Information Spillovers in Asset Markets with Correlated Values

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April 2016

Big Picture

The availability of information and the degree to which it is incorporated into prices are central to our understanding of asset markets.

This paper: focus on transaction data in decentralized markets.

Motivation

In many decentralized markets, values are positively correlated.

- Houses in the same neighborhood.
- Startups in the same sector.
- ABS with the same underlying collateral.
- Corporate bonds with different maturities.

Therefore, if traders have asymmetric information,

- A trade of one asset (or lack thereof) can provide information about the value of other assets, which can in turn influence trading behavior...

We refer to this as an **information spillover**

Questions

- How do information spillovers affect trade and efficiency in decentralized markets?
- Can a transparent (but decentralized) market effectively aggregate information?
- What happens when regulation "levels the playing field" between dealers and investors?

Main results

- Multiple equilibria: when correlation and transparency are high
    - Best: high volume, lots of information, and high welfare
    - Worst: low volume, little information, and low welfare
- Welfare: a fully transparent marketplace is better than a fully opaque one but the effect can be non-monotonic.
- Information: is not necessarily aggregated as the number of informed traders becomes arbitrarily large.
- Leveling the playing field: reduces dealer profits, helps “naive” investors, rational investors are no better off, and total surplus may decrease.

Empirical/Policy Relevance

Mixed Empirical Findings on TRACE:

- Positive effects: Bessembinder et al. (2006), Edwards et al. (2007).
- Inconclusive: Goldstein et al. (2007).
- Mixed/Negative: Asquith et al. (2013).
  - Found a significant decline in trading activity for high-yield bonds.

Policy Debate on Mandatory Transaction Transparency:

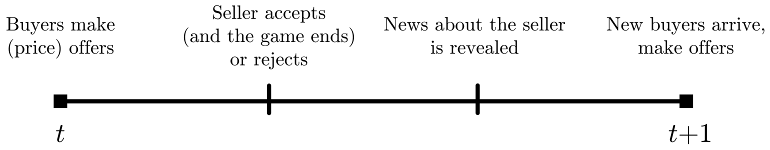
- Regulators (e.g., FINRA) are strong proponents of mandated transparency to "create a level playing field for all investors".
- Opponents (e.g., Bond Market Association) argue it is unnecessary and potentially harmful.
  - Reduce dealer margins and liquidity
  - Likely to be exacerbated for lower-rated bonds

Related literature

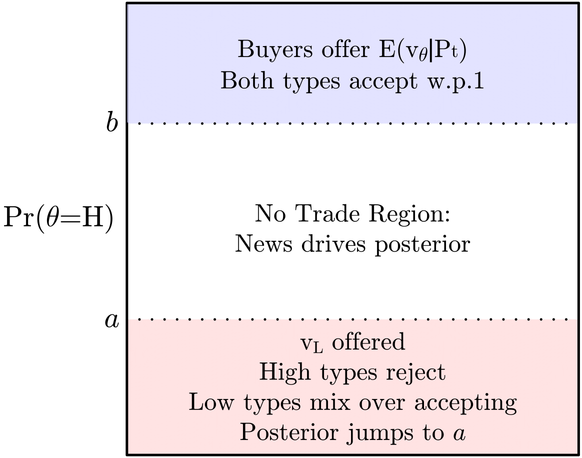
- **Dynamic Adverse Selection:** Nöldeke and Van Damme (1990), Swinkels (1999), Janssen and Roy (2002), Hörner and Vielle (2009), Fuchs and Skrzypacz (2014), Fuchs, Öry and Skrzypacz (2015).
  - **with "news":** Daley and Green (2012, 2016), Kaya and Kim (2015), Drugov (2010, 2015).
- **Information Aggregation:** Grossman (1976), Wilson (1977) , Milgrom (1979), Pesendorfer and Swinkels (1997), Kremer (2002), Ostrovsky (2012), Lauermann and Wolinsky (2013,15), Siga (2013), Axelson and Makarov (2015).
- **Related Ideas:** Cespa and Vives (2015), Duffie et al. (2014).

