

# The Design and Efficiency of Over-the-Counter Markets

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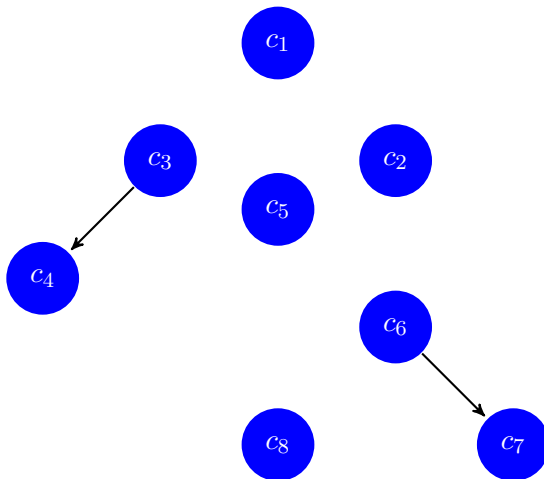
Drawing from recent work with Piotr Dworczak, Chaojun Wang, and  
Haoxiang Zhu

Disclosure of potential conflicts of interest at [www.darrellduffie.com](http://www.darrellduffie.com)

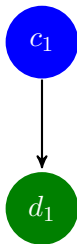
# Outline

- ▶ 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).

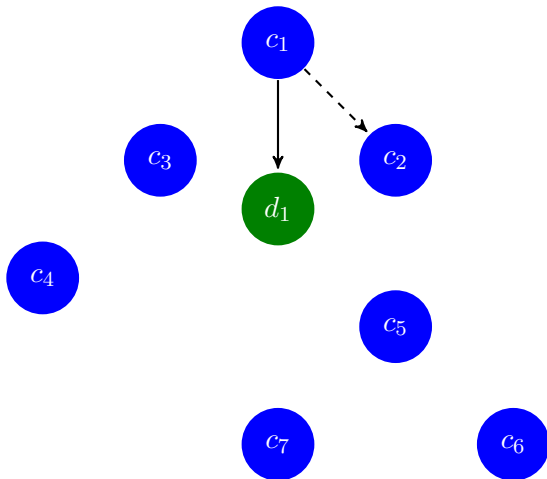
# Search and bargain over trades



Or request a quote from a dealer

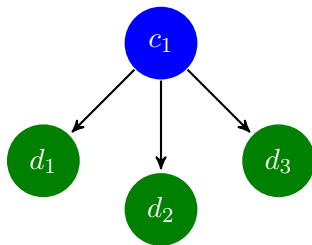


## With the outside option to search

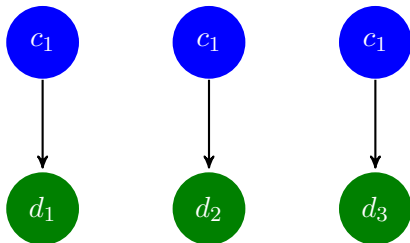


Duffie, Gârleanu, Pedersen (2007)

# Request quotes from several dealers

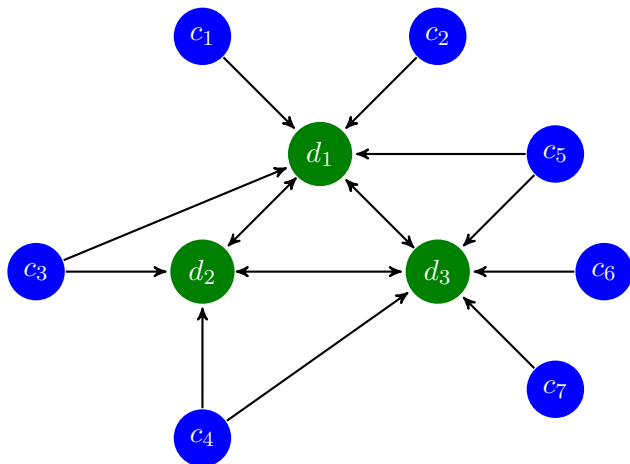


## But only one at a time in bilateral OTC markets



Zhu (2013)

