counter Financial Markets

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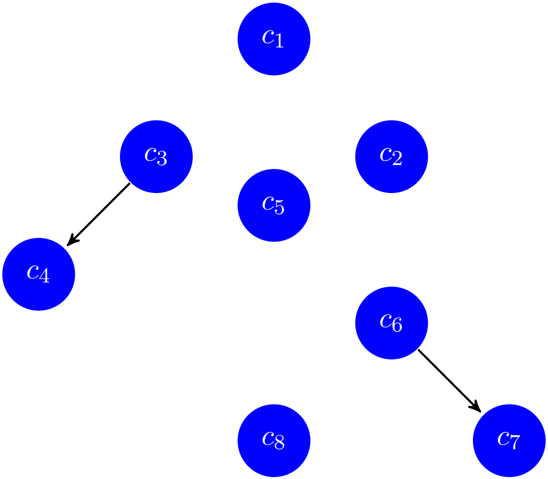
Drawing from recent work with Piotr Dworczak, Chaojun Wang, and Haoxiang Zhu

Disclosure of potential conflicts of interest at www.darrellduffie.com

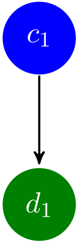
Outline

- 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).

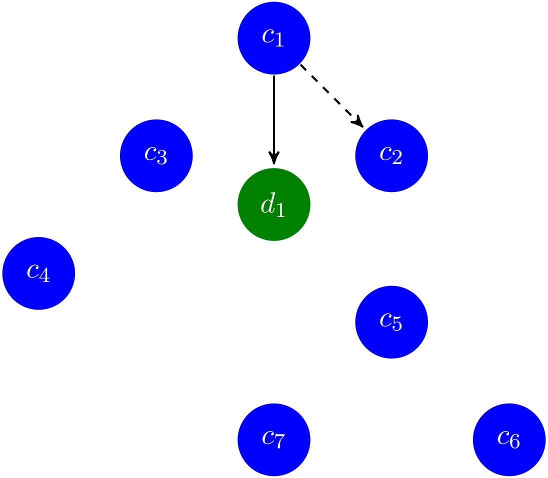
Search and bargain over trades



Or request a quote from a dealer

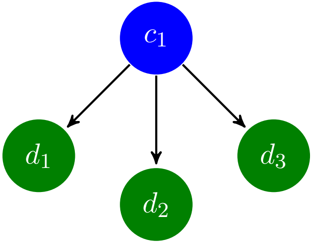


With the outside option to search

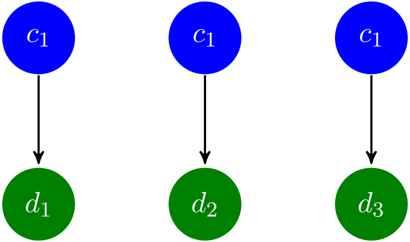


Duffie, Gârleanu, Pedersen (2007)

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

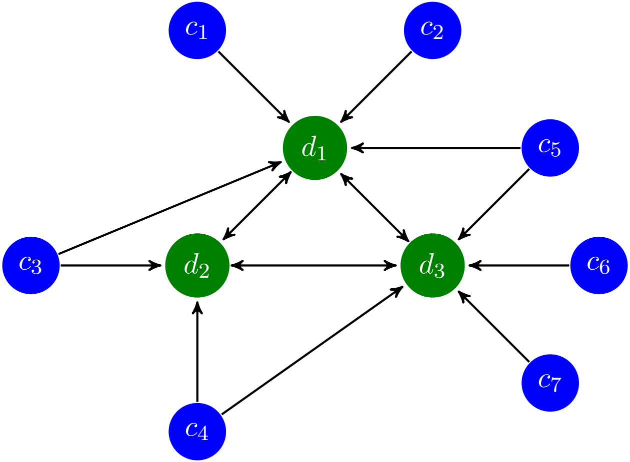
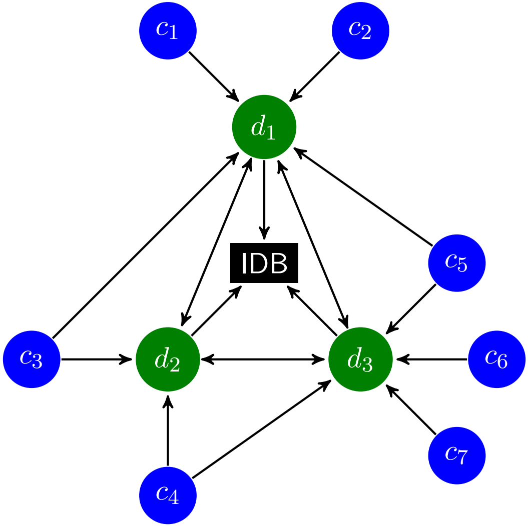
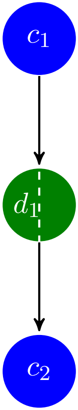


