Contagious Adverse Selection

Stephen Morris and Hyun Song Shin
Princeton Economics Department Seminar

November 2008
Credit Crunch

- "market confidence"
Credit Crunch

- "market confidence" undermined by
  - unexpected losses (in housing and some related financial instruments)
Credit Crunch

- "market confidence" undermined by
  - unexpected losses (in housing and some related financial instruments)
  - "opaqueness" of those financial instruments
Credit Crunch

- "market confidence" undermined by
  - unexpected losses
  - "opaqueness" of those financial instruments

- an interpretation:
  - "opaqueness" no accident: informational rents for financial intermediaries
  - informational rents imply uninformed traders faced adverse selection (broadly interpreted)
Credit Crunch

- "market confidence" undermined by
  - unexpected losses
  - "opaqueness"

- an interpretation:
  - "opaqueness" no accident: informational rents for financial intermediaries
  - informational rents imply uninformed traders faced adverse selection
  - but markets operated OK with adverse selection in good times
A Contagious Adverse Selection Propagation Channel

- Shock to system shows that common understanding of background adverse selection is wrong in asset market A
- A few (pessimistic) uninformed traders drop out of market A
- A few other traders - thinking that uninformed traders on the other side of the market are dropping out - also drop out
- and so on
- A few (pessimistic) uninformed traders drop out of market B, which they think may be correlated with market A
- and so on...
Contagious Adverse Selection

Contagious adverse selection propagation channel:

- Shock to system shows that common understanding of background adverse selection is wrong in asset market A
- A few (pessimistic) uninformed traders drop out of market A
- A few other traders - thinking that uninformed traders on the other side of the market are drop out - also drop out
- and so on
- A few (pessimistic) uninformed traders drop out of market B, which they think may be correlated with market A
- and so on...

- c.f., other propagation channels, e.g., Kiyotaki and Moore (1998)
- understand a contagious adverse selection channel in a clean simple theoretical model
Higher Order Adverse Selection

- Uninformed are unsure if others in market are "informed"
- "Adverse selection" is selection of informed market partners
  - In Akerlof (1970), all sellers are informed: "Adverse Selection" is selection of informed sellers with bad cars.
- Leads to coordination problem between uninformed agents (uninformed agents want to trade only if other uninformed agents trade)
Contagious Miscoordination (driven by Adverse Selection)

- Coordination on risky outcomes possible if and only if approximate common knowledge of gains from coordination
- Lack of common knowledge of gains from coordination implies contagious spreading of inefficient outcomes
- Thus **market confidence** = approximate common knowledge of upper bound on expected losses of uninformed agents

George Akerlof, QJE 1970, "The Market for 'Lemons"
Ariel Rubinstein, AER 1989, "The Electronic Mail Game"
Accounting Standards / Credit Ratings

- One purpose is to provide sufficient common understanding of "value" of underlying asset to allow impersonal transactions (Morris and Shin 2007 "Optimal Communication")
- Or create "market confidence" i.e., approximate common knowledge of upper bound on expected losses
- This was our original motivation for understanding contagious adverse selection: identifying model-based social value of widely available and focal information sources
This Talk

- Present "minimal" model of higher order adverse selection leading to contagious miscoordination (work in progress)
- Review results on common knowledge and coordination and why we think they are of applied interest (research agenda review)
- Discussing accounting agenda and implications (if any) for credit crunch
Efficient Bilateral Trade

- Agent 1’s private value of a house is $v - c$
- Agent 2’s private value of a house is $v + c$
- Agent 1 owns the house
- Efficient for 1 to sell the house to 2, say at price $v$
Adding Adverse Selection

- But the house may be falling down, in which case the seller (agent 1) knows it and the values are \((v - M - c, v - M + c)\) respectively.
- Or the buyer (agent 2) may be developer may be planning a new complex, in which case he knows it and the values are \((v + M + c, v + M - c)\) respectively.
- Potential losses bigger than certain gains \(M \gg c\)
Adding Adverse Selection

