Transaction costs, network topologies, and information cascades in the financial markets

Joohyun Kim and Duk Hee Lee
(jaykim_ms@kaist.ac.kr)

Dept. of Management Science
Korea Advanced Institute of Science and Technology

FNET 2013 Kyoto
Motivation

• Runners furious as only one person completes full distance in Marathon of the North  By Eurosport, May 12

Why?
Information Cascades

- Regardless of private information, information cascades occur by following others decision (Easley, D. and Klinberg, J., 2010).
Developed IT World

- Highly connected network with lower transaction costs
Research Question

• How do lower transaction costs have an effect on the occurrence of information cascades?

• Is there any relationship between cascade behaviors and network topologies in the financial market?
Literature Review – Information cascades

• An information cascade can be occurred when the imbalance of trading decisions are greater than a certain threshold (Bikchandani at al., 1992).

• Avery and Zemsky (1998) proved that there is no occurrence of information cascades when the asset price is fluctuated by order flow.
Literature Review – Transaction costs

• *Transaction costs block the access of information*; thus, people cannot aggregate information uniformly (Avery and Zemsky, 1998).

• *No-trade information cascades* occur when trading profits are less than transaction costs (Cipriani and Guarino, 2008).
Assumptions in our model

- Sequential decision
  - *Individuals can only access the previous decisions of traders connected with them under the restriction of search costs.*

- Communication probability
  - *Considering search costs*
  - *The difficulty of attaining previous decisions*

- Network topology
  - *Spatially-clustered network, random network, scale-free network*
Methodology

• Computational model
  • *A computational model allows us to handle various environmental conditions without any restrictions.*

• Empirical approach
  • *Unable to obtain initial private information of traders*
  • *It is impossible to determine whether traders imitate the trend decision regardless of private own signals via empirical approach.*
Model

• Market structure and asset price

  • Fundamental value of the asset, $FV$
    o A random variable, $\{0, 100\}$ with $Pr(FV=0)=0.5=p$
  • Agent’s action space : $A = \{buying, selling, holding\}$
    o $\chi_i \in A$ for all $i$
  • Information: $\omega_i$
    o Via a connected network, the agent can obtain peers’ former decisions.
  • Asset price, $P = E(FV) = 50$.
    o $P$ is fixed without consideration of order flows.
Model

- Trader’s behavior

- *A private signal, $S_i$*
  - A random variable, \{0, 100\}

- $Pr(S_i=100 \mid FV=100) = Pr(S_i=0 \mid FV=0) = 0.65 = q$

\[
\begin{array}{ccc}
  & FV = 100 & FV = 0 \\
 S_i = 100 & q & 1 - q \\
 S_i = 0 & 1 - q & q \\
\end{array}
\]
Model

• Information cascades

  • Cipriania and Guarino (2008) defined information cascades as follows:

    \[ Pr(\chi_i = \xi|\omega_i, S_i = s) = Pr(\chi_i = \xi|\omega_i), \forall \xi \in A \text{ and } \forall s \in \{0, 100\}. \]

    o Does not consider a contrarian behavior.
    o But, no-trade cascades are considered.
Model

• Trader’s behavior

• Payoff function
  o An initial endowment, $k = 100$, Trading fees, $\theta$

\[
U(v, \chi_i) = \begin{cases} 
  v - P + k - \theta \times P & \text{if } \chi_i = \text{buying}, \\
  k & \text{if } \chi_i = \text{holding}, \\
  P - v + k - \theta \times P & \text{if } \chi_i = \text{selling}.
\end{cases}
\]

• Trading strategy

If $E(FV|\omega_i, s_i) > (1 + \theta) \times P$, then $\chi_i = \text{buying}$,
If $(1 - \theta) \times P \leq E(FV|\omega_i, s_i) \leq (1 + \theta) \times P$, then $\chi_i = \text{holding}$,
If $E(FV|\omega_i, s_i) < (1 - \theta) \times P$, then $\chi_i = \text{selling}$.
Model

• Relative influence on decision

• Determine relative influence, $\varphi_i$
  - Using an interpolation between fixed minimum value and maximum value

