Estimating Geographic Frictions on Interfirm Transactions

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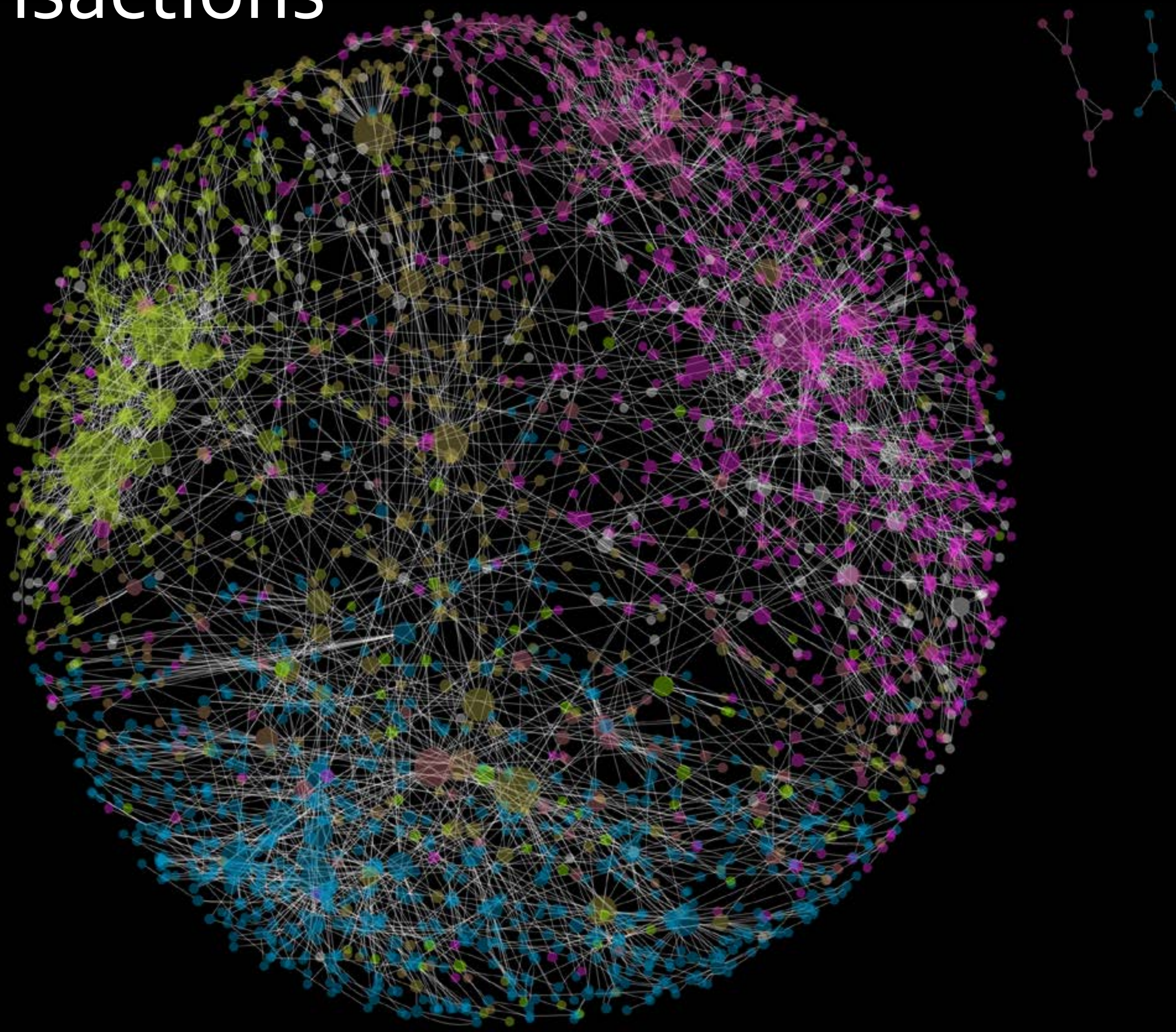


Agglomeration of economic activities

- Economic activities are concentrated in certain areas
  - Tokyo, Seoul, Shanghai, NYC, …
  - Motor vehicles in Toyota, ICT in Silicon valley
- Why do economic activities concentrate?
  - Knowledge spillovers
    - Transfer of knowledge has geographical frictions
  - Labor pooling
    - Matching b/w firms and workers has geographical frictions
  - Interfirm transactions
    - Profit from transaction has geographical frictions

My current projects

- Estimating those geographical frictions on the interactions b/w economic agents by using actual micro interaction data
- This paper tries to understand the geographical frictions on transactions b/w firms

Indirect approach

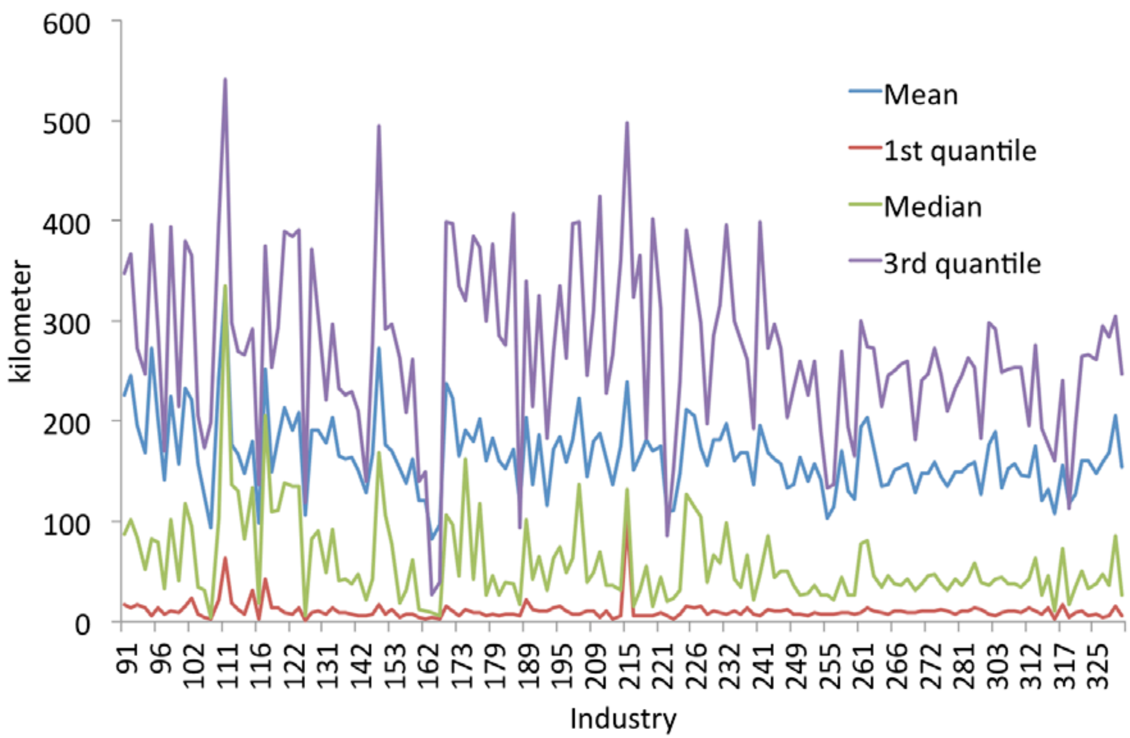
- The indirect approach already found that the importance of transactions
  - Rosenthal & Strange (2001,2004), Ellison, Glaeser, and Kerr (2010)
    - They found positive causal effects from intensity of intra (inter) sector transactions to sector (co)agglomerations

$$(\text{Agglomeration index})_i = \alpha + \beta(\text{Intensity of transactions})_i + \varepsilon_i$$