So total values are

<table>
<thead>
<tr>
<th></th>
<th>value to agent 1</th>
<th>value to agent 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;normal&quot; state</td>
<td>$v - c$</td>
<td>$v + c$</td>
</tr>
<tr>
<td>1's informed state</td>
<td>$v - M - c$</td>
<td>$v - M + c$</td>
</tr>
<tr>
<td>2's informed state</td>
<td>$v + M - c$</td>
<td>$v + M + c$</td>
</tr>
</tbody>
</table>
## Adding Adverse Selection

So total values are

<table>
<thead>
<tr>
<th></th>
<th>value to agent 1</th>
<th>value to agent 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>”normal” state</td>
<td>$v - c$</td>
<td>$v + c$</td>
</tr>
<tr>
<td>1’s informed state</td>
<td>$v - M - c$</td>
<td>$v - M + c$</td>
</tr>
<tr>
<td>2’s informed state</td>
<td>$v + M - c$</td>
<td>$v + M + c$</td>
</tr>
</tbody>
</table>

If agents trade at price $v$, total gains from trade are

<table>
<thead>
<tr>
<th></th>
<th>gains of agent 1</th>
<th>gains of agent 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>”normal” state</td>
<td>$c$</td>
<td>$c$</td>
</tr>
<tr>
<td>1’s informed state</td>
<td>$c + M$</td>
<td>$c - M$</td>
</tr>
<tr>
<td>2’s informed state</td>
<td>$c - M$</td>
<td>$c + M$</td>
</tr>
</tbody>
</table>
Adding Adverse Selection

Uninformed agent assigns probability $1 - \delta$ to normal state, probability $\delta$ to partner’s informed state

<table>
<thead>
<tr>
<th>State</th>
<th>Gains of 1</th>
<th>Gains of 2</th>
<th>Prior Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;normal&quot; state</td>
<td>$c$</td>
<td>$c$</td>
<td>$\frac{1-\delta}{1+\delta}$</td>
</tr>
<tr>
<td>1’s informed state</td>
<td>$c + M$</td>
<td>$c - M$</td>
<td>$\frac{\delta}{1+\delta}$</td>
</tr>
<tr>
<td>2’s informed state</td>
<td>$c - M$</td>
<td>$c + M$</td>
<td>$\frac{\delta}{1+\delta}$</td>
</tr>
</tbody>
</table>
The Loss Ratio

- "Loss Ratio" of uninformed agents:

\[ \psi = \frac{\text{expected losses}}{\text{gains}} = \frac{\delta M}{c} \]

- renormalization: fix gains from trade \( c \) and loss ratio \( \psi \), vary absolute losses \( M \) and let the probability of losses be

\[ \delta = \frac{c \psi}{M} \]

- later introduce uncertainty about \( \psi \)
Welfare

\[
\text{Ex Ante Welfare} = 2c \times \text{Probability of Trade}
\]
Complete Information

- Complete Information about loss ratio $\psi$
- There is still background asymmetric information about whether we are in normal state or not
Trading Game

- each agent says "yes" or "no"
- if and only if both say "yes," trade takes place
- informed types always trade (dominant strategy)
Trading Game

- each agent says "yes" or "no"
- if and only if both say "yes," trade takes place
- informed types always trade
- uninformed types play coordination game
  - if uninformed partner trades, expected payoff to trade is
    \[
    \left(1 - \frac{c\psi}{M}\right)c + \frac{c\psi}{M}(c - M) = c - \frac{c\psi}{M}M = c(1 - \psi)
    \]
  - if uninformed partner does not trade, expected payoff to trade is
    \[
    \frac{c\psi}{M}(c - M) = -c\psi\left(1 - \frac{c}{M}\right) < 0
    \]
# Simple Trading Game

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>$c(1 - \psi), c(1 - \psi)$</td>
<td>$-c\psi(1 - \frac{c}{M}), 0$</td>
</tr>
<tr>
<td>No</td>
<td>$0, -c\psi(1 - \frac{c}{M})$</td>
<td>$0$</td>
</tr>
</tbody>
</table>

- If loss ratio $\psi \leq 1$, (Yes, Yes) is an equilibrium with probability of trade 1
- If loss ratio $\psi > 1$, (No, No) is a unique equilibrium with probability of trade 0
Simple Trading Game

\[ M \to \infty \]

