Network-Motivated Lending Decisions

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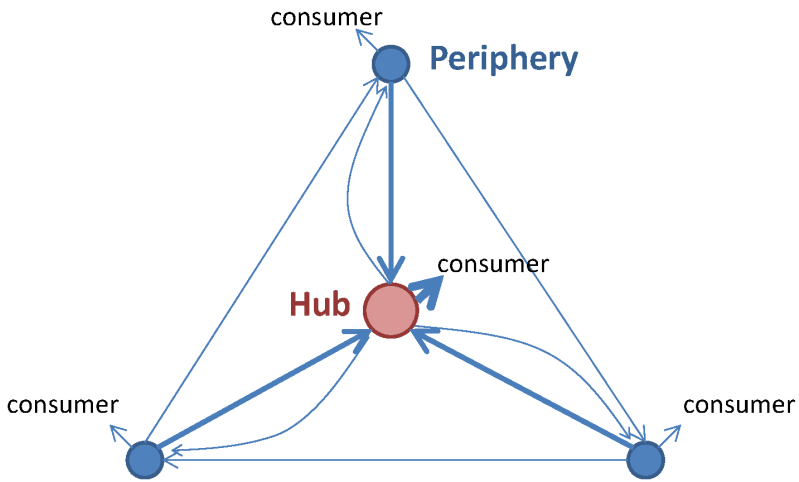
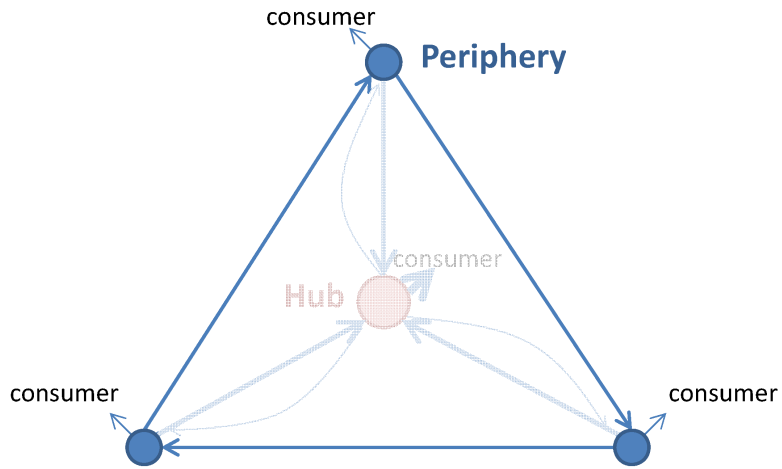
March, 7, 2016
RIETI International Workshop on
Geography, Inter-firm Networks,
and International Trade

Simple Example (4 Firms)



(a) Keeping the Hub Open.



(b) Closing the Hub.

Each node: firm. Arrow: direction of sales. Thickness: amounts of sales.

Motivation: Position in a Network Matters for Financing.

(e.g.) Salvaging a loss-making hub company can be profitable for a bank.

- 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, the bail-out is its optimal response.

Interpretation

1. **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).
2. **Government bailout**: Public bailout of under-performing giant companies: GM and Chrysler in 2009, Daiei in 2003.

   "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"

   ("Detroit Gets Access To Bailout Funds," Dec.13, 2008, WSJ).

Empirical Analysis Shows

- Reasonable and tractable method to estimate the influence coefficient.
- Firms with a higher influence coefficient enjoy;
  1. lower interest costs in bank lending in a financial distress,
  2. and this effect is more significant when their main bank is a regional bank,

  which is often a dominant lender in a less competitive local lending market in Japan.
- Japanese dataset includes information about suppliers and customers as well as main bank of each firm.

Measure of being the hub: Influence coefficient i.