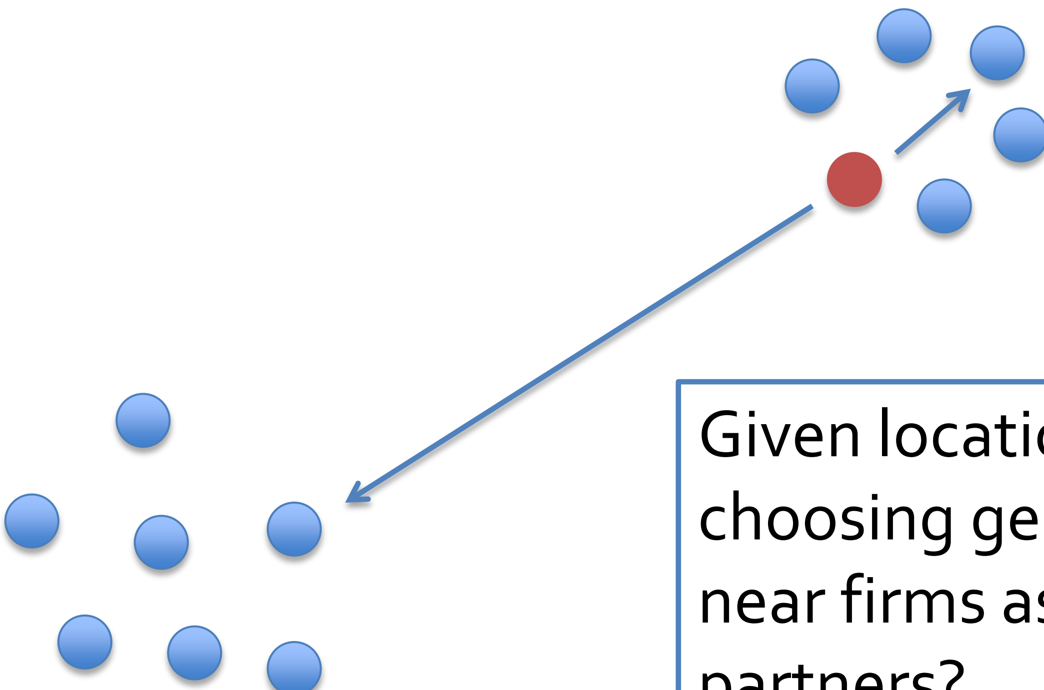
- But, do firms actually transact with geographically close firms?
- Does geographical closeness has a positive effect on firm profits?
- To answer those questions, we need microdata on interfirm transaction relationship

Related literature using microdata

- Nakajima, Saito, and Uesugi (2011)
    - They found the geographical proximities of transaction partners
    - Positive correlation b/w transaction distance and location agglomeration



What I want to do in this paper



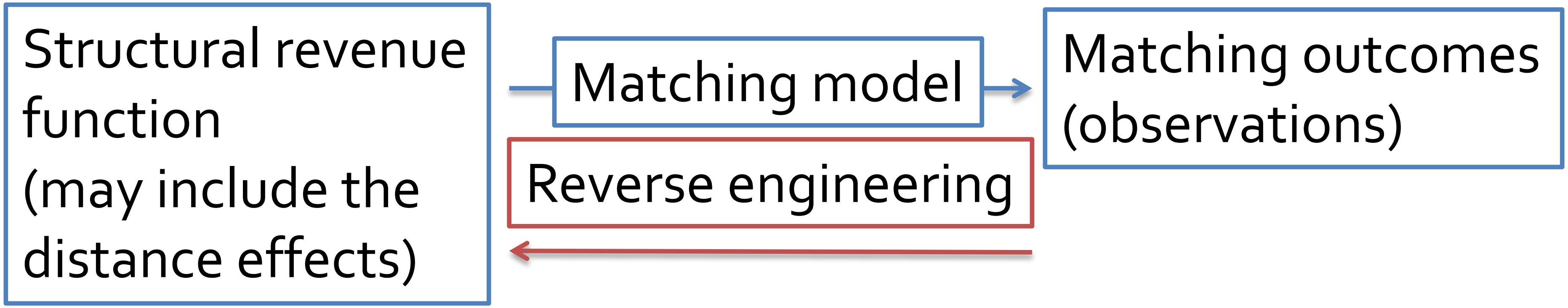
Given locations, are firms choosing geographically near firms as their transaction partners?
If so, how much is the geographical friction relative to the other factors (e.g. firm size, credibility,...)

Purpose & features of this paper

- Empirically examine the interfirm transactions as an agglomeration force:
  - Using microdata on interfirm transactions
  - Not case study, but using whole manufacturing data
  - Structural approach
    - Considering each firm’s optimizing strategy
    - Application for the matching game

Research design

- Application of the identification strategy on the two-sided matching game developed by Fox (2010, 2011)
  - He analyzed transaction relationship in motor vehicle industry (IO paper)
- Framework of the analysis



Theoretical concept

- Two-sided many-to-many matching game with transferable utility model
  - Each firm decides its transaction partners
  - Considering vertical market
    - There exists upstream and downstream firms
    - There exists monetary transfer
  - It is similar to marriage
    - But, interfirm transactions allow to transact with multiple agents

matching

two-sided

transferable utility

many-to-many

Theoretical background

- Two-sided:
  - Upstream firms: u
  - Downstream firms: d
- A match with u and d refers to $\langle u, d \rangle$

Profit from transaction

- Firm u's profit who transacts with the set of firms, D, is

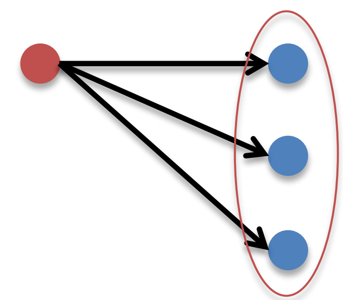
$$r^{\text{up}}(M) + \sum_{d \in D} t_{\langle u,d \rangle}$$

