Motivation: Bank lends to many interconnected companies

- Traditional models of banking focused on one-to-one bank-firm relationship.
- But, usually a bank lends to thousands of companies, which are interconnected with each other.
- Can we say anything novel from this viewpoint?
Position in a supply network may matter for capital costs.

(Ex.) It could be rational for a monopolistic bank to keep lending to a loss-making company.

- A monopolistic bank observes the entire supply network among its borrowers.
- All loans to them could become non-performing loans if the hub company is closed.
- Interest income from non-hub companies may exceed the cost of bailing out the hub.
- If so, keep lending to the loss-making hub is the optimal response for the bank.
Simple Example (4 firms, two-way)

(a) Keeping the Hub Open.

(b) Closing the Hub.

Interpretation 1: Zombie Lending

- Zombie/forbearance lending: lending to an under/non-performing firm by a bank that has the existing exposure to the firm (Sekine et al 2003; Peek et al 2005; Caballero et al 2008).

- Mechanism of the forbearance lending:
  - Baba 2001: real option (value of waiting for resurrection).
  - Peek/Rosengren 2005: “balance sheet cosmetics”.

- Does not seem to be sufficient.
  - Forbearance lending was prevalent among large publicly traded companies while it is not among small private companies (Hosono 2008; Ogawa 2008; Sakai et al 2010; Hamao et al 2012).
  - Threat of a possible legal liability (special breach of trust, shareholder derivative lawsuit).
Interpretation 2: Government Bailout.


“The Big Three directly employ almost 250,000, [...], not counting the vast network of suppliers and dealers whose businesses are intertwined. In all, administration officials estimate that the failure of the U.S. auto makers would cost the economy more than one million jobs and would reduce economic output by more than 1%, significantly prolonging the downturn.” (“Detroit Gets Access To Bailout Funds,” Dec.13, 2008, WSJ).

“‘The attitude of the Prime Minister Office toward Daiei has switched all of a sudden in the mid last December. The government’s strong will to avoid its bankruptcy was felt’ (Top executives of main banks for Daiei). [...] The bankruptcy of Daiei damages seriously a numerous suppliers and the regional economy.” (“Document Daiei Sai Shuppatsu,” Jan 19, 2002, NIKKEI)
Empirical analysis shows

1. Hub firms with a higher influence coefficient in a supply network obtain loans at a lower interest cost.

2. This effect is stronger for,
   - less credit-worthy firms, or
   - those whose main bank is a regional bank, which is often a dominant lender in a region.
One period. Perfect foresight.

1. The financial market determines the allocation of funds before production. Each firm has to finance its fixed cost from households through the market (trade credits for the other transactions).

2. Those firms that can finance its fixed cost produces a differentiated product for both consumption and input for other firms.
   - Supply network is an incomplete network.
   - Each firm cannot make a new link to the inside or outside of the network. ⇐ Products are something relation-specific.
Model: Household

- Household $h$’s (countable, symmetric, $h = 1, \cdots, H$) utility is:

$$U_h = \left( \sum_{j=1}^{n} e_j c_{hj} \right)^{\frac{\theta}{\theta - 1}}, \quad \theta > 1,$$

(1)

- $e_i (i = 1, 2, \cdots, n)$ equals one if firm $i$ operates or zero otherwise. Every household knows which companies will operate at the consumption decision.
- $c_{hj}$: consumption of the firm $j$’s product by household $h$.

The budget constraint of household $h$:

$$\sum_{j=1}^{n} c_{hj} p_j \leq R_h,$$

(2)

- $p_j$: Price of product $j$.
- $R_h$: Household $h$’s nominal income (exogenous; $R \equiv \sum_h R_h$).
- Each household is endowed with numeraire $\kappa/H$ (real term).
The production function of Firm $i$ (countable, $i = 1, \cdots, n$), which produce product $i$, is

$$x_i = \left( \sum_{j=0}^{n} e_j w_{ij} x_{ij}^{\frac{1}{\theta}} x_{ij}^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}}, \quad \theta > 1,$$

(3)

- Sales network: $w_{ij}$ (fixed) is the technological importance of the input $j$ for the production of firm $i$. $0 \leq w_{ij} \leq 1, \forall i, j$. $w_{ii} = 0$ (no self-input), and $0 < \sum_{i=0}^{n} w_{ij} \leq 1$.
- $x_{ij}$: quantity of the firm $i$’s input from firm $j$.
- The input good $j = 0$ is an input from the outside of the network. Its price is an exogenously given constant $p_0$.
- $\theta$: elasticity of input substitution. Assumed to be equal to that in the utility function.
Each firm chooses the input basket so as to min cost, and set its price to max profit.