Benchmark: Daley and Green (2012)

- A single privately-informed seller
  - Asset either of high or low value $\theta \in \{L, H\}$
- Competitive investors
  - Common knowledge of gains from trade: $v_\theta > c_\theta$
  - Lemons condition: $v_L < c_H$
- "News" about θ revealed over time



Equilibrium: Daley and Green (2012)



Benchmark: Daley and Green (2012)

Key Result: Unique equilibrium features a "fully illiquid" region

- Buyer's make non-serious offers that are rejected w.p.1
- No trade period ends after sufficient good or bad news

One Implication: More information can actually decrease efficiency

- More news $\implies$ more incentive to wait $\implies$ size of illiquid region increases.

Implications for prices and liquidity: Daley and Green (2016)

- Liquidity endogenously varies over time
- No trade region $\implies$ illiquidity discount and excess volatility

This Paper

The distribution of "news" is endogenously determined by trading behavior of other sellers.

Key differences with endogenous news:

1. Multiple equilibria
2. But none of them have periods of no trade
   - No trade $\implies$ no news, but then nothing to wait for.

Outline

1. Basic setup
2. Equilibrium
3. Welfare
4. Many assets and information aggregation
5. Asymmetric buyers and leveling the playing field
6. Conclude

Basic setup: 2 x 2 x 2

Two trading dates, two sellers, two types of assets.

- Seller $i \in \{A, B\}$ owns one indivisible asset and is privately informed of her asset's type, denoted by $\theta_i \in \{L, H\}$, where $\pi = \Pr(\theta_i = H)$.
- Trade takes place on different platforms or markets.
  - At each date, multiple buyers make price offers to each seller.
  - Buyers making offers to A are distinct from those who offer to B.
- The payoffs to a seller who trades at time t for a price of p is

$$(1 - \delta^{t-1})c_\theta + \delta^{t-1}p,$$

where $\delta \in (0, 1)$ is the discount factor. The buyers payoff is

$$v_\theta - p.$$

Parametric assumptions

- Common knowledge of gains from trade: $v_\theta > c_\theta$.
- High quality assets are worth more: $v_H > v_L$, $c_H > c_L = 0$

We focus on the following parametric setting:

1. Lemons Condition: $\pi v_L + (1-\pi) v_H < c_H$
   - Rules out fully efficient trade at $t = 0$
2. Partial Separation: $v_L < \delta c_H$
   - Think of δ as being close to 1 (i.e., dynamics are relevant)
   - Rules out separating equilibria

Key features

- Asset Correlation (λ)
    - The payoffs of assets are correlated,

$$\mathbb{P}(\theta_i = L | \theta_j = L) = \lambda > \mathbb{P}(\theta_i = L)$$

- Transparency (ξ)
    - Any transaction in the first period becomes public prior to trading in the second period with probability ξ.

Equilibrium notion

We use **Perfect Bayesian Equilibria (PBE)** as our equilibrium concept. This has three implications:

1. *Seller Optimality:* Each seller's acceptance rule must maximize her expected payoff taking into account the future offers she can expect if she rejects the current offer.
2. *Buyer Optimality:* Any offer in the support of a buyer's strategy must maximize his expected payoff conditional on the other buyers' and the seller's strategies.
3. *Belief Consistency:* Given their information, the buyers' beliefs are updated according to Bayes rule whenever possible.