Oligopoly under the Dixit-Stiglitz type production/utility function gives the following sales vector

$$\mathbf{s} = \mathbf{f} + \mathbf{Q}\mathbf{s}, \tag{1}$$

where $\mathbf{s}$ (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 $\mathbf{Q}$: $q_{ij} \equiv e_i w_{ji} p_i^{1-\theta} p^{j\theta} / p_j$,

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

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

$$\begin{aligned} \mathbf{s} &= (\mathbf{I} - \mathbf{Q})^{-1}\mathbf{f}, \\ &= \sum_{k=0}^{\infty} \mathbf{Q}^k \mathbf{f}. \end{aligned} \tag{2}$$

Aggregate Sales and the Influence Vector.

The aggregate sales of all operating firms is

$$\begin{aligned} \mathbf{1}'\mathbf{s} &= \mathbf{1}'(\mathbf{I}-\mathbf{Q})^{-1}\mathbf{f} \\ &= \mathbf{v}'\mathbf{f}, \end{aligned} \tag{3}$$

where

Influence vector

$$\mathbf{v}' \equiv \mathbf{1}'(\mathbf{I}-\mathbf{Q})^{-1} \tag{4}$$

$$= \mathbf{1}'\sum_{k=0}^{\infty}\mathbf{Q}^k. \tag{5}$$

$$\text{Influence coef of firm } i = \frac{\Delta\text{total sales of the network}}{\Delta\text{sales of firm } i \text{ to households.}}$$

Hypotheses

Hypothesis

1. *The influence coefficient has a negative impact on the interest rate paid by a less credit-worthy firm.*
2. *The effect of the influence coefficient is larger for firms with regional banks as their main bank.*

Data

- 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, credit score, # employees, name and ID of the largest 10 lenders, security code if listed.
- More detailed financial data of randomly sampled some 8,000 firms including loans and interest expenses.

Step 1: Estimate the Influence Vector **v**

- Estimate Eq. (1).

$$\Delta \mathbf{s} = \hat{\mathbf{Q}} \Delta \mathbf{s} + \gamma_I' \mathbf{Ind} + \gamma_P' \mathbf{Pref} + \epsilon, \tag{6}$$

where **Ind** is industry dummies, **Pref** is prefecture dummies, γ's are the vectors of coefficients.

1. Simple v: $\hat{\mathbf{Q}} = \beta_1 \mathbf{G}$, where $\mathbf{G}$ 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. Counterpart-risk v_s: $\hat{\mathbf{Q}} = \beta_3 \mathbf{GS}$, where $\mathbf{S}$ 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 β's and γ'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 1