## Dealers lay off risk with other clients and dealers

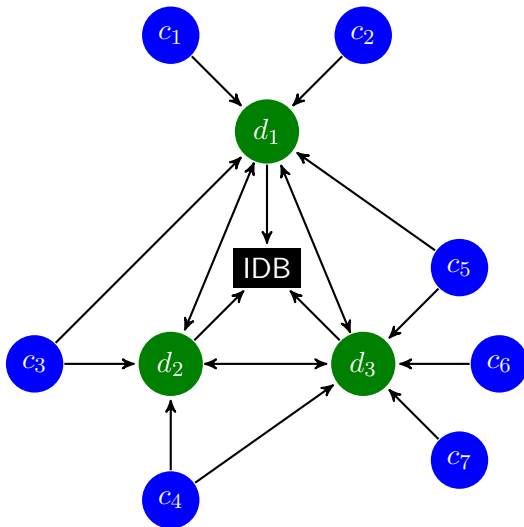


Farboodi (2014),

Chang and Zhang (2015), Wang (2015), Shen, Wei, Yan (2015)



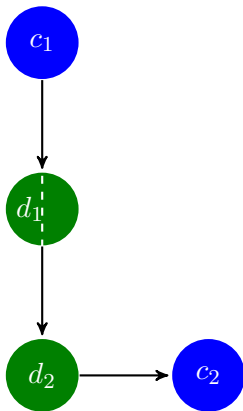
## Dealers also transact via inter-dealer platforms



# Dealers are increasingly agents, not principals

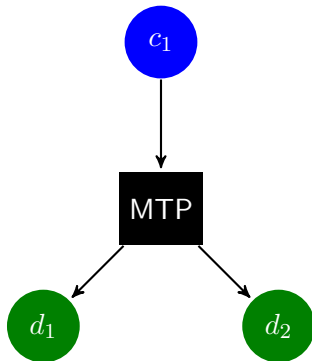


## Some dealers sell more immediacy, for a price

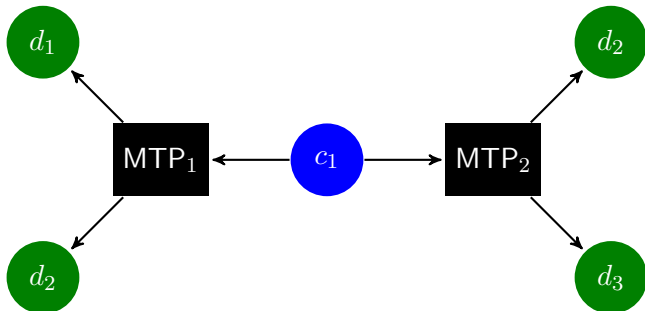


Li and Schürhoff (2013)

# Request quotes at a multilateral trading platform

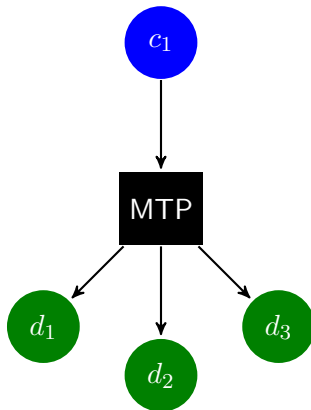


## Fragmenting trade across platforms



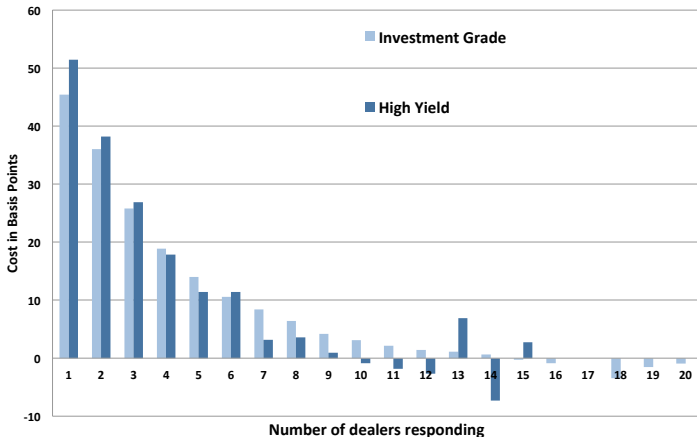
Babus and Parlato (2015)