Figure: Core-periphery OTC markets. Examples: Farboodi (2014), Afonso, Kovner, and Schoar (2014), Hugonnier, Lester, and Weill (2015), Chang and Zhang (2015), Wang (2015), Shen, Wei, Yan (2015), Uslu (2015)

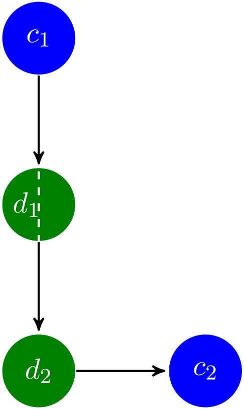
Dealers also transact via inter-dealer platforms



Dealers are increasingly agents, not principals

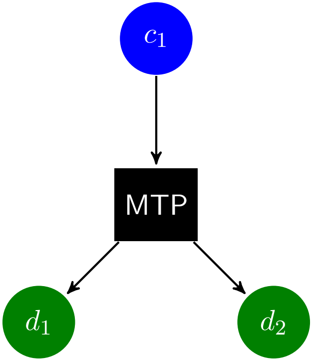


Some dealers sell more immediacy, for a price

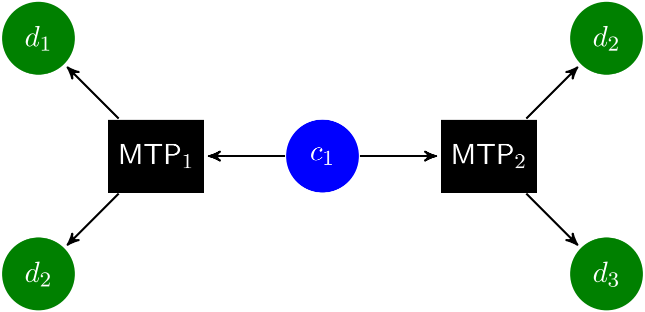


Li and Schürhoff (2013)

Request quotes at a multilateral trading platform

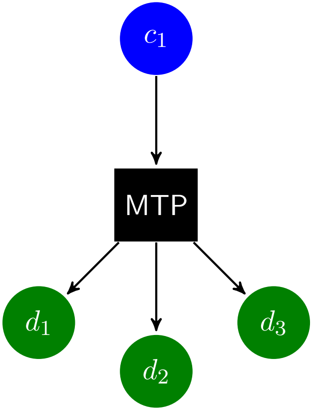


Fragmenting trade across platforms

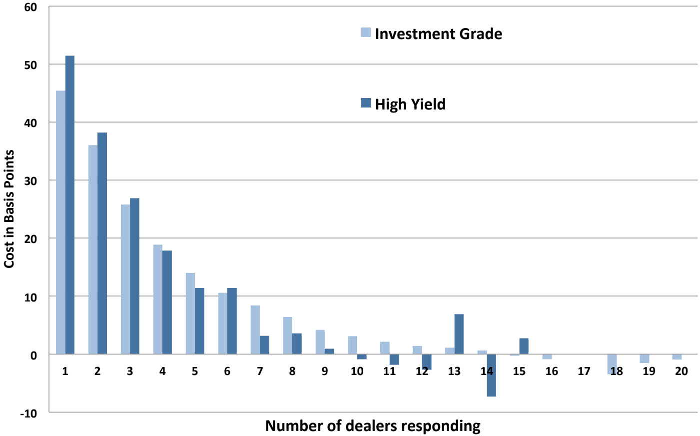


Babus and Parlatore (2015)