Backward induction: second period

Given a posterior belief of buyers in market i of $\pi_i \in [0, 1]$ the expected value of asset i is:

$$V(\pi_i) \equiv \pi_i v_H + (1 - \pi_i) v_L$$

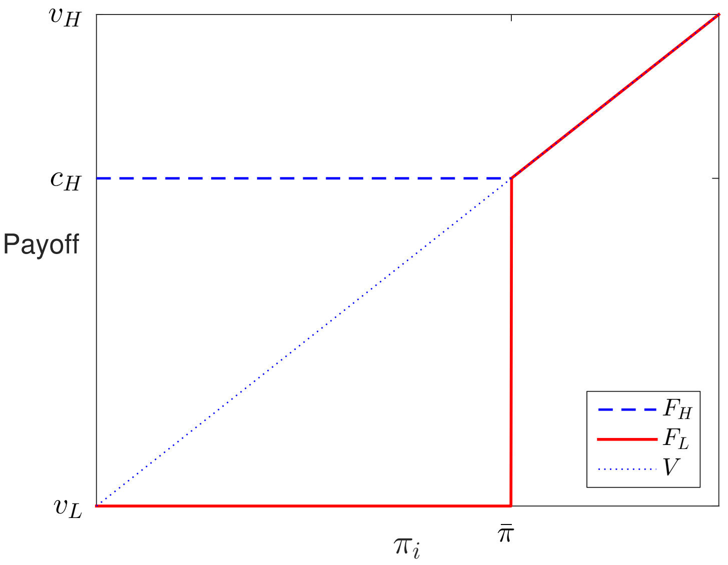
Let $\bar{\pi}$ be defined by $V(\bar{\pi}) = c_H$.

Lemma

Given posterior π_i, second period play looks as follows:

- *If $\pi_i < \bar{\pi}$, price is v_L and only low type trades.*
- *If $\pi_i > \bar{\pi}$, price is $V(\pi_i)$ and both types trade.*
- *If $\pi_i = \bar{\pi}$, price is c_H w.p. $\phi_i \in [0, 1]$ (both types trade) and v_L w.p. $1 - \phi_i$ (only low type trades).*

Second period payoffs



Skimming property

Seller i's expected continuation value from rejecting the bid in the first period is:

$$Q^i_\theta \equiv (1-\delta)\, c_\theta + \delta \mathbb{E}_\theta\{F_\theta(\pi_i)\}$$

Notice that $Q^i_H > Q^i_L$ for three reasons:

1. The flow payoff to a high type from delay is higher, $c_H > c_L$
2. For any posterior π_i, $F_H(\pi_i) \geq F_L(\pi_i)$
3. Due to correlation, a high type expects a better distribution of posteriors in the second period

Implication: Offers acceptable to a high type must be accepted by a low type w.p.1.

First period

Lemma

In the first period, any equilibrium must satisfy the following:

- *The highest offer or "bid" is* v_L
- *High type rejects the bid w.p.1*
- *Low type accepts with probability* $\sigma_i \in [0, 1)$

Implications:

- Equilibrium can be characterized by (σ_A, σ_B),
  - i.e., trading volume at $t = 1$
- Observing a trade in market j is bad news about θ_i

Updating and news

Buyers beliefs about seller i updated for two reasons:

1. That seller i rejected at $t = 1$ leads to an interim belief

$$\pi_{\sigma_i} = \mathbb{P}(\theta_i = H | \text{reject at } t = 1) = \frac{\pi}{\pi + (1 - \sigma_i)(1 - \pi)}$$

2. News from market j leads to a posterior belief

$$\pi_i(good) \geq \pi_{\sigma_i} \geq \pi_i(bad)$$

Seller i expects bad news with probability $\xi \sigma_j \mathbb{P}(\theta_j = L | \theta_i)$

- Higher if $\theta_i = L$ due to correlation

Equilibrium construction strategy

- Take $\sigma_j \in [0, 1)$ as exognously given.
  - Parameterizes informativeness of news in market i
- Solve for "partial" equilibrium in market i
  - Denote solution as $S(\sigma_j)$
- Equilibrium is a pair (σ_A^*, σ_B^*) such that

$$S(\sigma_A^*) = \sigma_B^* \text{ and } S(\sigma_B^*) = \sigma_A^*$$

Partial equilibria

Taking as given σ_j, we solve for a partial equilibrium in market i:

- σ_i (and ϕ_i) is pinned down by:

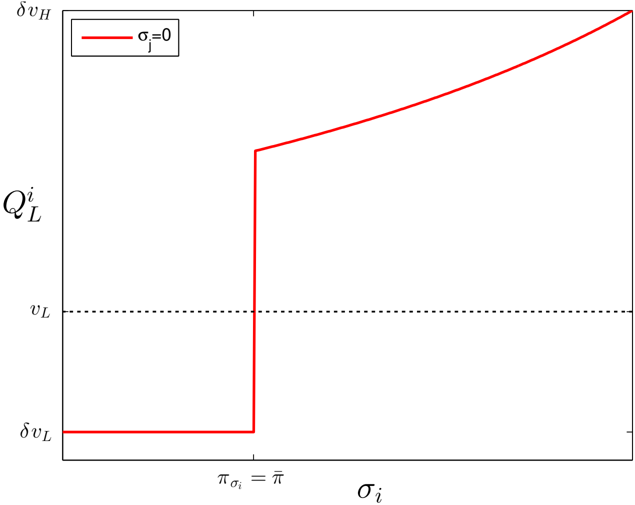
$$v_L \leq Q_L^i(\sigma_i, \sigma_j),$$

where the inequality must hold with equality if $\sigma_i > 0$.

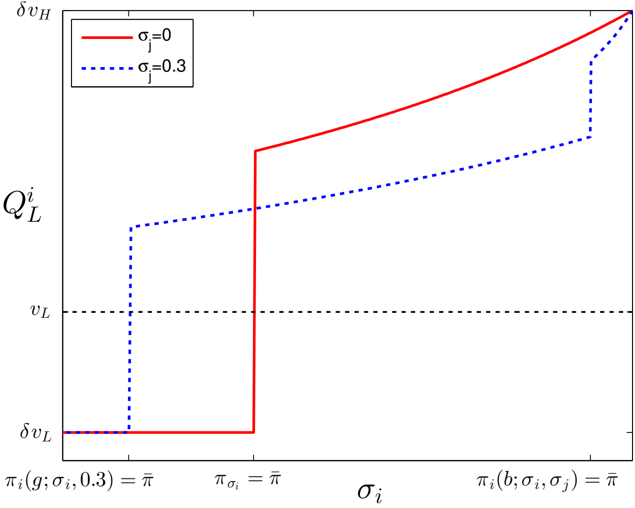
Proposition (Partial Equilibrium)

Given $\sigma_j \in [0, 1]$, a partial equilibrium in market i exists and is unique. The equilibrium may involve $\sigma_i = 0$, in which case the seller in market i "waits for news" regardless of her type.