Higher Degree Centrality

Lower Degree Centrality
Model

- **Search costs**
  - A search cost, $\tau$, is not a payment for accessing information.
  - It is defined as the difficulty to access others’ information.
    - The search cost is relatively high, it would be difficult to obtain the decision of others.
Results

• Computational model
  • Using Netlogo 5.0
  • Fixed numerical assumptions and other assumptions in our simulations

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$N$</td>
<td>1000</td>
<td>the number of agents</td>
</tr>
<tr>
<td>$L$</td>
<td>4000</td>
<td>the number of total links</td>
</tr>
<tr>
<td>$P$</td>
<td>50</td>
<td>the asset price</td>
</tr>
<tr>
<td>$p$</td>
<td>0.5</td>
<td>the deciding probability of fundamental value of asset</td>
</tr>
<tr>
<td>$q$</td>
<td>0.65</td>
<td>the deciding probability of private signal</td>
</tr>
<tr>
<td>$\eta_{\text{min}}$</td>
<td>0.7</td>
<td>the minimum relative influence</td>
</tr>
<tr>
<td>$\eta_{\text{max}}$</td>
<td>3.0</td>
<td>the maximum relative influence</td>
</tr>
</tbody>
</table>

Updating  sequential updating mechanism
Results

• Measurements
  
  • *Gross information cascades, $I$*
    
    o *$I$ is defined as the sum of the occurrence of information cascades in the market*

  • *Trend shift cascades, $C$*
    
    o *How many traders move to the trend decision?*

<table>
<thead>
<tr>
<th></th>
<th>Intended Buyer</th>
<th>Intended Seller</th>
<th>Final Buyer</th>
<th>Final Seller</th>
<th>Gross info. Cascades (I)</th>
<th>Trend shift cascades (C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case 1</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Case 2</td>
<td>50</td>
<td>50</td>
<td>65</td>
<td>35</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>
Results

• Regression on trading fees, search costs, and network topologies
  • Initial conditions

<table>
<thead>
<tr>
<th>Input Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg. nodes</td>
<td>4</td>
<td>Spatially-clustered network</td>
</tr>
<tr>
<td>Network Density</td>
<td>0.004</td>
<td>Random network</td>
</tr>
<tr>
<td>$h$</td>
<td>2</td>
<td>Scale-free network</td>
</tr>
<tr>
<td>Network Topologies</td>
<td>Cluster, Random, Scale–free</td>
<td></td>
</tr>
<tr>
<td>$\theta$</td>
<td>0.01, 0.02, 0.03, 0.04, 0.05</td>
<td>Trading fees</td>
</tr>
<tr>
<td>$\tau$</td>
<td>0.02, 0.04, 0.06, 0.08, 0.10</td>
<td>Searching costs</td>
</tr>
<tr>
<td>Total cases</td>
<td>75 cases</td>
<td></td>
</tr>
<tr>
<td>Replications</td>
<td>30 times</td>
<td></td>
</tr>
</tbody>
</table>
Results

• Regression on trading fees, search costs, and network topologies
  • $C$ and $I$ are defined using dummy variables as:

\[
C = \beta_0 + \beta_1 \theta + \beta_2 \tau + \beta_3 \text{cluster} + \beta_4 \text{random} + \varepsilon,
\]

\[
I = \beta_0 + \beta_1 \theta + \beta_2 \tau + \beta_3 \text{cluster} + \beta_4 \text{random} + \varepsilon,
\]

\[
\text{cluster} = \begin{cases} 
1 & \text{if network topology = cluster}, \\
0 & \text{otherwise}.
\end{cases}
\]

\[
\text{random} = \begin{cases} 
1 & \text{if network topology = random}, \\
0 & \text{otherwise}.
\end{cases}
\]
Results

• Trend shift cascades

\[ C = \beta_0 + \beta_1 \theta + \beta_2 \tau + \beta_3 \text{cluster} + \beta_4 \text{random} + \varepsilon, \]