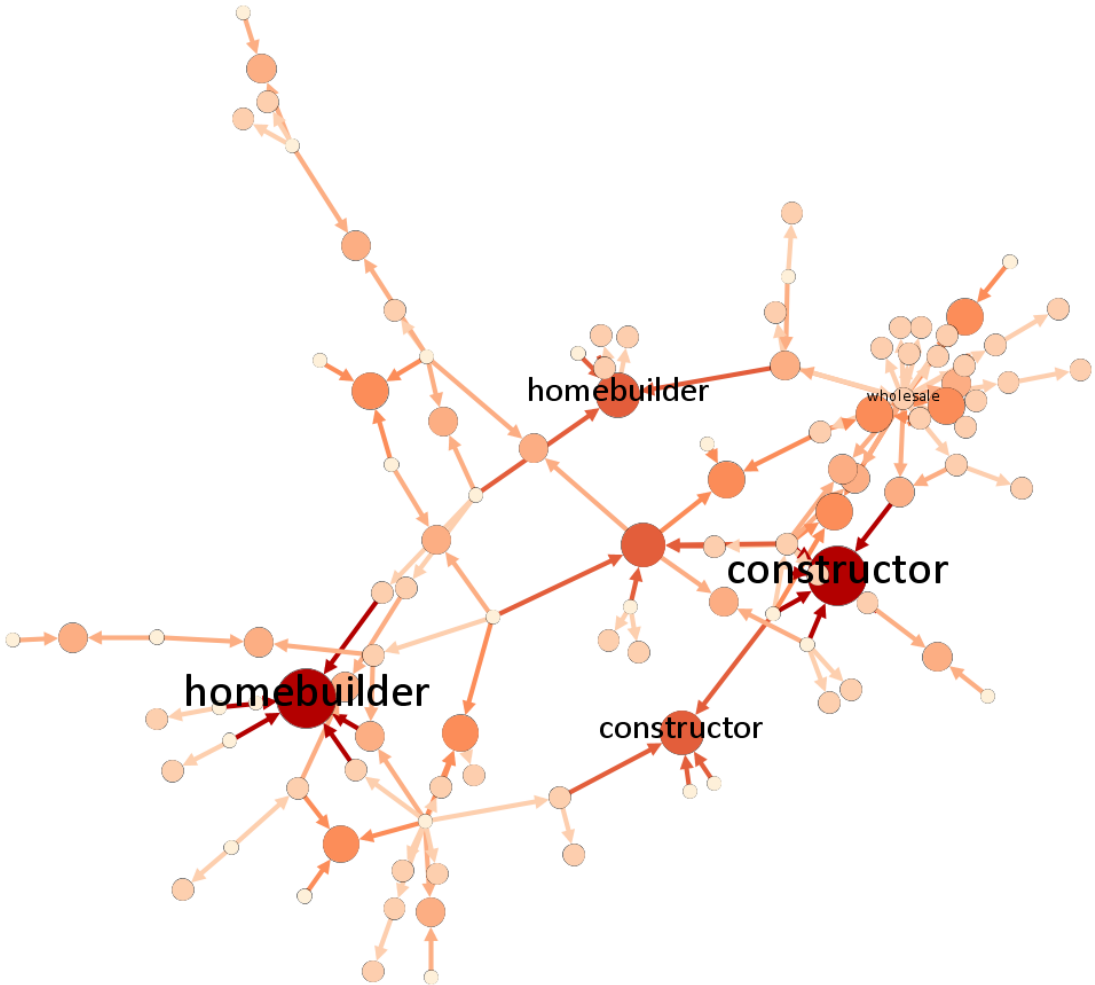
Table : Descriptive statistics of the influence coefficient

# of obs.	mean	sd	min	p10	med	p75	p90	p95	p99	max
306,354	1.003	0.011	1.000	1.000	1.002	1.004	1.006	1.010	1.025	2.837

Table : Estimation results of the spatial autoregressive model

	est. coef.	s.e.	
β	0.00197	0.0000494	***
industry factor	yes		
prefecture factor	yes		
adj. R-squared	0.1451		
# of observations	652,280		

Example: Supply Network among Borrowers



(#firms:152, max(v)= 1.0119; by *Gephi*)

Specification for the Tests

$$rate_i = b_0 + b_1 \cdot ln(v_i) + b_2 \cdot score_i + b_3 \cdot ln(v_i) \times score_i + \mathbf{b_4}'\mathbf{X}_i + \epsilon_i,$$

where

$$rate_i \equiv \frac{\text{current interest expense}}{\text{Average of outstanding loans in current and previous years}}.$$

$$\textbf{H1} \rightarrow b_1 < 0 \textbf{ and } b_3 > 0.$$

Also estimated by replacing score with DISTRESS (1 if score < 0) or INSOLVENT (1 if asset $<$ liability).