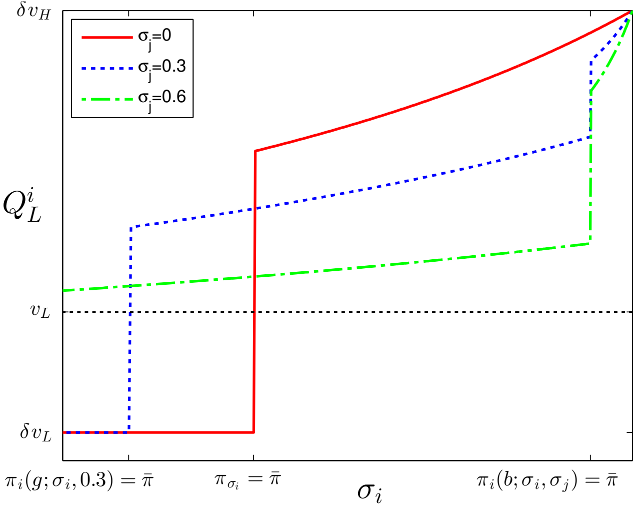
Constructing partial equilibria



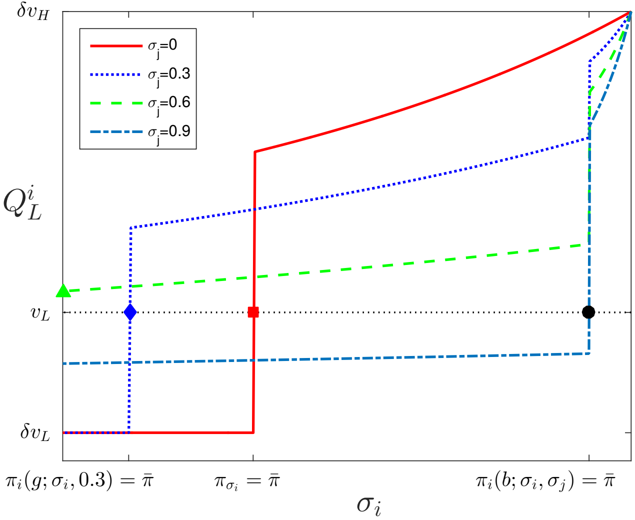
Constructing partial equilibria



Constructing partial equilibria



Constructing partial equilibria



Intuition

As σ_j increases, there are two opposing effects on Q_L

- **Good news effect:** Conditional on good news, seller i will get a higher price, since good news in more informative.
- **Bad news effect:** The likelihood that bad news arrives increases.

In order to have $Q_L^i(\sigma_i, \sigma_j) = v_L$, $S(\sigma_j)$ may increase or decrease with σ_j.

Illustration of S

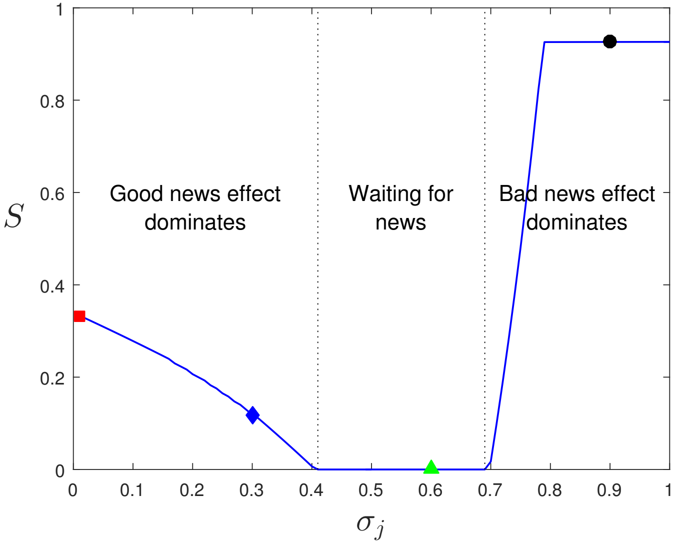


Figure: Partial equilibrium trading strategies in market A given σ_j.

Endogenous news $\Rightarrow$ No waiting for news

Proposition (Symmetry and no no-trade region)

Any equilibrium is symmetric (i.e., $\sigma_A^* = \sigma_B^* = \sigma^*$) and involves strictly positive probability of trade in the first period (i.e., $\sigma^* > 0$).

Why symmetric?

- Suppose $\sigma_A > \sigma_B$, then $Q_L^A > Q_L^B$.
- But $Q_L^B \geq v_L \implies Q_L^A > v_L$ violating $\sigma_A > 0$.

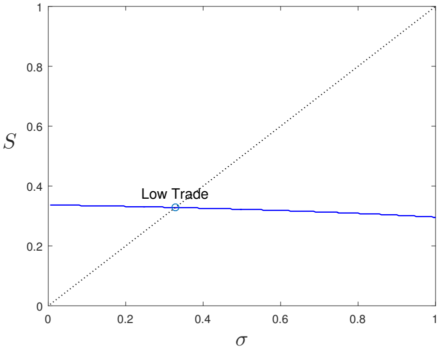
Why strictly positive?

- If $\sigma_A = \sigma_B = 0 \Rightarrow$ no news
- Buyer's beliefs are the same in the second period $\Rightarrow$ L strictly prefers to trade in the first period.