Structural revenue function

Monetary transfer

Firm u's matching outcome

$$M = \bigcup_{d \in D} \{\langle u, d \rangle\}$$



- Similarly, downstream firm's profit can be described as

$$r^{\text{down}}(M) - \sum_{u \in U} t_{\langle u,d \rangle}$$

Concept of an equilibrium of the game

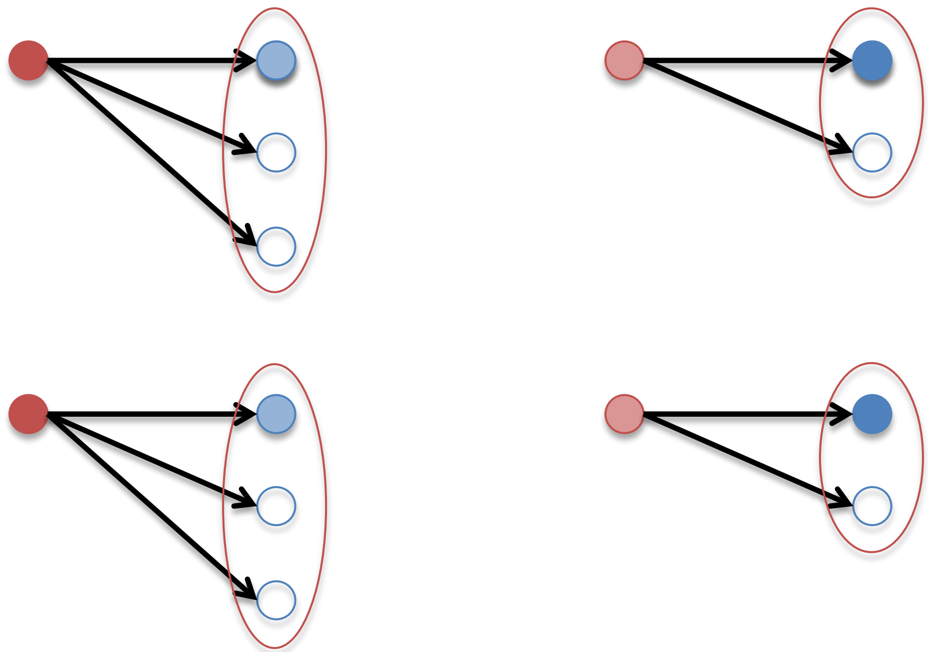
- Pairwise stable equilibrium
  - In taking any two matches, swapping partners does not improve profits
    - Actual partner is preferred than the swapped one
  - Formally, if the matching outcome is pairwise stable, and we take two matches <u1, d1> and <u2, d2>, the condition below is satisfied

$$r^{\mathrm{up}}(M_{u1}) + t_{\langle u_1, d_1 \rangle} \geqslant r^{\mathrm{up}}((M_{u1} \backslash \{\langle u_1, d_1 \rangle\}) \cup \{\langle u_1, d_2 \rangle\}) + \tilde{t}_{\langle u_1, d_2 \rangle}$$

,where

$$\tilde{t}_{\langle u_1, d_2 \rangle} \equiv r^{\mathrm{down}}((M_{d_2} = \{\langle u_2, d_2 \rangle\}) \cup \{\langle u_1, d_2 \rangle\}) - (r^{\mathrm{down}}(M_{d_2}) - t_{\langle u_2, d_2 \rangle})$$

Concept of an equilibrium of the game



Bridge to the estimation

- Sum of revenues inequalities
  - Adding inequality conditions for u1 and for u2

$$
\begin{aligned}
r^{\text{up}}(M_{u_1}) + t_{\langle u_1, d_1 \rangle} + r^{\text{down}}(M_{d_2}) \geqslant \\
& r^{\text{up}}((M_{u_1} \backslash \{\langle u_1, d_1 \rangle\}) \cup \{\langle u_1, d_2 \rangle\}) + \\
& r^{\text{down}}((M_{d_2} \backslash \{\langle u_2, d_2 \rangle\}) \cup \{\langle u_1, d_2 \rangle\}) + t_{\langle u_2, d_2 \rangle}
\end{aligned}
$$

$$
\begin{aligned}
r^{\text{up}}(M_{u_2}) + t_{\langle u_2, d_2 \rangle} + r^{\text{down}}(M_{d_1}) \geqslant \\
& r^{\text{up}}((M_{u_2} \backslash \{\langle u_2, d_2 \rangle\}) \cup \{\langle u_2, d_1 \rangle\}) + \\
& r^{\text{down}}((M_{d_1} \backslash \{\langle u_1, d_1 \rangle\}) \cup \{\langle u_2, d_1 \rangle\}) + t_{\langle u_1, d_1 \rangle}
\end{aligned}
$$

Sum of revenues inequality

- Sum of revenues inequality

$$r^{\text{up}}(M_{u_1}) + r^{\text{down}}(M_{d_1}) + r^{\text{down}}(M_{d_2}) + r^{\text{up}}(M_{u_2}) \geqslant$$
$$r^{\text{up}}((M_{u_1} \backslash \{\langle u_1, d_1 \rangle\}) \cup \{\langle u_1, d_2 \rangle\}) +$$
$$r^{\text{down}}((M_{d_2} \backslash \{\langle u_2, d_2 \rangle\}) \cup \{\langle u_1, d_2 \rangle\}) +$$
$$r^{\text{up}}((M_{u_2} \backslash \{\langle u_2, d_2 \rangle\}) \cup \{\langle u_2, d_1 \rangle\}) +$$
$$r^{\text{down}}((M_{d_1} \backslash \{\langle u_1, d_1 \rangle\}) \cup \{\langle u_2, d_1 \rangle\}).$$

Total profit of observed match ≥ Total profit of swapped (artificial) match

Simplification

- If we assume linearity of structural revenue function as follows,

$$r^{\mathrm{up}}_{\beta^{\mathrm{up}}}(M) = Z^{\mathrm{up}}(M)'\beta^{\mathrm{up}}$$
$$r^{\mathrm{down}}_{\beta^{\mathrm{down}}}(M) = Z^{\mathrm{down}}(M)'\beta^{\mathrm{down}}$$

$$Z^{\mathrm{up}}(M) = \left(z^{\mathrm{up}}_{\mathrm{distance}}, z^{\mathrm{up}}_{\mathrm{evaluation}}, z^{\mathrm{up}}_{\mathrm{worker}}, z^{\mathrm{up}}_{\mathrm{degree}}\right)$$