$$\textbf{H1} \rightarrow b_1 + b_3 < 0 \textbf{ and } b_3 < 0.$$

Descriptive Statistics 2

	N	mean	sd	min	p1	p10	p50	p90	p99	max
rate	7,408	2.269	1.359	0.000	0.181	0.896	2.025	3.776	7.262	11.379
$ln(v)$	7,408	0.011	0.033	0.000	0.000	0.000	0.004	0.020	0.129	0.979
$ln(v_s)$	7,408	0.010	0.032	0.000	0.000	0.000	0.003	0.018	0.116	0.922
score	7,408	0.136	0.153	-1.000	-0.200	-0.040	0.120	0.340	0.520	0.840
DISTRESS	7,408	0.154	0.361	0	0	0	0	1	1	1
INSOLVENT	7,408	0.049	0.216	0	0	0	0	0	1	1
LN(INT_COV)	7,408	1.838	1.418	0.000	0.000	0.000	1.625	3.761	6.001	10.571
LEVERAGE	7,408	0.723	0.307	0.008	0.165	0.395	0.739	0.950	1.553	7.161
TANGIBLE	7,408	0.291	0.202	0.000	0.001	0.038	0.264	0.573	0.835	0.989
CURRENT	7,408	1.683	3.248	0.024	0.257	0.733	1.262	2.580	7.519	135.105
PROFITABLE	7,408	0.041	0.826	-46.771	-0.145	-0.008	0.027	0.110	0.337	52.643
EBITDA_G	7,408	0.015	0.883	-0.987	-0.166	-0.042	0.001	0.050	0.238	75.757
SALES_G	7,408	0.045	0.273	-0.959	-0.449	-0.146	0.024	0.235	0.777	9.767
LN(SALES)	7,408	7.905	1.836	2.059	4.396	5.696	7.735	10.346	12.900	16.221
LN(LOAN)	7,408	6.367	2.006	-2.198	1.859	3.890	6.297	8.852	11.695	15.864
LN(FIRM AGE)	7,408	3.575	0.573	-1.792	1.792	2.752	3.712	4.096	4.477	4.827
LISTED	7,408	0.120	0.325	0	0	0	0	1	1	1
BOND_RATIO	7,408	0.061	0.156	0.000	0.000	0.000	0.000	0.225	0.835	1.000
#LENDING_BKS	7,408	4.660	2.300	1	1	2	4	8	10	10
MAJOR_BK	7,408	0.380	0.485	0	0	0	0	1	1	1
REGIONAL_BK	7,408	0.539	0.499	0	0	0	1	1	1	1
HI	7,408	0.182	0.109	0.050	0.050	0.050	0.164	0.324	0.510	1.000

Results 1: OLS (regional bank only)

	(1) coef. (s.e.)		(2) coef. (s.e.)		(3) coef. (s.e.)		(4) coef. (s.e.)	
$\ln(v)$	-5.682	***	-3.047	*	1.027		0.774	
	(1.599)		(1.553)		(1.346)		(1.322)	
$\ln(v)\times$ score	17.295	**	18.225	**				
	(7.956)		(7.514)					
$\ln(v)\times$ DISTRESS					-6.300	***		
					(2.384)			
$\ln(v)\times$ INSOLVENT							-6.904	*
							(3.933)	
score	-2.778	***	-2.539	***	-2.310	***	-2.257	***
	(0.174)		(0.242)		(0.226)		(0.227)	
DISTRESS			0.230	***	0.282	***	0.240	***
			(0.071)		(0.076)		(0.071)	
INSOLVENT							-0.117	
							(0.124)	
score $\times$ DISTRESS			2.425	***	2.336	***	2.014	***
			(0.632)		(0.634)		(0.679)	
LN(INT_COV)			-0.364	***	-0.364	***	-0.362	***
			(0.041)		(0.041)		(0.041)	
LEVERAGE			0.172		0.175		0.237	*
			(0.118)		(0.118)		(0.131)	
TANGIBLE			0.408	***	0.416	***	0.423	***
			(0.116)		(0.115)		(0.115)	
CURRENT			0.014		0.013		0.014	
			(0.013)		(0.013)		(0.013)	
PROFITABLE			3.693	***	3.682	***	3.658	***
			(0.907)		(0.903)		(0.901)	
EBITDA_G			0.362		0.368		0.359	
			(0.377)		(0.377)		(0.378)	

(cont.)