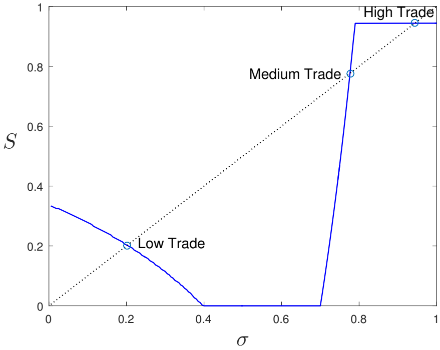
Implication: When news arises endogenously from trades of correlated assets, no trade periods cannot be part of an equilibrium!

Spillover effects

Symmetry implies that all equilibria are fixed points of $S(\cdot)$.



(a) Weak Spillovers (i.e., low ξ, λ)



(b) Strong Spillovers (i.e., high ξ, λ)

Multiplicity

Theorem

When both correlation and transparency are sufficiently large, there exist three equilibria, $\sigma^{low} < \sigma^{med} < \sigma^{high}$.

1. *Low trade: trade only after good news with* $\phi(g) \in (0, 1)$.
2. *Medium trade: trade only after good news and w.p.1.*
3. *High trade: trade after good news w.p.1., after bad news with* $\phi(b) \in (0, 1)$.

When either λ *or* ξ *is sufficiently small, the low trade equilibrium is unique.*

Welfare

To understand implications for welfare and efficiency, note that:

- Buyers make zero expected profit.
- Low type welfare is v_L in all equilibria.
- Therefore, total welfare can be measured by the equilibrium payoff of a high-type seller, Q_H^q, where $q \in \{low, med, high\}$ labels the equilibrium.
- All rankings are Pareto.

Welfare

Proposition (Welfare)

Welfare with in an economy with full transparency is always weakly greater than an economy with full opaqueness.

When the three equilibria coexist, we have $Q_H^{low} < Q_H^{med} < Q_H^{high}$*, and*

- Q_H^{high} *is increasing in* ξ *and* λ*.*
- Q_H^{med} *is decreasing in* ξ *and can be decreasing in* λ*.*
- $Q_H^{low} = c_H$ *for all* ξ *and* λ*.*

Welfare

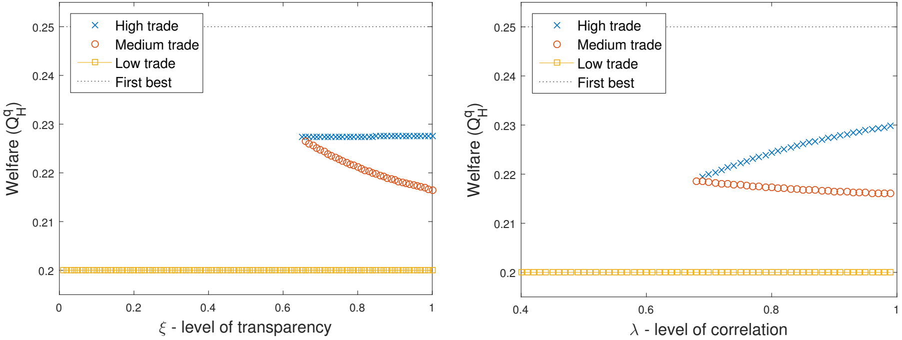


Figure: Effect of Transparency and Correlation on Welfare.

Many assets

Suppose now that there are $N \geq 2$ assets/sellers

- There is a common state of nature $\omega \in \{l, h\}$ with $\mathbb{P}(\omega = h) = \pi$
- Types are i.i.d. conditional on ω with $\mathbb{P}(\theta_i = H) = \pi$ and

$$\mathbb{P}(\theta_i = L | \omega = l) = \lambda > \mathbb{P}(\theta_i = L)$$

- News is now a vector $z \in \{b, g\}^N$

Many assets

Our main results with two assets generalize

Result

In an economy with N assets and for δ sufficiently close to 1:

1. *Multiple symmetric equilibria exist for high λ, ξ.*
   - *There can be many more than 3 equilibria (up to $N+1$).*
2. *We can rank trade and welfare of equilibria as before.*

Question: Do traders learn the state as $N \to \infty$?