- Using this specification, the inequalities can be written like

$$\begin{aligned}
&Z^{\mathrm{up}}(M_{u_1})'\beta^{\mathrm{up}} + Z^{\mathrm{down}}(M_{d_1})'\beta^{\mathrm{down}} + Z^{\mathrm{up}}(M_{u_2})'\beta^{\mathrm{up}} + Z^{\mathrm{down}}(M_{d_2})'\beta^{\mathrm{down}} \geqslant \\
&\quad Z^{\mathrm{up}}((M_{u_1}\backslash\{\langle u_1, d_1\rangle\}) \cup \{\langle u_1, d_2\rangle\})'\beta^{\mathrm{up}} + Z^{\mathrm{down}}((M_{d_2}\backslash\{\langle u_2, d_2\rangle\}) \cup \{\langle u_1, d_2\rangle\})'\beta^{\mathrm{down}} + \\
&\quad Z^{\mathrm{up}}((M_{u_2}\backslash\{\langle u_2, d_2\rangle\}) \cup \{\langle u_2, d_1\rangle\})'\beta^{\mathrm{up}} + Z^{\mathrm{down}}((M_{d_1}\backslash\{\langle u_1, d_1\rangle\}) \cup \{\langle u_2, d_1\rangle\})'\beta^{\mathrm{down}}.
\end{aligned}$$

Simplification

- Further, we define those two vectors
  - $\beta = (\beta^{\text{up}}, \beta^{\text{down}})$
  - $X_{u_1,u_2,d_1,d_2} = (X^{\text{up}}_{u_1,u_2,d_1,d_2}, X^{\text{down}}_{u_1,u_2,d_1,d_2})$
    - where

$$\begin{aligned}
X^{\text{up}}_{u_1,u_2,d_1,d_2} =& Z^{\text{up}}(M_{u_1}) + Z^{\text{up}}(M_{u_2}) + \\
& Z^{\text{up}}((M_{u_1} \backslash \{\langle u_1, d_1 \rangle\}) \cup \{\langle u_1, d_2 \rangle\}) + Z^{\text{up}}((M_{u_2} \backslash \{\langle u_2, d_2 \rangle\}) \cup \{\langle u_2, d_1 \rangle\}) \\
X^{\text{down}}_{u_1,u_2,d_1,d_2} =& Z^{\text{down}}(M_{d_1}) + Z^{\text{down}}(M_{d_2}) + \\
& Z^{\text{down}}((M_{d_2} \backslash \{\langle u_2, d_2 \rangle\}) \cup \{\langle u_1, d_2 \rangle\}) + Z^{\text{down}}((M_{d_1} \backslash \{\langle u_1, d_1 \rangle\}) \cup \{\langle u_2, d_1 \rangle\})
\end{aligned}$$

- Using them, we can simplify the inequality as

$$X_{u_1,u_2,d_1,d_2}{}' \beta \geqslant 0$$

Intuition of the estimation

- We want to obtain β in the structural revenue
  1. Consider the observed matching outcome is in the pairwise stable equilibria
  2. Providing a candidate of the β
  3. Taking two matches from observed matching outcome
  4. Checking whether satisfying the sum of revenues inequality for the matches
     - Once β is given, we can numerically check whether the condition is satisfied or not for the matches
     - Ideally, if true β is given, the condition is always satisfied in any pair of matches from observed outcome

Estimation

- Maximum score estimator
  - The parameter that maximizes the following maximum score function

$$Q_H(\beta) = \frac{1}{H} \sum_{h \in H} \sum_{\{\langle u_1, d_1 \rangle, \langle u_2, d_2 \rangle\} \in I_h} 1[X_{u_1,u_2,d_1,d_2}{}' \beta \geqslant 0]$$

Number of markets

Set of inequalities

Indicator function
= 1 if the inequality in the bracket is satisfied

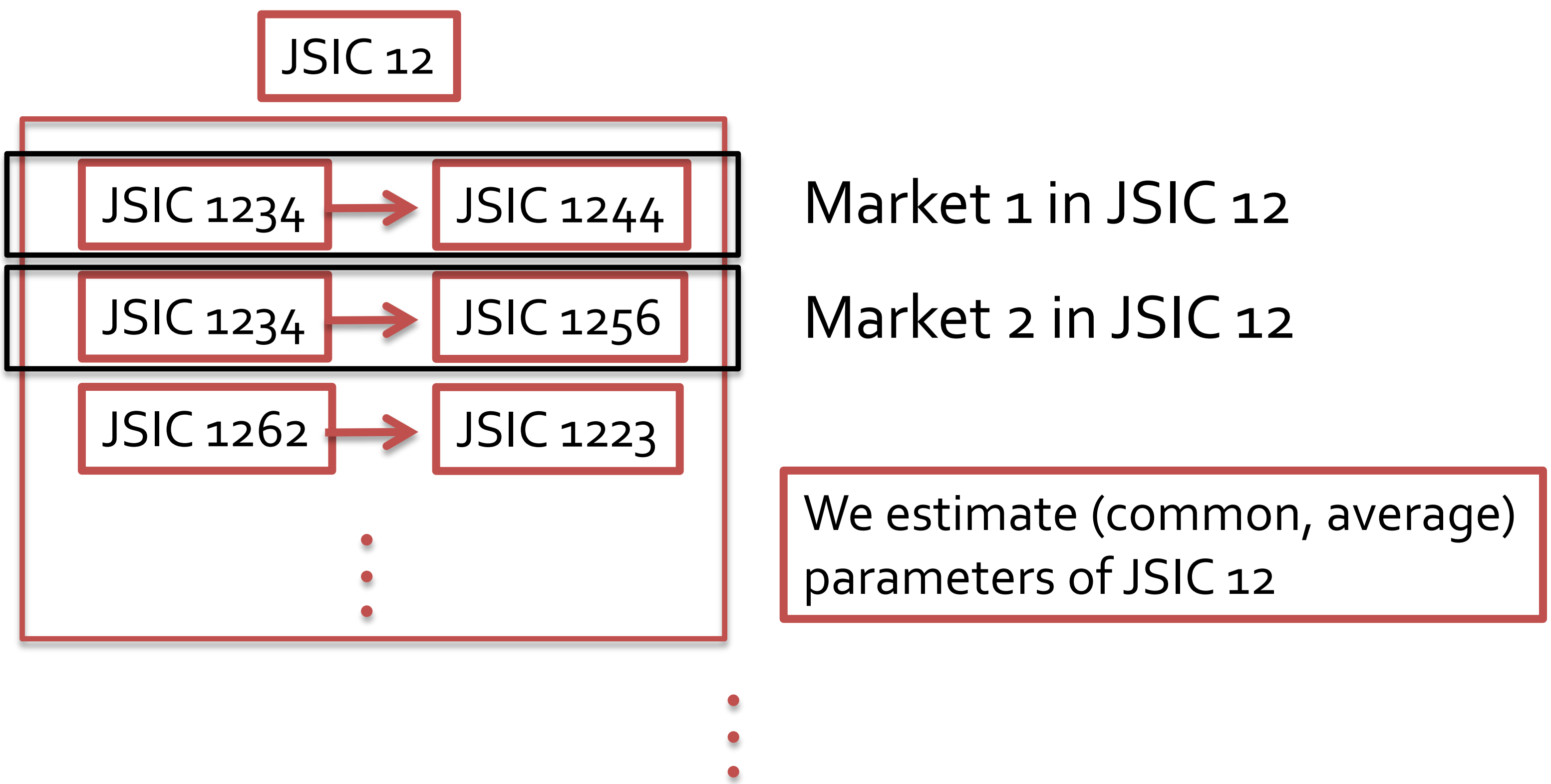
- Numerically maximizing this function
  - Searching the value that satisfies maximum number of inequalities