<table>
<thead>
<tr>
<th></th>
<th>Constant</th>
<th>( \theta )</th>
<th>( \tau )</th>
<th>( \text{cluster} )</th>
<th>( \text{random} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>OLS coefficients</td>
<td>111.95***</td>
<td>-300.71***</td>
<td>-145.79***</td>
<td>-41.88***</td>
<td>-18.32***</td>
</tr>
<tr>
<td>OLS standard errors</td>
<td>3.93</td>
<td>80.23</td>
<td>40.13</td>
<td>2.78</td>
<td>2.78</td>
</tr>
<tr>
<td>White robust standard errors</td>
<td>4.13</td>
<td>79.64</td>
<td>40.68</td>
<td>2.80</td>
<td>3.07</td>
</tr>
<tr>
<td>FGLS coefficients</td>
<td>109.91***</td>
<td>-277.41***</td>
<td>-123.45***</td>
<td>-41.88***</td>
<td>-18.32***</td>
</tr>
<tr>
<td>FGLS standard errors</td>
<td>3.94</td>
<td>73.71</td>
<td>36.86</td>
<td>2.80</td>
<td>3.08</td>
</tr>
</tbody>
</table>

*** \( p < 0.01 \), ** \( p < 0.05 \)

Scale-free network > Random network > Spatially-clustered network
## Results

- **Gross information cascades**

\[ I = \beta_0 + \beta_1 \theta + \beta_2 \tau + \beta_3 \text{cluster} + \beta_4 \text{random} + \varepsilon, \]

<table>
<thead>
<tr>
<th></th>
<th>Constant</th>
<th>( \theta )</th>
<th>( \tau )</th>
<th>cluster</th>
<th>random</th>
</tr>
</thead>
<tbody>
<tr>
<td>OLS coefficients</td>
<td>191.34***</td>
<td>-251.15***</td>
<td>-139.73***</td>
<td>107.80***</td>
<td>81.48***</td>
</tr>
<tr>
<td>OLS standard errors</td>
<td>1.10</td>
<td>22.61</td>
<td>11.31</td>
<td>0.78</td>
<td>0.78</td>
</tr>
<tr>
<td>White robust</td>
<td>1.09</td>
<td>22.69</td>
<td>11.24</td>
<td>0.78</td>
<td>0.74</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>FGLS coefficients</th>
<th>FGLS standard errors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>191.68***</td>
<td>107.80***</td>
</tr>
<tr>
<td></td>
<td>-255.39***</td>
<td>81.48***</td>
</tr>
<tr>
<td></td>
<td>-143.42***</td>
<td>2.80</td>
</tr>
<tr>
<td></td>
<td>1.07</td>
<td>0.74</td>
</tr>
<tr>
<td></td>
<td>22.40</td>
<td></td>
</tr>
</tbody>
</table>

### Symbols

- *** \( p < 0.01 \)
- ** \( p < 0.05 \)

Spatially-clustered network > Random network > Scale-free network
Results

• Interpretation
  • Spatially-clustered network

Interior : High interaction $\rightarrow$ I $\uparrow$
Exterior : Low interaction $\rightarrow$ C $\downarrow$

the counter balanced situation!!
Results

• **Interpretation**
  • *Scale-free network*

Interior: Low interaction $\rightarrow I \downarrow$
Exterior: a governing decision from the hub
$\rightarrow$ a synchronized choice in the market $\rightarrow C \uparrow$

*A misled cascading behavior*
• A dominant trader: buying an asset
• Fundamental value of asset: 0
• Many intended sellers
  $\rightarrow$ buying an asset
Discussion

• Summary
  • Main findings
    o Lower search costs and trading fees may amplify the occurrence of information cascades.
    o The highly spread trend shift cascades can be observed in a scale-free network when the influence of a dominant agent’s decision significantly affects the connected agents.
    o Misled trend shift cascades may occur when an influential trader makes a decision against the fundamental value of an asset in a scale-free network structure.
Discussion

• **Summary**

• **Limitations**
  o Not considering *bid-ask spread*.
  o The asset *price is fixed* regardless of order flow

• **Future studies**
  o Considering *time flow*
  o Taking into account the order flow for *a flexible asset price*
Thank you!

Question?

jaykim_ms@kaist.ac.kr

Acknowledgement

This paper was supported by the National Research Foundation of Korea Grant funded by the Korean Government (NRF-2011-330-B00046).