- Assume $\xi = 1$ for simplicity...

Information aggregation

For an economy with N assets:

- Let σ_N denote an equilibrium trading probability, and
- Let $\pi_N^{state}(z)$ denote the buyers' posterior belief at $t = 2$ that the state is high after observing the news z.

Definition

We say that there is information aggregation about the state along a sequence $\{\sigma_N\}_{N=1}^{\infty}$ of equilibria if along this sequence

$$\lim_{N\to\infty} \pi_N^{state}(z) \to^p 1_{\{\omega=h\}}$$

Clearly if σ_N is uniformly bounded above zero than aggregation obtains

- But what if $\sigma_N \to 0$?

Information aggregation

The following two conditions guarantee that if the state ω were to be revealed in the second period, low types would strictly prefer to wait:

(i) $1 - \frac{(1-\lambda)(1-\pi)}{\pi} > \bar{\pi}$

(ii) $v_L < (1-\delta)\, c_L + \delta \left(\lambda v_L + (1-\lambda) V \left(1 - \frac{(1-\lambda)(1-\pi)}{\pi} \right) \right)$

Proposition (Information Aggregation)

If conditions (i) and (ii) hold, then there is no sequence of equilibria along which information aggregates. Conversely, if either (i) or (ii) is reversed, there exists a sequence of equilibria along which information aggregates.

Intuitively, along low trade equilibria $\sigma_N \downarrow 0$ as fast as $N \uparrow \infty$.

- Larger sample size, but each observation is less informative.

Does transparency "level the playing field"?

Pro-transparency policies are sometimes motivated as a way to "level the playing field" between traders with heterogenous access to information.

To explore the merits of this argument, suppose there are two types of buyers in each market

1. A dealer: sees transactions in other markets.
2. Many investors: only observe trades in their own market in the absence of transparency.
    - *Naive:* bid without realizing that a dealer is present
    - *Sophisticated:* fully rational

Exercise: Compare fully transparent vs fully opaque.

- Note that equilibrium behavior and welfare with $\xi = 1$ exactly the same as with symmetric buyers.
- Assume second price auction with hidden reserve as trading mechanism (primarily for simplicity).

Proposition (Naive)

If investors are naive and markets are fully opaque:

- *There exists a unique equilibrium. This equilibrium generates the same total surplus as the low-trade equilibrium in the main theorem.*
- *However, dealers make positive trading profits while naive investors experience trading losses.*

Therefore, introducing transparency redistributes dealer profits to naive investors.

- Prices are set by the naive buyers, who bid as in the symmetric buyers case, the overall welfare effect of transparency is the same as before.
- When the market is opaque, naive fall prey to the winner's curse: they overbid for the asset in the event of bad news.

Proposition (Sophisticated)

When investors are sophisticated and markets are fully opaque:

- *There exists a unique equilibrium that Pareto dominates the low-trade equilibrium in the main theorem.*
- *The additional surplus is captured entirely by dealers.*

Therefore, introducing transparency reduces dealer profits without affecting sophisticated investors' welfare, but may decrease overall trading surplus.

- When the market is opaque, the sophisticated bid conservatively to correct for the winner's curse.
- There is effectively less competition in the second period, which increases the incentives to trade early (higher σ).

Takeaway: Welfare effects of transparency depend on both (i) the equilibrium upon which agents coordinate and (ii) on the composition of market participants.

Summary

Explored the role of transparency in asset markets with correlated values

- Feedback between information revealed and trading behavior
- When information spillovers are sufficiently strong, multiple equilibria exist
    - More transparency (or correlation) can produce more efficient equilibria
    - However, fixing equilibrium, welfare not necessarily increasing

Multiplicity robust to $N > 2$ assets

- As $N \to \infty$, information may or may not be efficiently aggregated
    - Informativeness of each trade may go to zero offsetting additional data

Transparency can "level the playing field" if investors are naive but may reduce overall surplus if investors are sophisticated