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>( c(1-\psi), c(1-\psi) )</td>
<td>( -c\psi, 0 )</td>
</tr>
<tr>
<td>No</td>
<td>0, (-c\psi)</td>
<td>0</td>
</tr>
</tbody>
</table>

- If loss ratio \( \psi \leq 1 \), (Yes, Yes) is an equilibrium with probability of trade 1
- If loss ratio \( \psi > 1 \), (No, No) is a unique equilibrium with probability of trade 0
Optimal Mechanism

- Suppose loss ratio $\psi > 1$ (so no trade in simple trading game)
- Trade with probability 1 in informed state, with probability $q \in (0, 1)$ in normal state
- Informed agent pays $p$ to uninformed agent in his informed state
- Binding individual rationality constraint of uninformed agent:

\[
\left(1 - \frac{c\psi}{M}\right) c + \frac{c\psi}{M} (c - M) + p = 0
\]

- Binding incentive compatibility of informed agent:

\[
c + M - p = q (c + M)
\]
Optimal Mechanism

- Solving gives:

\[ p = (1 - q) (c + M) \]
\[ q = \frac{2c}{2c + \left(1 - \frac{1}{\psi}\right) M} \]

- Total probability of trade is

\[ \frac{2c\psi}{M} + \left(1 - \frac{2c\psi}{M}\right) \frac{2c}{2c + \left(1 - \frac{1}{\psi}\right) M} \]

- Bottom line: as \( M \to \infty \), probability of trade decreases to 0.
There is background asymmetric information about whether we are in normal state or not

\textbf{ALSO} there is a lack of common knowledge of loss ratio $\psi$
Example: Uncertainty

- Uncertainty about loss ratio
- $\Omega = \{1, 2, \ldots, 2K + 1\}$, uniform prior
- Loss ratios $\psi_1 \geq \ldots \geq \psi_{2K+1}$
- **NB**: for each $\omega$ state, three substates: normal, 1’s informed, 2’s informed
- Almost perfect information:
  - Agent 1 observes partition
    $\left(\{1\}, \{2, 3\}, \ldots, \{2K - 2, 2K - 1\}, \{2K, 2K + 1\}\right)$
  - Agent 2 observes partition
    $\left(\{1, 2\}, \{3, 4\}, \ldots, \{2K - 1, 2K\}, \{2K + 1\}\right)$
Example: Losses

- Losses very high in state 1
- Losses quite high but less than 1 in other states
- $\psi_1 = \psi_H \gg 1$
- $\psi_\omega = \psi_L \in (\frac{1}{2}, 1)$ for $\omega \geq 2$
Example: Summary

- $\Omega = \{1, 2, \ldots, 2K + 1\}$, uniform prior
- $\psi_1 = \psi_H \gg 1; \psi_\omega = \psi_L \in (\frac{1}{2}, 1)$ for $\omega \geq 2$
- Almost perfect information:
  - Agent 1 observes partition
    $\left(\{1\}, \{2, 3\}, \ldots, \{2K - 2, 2K - 1\}, \{2K, 2K + 1\}\right)$
  - Agent 2 observes partition
    $\left(\{1, 2\}, \{3, 4\}, \ldots, \{2K - 1, 2K\}, \{2K + 1\}\right)$
Simple Trading Game

- Uninformed type \{1\} of agent 1 does not trade in equilibrium
- Uninformed type \{1, 2\} of agent 2 does not trade in equilibrium
- Candidate equilibrium:
  - agent 1 trades if \( \omega \geq 2 \)
  - agent 2 trades if \( \omega \geq 3 \)
Simple Trading Game

Expected payoff of uninformed type \{2, 3\} of agent 1 in proposed equilibrium:

\[
\frac{1}{2} \left( \frac{c\psi_L}{M} \right) (c - M) + \frac{1}{2} \left( 1 - \frac{c\psi_L}{M} \right) c + \frac{1}{2} \left( \frac{c\psi_L}{M} \right) (c - M)
\]

\[
= c - \frac{c\psi_L}{M} \frac{c\psi_L}{M} = c - \frac{2c\psi_L M}{M + c\psi_L}
\]

\[
\rightarrow c \left( 1 - 2\psi_L \right) \text{ as } M \rightarrow \infty
\]

\[
< 0
\]