SALES_G		0.023		0.025		0.021	
		(0.086)		(0.086)		(0.086)	
LN(SALES)		0.371	***	0.368	***	0.364	***
		(0.045)		(0.045)		(0.045)	
LN(LOAN)		-0.419	***	-0.419	***	-0.422	***
		(0.042)		(0.042)		(0.042)	
LN(AGE)		-0.004		-0.006		-0.007	
		(0.043)		(0.043)		(0.043)	
LISTED		-0.077		-0.052		-0.040	
		(0.076)		(0.073)		(0.074)	
BOND_RATIO		-0.088		-0.103		-0.093	
		(0.170)		(0.171)		(0.171)	
#LENDING_BKS		0.037	***	0.037	***	0.037	***
		(0.009)		(0.009)		(0.009)	
HI		-0.174		-0.165		-0.184	
		(0.226)		(0.226)		(0.226)	
industry factor	yes	yes		yes		yes	
region factor	yes	yes		yes		yes	
t-stat. (p-value)				-2.34(0.019)		-1.62(0.106)	
N	3,991	3,991		3,991		3,991	
adj. R-squared	0.127	0.216		0.216		0.215	

S.E.s are adjusted for the estimated regressor problem.
[t-stat.] H_0: (coef of $\ln(v)$)+(coef of $\ln(v) \times DISTRESS(INSOLVENT)$) $=0$.

Marginal Effect of Influence Coefficient

at score =	d rate/d ln(v)	(s.e.)	
-0.2	-6.692	2.739	**
-0.1	-4.869	2.096	**
0	-3.047	1.553	*
0.1	-1.224	1.249	
0.2	0.598	1.355	
0.3	2.421	1.800	
0.4	4.243	2.403	*
0.5	6.066	3.072	**

For a firm with score of -0.2 (insolvent),

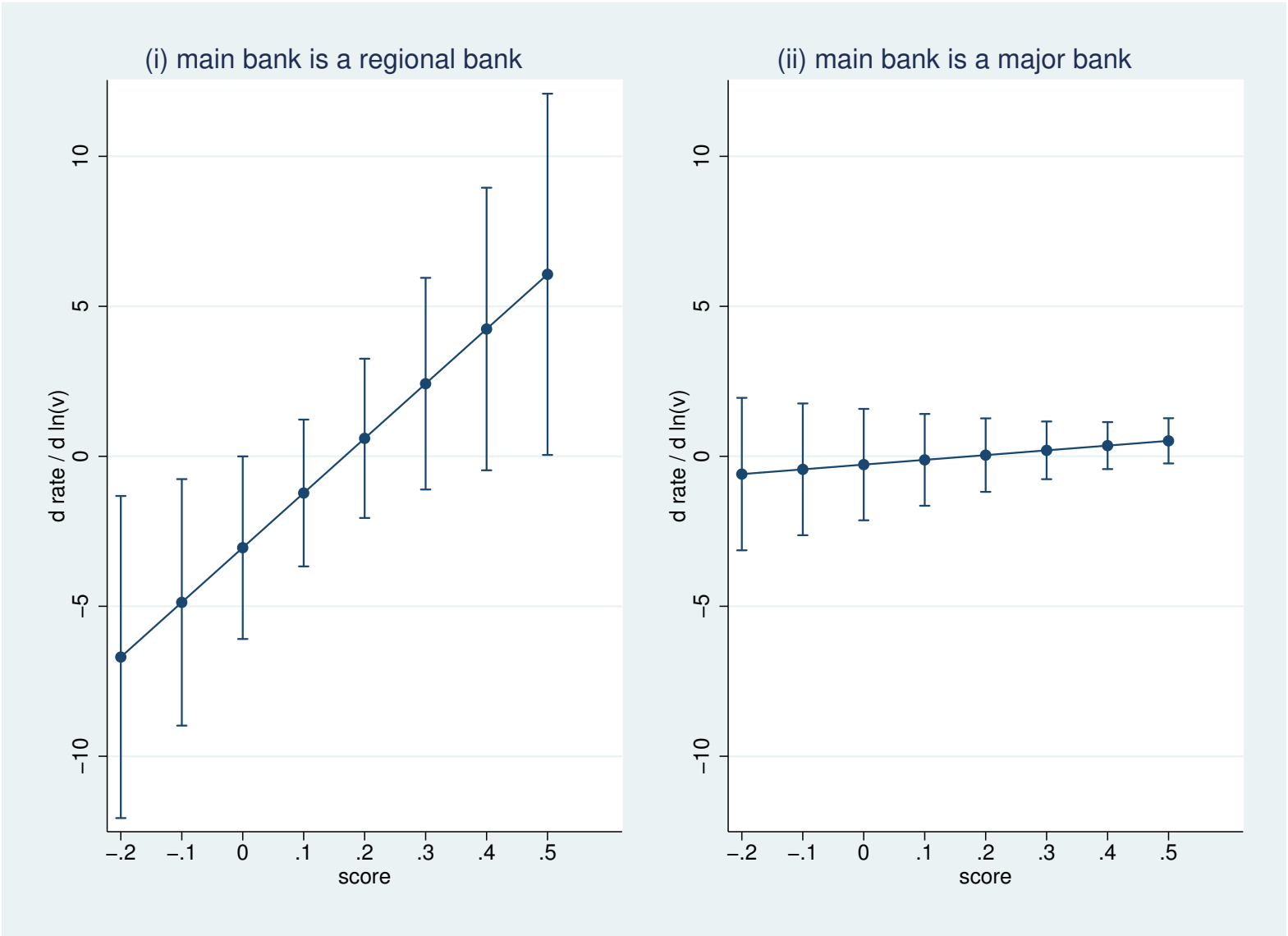
Influ. coef (med $\rightarrow$ 90%) reduces rate by 11bp.