# Reducing fragmentation improves competition



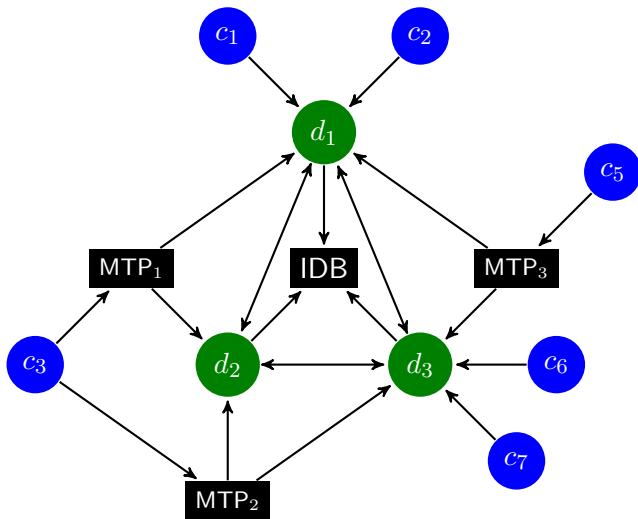
# Corporate bond platform

## More dealers lower buy-side trade costs



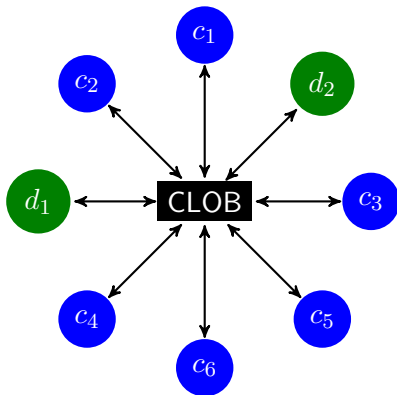
Source: Hendershott and Madhavan (2014)

## Two-tiered OTC markets



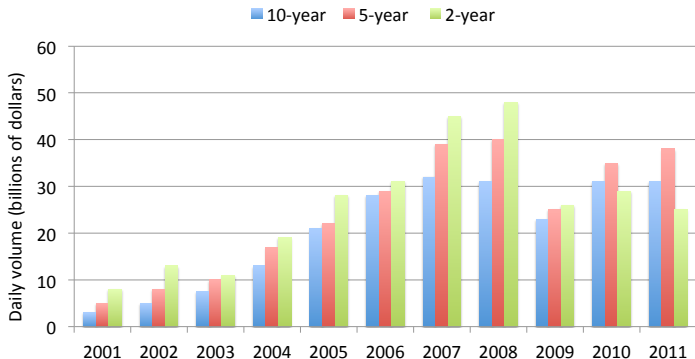


# All-to-all central-limit-order-book platforms



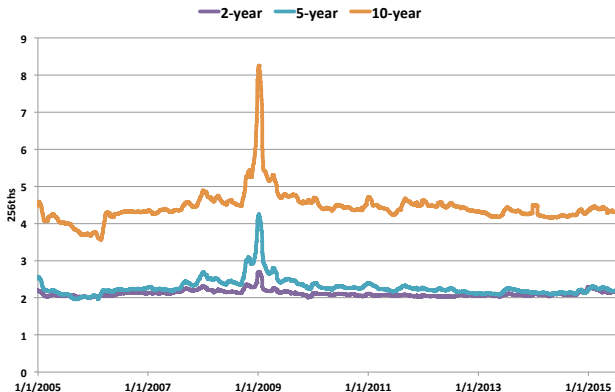
# Emergence of all-to-all treasuries trade platforms

## Significant disintermediation of dealers



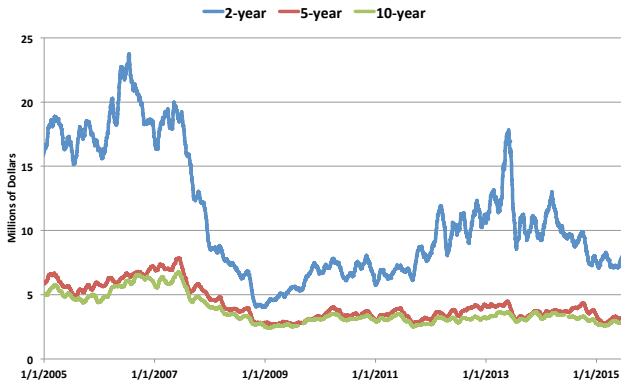
Source: Fleming (2014) (BrokerTec data)