Unique equilibrium has no trade (Rubinstein (1989))
General Information Structure

- Finite state space $\Omega$
  - example: $\Omega = \{1, 2, \ldots, 2K + 1\}$
- Prior $\pi \in \Delta (\Omega)$
  - example: $\pi (\omega) = \frac{1}{2K+1}$ for all $\omega$
- Loss ratio $\psi : \Omega \rightarrow \mathbb{R}_+$
  - example: $\psi (1) = \psi_H$ and $\psi (\omega) = \psi_L$ for $\omega \geq 2$
- Partitions $\mathcal{P}_1, \mathcal{P}_2$
  - example, e.g.,
    $\mathcal{P}_1 = (\{1\}, \{2, 3\}, \ldots, \{2K - 2, 2K - 1\}, \{2K, 2K + 1\})$
- Write $P_i (\omega)$ for set of states $i$ thinks possible
  - example, e.g., $P_1 (3) = \{2, 3\}$
Higher Order Beliefs

- Write \( \tilde{\psi}_i(\omega) \) for agent \( i \) expected loss ratio at state \( \omega \):

\[
\tilde{\psi}_i(\omega) = \frac{\sum_{\omega' \in P_i(\omega)} \pi(\omega') \psi(\omega')}{\sum_{\omega' \in P_i(\omega)} \pi(\omega')}
\]

- in example:
  - \( \tilde{\psi}_1(1) = \psi_H \) and \( \tilde{\psi}_1(\omega) = \psi_L \ \forall \ \omega \geq 2 \)
  - \( \tilde{\psi}_2(1) = \psi_2(2) = \frac{1}{2} (\psi_H + \psi_L) \) and \( \tilde{\psi}_2(\omega) = \psi_L \ \forall \ \omega \geq 3 \)
Higher Order Beliefs

- Fix event $E \subseteq \Omega$.
- Write $B_i^\psi (E)$ for states $\omega$ where $i$ believes that event $E$ occurs with probability at least $\tilde{\psi}_i (\omega)$:

$$B_i^\psi (E) = \{ \omega \mid \pi (E \mid P_i (\omega)) \geq \tilde{\psi}_i (\omega) \} \sum_{\omega' \in E \cap P_i (\omega)} \frac{\pi (\omega')}{\sum_{\omega' \in P_i (\omega)} \pi (\omega')}$$

where $\pi (E \mid P_i (\omega)) = \frac{\sum_{\omega' \in E \cap P_i (\omega)} \pi (\omega')}{\sum_{\omega' \in P_i (\omega)} \pi (\omega')}$

- example:

$$B_2^\psi (\{2, 3, \ldots, 2K + 1\}) = \{3, \ldots, 2K + 1\}$$
Higher Order Beliefs

Write $B_*^\psi (E)$ for states $\omega$ where each agent believes that event $E$ occurs with probability at least $\tilde{\psi}_i (\omega)$:

$$B_*^\psi (E) = B_1^\psi (E) \cap B_2^\psi (E)$$

example:

$$B_*^\psi (\{2, 3, \ldots, 2K+1\}) = \{3, \ldots, 2K+1\}$$

$$B_*^\psi (\{k, k+1, \ldots, 2K+1\}) = \{k+1, \ldots, 2K+1\} \text{ for each } k = 2, 3, \ldots$$

$$B_*^\psi (\{2K+1\}) = \emptyset$$
Market Confidence

There is "market confidence" at $\omega$ if

1. each agent’s expected loss ratio is less than 1
2. each agent $i$ believes (1) with probability at least $\tilde{\psi}_i(\omega)$
3. each agent $i$ believes (2) with probability at least $\psi_i(\omega)$
4. ....

write $C^\psi$ for the set of states where there is market confidence

$$C^\psi = B^\psi_*(\Omega) \cap [B^\psi_*(\Omega)]^2 \cap ......$$

$$= \bigcap_{k \geq 1} [B^\psi_*(\Omega)]^k$$

- Say that event $E$ is $\psi$-evident if $E \subseteq B^\psi_*(E)$.