Data

- TSR database provided by Tokyo Shoko Research
  - Firm-level dataset on 142282 manufacturing firms in Japan
  - It has information on main suppliers and customers
  - 2005 data

Market definition

- We estimate by each 2 digit industry
  - Markets are defined as pairs of 4-digit industries within each 2-digit branch



Structural revenue function

- Specification of structural revenue functions

$$r^{\text{up}}_{\beta^{\text{up}}}(M) = Z^{\text{up}}(M)'\beta^{\text{up}}$$

$$r^{\text{down}}_{\beta^{\text{down}}}(M) = Z^{\text{down}}(M)'\beta^{\text{down}}$$

,where

$$Z^{\text{up}}(M) = \left(z^{\text{up}}_{\text{distance}}(M), z^{\text{up}}_{\text{worker}}(M), z^{\text{up}}_{\text{degree}}(M), z^{\text{up}}_{\text{credit}}(M)\right)$$

Average distance to transaction partners

Average size of workers of partners

Average # of transaction partners of partners

Average credit score of partners

$$Z^{\text{down}}(M) = \left(z^{\text{down}}_{\text{distance}}(M), z^{\text{down}}_{\text{worker}}(M), z^{\text{down}}_{\text{degree}}(M), z^{\text{down}}_{\text{credit}}(M)\right)$$

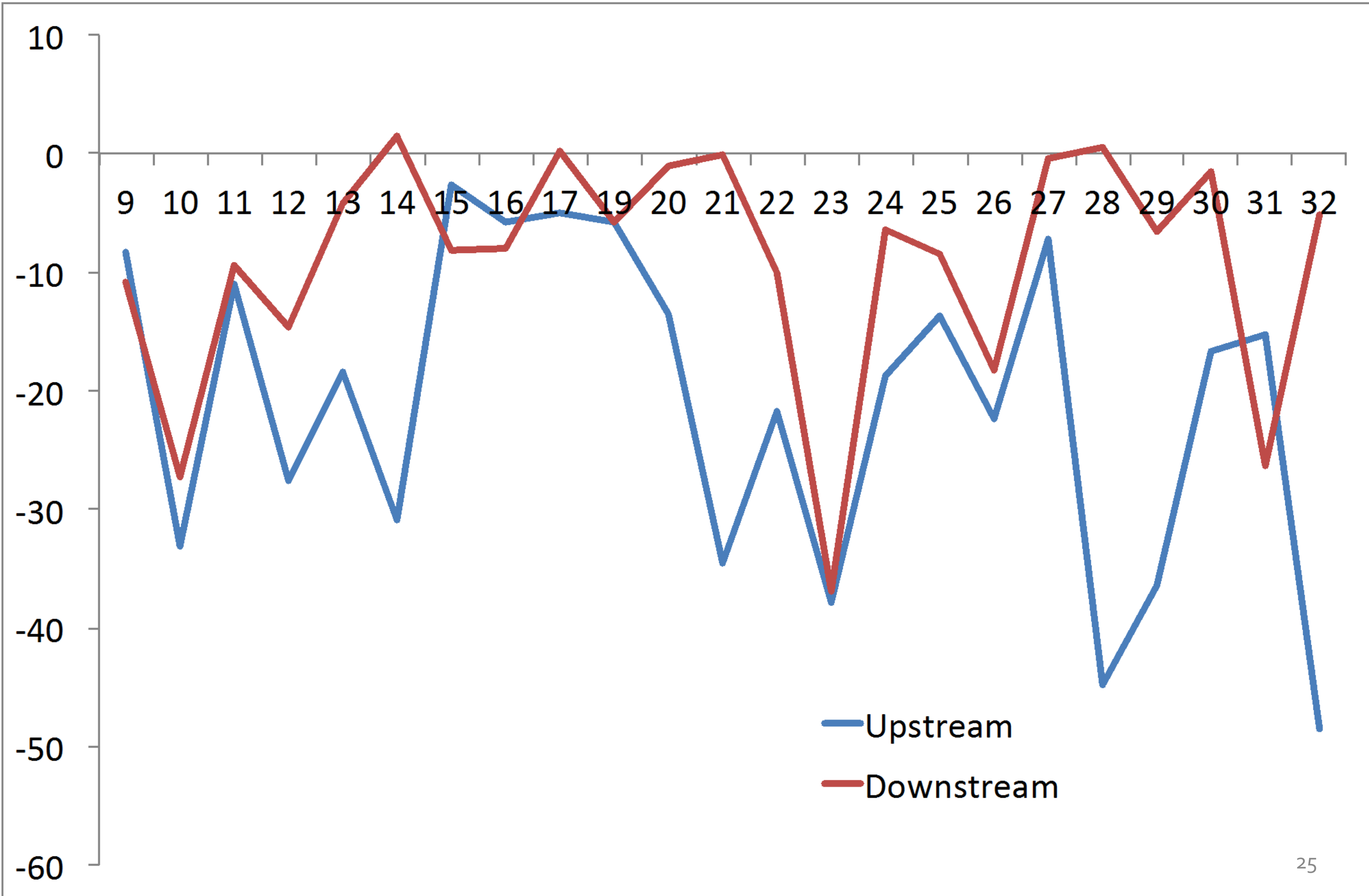
Table 5: Results of the structural revenue function estimates

