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
    • 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
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

Structural revenue function (may include the distance effects)

Matching model

Reverse engineering

Matching outcomes (observations)
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
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

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

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

$$r_{down}(M) = \sum_{u \in U} t_{\langle u, d \rangle}$$

$$M = \bigcup_{d \in D} \{ \langle u, d \rangle \}$$
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 \( \langle u_1, d_1 \rangle \) and \( \langle u_2, d_2 \rangle \), the condition below is satisfied

\[
\begin{align*}
    r_{\text{up}}(M_{u_1}) + t_{\langle u_1, d_1 \rangle} & \geq r_{\text{up}}((M_{u_1} \setminus \{\langle u_1, d_1 \rangle\}) \cup \{\langle u_1, d_2 \rangle\}) + \tilde{t}_{\langle u_1, d_2 \rangle}, \\
\tilde{t}_{\langle u_1, d_2 \rangle} & \equiv r_{\text{down}}((M_{d_2} = \{\langle u_2, d_2 \rangle\}) \cup \{\langle u_1, d_2 \rangle\}) - (r_{\text{down}}(M_{d_2}) - t_{\langle u_2, d_2 \rangle})
\end{align*}
\]
Concept of an equilibrium of the game
Bridge to the estimation

- Sum of revenues inequalities
  - Adding inequality conditions for $u_1$ and for $u_2$

\[
\begin{align*}
    r^{\text{up}}(M_{u_1}) + t_{\langle u_1, d_1 \rangle} + r^{\text{down}}(M_{d_2}) & \geq \\
    r^{\text{up}}((M_{u_1} \setminus \{\langle u_1, d_1 \rangle\}) \cup \{\langle u_1, d_2 \rangle\}) + \\
    r^{\text{down}}((M_{d_2} \setminus \{\langle u_2, d_2 \rangle\}) \cup \{\langle u_1, d_2 \rangle\}) + t_{\langle u_2, d_2 \rangle}
\end{align*}
\]

\[
\begin{align*}
    r^{\text{up}}(M_{u_2}) + t_{\langle u_2, d_2 \rangle} + r^{\text{down}}(M_{d_1}) & \geq \\
    r^{\text{up}}((M_{u_2} \setminus \{\langle u_2, d_2 \rangle\}) \cup \{\langle u_2, d_1 \rangle\}) + \\
    r^{\text{down}}((M_{d_1} \setminus \{\langle u_1, d_1 \rangle\}) \cup \{\langle u_2, d_1 \rangle\}) + t_{\langle u_1, d_1 \rangle}
\end{align*}
\]
### Sum of revenues inequality

- **Sum of revenues inequality**

\[
\begin{align*}
    r^{\text{up}}(M_{u_1}) + r^{\text{down}}(M_{d_1}) + r^{\text{down}}(M_{d_2}) + r^{\text{up}}(M_{u_2}) \\
    \geq \\
    r^{\text{up}}((M_{u_1} \backslash \{\langle u_1, d_1 \rangle \}) \cup \{\langle u_1, d_2 \rangle \}) + \\
    r^{\text{down}}((M_{d_2} \backslash \{\langle u_2, d_2 \rangle \}) \cup \{\langle u_1, d_2 \rangle \}) + \\
    r^{\text{up}}((M_{u_2} \backslash \{\langle u_2, d_2 \rangle \}) \cup \{\langle u_2, d_1 \rangle \}) + \\
    r^{\text{down}}((M_{d_1} \backslash \{\langle u_1, d_1 \rangle \}) \cup \{\langle u_2, d_1 \rangle \}).
\end{align*}
\]

**Total profit of observed match** \(\geq\) **Total profit of swapped (artificial) match**
Simplification

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

\[ r_{\beta_{\text{up}}}^\text{up}(M) = Z_{\text{up}}^\text{up}(M)'\beta_{\text{up}} \]

\[ r_{\beta_{\text{down}}}^\text{down}(M) = Z_{\text{down}}^\text{down}(M)'\beta_{\text{down}} \]

\[ Z_{\text{up}}^\text{up}(M) = \left( z_{\text{up}}^\text{distance}, z_{\text{up}}^\text{evaluation}, z_{\text{up}}^\text{worker}, z_{\text{up}}^\text{degree} \right) \]