**PROPOSITION.** $C^\psi$ is the largest $\psi$-evident event. Aumann (1976), Monderer-Samet (1989), Morris-Shin (2007).
Market Confidence in Example

\[ \Omega = \{1, 2, 3, \ldots, 2K + 1\} \]

\[ B^\psi_\ast (\Omega) = \{2, 3, \ldots, 2K + 1\} \]

\[ \left[B^\psi_\ast \right]^2 (\Omega) = \{3, 4, \ldots, 2K + 1\} \]

\[ \left[B^\psi_\ast \right]^n (\Omega) = \{n + 1, \ldots, 2K + 1\} \]

\[ \left[B^\psi_\ast \right]^{2K+1} (\Omega) = \emptyset \]

\[ C^\psi = \emptyset \]

There is never market confidence in the example.
Simple Trading Game

PROPOSITION.

1. There is always a no trade equilibrium.
2. There is a "largest" trade equilibrium.
3. In the largest equilibrium, informed agents always trade.
4. Uninformed agents trade only if there is market confidence.
5. For sufficiently large $M$, they trade if and only if there is market confidence.
Optimal Mechanism (with small transaction costs)

Fix an event $E$ and write $E_i = \{\omega \mid P_i(\omega) \cap E \neq \emptyset\}$.

- Event $E$ is $\psi$-evident if
  \[ \pi(E \mid P_i(\omega)) \geq \tilde{\psi}_i(\omega) \text{ for all } i \text{ and } \omega \in E_i \]

- Event $E$ is weakly $\psi$-evident (Geanakoplos 1994) if
  \[ \pi(E_2 \mid E_1) + \pi(E_1 \mid E_2) \geq \text{Exp}(\psi \mid E_1) + \text{Exp}(\psi \mid E_2) \]

- Write $W^\psi$ for the largest weakly $\psi$-evident event

- There is weak market confidence at $\omega$ if $\omega \in W^\psi$.

**PROPOSITION.** If $W^\psi = \emptyset$, then for each $\varepsilon > 0$, there exists $M > 0$ such that the ex ante probability of trade in the optimal mechanism is at most $\varepsilon$. 
Bound in Example

- $\Omega = \{1, 2, \ldots, 2K + 1\}$, uniform prior
- $\psi_1 = \psi_H \gg 1$; $\psi_\omega = \psi_L \in \left(\frac{1}{2}, 1\right)$ for $\omega \geq 2$
- Almost perfect information:
  - Agent 1 observes partition
    $\left(\{1\} , \{2, 3\} , \ldots, \{2K - 2, 2K - 1\}, \{2K, 2K + 1\}\right)$
  - Agent 2 observes partition
    $\left(\{1, 2\} , \{3, 4\} , \ldots, \{2K - 1, 2K\}, \{2K + 1\}\right)$
- small trade for large $M$ if $\psi_L > 1 - \frac{1}{2K}$
Bound in Example

- $K = 1$
- $\Omega = \{1, 2, 3\}$, uniform prior
- $\psi_1 = \psi_H \gg 1; \psi_2 = \psi_3 = \psi_L$
- Almost perfect information:
  - Agent 1 observes partition ($\{1\}, \{2, 3\}$)
  - Agent 2 observes partition ($\{1, 2\}, \{3\}$)
- small trade for large $M$ if $\psi_L > \frac{3}{4}$
Idea of Proof in Optimal Mechanism Bound

Bound probability of trade using only:

- Individual Rationality Constraints of Uninformed Types
- Incentive Compatibility Constraints of Informed Types
- Assume w.l.o.g. trade with probability 1 in informed states, \( q^* (\omega) \) in normal state \( \omega \)
- Agent \( i \) in informed state gets rent \( M \left( 1 - \max_{\omega' \in P_i(\omega)} q^* (\omega') \right) \)
- High \( q^* \) implies rents bigger than \( 2c \), contradiction