Each firm has to finance from banks or investors the fixed cost $F_i$, $(i = 1, 2, \cdots, n)$ (real term).

Those companies that can finance the fixed cost always operate (limited liability for firm owners).

Every firm knows which companies will operate when it decides the input basket and its price.

Total demand for firm $i$:

$$x_i = \sum_{j=1}^{n} e_j x_{ji} + \sum_{h=1}^{H} c_{hi}, \quad \text{for each product } i. \quad (4)$$
Centralized case: All households pool their numeraire at a monopolistic bank, which invest in firms or outside opportunity. Profit is shared by households.

Decentralized case: All households directly invest in each firm (hold a share of $s_i$ of firm $i$ by paying $s_iF_i$ to the firm). Or, deposit at several oligopolistic banks.

* Assume $\kappa > \sum_{i=1}^{n} F_i$ (supply of loanable funds $>$ demand of loanable funds).

* In any case, households and banks have an outside opportunity that can yield the real prime rate of return $\rho (> 0)$. They are all protected by the limited liability.
Product market: Total sales of firm $i$.

Demand for firm $i$ is

$$x_i = \sum_{h=1}^{H} c_{hi} + \sum_{j=1}^{n} x_{ji} = \frac{\sum_{h=1}^{H} R_h}{p_c} \cdot \left( \frac{p_c}{p_i} \right)^\theta + \sum_{j=1}^{n} \left( \frac{p_j}{p_i} \right)^\theta e_j w_{ji} x_j. \quad (5)$$

In the vector expression; the total sales are

$$s = f + Qs, \quad (6)$$

where $s$ (total sales) $\equiv (e_1 p_1 x_1, e_2 p_2 x_2, \cdots, e_n p_n x_n)'$,

$(i,j)$ element of $Q$: $q_{ij} \equiv e_i w_{ji} p_i^{1-\theta} p_j^\theta / p_j$,

$f$ (sales to consumers) $\equiv (e_1 p_1 c_1, e_2 p_2 c_2, \cdots, e_n p_n c_n)'$.

By the assumptions w.r.t. $w_{ij}$ and the definition of $p^i$, $I - Q$ is invertible.

$$s = (I - Q)^{-1} f,$$

$$= \sum_{k=0}^{\infty} Q^k f. \quad (7)$$
The aggregate sales of all operating firms is

\[ 1's = 1'(I - Q)^{-1}f \]

\[ = v'f, \]  

(8)

where

**Influence vector**

\[ v \equiv 1'(I - Q)^{-1} \]  

(9)

\[ = 1' \sum_{k=0}^{\infty} Q^k. \]  

(10)

The influence coef of firm \( i \) = \[
\frac{\Delta \text{Aggregate Sales}}{\Delta \text{Sales of firm } i \text{ to households}}.
\]
We say a bank undertakes the **forbearance** if it extends a loan to firm \( z \) despite that its real economic profit is negative; namely,

\[
e_z = 1 \text{ and } \frac{x_z p_z}{\theta p_c} - (1 + \rho) F_z < 0. \quad (11)
\]

- Indicator, \( e_i = 1 \) if firm \( i \) can finance \( F_i \) or 0 otherwise.
- Network-motivated forbearance for firm \( z \) occurs if
  - firm \( z \) is financed at the bank optimum, despite that
  - (11) holds.

