Supply Chain Network Structure and the Role of Financing

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1University of Chicago Booth School of Business (some work joint with Alex Yang, LBS, and Jing Wu, Chicago Booth)

NYU Stern
Themes

- Supply chains operate as financial vehicles that can also help with coordination
- Multiple suppliers as creditors can create difficulties
- Correlation and reliability issues of suppliers and creditors create nonlinear effects on the value of supplier connections
- Including nonlinear effects leads to a wide variety of equilibrium network configurations
- New databases (e.g., Bloomberg SPLC) provide opportunities to investigate financial and operational supply chain network interactions
Outline

- Basic of trade credit interactions
- Conflict examples with multiple creditors
- Basic network configurations
- Empirical data analysis


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- retailers (NAICS code: 441 - 454)
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- total 2,117 firm-years
- median size: $424 million

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On November 10th, 2008, Circuit City filed for bankruptcy. Total accounts payable: $754.5 million (total liabilities: $2.32 billions) Out of its 50 largest unsecured creditors, 48 were trade creditors.

48th (Kingston): $1.65 million
3rd (Sony): $60.01 million
2nd (Samsung): $115.93 million
1st (Hewlett-Packard): $118.80 million
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The “Flexibility” in Trade Credit

2/10 Net 30
The “Flexibility” in Trade Credit

![Graph showing cumulative distribution of days payable for trade credit options 2/10 Net 30 and All Firm (N = 2127).]
The “Flexibility” in Trade Credit

- 2/10 Net 30
- All Firm (N = 2127)
- Cash/Sales >0.05 (N = 675)
## Flexibility within a Subcategory

<table>
<thead>
<tr>
<th>Subcategory in Retail (North America Industry Classification System)</th>
<th>Num. of firm-years</th>
<th>Days Payable</th>
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</thead>
<tbody>
<tr>
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<td>2127</td>
<td>27.8 41.1 58.8</td>
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<td>Motor vehicle and parts dealers (441)</td>
<td>183</td>
<td>5.7 13.2 66.9</td>
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February 26, 2014
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Trade Credit and Inventory

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- Net 30

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Consignment

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Focus: Multiple Creditors and Priority Rules;
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  - Priorities and other trade credit theories.
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- General Case:
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  - Pre-petition: general unsecured claim;

Trade Creditors' Reclamation Rights:
- Uniform Commercial Code (U.C.C.) § 2-702: reclamation of goods or value within 10 days;
- Bankruptcy Abuse Prevention and Consumer Protection Act of 2005 (BAPCPA) § 546(c): reclamation of goods or value within 45 days before bankruptcy;
- Chapter 11 Critical Vendor Motion: reclamation within 90 days;
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- **How Do Judges Rule?**
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The Model

The retailer decides whether to invest in the generic project.

The supplier proposes a contract; the retailer places an order.

The order is delivered.

Both demand and the generic project payoff are realized.

If yes, the retailer borrows a bank loan to finance this project.

A noisy signal of the realizations of payoffs are revealed.

The retailer uses trade credit or bank loan to finance inventory.

Bank loan and trade credit are paid off, or the retailer default.
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One type of goods, all three parties know and agree on demand distribution $\xi \sim F(y) \ (f(y), \bar{F}(y) = 1 - F(y), g(y) = y \frac{f(y)}{\bar{F}(y)})$;
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A long term (generic) project with risky payoff; 

All parties are risk-neutral (or equivalent risk-neutral measure).
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\text{Figure: } c &= 0.4, \xi \sim \text{Uniform}[0, 1]
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**Figure:** $c = 0.4$, $\xi \sim \text{Uniform}[0, 1]$
Trade Credit with High Priority

Proposition (Trade Credit with High Priority)

\[ \exists \kappa_n^{ts} \geq 0 \text{ such that:} \]

1. when \( K < \kappa_n^{ts} \), the supplier does not offer trade credit;
2. when \( K \geq \kappa_n^{ts} \), the supplier offers a line of trade credit \( \bar{L}_s^* = \bar{F}^{-1}(c/w) \), and the retailer uses only trade credit.
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Trade Credit with Low Priority

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Comparing with the case when trade credit is senior, when trade credit has low priority:

1. More retailers receive trade credit;
2. $L_t^{ij} \leq \bar{L}_s^*$ (less trade credit is offered);
3. The supplier’s profit is higher.
Comparing Different Priorities . . .