Contagious Adverse Selection
Idea of Proof in Optimal Mechanism Bound

Bound probability of trade using only

- Individual Rationality Constraints of Uninformed Types
- Incentive Compatibility Constraints of Informed Types
- Assume w.l.o.g. trade with probability 1 in informed states, $q^*(\omega)$ in normal state $\omega$
- Agent $i$ in informed state gets rent $M \left( 1 - \max_{\omega' \in P_i(\omega)} q^*(\omega') \right)$
- High $q^*$ implies rents bigger than $2c$, contradiction

**NOTE**: despite correlated types, no full surplus extraction (Cremer-McLean 88) because linearly dependent beliefs (Neeman 04, Parreiras 05)
Future Work on Optimal Mechanism

- tightness?
- useful mechanisms that do better than simple trading mechanism?
- richer higher order beliefs limit returns to more complex mechanisms?
Recognition versus Disclosure

- Recognition: in financial bottom line
- Disclosure: in the footnote
- Makes a difference [Barth, Clinch and Shibano (2003), Espahbodi et al. (2002)]
Accounting Standards

- Finding the balance between
  - accurate measurement
  - common understanding

- Attempting to convey more information may lead to less focussed attention and less common understanding

- One purpose of accounting standards is to signal to audience what numbers others will simultaneously be focussing on
Back to the Example

- $\Omega = \{1, 2, \ldots, 2K + 1\}$, uniform prior
- $\psi_1 = \psi_H \gg 1; \psi_\omega = \psi_L \in (\frac{1}{2}, 1)$ for $\omega \geq 2$
- what is the social value of different information structures concerning losses?
- choose $\mathcal{P} = (\mathcal{P}_1, \mathcal{P}_2)$ to maximize $C_\mathcal{P}^{\psi}$ subject to $\mathcal{P} \in \mathcal{F}$
Low loss ratio in bad state

$\psi_H$ not too high

no information

$P_1 = P_2 = (\{1, 2, 3, \ldots, 2K + 1\})$

- is optimal information structure
High loss ratio in bad state

\( \psi_H \) is very high,

- unconstrained optimal information structure is
  \[ P_1 = P_2 = (\{1\}, \{2, 3, \ldots, 2K + 1\}) \]

- with noisy interpretation constraint that information must coarsen
  \[ P_1 = (\{1\}, \{2, 3\}, \ldots, \{2K - 2, 2K - 1\}, \{2K, 2K + 1\}) \]
  \[ P_2 = (\{1, 2\}, \{3, 4\}, \ldots, \{2K - 1, 2K\}, \{2K + 1\}) \]

optimal information structure is

\[ P_1 = (\{1\}, \{2, 3, \ldots, 2K + 1\}) \]
\[ P_2 = (\{1, 2\}, \{3, 4, \ldots, 2K + 1\}) \]
High loss ratio in bad state

$\psi_H$ is very high,

- with background information constraint that information must refine

$$\mathcal{P}_1 = (\{1\}, \{2, 3\}, \ldots, \{2K - 2, 2K - 1\}, \{2K, 2K + 1\})$$
$$\mathcal{P}_2 = (\{1, 2\}, \{3, 4\}, \ldots, \{2K - 1, 2K\}, \{2K + 1\})$$

optimal information structure is

$$\mathcal{P}_1 = (\{1\}, \{2, 3\}, \ldots, \{2K - 2, 2K - 1\}, \{2K, 2K + 1\})$$
$$\mathcal{P}_2 = (\{1\}, \{2\}, \{3, 4\}, \ldots, \{2K - 1, 2K\}, \{2K + 1\})$$
Credit Crunch (Outside of Model) Observations

- Original TARP concept - "getting toxic assets off the balance sheet" - not so crazy?
- Credit cycles resulting from endogenous adverse selection: market participants have incentive to pool as much adverse selection as market will bear, bringing system to critical point?
- "Common rank beliefs" = lack of common knowledge giving rise to contagion in coordination games (Morris and Shin 2007). If public shocks give rise to common rank beliefs, there is strategic propagation mechanism of shocks.
Conclusion of Work in Progress

- Analyzed a particular two sided adverse selection model
- Distinctive ingredient: unravelling along different assessments of expected losses
- New Directions
  - Accounting / Credit Rating Application
  - Mechanism Design Results
  - Develop insights within standard financial models