The first statement means

\[
\sum_{i=1}^{n} e_i^* \left( \frac{x_i^* p_i^*}{\theta p_c^*} - (1 + \rho) F_i \right) > \sum_{i=1}^{n} \tilde{e}_i \left( \frac{\tilde{x}_i \tilde{p}_i}{\theta \tilde{p}_c} - (1 + \rho) F_i \right).
\]

where \( \ast \) indicates values at the bank profit maximizing, the tilde indicates values at the constrained maximum s.t. \( e_z = 0 \).
Rearranging the last inequality and combining with (11) at $e_i = e_i^*$ give

$$\frac{v_z^* p_z^* c_z^* - p_z^* x_z^*}{\theta p_c^*}$$

profit of the network induced by $z$

$$+ \sum_{i \neq z} \left[ e_i^* \left( \frac{v_i^* p_i^* c_i^*}{\theta p_c^*} - (1 + \rho) F_i \right) - \tilde{e}_i \left( \frac{\tilde{v}_i \tilde{p}_i \tilde{c}_i}{\theta \tilde{p}_c} - (1 + \rho) F_i \right) \right]$$

business-stealing effect/influence-enhancing effect by $z$

$$> - \left( \frac{p_z^* x_z^*}{\theta p_c^*} - (1 + \rho) F_z \right) > 0$$

direct cost to support firm $z$

Monopolistic bank internalizes the externality of firm $z$.

If the inequality holds, Firm $z$ obtains a loan at the rate lower than $\rho$:

$$\frac{x_z^* p_z^*}{\theta p_c^* F_z} - 1 < \rho.$$  \hfill (15)

Caballero et al (2008): negative spread is the indicator of forbearance.
Proposition (Network-Motivated Forbearance)

The monopolistic bank can maximize its profit by undertaking the forbearance for firm z if the inequality consisting of (12), (13) and (14) holds. The interest rate of a loan to firm z is below the prime rate, and that of at least a loan to the other firm is over the prime rate. Forbearance is welfare improving.
(Assumption) No single household can financially support a firm; $F_i > \kappa/H$ for any $i$.

- Given that each household behaves as a price taker without any coalition, the investor is not willing to provide funds at the rate less than the opportunity cost $\rho$.
- No possibility of forbearance lending.

Coordination failure.

(“Credit market freeze”; Bebchuk-Goldstein 2011 RFS).
1. Tacit collusion.

2. Relationship Banking (conjecture)
   Banks can cover the cost of forbearance by the excess return from peripheral firms due to information advantage (e.g., Sharpe 1990, Rajan 1992).
1. **Companies with a higher influence factor is likely to obtain a loan at a lower (even negative) rate and less likely to close.**

2. Forbearance lending to a hub company is likely when a certain bank is the primary lender to a supply network.

3. Forbearance to a hub firm is more likely when a bank can earn quasi-rents from peripheral firms; such as those from relational lending or coalition.
Firm transaction data of 652,280 companies (main bank information is available for 306,354) as of March 2006 (after dropping those whose latest sales report is before September 2004, or missing), Tokyo Shoko Research (TSR).

Name and TSR company ID of major corporate customers and suppliers up to 24 for each company.

Also includes: sales (latest 3 yrs), profit, total assets, credit score, # employees, name and ID of the largest 10 lenders, security code if listed.

More detailed financial data of randomly sampled some 20,000 firms including loans and interest expenses.
Step 1: Estimate the influence vector $v$

- Estimate Eq. (6).

$$\Delta s = \hat{Q}\Delta s + \gamma'\text{Ind} + \gamma'\text{Pre} + \epsilon, \quad (16)$$

where $\text{Ind}$ is industry dummies, $\text{Pref}$ is prefecture dummies, $\gamma$’s are the vectors of coefficients.

1. Simple $v$: $\hat{Q} = \beta_1 G$, where $G$ is the adjacent matrix of a sales network where the $(i,j)$ element is equal to 1 if firm $i$ purchases from firm $j$ or zero otherwise.

2. Labor-dependent $v$: $\hat{Q} = \beta_{21}G + \beta_{22}GL$, where $L$ is the diagonal matrix where the $(i,i)$ element is $\#\text{employees} / \text{sales of firm } i$ (10000 if sales = 0).

3. Counterpart-risk $v$: $\hat{Q} = \beta_3 GS$, where $S$ is the $n \times n$ diagonal matrix whose $i$-th diagonal element is the square root of firm $i$’s credit score provided by TSR (the credit score is divided by 100).