Figure: $c = 0.6$, $w = 0.8$, $\xi \sim \text{Uniform}[0, 1]$
Comparing Different Priorities . . .

Figure: \( \xi \sim \text{Uniform}[0, 1] \)
The Optimal Trade Credit Contract

**Proposition**

When demand uncertainty is the only risk the retailer faces, if the supplier has control of the wholesale price $w$, she offers **unlimited** trade credit with **net terms**, and the retailer only uses trade credit. Priority rules become **irrelevant**.
Priorities and Efficiency

**Proposition**

When the retailer has to borrow a bank loan, assigning trade credit with low priority improves the chain efficiency and the supplier’s profit, compared with the case when trade credit has high priority.
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- When trade credit is junior, the supplier has the option to cut off trade credit.
- Anticipating that, the retailer increases cash holding.
- When trade credit is senior, trade credit is offered only when it is riskless.
Empirical Tests of Priority Effects

BAPCA Effect Hypothesis

BAPCA (2005) raised the priority of trade credit through the 20-day administrative-claim and 45-day reclamation-right periods. The result should be a decrease in retailers’ use of trade credit and an increase in their use of bank debt.

Analysis

- Model as follows:

\[ Y_t = \sum_i \left( \frac{\text{Trade Payable}}{\text{Trade Payable} + \text{Debt in Current Liability}} \right)_{it}, \]

where \( t \) represents year and \( i \) for individual firms. Test the following specification:

\[ Y_t = \alpha + \beta_1 D_1 + \beta_2 D_2 + \beta_3 X_t + \epsilon_t, \]

where \( D_1 \) and \( D_2 \) are dummies for 1999 – 2002 and 2006 – 2008 and \( X_t \) is GDP.
### Relative Trade Credit Regression Results

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999-2002</td>
<td>-0.0397*</td>
<td>-0.0215*</td>
</tr>
<tr>
<td></td>
<td>(0.0089)</td>
<td>(0.0080)</td>
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<td>2006-2008</td>
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<td>-0.0147*</td>
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<tr>
<td></td>
<td>(0.0095)</td>
<td>(0.0069)</td>
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<tr>
<td>GDP Growth</td>
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</tr>
<tr>
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</tr>
<tr>
<td>Receivable</td>
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<tr>
<td></td>
<td>(0.7498)</td>
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<tr>
<td>Constant</td>
<td>0.820*</td>
<td>1.026*</td>
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<tr>
<td></td>
<td>(0.0067)</td>
<td>(0.0656)</td>
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<tr>
<td>Observations</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.67</td>
<td>0.85</td>
</tr>
</tbody>
</table>

Notes:
- The standard errors are shown in the parenthesis. * represent coefficients significant at 5%.
- The reduction in trade credit is significant (4% or 1.4% according to the specification).
## Summary: Priority under Trade Credit Theories

<table>
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<td><strong>Risk-Sharing</strong></td>
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Connections

- With other supply chain contracts:
Connections

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  - trade credit *dominates* price-only contract;
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- With classical static capital structure theories:
  - trade-off: risk-sharing vs. financial distress;
  - pecking order: $\textbf{Cash} \succ \textbf{Trade Credit} \succ \textbf{Debt}$.
  - Potential for conflicts implies that trade credit not favored for firms facing negatively correlated risks (and, hence, diversification may destroy value)
Network Implications

Correlation among business interests and suppliers may create opportunities for increased risk.
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2. Diversification may lead to reduced incentives for financing
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Nonlinear (joint firm) effects may be critical in the formation of supply chain links.

Nonlinear effects may have implications for supply chain structure.
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Previous work: Jackson and Wolinsky (1996): Firm $i$ maximizes utility $u_i$ by creating connections $ij$ in graph $G$ (distance $d_{ij}$) where

$$u_i = w_{ii} + \sum_{j \neq i} \delta d_{ij} w_{ij} - \sum_{(ij) \in G} c_{ij}.$$
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2. Results: For symmetric networks, either $G$ is complete, a star graph, or linkless.