Reducing fragmentation improves competition

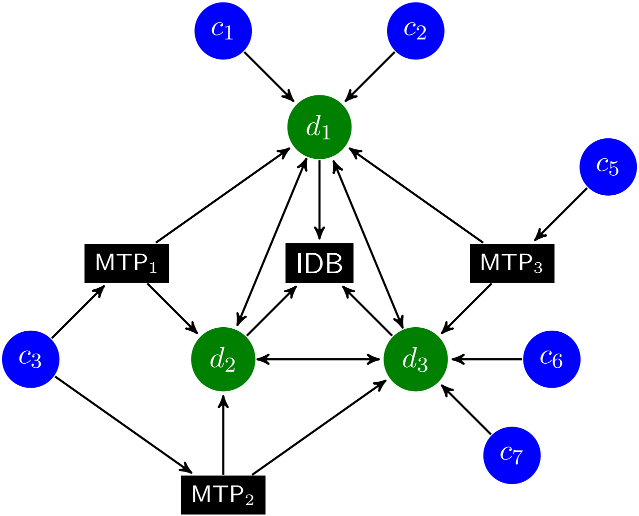


Corporate bond platform
More dealers lower buyside trade costs

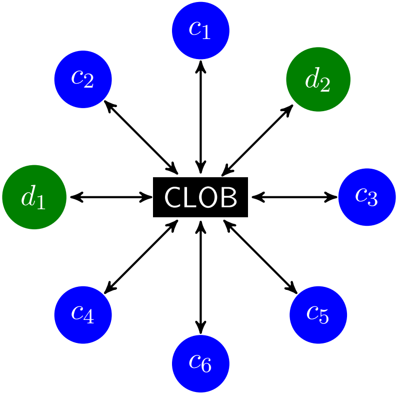


Source: Hendershott and Madhavan (2014)

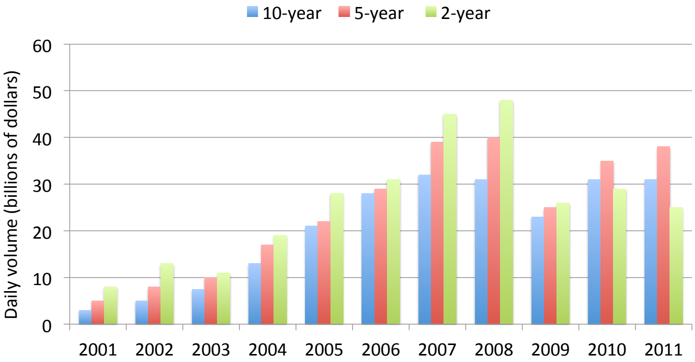
Two-tiered OTC markets



All-to-all central-limit-order-book platforms

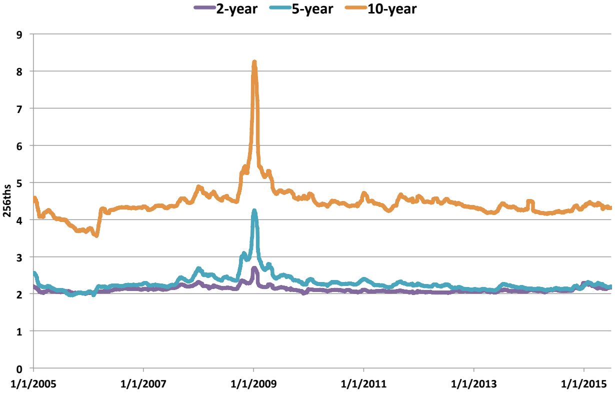


Emergence of all-to-all treasuries trade platforms
Significant disintermediation of dealers



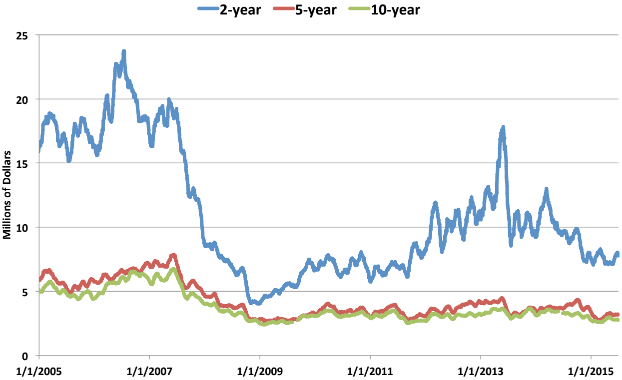
Source: Fleming (2014) (BrokerTec data)