Influ. coef (med $\rightarrow$ 99%) reduces rate by 84bp.

Result 2: Major banks

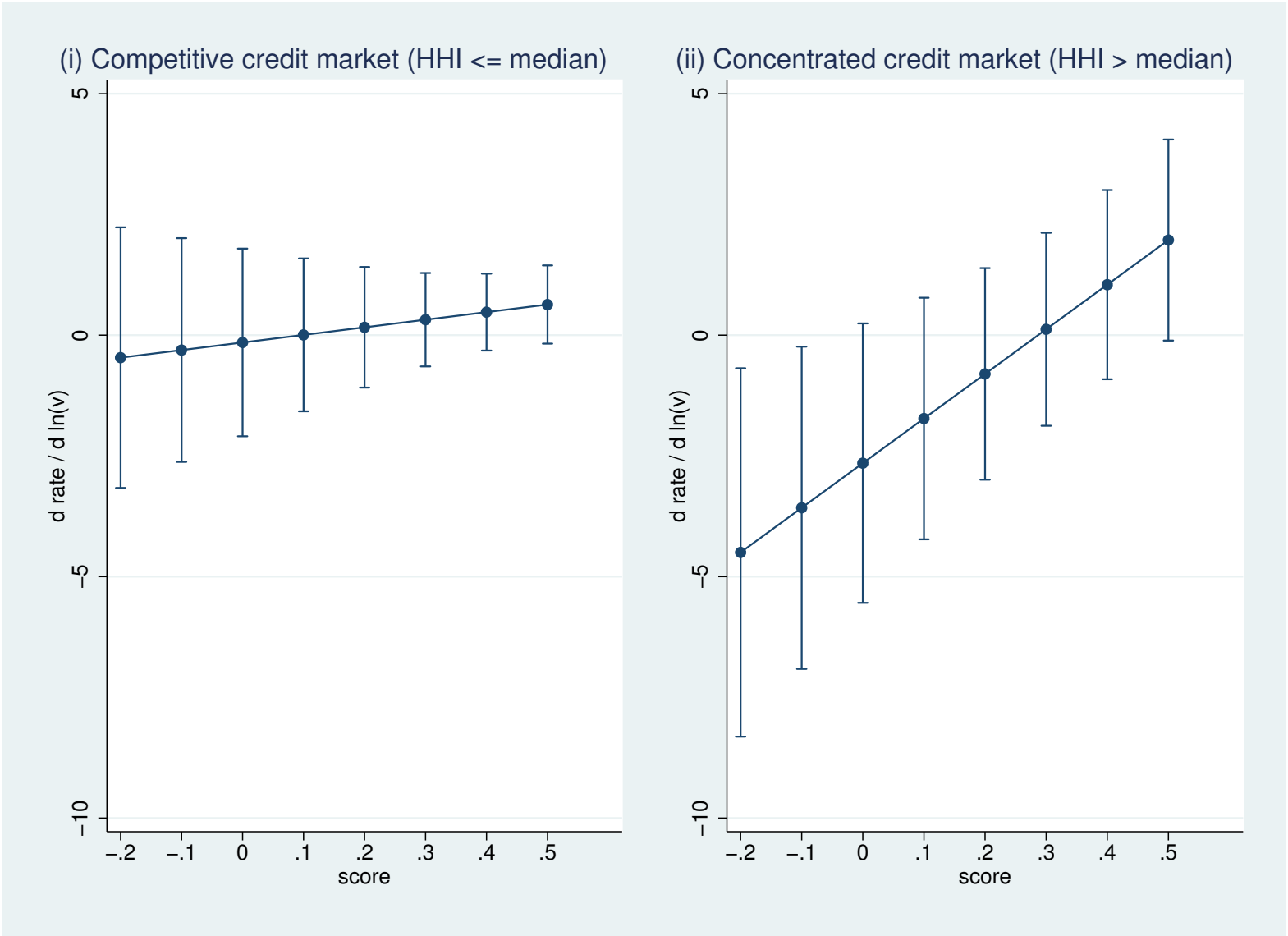
	(1) major banks only		(2) full sample		
	coef.	(s.e.)	coef.	(s.e.)	
ln(v)	-0.277	(0.948)	-1.107	(0.853)	
ln(v)$\times$ score	1.583	(1.857)	4.201	(1.596)	***
controls	yes		yes		
region factor	yes		yes		
industry factor	yes		yes		
adj. R-squared	0.234		0.220		
N	2,816		7,408		
(Marginal Effect)					
at score =	d rate/d ln(v)	(s.e.)	d rate/d ln(v)	(s.e.)	
-0.2	-0.594	(1.297)	-1.947	(1.150)	*
-0.1	-0.435	(1.120)	-1.527	(1.000)	
0	-0.277	(0.948)	-1.107	(0.853)	
0.1	-0.119	(0.781)	-0.687	(0.712)	
0.2	0.040	(0.625)	-0.267	(0.581)	
0.3	0.198	(0.491)	0.154	(0.467)	
0.4	0.356	(0.400)	0.574	(0.387)	
0.5	0.515	(0.384)	0.994	(0.365)	***