JSIC	Industry	Upstream				Downstream				# of	%of
		ln(Credit Score)	ln(Distance)	ln(Worker)	ln(Degree)	ln(Credit Score)	ln(Distance)	ln(Worker)	ln(Degree)	inequalities	satisfied
9	Food	27.64	-8.32	-3.24	2.4	45.45	-10.82	-2.63	1	7900	0.81
		(26.41 28.07)	(-9.81 -2.83)	(-3.62 -3.22)	(2.02 2.92)	(45.16 45.79)	(-45.41 -4)	(-6.09 -1.83)	Reference		
10	Beverages,tobacco	38.58	-33.07	-2.09	-4.82	40.65	-27.34	5.3	1	700	0.75
	and feed	(Inf -Inf)	(-44.57 -28.96)	(-2.38 -1.91)	(-10.16 -4.22)	(30.33 37.47)	(-50 50)	(4.18 6.07)	Reference		
11	Textile mill products	6.03	-10.99	9.65	4.01	17.38	-9.36	-3.75	1	700	0.68
		(Inf -Inf)	(-14 -7.45)	(9.27 10.15)	(3.82 4.17)	(15.23 17.83)	(-14.91 -8.34)	(-4.24 -3.38)	Reference		
12	Apparel	15.66	-27.61	-14.32	41.69	-4.96	-14.69	-9.1	1	1400	0.69
		(Inf -Inf)	(-28.87 14.68)	(-34.24 -12.82)	(40.9 50)	(-9.98 -3.24)	(-50 -10.25)	(-16.3 -5.74)	Reference		
13	Lumber and wood products	5.31	-18.38	13.07	-5.18	0.68	-4.15	-5.35	1	1400	0.81
		(Inf -Inf)	(-20.5 -17.58)	(12.48 13.53)	(-7.73 -4.72)	(-0.32 1.94)	(-15.06 -2.82)	(-9.14 -4.7)	Reference		
14	Furniture and fixtures	15.42	-30.84	7.57	-15.9	-43.25	1.45	-6.9	1	600	0.79
		(Inf -Inf)	(-31.5 -29.97)	(7.24 8.13)	(-17.24 -14.45)	(-50 -31.59)	(1.05 50)	(-7.62 -4.97)	Reference		
15	Pulp, paper	-20.8	-2.56	0.48	1.25	46.16	-8.21	-0.77	1	2600	0.79
	and paper products	(-21.56 -17.09)	(-2.81 -2.03)	(0.31 0.67)	(1.2 1.59)	(45.46 45.62)	(-8.84 -7.87)	(-4.71 -0.47)	Reference		
16	printing and allied industries	39.9	-5.78	-10.61	4.57	22.75	-8.02	-4.95	1	800	0.83
		(Inf -Inf)	(-6.26 -2.94)	(-10.74 -9.9)	(4.44 4.99)	(Inf -Inf)	(-9.49 -7.34)	(-5.39 -4.86)	Reference		
17	chemical and allied products	34.61	-4.94	-7.16	6.82	46.85	0.13	-0.74	1	1700	0.61
		(28.84 35.25)	(-6.16 -4.39)	(-7.28 -6.69)	(5.99 7.48)	(46.81 47.47)	(-0.28 0.26)	(-0.8 -0.74)	Reference		
19	plastic products, except otherwise classified	33.14	-5.79	0.72	-1.5	28.09	-5.73	-1.4	1	3100	0.83
		(33.81 36.06)	(-6.38 -5.29)	(0.64 0.77)	(-1.59 -1.49)	(26.45 28.98)	(-8.17 -3.55)	(-1.55 -1.21)	Reference		
20	rubber products	49.85	-13.6	-8.3	3.25	-29.46	-1.05	-0.13	1	300	0.88
		(Inf -Inf)	(-13.62 -13.21)	(-8.41 -8.29)	(Inf -Inf)	(Inf -Inf)	(-1.16 -1)	(-0.06 0.1)	Reference		
21	leather tanning, leather products and fur skins	-25.37	-34.5	-2.03	-0.59	-5.45	-0.12	12.24	1	300	0.74
		(Inf -Inf)	(-50 -27.48)	(Inf -Inf)	(-2.62 2.13)	(-8.26 -6.81)	(-50 36.29)	(8.23 26.12)	Reference		
22	ceramic, stone and clay products	-42.94	-21.72	-9.05	14.72	-30.38	-10.09	7.58	1	1300	0.78
		(-39.68 -38.94)	(-24.35 -16.3)	(-10.86 -7.31)	(12.46 23.61)	(Inf -Inf)	(-34.89 -8.38)	(7.38 9.5)	Reference		
23	iron and steel	2.22	-37.89	-8.75	4.49	25.11	-36.96	0.4	1	400	0.86
		(Inf -Inf)	(11.98 50)	(Inf -Inf)	(8.1 8.75)	(Inf -Inf)	(-50 50)	(Inf -Inf)	Reference		
24	non-ferrous metals and products	23.88	-18.76	-0.55	4.56	-47.52	-6.36	7.66	1	700	0.84
		(Inf -Inf)	(-19.44 -18.22)	(-0.59 -0.49)	(4.5 4.54)	(-50 -47.09)	(-7.15 -5.56)	(5.39 11.19)	Reference		
25	fabricated metal products	-17.22	-13.66	4.02	-4.04	8.52	-8.43	-8.31	1	6700	0.86
		(-22.13 -15.56)	(-14.59 -10.69)	(1.55 4.35)	(-4.66 -3.75)	(4.78 8.89)	(-15.15 -1.38)	(-17.91 -6.03)	Reference		
26	general machinery	-13.1	-22.32	-6.07	5.44	-14.98	-18.28	1.81	1	8900	0.78
		(-29 -12.66)	(-22.72 19.18)	(-9.59 -5.73)	(4.13 5.61)	(-19.4 -10.2)	(-50 -10.87)	(1.62 2.29)	Reference		
27	electrical machinery, equipment and supplies	47.7	-7.27	-0.39	-0.05	8.12	-0.45	-2.88	1	4600	0.75
		(47.27 48.4)	(-14.71 -6.56)	(-0.51 -0.19)	(-0.17 0.12)	(6.36 8.87)	(-2.02 -0.1)	(-3.32 -2.02)	Reference		
28	information and communicaion electronics equipmet	30.97	-44.83	-9.64	4.76	-14.7	0.54	-1.82	1	400	0.75
		(Inf -Inf)	(-50 -27.5)	(-11.36 -8.3)	(Inf -Inf)	(-18.71 -13)	(0.51 50)	(-2.16 -1.23)	Reference		
29	electronic parts and devices	-0.5	-36.42	0.4	20.36	42.01	-6.53	-4.08	1	1600	0.78
		(-1.2 -0.51)	(-39.84 -35.84)	(-0.06 0.58)	(18.36 20.59)	(41.68 43.71)	(-29.84 50)	(-12.3 -3.29)	Reference		
30	trasportation equipment	-41.88	-16.62	-0.78	4.17	-10.53	-1.53	-1.9	1	1300	0.77
		(-44.24 -41.15)	(-19.15 -15.86)	(-0.88 -0.54)	(4.03 4.25)	(-12.74 -8.32)	(-3.43 -0.61)	(-2.13 -1.61)	Reference		
31	precision instruments and machinery	45.46	-15.3	-2.77	-1.25	-42.61	-26.3	13.35	1	900	0.66
		(Inf -Inf)	(-15.64 -14.02)	(-2.98 -2.46)	(-2.82 -0.56)	(-50 -41.62)	(-50 -23.8)	(10.4 18.14)	Reference		
32	miscellaneous manufacturing industries	15.28	-48.53	-6.29	5.74	4.04	-5.17	-21.96	1	1200	0.76
		(Inf -Inf)	(-50 -32.45)	(-6.46 -6.35)	(Inf -Inf)	(-6.83 17.6)	(-49.24 50)	(-50 -16.48)	Reference		