At treasury all-to-all trade platforms Bid-ask spreads are narrow and stable



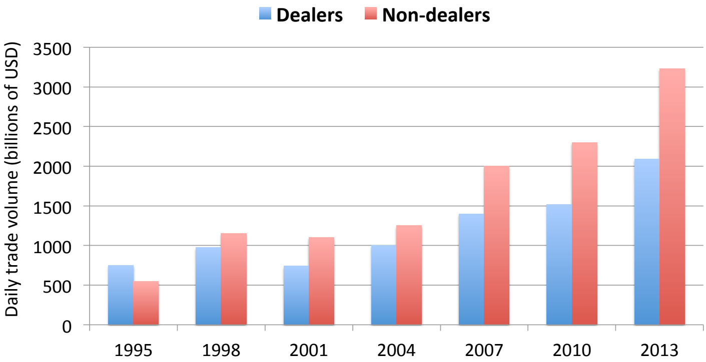
Source: Adrian, Fleming, Stackman, and Vogt (2015) (BrokerTec data)

At treasury all-to-all trade platforms Trade size has declined over time



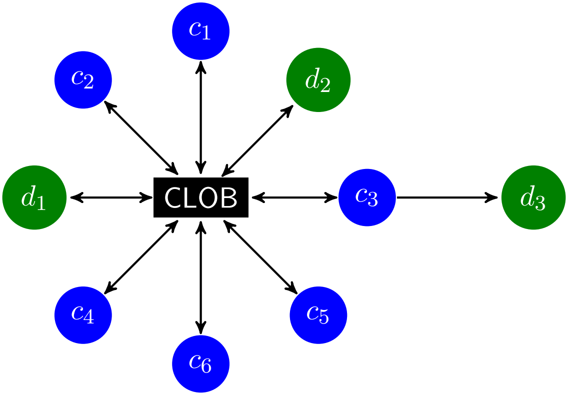
Source: Adrian, Fleming, Stackman, and Vogt (2015) (BrokerTec data)

FX all-to-all platforms bring in non-dealer trade



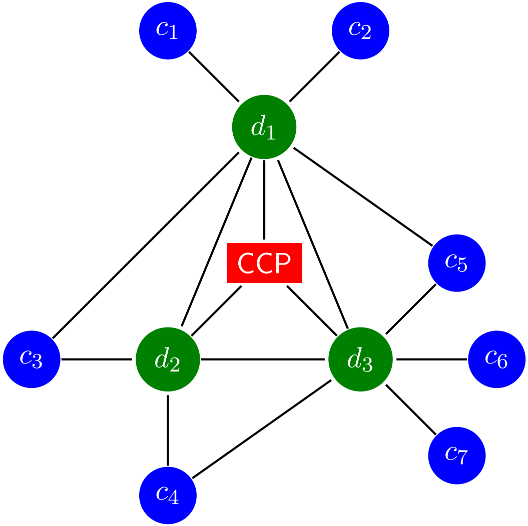
Source: Rime and Schrimpf (2014) (BIS data)

Combined use of exchange and OTC markets



Hendershott and Madhavan (2014), Duffie and Zhu (2015)

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.
2. Monitoring agent-based trade execution.
3. Pre-trade price transparency: allowing easier comparison shopping in OTC markets.

Selected LIBOR and EURIBOR dependencies

(amounts in billions of USD equivalent notional)

	U.S.	LIBOR fraction	Eurozone	EURIBOR fraction
Syndicated loans	3400	97%	535	90%
Bilateral corporate loans	1650	$\simeq$40%	4322	60%
Retail mortgages	9608	15%	5073	28%
Floating rate notes	1470	84%	2645	70%
Interest rate swaps	106700	65%	137553	high
Exchange-traded derivatives	32900	93%	17300	100%

Source: Market Participant Group Report (2014)

A sample of research on OTC price transparency

- *Theory:* Benabou and Gertner (1993), Madhavan (1995), Pagano and Roell (1996), Janssen, Pichler, and Weidenholzer (2011), Duffie, Manso, Malamud (2014), Janssen, Parakhonyak, and Parakhonyak (2015).
- *Empirical:* Impact of TRACE post-trade price transparency in corporate bond markets: Bessembinder, Maxwell, and Venkataraman (2006), Edwards, Harris, and Piwowar (2007), Goldstein, Hotchkiss, and Sirri (2007), Bessembinder and Maxwell (2008), Green, Hollifield, and Schürhoff (2007), Asquith, Covert, and Pathak (2013).