- Estimate $\beta$’s and $\gamma$’s by the entire network.
- We use the networks of firms with a common main bank (main bank is identified by the first lender in the TSR data).
### Descriptive statistics of the influence coefficient

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### Estimation results of the spatial autoregressive model

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<td>prefecture factor</td>
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Example: Supply network among borrowers

(#firms:152, max(v) = 1.0119; by Gephi)
Step 2: Hypothesis test

Hypothesis

1. A higher influence coefficient reduces the interest cost per unit of loans.
2. The above effect is larger for less credit-worthy firms.
3. The effect of the influence coefficient is larger for firms with regional banks as their main bank.
Specification for the tests

\[ rate_i = b_0 + b_1 \cdot \ln(v_i) + b_2 \cdot \text{score}_i + b_3 \cdot \ln(v_i) \times \text{score}_i + b_4'X_i + \epsilon_i, \tag{17} \]

where

\[ rate_i \equiv \frac{\text{current interest expense}}{\text{total loan outstanding in the previous accounting year}}. \]
Descriptive statistics 2

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<td>0.000</td>
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<td>0.000</td>
<td>0.000</td>
<td>1.623</td>
<td>3.724</td>
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<td>0.001</td>
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(note) Those with non-positive rate, and those above 99 percentile w.r.t. rate are dropped.
\begin{table}
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\begin{tabular}{lrrr}
\hline
 & (1) & (2) & (3) \\
 & coef. & coef. & coef. \\
 & (s.e.) & (s.e.) & (s.e.) \\
\hline
\text{ln(v)} & -3.913 & 0.372 & -1.681 \\
 & (1.113) & (0.410) & (0.972) \\
\text{ln(v) } \times \text{ score} & 7.726 & 4.578 \\
 & (2.050) & (1.828) & \\
\text{score} & -2.879 & -1.402 & -1.511 \\
 & (0.132) & (0.186) & (0.194) \\
\text{DISTRESS} & 0.296 & 0.290 \\
 & (0.071) & (0.071) & \\
\text{score } \times \text{ DISTRESS} & 2.539 & 2.598 \\
 & (0.636) & (0.635) & \\
\text{LN(INT_COV)} & -0.205 & -0.205 \\
 & (0.016) & (0.016) & \\
\text{LEVERAGE} & -0.044 & -0.049 \\
 & (0.074) & (0.073) & \\
\text{TANGIBLE} & -0.268 & -0.270 \\
 & (0.093) & (0.093) & \\
\text{CURRENT} & -0.009 & -0.008 \\
 & (0.005) & (0.005) & \\
\text{PROFITABLE} & -0.050 & -0.050 \\
 & (0.018) & (0.018) & \\
\text{EBITDA.G} & 0.097 & 0.098 \\
 & (0.013) & (0.013) & \\
\text{SALES.G} & 0.359 & 0.355 \\
 & (0.098) & (0.098) & \\
\text{LN(SALES)} & -0.038 & -0.031 \\
 & (0.016) & (0.016) & \\
\text{LN(AGE)} & -0.183 & -0.180 \\
 & (0.038) & (0.038) & \\
\hline
\end{tabular}
\caption{Results 1: OLS with the estimated-regressor-adjusted SE}
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<td>(0.209)</td>
</tr>
<tr>
<td>industry factor</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>region factor</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>N</td>
<td>7,355</td>
<td>7,328</td>
</tr>
<tr>
<td>adj. R-squared</td>
<td>0.123</td>
<td>0.160</td>
</tr>
</tbody>
</table>
Firm with \( \text{score} = 0 \): \textit{rate} of 90 percentile influential firm is lower than the median firm by 3bp. This difference is 21 bp between 99 percentile and median, and 164 bp between max and median.

