Information Spillovers in Asset Markets with Correlated Values

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Motivation

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 with informational asymmetries?
- 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.
Related literature


Benchmark: Daley and Green (2012)

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

![Diagram]

- Buyers make (price) offers
- Seller accepts (and the game ends) or rejects
- News about the seller is revealed
- New buyers arrive, make offers

$t$ $t+1$
Benchmark: Daley and Green (2012)

Main Result: Unique equilibrium features period of no trade
- 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 $\rightarrow$ more incentive for the high type to wait $\rightarrow$ size of no trade region increases.
Benchmark: Daley and Green (2012)

Buyers offer $E(v_{\theta} | P_t)$
Both types accept w.p. 1

Pr($\theta = \text{H}$)

No Trade Region:
News drives posterior

$v_L$ offered
High types reject
Low types mix over accepting
Posterior jumps to $a$
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: $2 \times 2 \times 2$

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 $\delta$ as being close to 1 (i.e., dynamics are relevant)
   - Rules out separating equilibria
Key features

- Asset Correlation ($\lambda$)
  - The payoffs of assets are correlated,
    \[
    \mathbb{P}(\theta_i = L | \theta_j = L) = \lambda > \mathbb{P}(\theta_i = L)
    \]

- Transparency ($\xi$)
  - Any transaction in the first period becomes public prior to trading in the second period with probability $\xi$. 
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 $\pi_i$, 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 $\pi_i$, $F_H(\pi_i) \geq F_L(\pi_i)$
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 pair $(\sigma_A, \sigma_B)$
- Observing a trade in market $j$ is bad news about $\theta_i$
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

\[
\pi_i(\text{good}) \geq \pi_{\sigma_i} \geq \pi_i(\text{bad})
\]

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 $(\sigma_A^*, \sigma_B^*)$ such that
  
  \[
  S(\sigma_A^*) = \sigma_B^* \text{ and } S(\sigma_B^*) = \sigma_A^*
  \]
Partial equilibria

Taking as given $\sigma_j$, we solve for a partial equilibrium in market $i$:

- $\sigma_i$ (and $\phi_i$) is pinned down by:

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

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

\[ \pi_{\sigma_i} = \bar{\pi} \]

\[ \pi_{i(g; \sigma_i, 0.3)} = \bar{\pi} \]

\[ \pi_{\sigma_i} = \bar{\pi} \]

\[ \sigma_j = 0 \]

\[ \sigma_j = 0.3 \]

\[ \sigma_j = 0.6 \]

\[ \sigma_j = 0.9 \]
As $\sigma_j$ 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 is more informative.

- **Bad news effect:** The likelihood that bad news arrives increases.

To keep $Q_L^i(\sigma_i, \sigma_j) = v_L$, $S(\sigma_j)$ may be increasing or decreasing in $\sigma_j$. 
Illustration of $S$

Figure: Partial equilibrium trading strategies in market $A$ given $\sigma_j$. 
Endogenous news ⇒ 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 \( Q_A^L > Q_B^L \).
- But \( Q_B^L \geq v_L \implies Q_A^L > v_L \) violating \( \sigma_A > 0 \).

Why strictly positive?

- If \( \sigma_A = \sigma_B = 0 \) ⇒ no news
- Buyer’s beliefs are the same in the second period ⇒ \( L \) strictly prefers to trade in the first

With endogenous news, no trade periods not part of an equilibrium!
Spillover effects

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

(a) Weak Spillovers (i.e., low $\xi, \lambda$)

(b) Strong Spillovers (i.e., high $\xi, \lambda$)
For $\xi$ and $\lambda$ both sufficiently close to 1, there exist three equilibria, where $0 < \sigma_{\text{low}} < \sigma_{\text{med}} < \sigma_{\text{high}} < 1$.

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 $\lambda$ or $\xi$ 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, $Q^q_H$, where $q \in \{\text{low, med, high}\}$ labels the equilibrium.
- All rankings are Pareto.
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 $Q_H^{\text{low}} < Q_H^{\text{med}} < Q_H^{\text{high}}$, and

- $Q_H^{\text{high}}$ is increasing in $\xi$ and $\lambda$.
- $Q_H^{\text{med}}$ is decreasing in $\xi$ and can be decreasing in $\lambda$.
- $Q_H^{\text{low}} = c_H$ for all $\xi$ and $\lambda$. 

Welfare

Figure: Effect of Transparency and Correlation on Welfare.
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 $\omega$ 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 $\delta$ sufficiently close to 1:

1. Multiple symmetric equilibria exist for high $\lambda, \xi$.
   - 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 $\sigma_N$ denote an equilibrium trading probability, and
- Let $\pi_{state}^N(z)$ 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*

\[
\lim_{N \to \infty} \pi_{state}^N(z) \to^p 1_{\{\omega = h\}}
\]

*Clearly if $\sigma_N$ 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 \( \omega \) 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 two types of buyers in each market:

1. **One 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 $\sigma$).

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