Price benchmark transparency

The cost of dealer i is $c_i = c + \epsilon_i$, where c is common, ϵ_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 ϵ_i, and whether there is a benchmark.

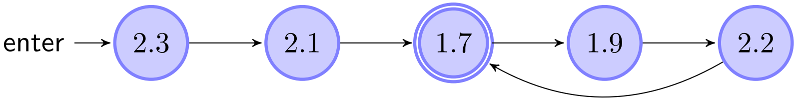
$2.1 \quad 1.9 \quad 2.2 \quad 1.7 \quad 2.3$

The payoff of dealer i is $(p_i - c_i)Q_i$, where Q_i is the total volume of trades.

Fast traders pick the best offer

All traders value the asset at some constant value v.

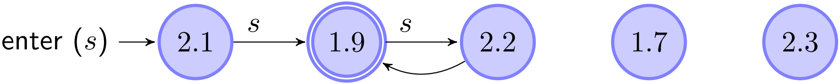
A fraction μ of traders are "fast," that is, have no search cost.



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).

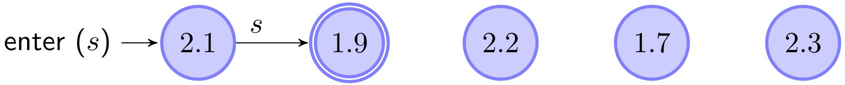


The net payoff of this path is $v - 1.9 - 3s$

Equilibrium search with a benchmark

Enter with a probability λ_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 λ.

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)

$$\begin{tikzcd} \text{Firm 1} & \text{Firm 2} & \text{Firm 3} \\ \boxed{s_1 \in C_1(s_2)} & \boxed{s_2 \in S_2} \arrow[l, "y_1"'] \arrow[r, "y_3"] & \boxed{s_3 \in C_3(s_2)} \end{tikzcd}$$

Utilities

$f_1(s_1, s_2) + y_1$ $\quad\quad$ $f_2(s_1, s_2, s_3) - y_1 - y_3$ $\quad\quad$ $f_3(s_2, s_3) + y_3$

Example: Selection of Creditor Seniority

Firm 1   Firm 2   Firm 3

$$\boxed{s_1 \equiv 0} \xleftarrow{\quad y_1 \quad} \boxed{s_2 \in \{1, 3, b\}} \xrightarrow{\quad y_3 \quad} \boxed{s_3 \equiv 0}$$

$f_1(0, b, 0) = -3$	$f_2(0, b, 0) = 0$	$f_3(0, b, 0) = 0$
$f_1(0, 1, 0) = 6$	$f_2(0, 1, 0) = 0$	$f_3(0, 1, 0) = -3$
$f_1(0, 3, 0) = -6$	$f_2(0, 3, 0) = 0$	$f_3(0, 3, 0) = 3$

Example: Selection of Creditor Seniority

Firm 1 | Firm 2 | Firm 3

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$f_1(0, 3, 0) = -6$ $\qquad$ $f_2(0, 3, 0) = 0$ $\qquad$ $f_3(0, 3, 0) = 3$

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_1^0. Nodes 2 and 3 choose from $\mathcal{S}_{2,3}^B$.
- Likewise, if Nodes 2 and 3 break down, the action of Node 3 is s_3^0. Nodes 1 and 2 choose from $\mathcal{S}_{1,2}^B$.
- Conditions on $\mathcal{S}_{2,3}^B$ and $\mathcal{S}_{1,2}^B$.