Innovation: allow nonlinear effects $w_{ij}, w_{jk}$ where $x_{ij} = 1$ for $(ij) \in G$. $w_{ij}, w_{jk}$ may be positive or negative depending on correlation of $j$ and $k$ interests and their reliability. Hypothesis: negative correlation yields negative $w_{ij}, w_{jk}$.
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Birge (Chicago Booth)
Supply Chain Networks
February 26, 2014
25 / 36
Implications for Supply Chain Structure

- Even symmetric networks with this cost structure may have widely varying equilibrium structure.
- With a single parameter $\alpha$ for the correlation, a full range of degree distributions exist.
- Examples:

  ![Graphs showing degree distributions with varying parameters $c$ and $\alpha$.](image)
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- New database: Bloomberg SPLC, $25000 \times 25000$ supply chain connections
- With effort can be fully collected (so far, $8000 \times 8000$)
- Initial observations: Size distribution:
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Supply Chain Relationship Hypotheses

- Performance metric: stock price
- First-order effects
  - Suppliers’ and customers’ concurrent performance relates to the firm
  - Supplier momentum (one-month lag) may be related to firm performance
  - Customer momentum (following Cohen and Frazzini (2008) not related to firm performance
- Second-order (systematic risk) effects
  - Centrality influences firm risk and return performance
  - More central manufacturing firms have lower returns
  - More central logistics firms have higher returns
First-Order Effects

Model:

\[ r_{i,t} = \alpha + \beta_1 r_{i,t-1} + \beta_2 \sum_j w_{ij}^{in} r_{j,t-1} + \beta_3 \sum_j w_{ij}^{out} r_{j,t-1} \]

\[ + \beta_4 \sum_j w_{ij}^{in} r_{j,t} + \beta_5 \sum_j w_{ij}^{out} r_{j,t} + \epsilon_{i,t}. \]

Coefficients \( \alpha \) and \( \beta_k \), \( k = 1, \ldots, 5 \) (estimated); \( \sum_j w_{ij}^{in} r_{j,t-1} \) - one-month supplier momentum, \( \sum_j w_{ij}^{out} r_{j,t-1} \) - one-month customer momentum, \( \sum_j w_{ij}^{in} r_{j,t} \) - concurrent supplier return, and \( \sum_j w_{ij}^{out} r_{j,t} \) - the concurrent customer return.

Use US firms in SPLC.

Monthly returns over 2010-2012.

Include common risk factors (MKT, SMB, HML, MOM).
### Table: Fama-Macbeth Regression of Concurrent Returns and Momentum.

<table>
<thead>
<tr>
<th>Ave. Coef</th>
<th>$\alpha$</th>
<th>$r_{i,t-1}$</th>
<th>$\sum_j w_{ij} r_{j,t-1}$</th>
<th>$\sum_j w_{ij}^{out} r_{j,t-1}$</th>
<th>$\sum_j w_{ij}^{in} r_{j,t}$</th>
<th>$\sum_j w_{ij}^{out} r_{j,t}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ave. Coef</td>
<td>-0.001</td>
<td>-0.088***</td>
<td>0.036**</td>
<td>0.024</td>
<td>0.399***</td>
<td>0.755***</td>
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<tr>
<td>(T-Stat)</td>
<td>(-0.96)</td>
<td>(-11.06)</td>
<td>(2.17)</td>
<td>(0.95)</td>
<td>(20.90)</td>
<td>(3.12)</td>
</tr>
<tr>
<td>Ave. Coef</td>
<td>0.009***</td>
<td>-0.090***</td>
<td>0.057***</td>
<td>0.004</td>
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<td>(T-Stat)</td>
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<td></td>
<td></td>
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<tr>
<td>Ave. Coef</td>
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<td>0.022**</td>
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<tr>
<td>(T-Stat)</td>
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<td>(1.83)</td>
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<td>Ave. Coef</td>
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<td>-0.040</td>
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<tr>
<td>(T-Stat)</td>
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<td>(-0.66)</td>
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<tr>
<td>Ave. Coef</td>
<td>0.003***</td>
<td></td>
<td></td>
<td>0.619***</td>
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</tr>
<tr>
<td>(T-Stat)</td>
<td>(3.61)</td>
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<td></td>
<td>(37.25)</td>
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<tr>
<td>Ave. Coef</td>
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<td>0.992***</td>
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<tr>
<td>(T-Stat)</td>
<td>(-2.26)</td>
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<td></td>
<td></td>
<td>(4.54)</td>
<td></td>
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<tr>
<td>Ave. Coef</td>
<td>0.004***</td>
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<td>0.018*</td>
<td>0.625***</td>
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<tr>
<td>(T-Stat)</td>
<td>(4.51)</td>
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<td>(1.57)</td>
<td>(36.44)</td>
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<tr>
<td>Ave. Coef</td>
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<td></td>
<td></td>
<td>0.001</td>
<td>1.001***</td>
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<tr>
<td>(T-Stat)</td>
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<td>(0.0274)</td>
<td>(4.51)</td>
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</tr>
<tr>
<td>Ave. Coef</td>
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<td>0.393***</td>
<td>0.744***</td>
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<td>(T-Stat)</td>
<td>(-1.80)</td>
<td></td>
<td></td>
<td>(22.48)</td>
<td>(3.20)</td>
<td></td>
</tr>
</tbody>
</table>