Marginal Effect of Influence Coefficient: Main Bank Type



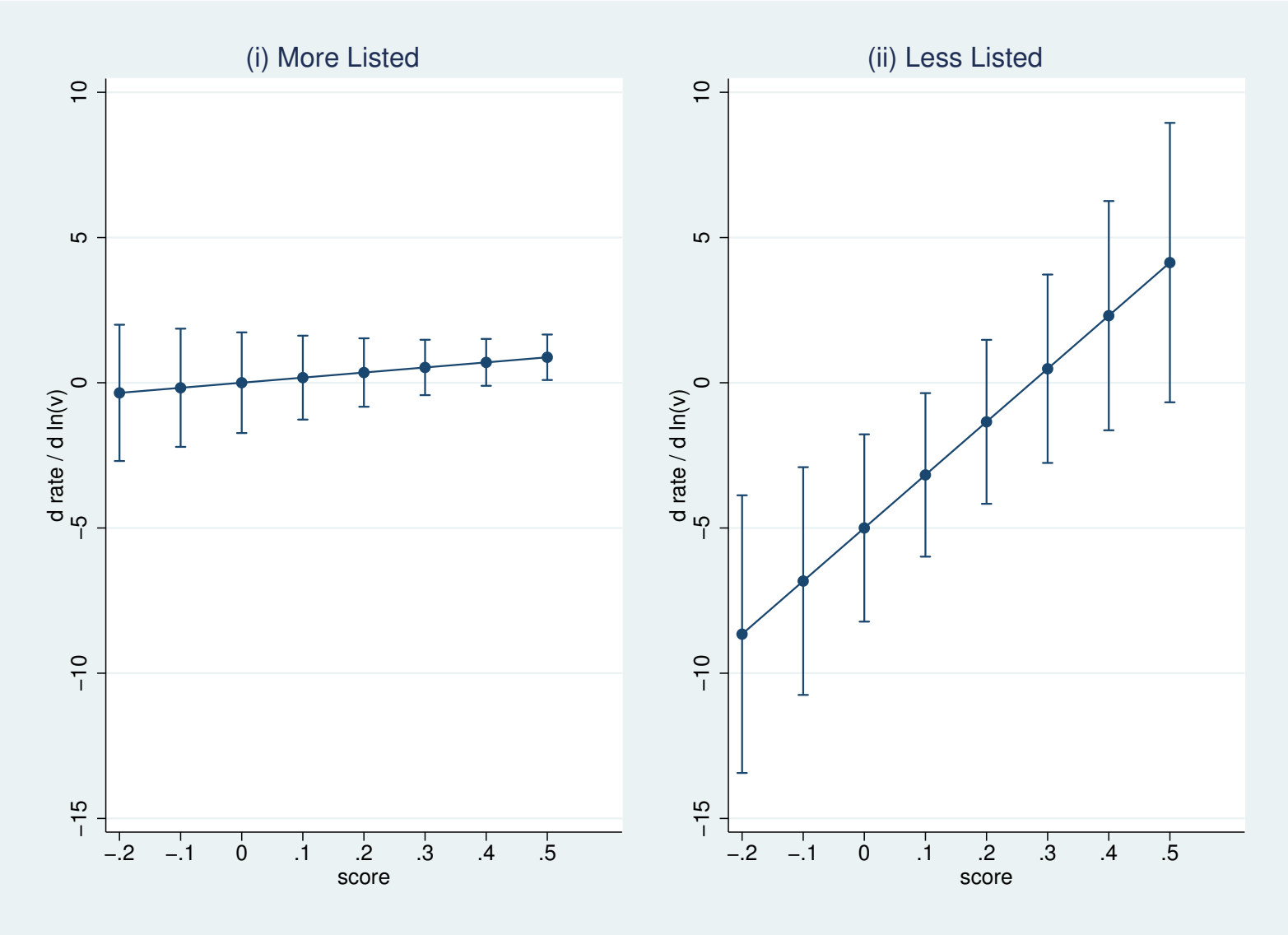
(Note) The vertical line segments indicate the 95% confidence interval.

Marginal Effect of Influence Coefficient: Competition



(Note) The vertical line segments indicate the 95% confidence interval.

Marginal Effect of Influence Coefficient: Bank Dependence



(Note) The vertical line segments indicate the 95% confidence interval.

Too-connected-to-fail or too-big-to-fail?

	(i) LN(SALE)			(ii) LN(LOAN)		
	coef.	(s.e.)		coef.	(s.e.)	
$ln(v)$	-2.800	(1.668)	*	-4.387	(1.768)	**
$ln(v)\times$ score	16.838	(8.780)	*	25.663	(8.693)	***
LN(SALES)	0.367	(0.045)	***			
LN(SALES) $\times$ score	0.044	(0.117)				
LN(LOAN)				-0.374	(0.047)	***
LN(LOAN) $\times$ score				-0.261	(0.112)	**
controls	yes			yes		
region factor	yes			yes		
industry factor	yes			yes		
adj. R-squared	0.216			0.218		
N	3,991			3,991		

Conclusion

1. An influential firm in a trading network among borrowers of a bank is more likely to enjoy lower interest costs, ceteris paribus.
2. This phenomenon is significant in regional banks that are easy to recoup the cost to support an influential firm because
   1. they are dominant lenders in less competitive rural markets, and
   2. their borrowers are non-listed and bank-dependent firms.