• Using this specification, the inequalities can be written like

\[ Z_{\text{up}}^\text{up}(M_{u_1})'\beta_{\text{up}} + Z_{\text{down}}^\text{down}(M_{d_1})'\beta_{\text{down}} + Z_{\text{up}}^\text{up}(M_{u_2})'\beta_{\text{up}} + Z_{\text{down}}^\text{down}(M_{d_2})'\beta_{\text{down}} \geq Z_{\text{up}}^\text{up}((M_{u_1}\setminus\{\langle u_1, d_1 \rangle \}) \cup \{\langle u_1, d_2 \rangle \})'\beta_{\text{up}} + Z_{\text{down}}^\text{down}((M_{d_2}\setminus\{\langle u_2, d_2 \rangle \}) \cup \{\langle u_1, d_2 \rangle \})'\beta_{\text{down}} + Z_{\text{up}}^\text{up}((M_{u_2}\setminus\{\langle u_2, d_2 \rangle \}) \cup \{\langle u_2, d_1 \rangle \})'\beta_{\text{up}} + Z_{\text{down}}^\text{down}((M_{d_1}\setminus\{\langle u_1, d_1 \rangle \}) \cup \{\langle u_2, d_1 \rangle \})'\beta_{\text{down}}. \]
Simplification

• Further, we define those two vectors
  
  \[ \beta = (\beta^{\text{up}}, \beta^{\text{down}}) \]

  \[ X^{\text{up}}_{u_1,u_2,d_1,d_2} = (X^{\text{up}}_{u_1,u_2,d_1,d_2}, X^{\text{down}}_{u_1,u_2,d_1,d_2}) \]

  • where

  \[ X^{\text{up}}_{u_1,u_2,d_1,d_2} = Z^{\text{up}}(M_{u_1}) + Z^{\text{up}}(M_{u_2}) + \]
  \[ Z^{\text{up}}((M_{u_1} \setminus \{u_1, d_1\}) \cup \{u_1, d_2\}) + Z^{\text{up}}((M_{u_2} \setminus \{u_2, d_2\}) \cup \{u_2, d_1\}) \]

  \[ X^{\text{down}}_{u_1,u_2,d_1,d_2} = Z^{\text{down}}(M_{d_1}) + Z^{\text{down}}(M_{d_2}) + \]
  \[ Z^{\text{down}}((M_{d_2} \setminus \{u_2, d_2\}) \cup \{u_1, d_2\}) + Z^{\text{down}}((M_{d_1} \setminus \{u_1, d_1\}) \cup \{u_2, d_1\}) \]

• Using them, we can simplify the inequality as

  \[ X^{\text{up}}_{u_1,u_2,d_1,d_2} / \beta \geq 0 \]
Intuition of the estimation

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

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

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

**Number of markets**

**Set of inequalities**

**Indicator function**

= 1 if the inequality in the bracket is satisfied
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

We estimate (common, average) parameters of JSIC 12

Market 1 in JSIC 12
Market 2 in JSIC 12
Structural revenue function

- Specification of structural revenue functions

\[ r_{\beta_{\text{up}}}^{\text{up}}(M) = Z^{\text{up}}(M)'\beta^{\text{up}} \]

\[ r_{\beta_{\text{down}}}^{\text{down}}(M) = Z^{\text{down}}(M)'\beta^{\text{down}} \]