<table>
<thead>
<tr>
<th>at score =</th>
<th>d rate/d ln(v)</th>
<th>(s.e.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.2</td>
<td>-2.597</td>
<td>1.314  **</td>
</tr>
<tr>
<td>-0.1</td>
<td>-2.139</td>
<td>1.141  *</td>
</tr>
<tr>
<td>0</td>
<td>-1.681</td>
<td>0.972  *</td>
</tr>
<tr>
<td>0.1</td>
<td>-1.223</td>
<td>0.809</td>
</tr>
<tr>
<td>0.2</td>
<td>-0.766</td>
<td>0.657</td>
</tr>
<tr>
<td>0.3</td>
<td>-0.308</td>
<td>0.524</td>
</tr>
<tr>
<td>0.4</td>
<td>0.150</td>
<td>0.430</td>
</tr>
<tr>
<td>0.5</td>
<td>0.608</td>
<td>0.402</td>
</tr>
</tbody>
</table>
## Result 2: by main bank type

(i) major banks only  
(ii) regional banks only  
(iii) cooperative banks only  

<table>
<thead>
<tr>
<th></th>
<th>(i) major banks only</th>
<th>(ii) regional banks only</th>
<th>(iii) cooperative banks only</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>coef.</td>
<td>(s.e.)</td>
<td>coef.</td>
</tr>
<tr>
<td>ln(v)</td>
<td>-1.403</td>
<td>(1.161)</td>
<td>-2.784</td>
</tr>
<tr>
<td>ln(v) × score</td>
<td>2.948</td>
<td>(2.188)</td>
<td>17.977</td>
</tr>
<tr>
<td>controls</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>region factor</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>industry factor</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>adj. R-squared</td>
<td>0.162</td>
<td>0.146</td>
<td>0.119</td>
</tr>
<tr>
<td>N</td>
<td>2,780</td>
<td>3,949</td>
<td>599</td>
</tr>
</tbody>
</table>

(Marginal Effect)

<table>
<thead>
<tr>
<th>at score = -0.2</th>
<th>d rate</th>
<th>(s.e.)</th>
<th>d rate</th>
<th>(s.e.)</th>
<th>d rate</th>
<th>(s.e.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>d ln(v)</td>
<td>-1.993</td>
<td>(1.577)</td>
<td>-6.380</td>
<td>(2.875) **</td>
<td>-40.644</td>
<td>(44.694)</td>
</tr>
<tr>
<td>-0.1</td>
<td>-1.698</td>
<td>(1.368)</td>
<td>-4.582</td>
<td>(2.240) **</td>
<td>-32.405</td>
<td>(30.498)</td>
</tr>
<tr>
<td>0</td>
<td>-1.403</td>
<td>(1.161)</td>
<td>-2.784</td>
<td>(1.710)</td>
<td>-24.167</td>
<td>(18.252)</td>
</tr>
<tr>
<td>0.1</td>
<td>-1.108</td>
<td>(0.961)</td>
<td>-0.987</td>
<td>(1.410)</td>
<td>-15.928</td>
<td>(14.370)</td>
</tr>
<tr>
<td>0.2</td>
<td>-0.814</td>
<td>(0.770)</td>
<td>0.811</td>
<td>(1.486)</td>
<td>-7.689</td>
<td>(23.456)</td>
</tr>
<tr>
<td>0.3</td>
<td>-0.519</td>
<td>(0.599)</td>
<td>2.609</td>
<td>(1.893)</td>
<td>0.550</td>
<td>(36.935)</td>
</tr>
<tr>
<td>0.4</td>
<td>-0.224</td>
<td>(0.469)</td>
<td>4.407</td>
<td>(2.473) *</td>
<td>8.789</td>
<td>(51.464)</td>
</tr>
<tr>
<td>0.5</td>
<td>0.071</td>
<td>(0.421)</td>
<td>6.204</td>
<td>(3.131) **</td>
<td>17.028</td>
<td>(66.357)</td>
</tr>
</tbody>
</table>
Marginal Effect of Influence Coefficient: Main bank type

(Note) The vertical line segments indicate the 95% confidence interval.
1. If the influence coefficient of the entire-economy network is much larger than the within-main-bank network, the bank is not willing to support the firm. Could lead to too early liquidation. Need a government support.

2. To identify such an important firm. Need to keep tracking the influence coefficient of important firms.

3. No point in procrastinating a bailout plan for an influential firm in a crisis at least in the short run.
Further Questions

- This motivation for a bank to support the hub firm in the network of its clients detrimental to the metabolism and the allocation efficiency?
- How does the market structure in the banking sector affect such motivation?
- Is this motivation more prominent in countries with a bank-oriented financial market?
- Does the hub supplier (not procurer) in the supply network enjoy a similar benefit?