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



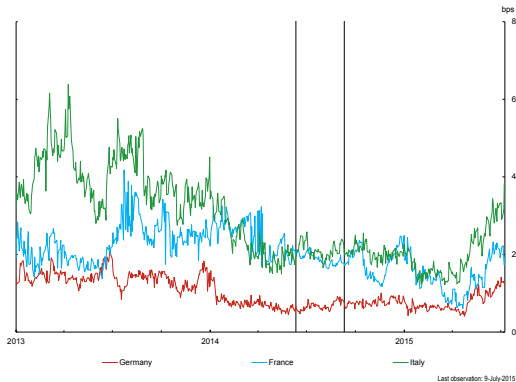
Source: Adrian, Fleming, Stackman, and Vogt (2015) (BrokerTec data)

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



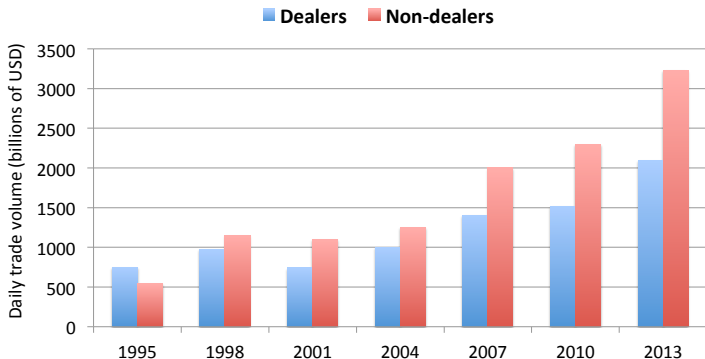
Source: Adrian, Fleming, Stackman, and Vogt (2015) (BrokerTec data)

# Dispersion shows recent illiquidity of OTC European sovereign bond markets



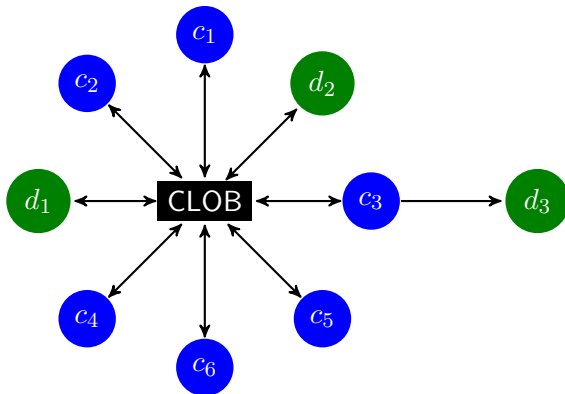
Source: Fontaine and Nolin (2015)

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



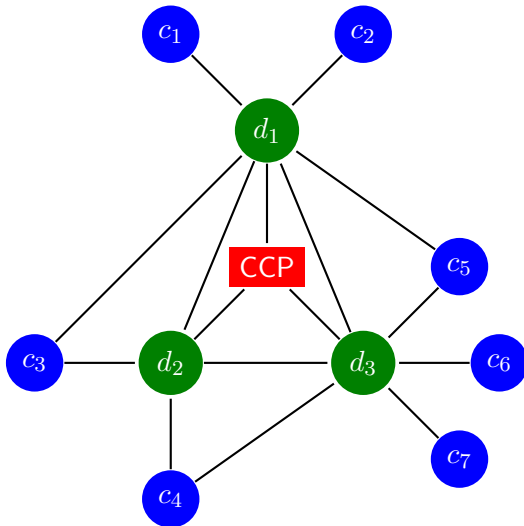
Source: Rime and Schrimpf (2014) (BIS data)

# 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	≈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,  $\epsilon_i$  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.

2.1

1.9

2.2

1.7

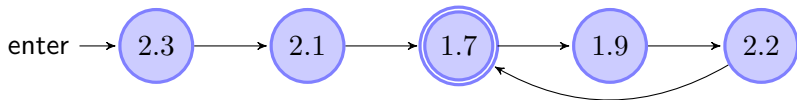
2.3

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  $v$ .