*p-value<10%, **p-value<5%, ***p-value<1%
Second-Order Effects

Model:
- Characterize centrality by eigenvector centrality and in- and out-degree centrality
- Use average of industry if no relationship in dataset
- Split by NAICS code (3 for manufacturing, 4 for logistics)

Split into quintiles of centrality.
Observe trends and significance in returns across quintiles.
## Second-Order Results: Manufacturing

**Table:** Factor Sensitivities by In-degree Centrality for Manufacturing Firms.

<table>
<thead>
<tr>
<th>N3 Portfolio</th>
<th>Alpha(%)</th>
<th>( R_{mt} - R_{ft} )</th>
<th>Factor Loadings</th>
<th>SMB</th>
<th>HML</th>
<th>MOM</th>
<th>Adj. ( R^2 ) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Low)</td>
<td>0.340</td>
<td>1.250***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>92.13</td>
</tr>
<tr>
<td></td>
<td>(0.99)</td>
<td>(15.71)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.630*</td>
<td>1.119***</td>
<td>0.327</td>
<td>-0.366</td>
<td>-0.145</td>
<td></td>
<td>93.25</td>
</tr>
<tr>
<td></td>
<td>(1.81)</td>
<td>(9.90)</td>
<td>(1.17)</td>
<td>(-1.68)</td>
<td>(-1.27)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.077</td>
<td>1.220***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>91.10</td>
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<tr>
<td></td>
<td>(0.22)</td>
<td>(14.70)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.414</td>
<td>1.085***</td>
<td>0.491</td>
<td>-0.594**</td>
<td>0.025</td>
<td></td>
<td>93.63</td>
</tr>
<tr>
<td></td>
<td>(1.25)</td>
<td>(10.07)</td>
<td>(1.85)</td>
<td>(-2.86)</td>
<td>(0.23)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.430</td>
<td>0.902***</td>
<td>-0.561*</td>
<td>-0.205</td>
<td>0.079</td>
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<td>-0.659***</td>
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<td>(0.10)</td>
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<tr>
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<td>-0.800***</td>
<td>-0.113***</td>
<td>-0.986***</td>
<td>-0.065</td>
<td>0.153***</td>
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<td>(-8.52)</td>
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<td>(-13.10)</td>
<td>(-1.10)</td>
<td>(5.03)</td>
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*p-value < 10%, **p-value < 5%, ***p-value < 1%
## Second-Order Results: Logistics

### Table: Factor Sensitivities by In-degree Centrality for Logistics Firms.

<table>
<thead>
<tr>
<th>N4 Portfolio</th>
<th>Alpha(%)</th>
<th>$R_{mt} - R_{ft}$</th>
<th>SMB</th>
<th>HML</th>
<th>MOM</th>
<th>Adj. $R^2$(%)</th>
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<td>1(Low)</td>
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<td>1.072***</td>
<td>-0.684</td>
<td>0.097</td>
<td>0.106</td>
<td>79.57</td>
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<td>(0.28)</td>
<td>(0.58)</td>
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<td>(7.19)</td>
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<td>2</td>
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<td>-0.875**</td>
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<td>-0.006</td>
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<td>3</td>
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<td>(8.59)</td>
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<tr>
<td>4</td>
<td>0.703*</td>
<td>0.893***</td>
<td>0.737*</td>
<td>-0.571*</td>
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<tr>
<td>5(High)</td>
<td>0.922**</td>
<td>0.638***</td>
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<td>-0.549**</td>
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<td>0.878**</td>
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<td>(2.81)</td>
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<tr>
<td>High-Low</td>
<td>0.861***</td>
<td>-0.434***</td>
<td>0.544***</td>
<td>-0.646***</td>
<td>0.096**</td>
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<td>(4.97)</td>
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<td>(8.80)</td>
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</table>

*p-value<10%, **p-value<5%, ***p-value<1%
Conclusions

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Thank you! Any questions?