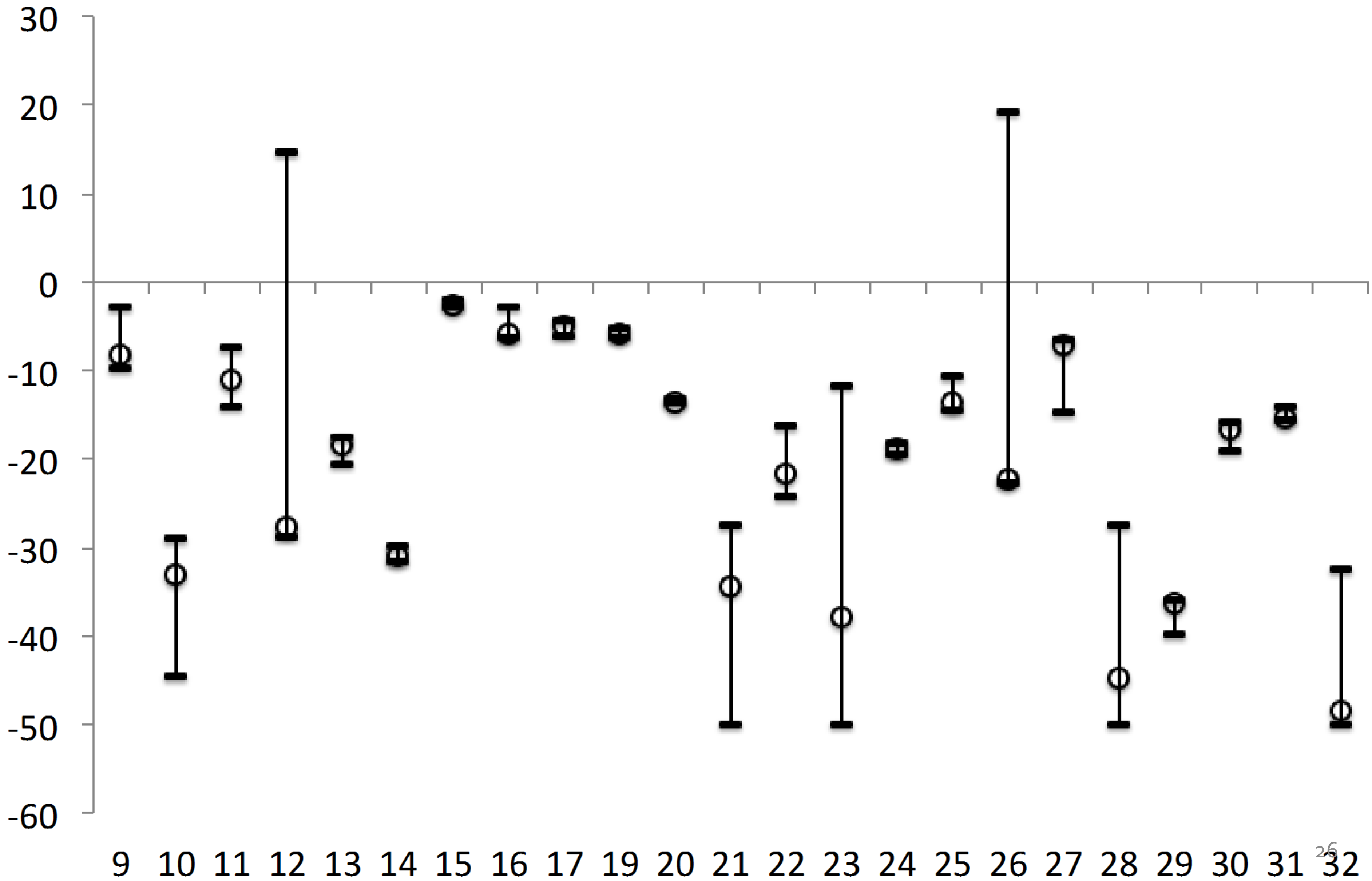
Electrical machinery, equipment and supplies (JSIC27)

Dependents	Point Estimate	95% CI
Upstream firms		
Average distance	–7.27	(–14.71, –6.56)
Average workers	–0.39	(–0.51, –0.19)
Average credit scores	47.7	(47.27, 48.40)
Average # of transaction partners	–0.05	(–0.17, 0.12)
Downstream firms		
Average distance	–0.45	(–2.02, –0.10)
Average workers	–2.88	(–3.32, –2.02)
Average credit scores	8.12	(6.36, 8.87)
Average # of transaction partners	1	Reference
# of inequalities	4600	
% satisfied	75.4	