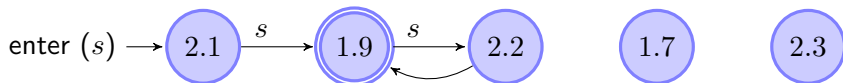
A fraction  $\mu$  of traders are “fast,” that is, have no search cost.



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).



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.



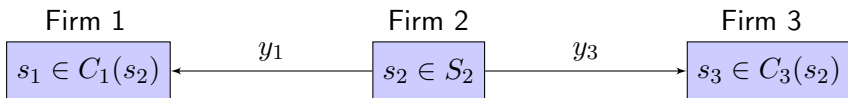
Because  $v < 2.1$ , this path has net payoff  $-s$ .

# 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)



Utilities

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

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

$$f_3(s_2, s_3) + y_3$$

# 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

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

## 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  $f_i : S \rightarrow \mathbb{R}$  that depends only on  $s_i$  and on  $s_j$  for directly connected  $j$ .
- ▶ For each agent  $i$ , an outside option value  $\underline{u}_i$ .



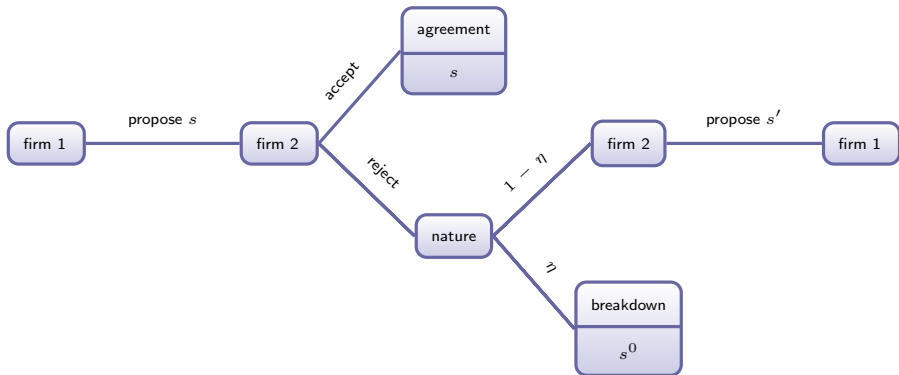
## Network Bargaining Solutions

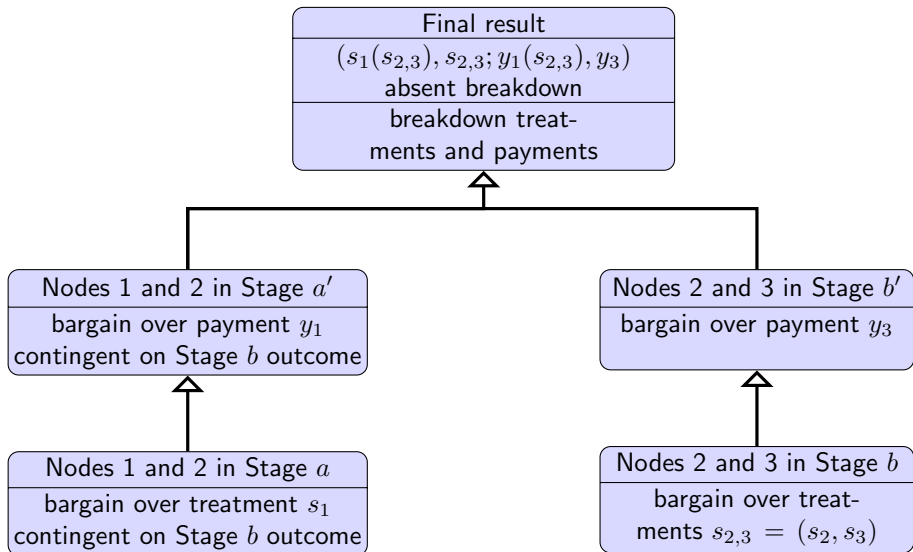
- ▶ An *outcome* of a network bargaining problem  $(G, S, C, f, \underline{u})$  consists of a compatible action vector  $s$  and a payment function  $y : E \rightarrow \mathbb{R}$  with  $y_{ij} = -y_{ji}$ .
- ▶ The total utility of node  $i$  for outcome  $(s, y)$  is

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

- ▶ 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





# 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  $(s^{**}, y^a)$ .