The Efficient Outcome s^{**}

$$(s_1^{**}, s_2^{**}, s_3^{**}) = \operatorname{argmax}_{\substack{s_2 \in S_2 \\ s_1 \in C_1(s_2) \\ s_3 \in C_3(s_2)}} U(s_1, s_2, s_3),$$

where

$$U(s_1, s_2, s_3) = \quad f_1(s_1, s_2) + f_2(s_1, s_2, s_3) + f_3(s_2, s_3).$$

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.
- Navarro and Perea (2010) model pairwise bargaining, with Myerson outcome values.

Network bargaining problems

A *network bargaining problem* $(G, S, C, f, \underline{u})$ 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 $f_i : S \to \mathbb{R}$ that depends only on s_i and on s_j for directly connected j.
- For each agent i, an outside option value $\underline{u}_i$.

Network Bargaining Solutions

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

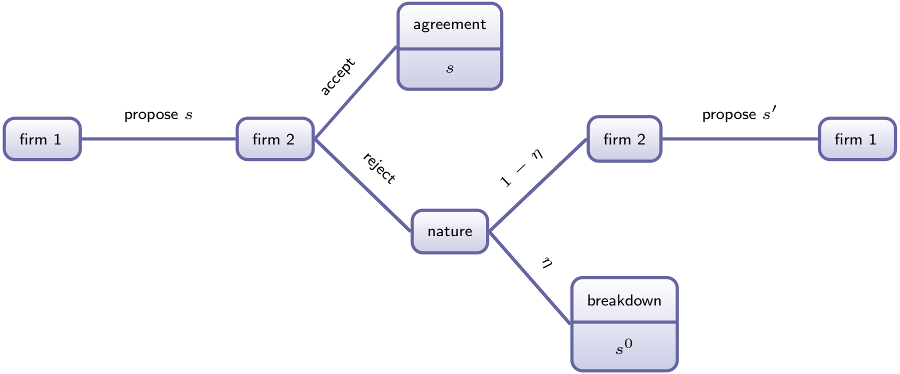
- The total utility of node i for outcome (s, y) is

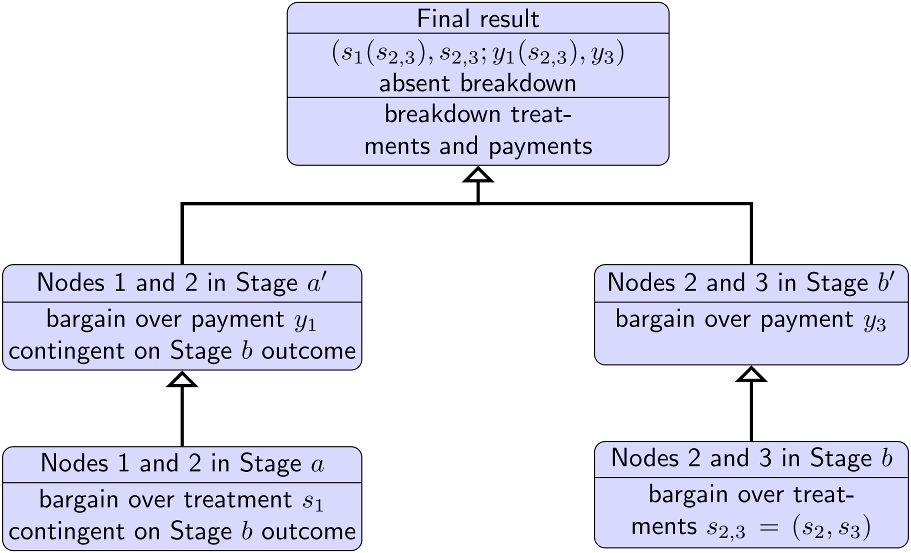
$$u_i(s, y) = f_i(s) + \sum_{\{j \colon (i,j) \in E\}} y_{ji}.$$

- A *solution* of network bargaining problems is a function that maps each problem $(G, S, C, f, \underline{u})$ 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




Final result
$(s_1(s_{2,3}), s_{2,3}; y_1(s_{2,3}), y_3)$
absent breakdown
breakdown treat-
ments 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 treat-
ments $s_{2,3} = (s_2, s_3)$

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 η:

- The network bargaining game (η, 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 $\eta \to 0$, these equilibrium utilities and payments converge to the associated axiomatic solution (s^{**}, y^a).