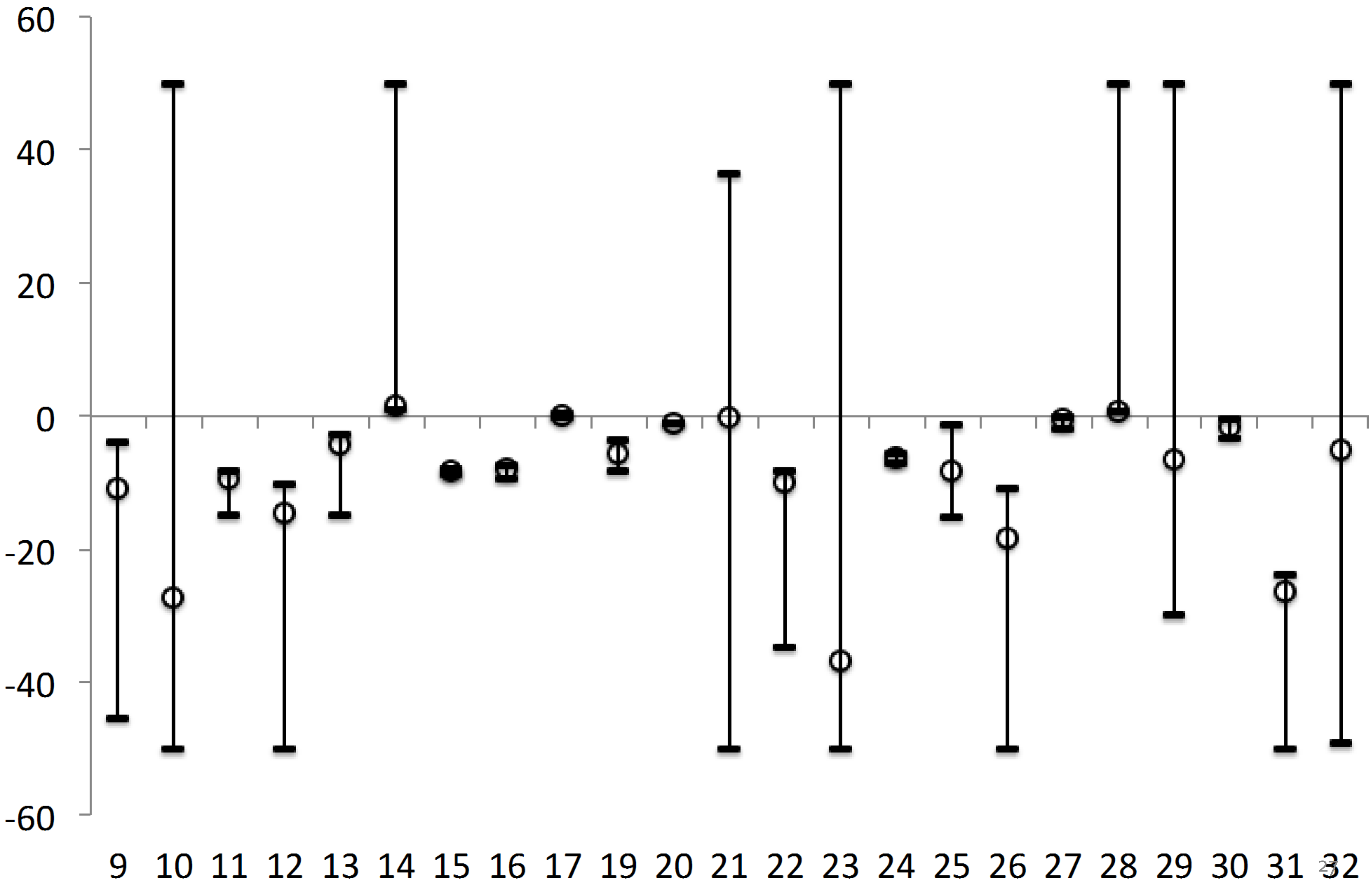
Distance frictions



Upstream


30
20
10
0
-10
-20
-30
-40
-50
-60
9 10 11 12 13 14 15 16 17 19 20 21 22 23 24 25 26 27 28 29 30 31 32

Downstream


60
40
20
0
-20
-40
-60
9 10 11 12 13 14 15 16 17 19 20 21 22 23 24 25 26 27 28 29 30 31 32

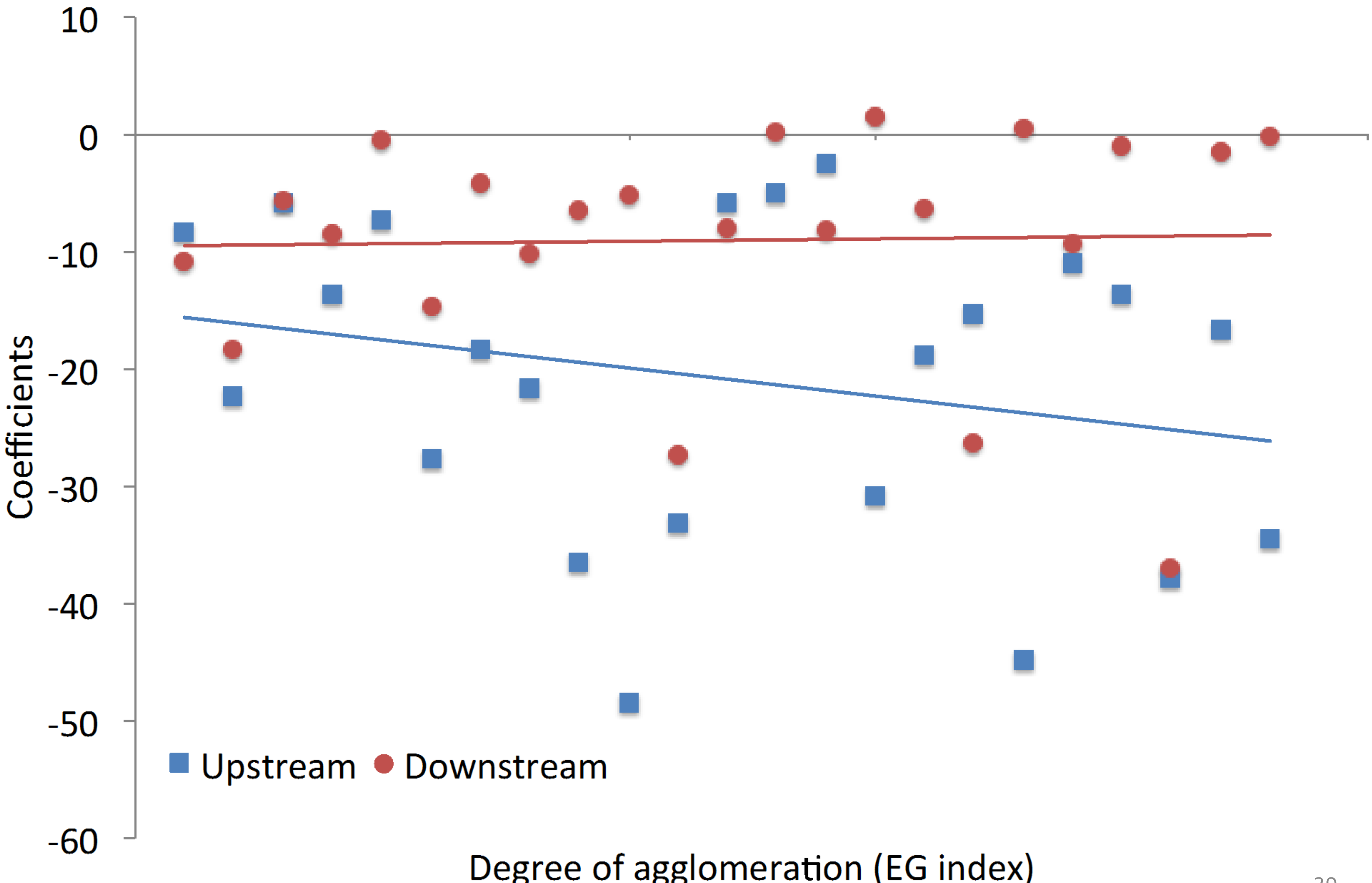
Correlation b/w distance friction and agglomeration

- Sectors that have larger friction on distance tend to concentrate
- Row correlations b/w friction parameters and strength of agglomerations

	$\beta^{up}_{distance}$	$\beta^{down}_{distance}$
Ellison and Glaeser's (1997) agglomeration index	-0.42	0.17

- Negative correlation b/w upstream distance parameter and agglomeration

Correlation



Remarks

- This paper investigated the agglomeration externality through the interfirm transactions by using
  - Actual micro dataset on interfirm transactions
  - Two-sided matching game approach
- I found that the existence of the distance effects in transaction decision in most of the industries
  - Average distance to the transaction partners has a negative effect on the structural revenue of the firms
  - This effect was basically larger in the upstream firms