, 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 credit score of partners
- Average # of transaction partners 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>
<thead>
<tr>
<th>JSIC Industry</th>
<th>Upstream</th>
<th>Downstream</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ln(Credit Score)</td>
<td>ln(Degree)</td>
</tr>
<tr>
<td>9 Food</td>
<td>27.64</td>
<td>-3.24</td>
</tr>
<tr>
<td></td>
<td>(26.41 28.07)</td>
<td>(26.02 2.92)</td>
</tr>
<tr>
<td>10 Beverages, tobacco and feed</td>
<td>38.58</td>
<td>-3.07</td>
</tr>
<tr>
<td></td>
<td>(Inf - Inf)</td>
<td>(Inf - Inf)</td>
</tr>
<tr>
<td>11 Textile mill products</td>
<td>6.05</td>
<td>-10.99</td>
</tr>
<tr>
<td></td>
<td>(Inf - Inf)</td>
<td>(Inf - Inf)</td>
</tr>
<tr>
<td>12 Apparel</td>
<td>15.66</td>
<td>-27.61</td>
</tr>
<tr>
<td></td>
<td>(Inf - Inf)</td>
<td>(Inf - Inf)</td>
</tr>
<tr>
<td>13 Lumber and wood products</td>
<td>5.31</td>
<td>-18.38</td>
</tr>
<tr>
<td></td>
<td>(Inf - Inf)</td>
<td>(Inf - Inf)</td>
</tr>
<tr>
<td>14 Furniture and fixtures</td>
<td>15.42</td>
<td>-30.84</td>
</tr>
<tr>
<td></td>
<td>(Inf - Inf)</td>
<td>(Inf - Inf)</td>
</tr>
<tr>
<td>15 Pulp, paper and paper products</td>
<td>-20.8</td>
<td>-2.56</td>
</tr>
<tr>
<td></td>
<td>(-21.56 -17.09)</td>
<td>(-21.56 -20.03)</td>
</tr>
<tr>
<td>16 Printing and allied industries</td>
<td>39.9</td>
<td>-5.78</td>
</tr>
<tr>
<td></td>
<td>(Inf - Inf)</td>
<td>(Inf - Inf)</td>
</tr>
<tr>
<td>17 Chemical and allied products</td>
<td>34.61</td>
<td>-4.94</td>
</tr>
<tr>
<td></td>
<td>(Inf - Inf)</td>
<td>(Inf - Inf)</td>
</tr>
<tr>
<td>18 Plastic products, except otherwise classified</td>
<td>33.34</td>
<td>-5.79</td>
</tr>
<tr>
<td></td>
<td>(33.81 36.06)</td>
<td>(33.81 36.06)</td>
</tr>
<tr>
<td>19 Rubber products</td>
<td>49.85</td>
<td>-13.6</td>
</tr>
<tr>
<td></td>
<td>(Inf - Inf)</td>
<td>(Inf - Inf)</td>
</tr>
<tr>
<td>20 Leather tanning, leather products and fur skins</td>
<td>-25.37</td>
<td>-34.5</td>
</tr>
<tr>
<td></td>
<td>(Inf - Inf)</td>
<td>(Inf - Inf)</td>
</tr>
<tr>
<td>21 Ceramic, stone and clay products</td>
<td>-42.94</td>
<td>-21.72</td>
</tr>
<tr>
<td></td>
<td>(Inf - Inf)</td>
<td>(Inf - Inf)</td>
</tr>
<tr>
<td>22 Iron and steel</td>
<td>2.22</td>
<td>-37.89</td>
</tr>
<tr>
<td></td>
<td>(Inf - Inf)</td>
<td>(Inf - Inf)</td>
</tr>
<tr>
<td>23 Non-ferrous metals and products</td>
<td>23.88</td>
<td>-18.76</td>
</tr>
<tr>
<td></td>
<td>(Inf - Inf)</td>
<td>(Inf - Inf)</td>
</tr>
<tr>
<td>24 Fabricated metal products</td>
<td>-17.22</td>
<td>-13.66</td>
</tr>
<tr>
<td>25 General machinery</td>
<td>-13.1</td>
<td>-22.32</td>
</tr>
<tr>
<td></td>
<td>(-29.12 -16.66)</td>
<td>(-29.12 -16.66)</td>
</tr>
<tr>
<td>26 Electrical machinery, equipment and supplies</td>
<td>47.7</td>
<td>-7.27</td>
</tr>
<tr>
<td></td>
<td>(47.27 48.4)</td>
<td>(47.27 48.4)</td>
</tr>
<tr>
<td>27 Information and communication electronics equip</td>
<td>30.97</td>
<td>-44.83</td>
</tr>
<tr>
<td></td>
<td>(Inf - Inf)</td>
<td>(Inf - Inf)</td>
</tr>
<tr>
<td>28 Electronic parts and devices</td>
<td>-0.5</td>
<td>-36.42</td>
</tr>
<tr>
<td></td>
<td>(-1.2 -0.51)</td>
<td>(-1.2 -0.51)</td>
</tr>
<tr>
<td>29 Transportation equipment</td>
<td>-41.88</td>
<td>-16.62</td>
</tr>
<tr>
<td></td>
<td>(-44.24 -41.15)</td>
<td>(-44.24 -41.15)</td>
</tr>
<tr>
<td>30 Precision instruments and machinery</td>
<td>45.46</td>
<td>-15.3</td>
</tr>
<tr>
<td></td>
<td>(Inf - Inf)</td>
<td>(Inf - Inf)</td>
</tr>
<tr>
<td>31 Miscellaneous manufacturing industries</td>
<td>15.28</td>
<td>-48.53</td>
</tr>
<tr>
<td></td>
<td>(Inf - Inf)</td>
<td>(Inf - Inf)</td>
</tr>
</tbody>
</table>
## Electrical machinery, equipment and supplies (JSIC27)

<table>
<thead>
<tr>
<th>Dependents</th>
<th>Point Estimate</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Upstream firms</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average distance</td>
<td>−7.27</td>
<td>(−14.71, −6.56)</td>
</tr>
<tr>
<td>Average workers</td>
<td>−0.39</td>
<td>(−0.51, −0.19)</td>
</tr>
<tr>
<td>Average credit scores</td>
<td>47.7</td>
<td>(47.27, 48.40)</td>
</tr>
<tr>
<td>Average # of transaction partners</td>
<td>−0.05</td>
<td>(−0.17, 0.12)</td>
</tr>
<tr>
<td><strong>Downstream firms</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average distance</td>
<td>−0.45</td>
<td>(−2.02, −0.10)</td>
</tr>
<tr>
<td>Average workers</td>
<td>−2.88</td>
<td>(−3.32, −2.02)</td>
</tr>
<tr>
<td>Average credit scores</td>
<td>8.12</td>
<td>(6.36, 8.87)</td>
</tr>
<tr>
<td>Average # of transaction partners</td>
<td>1</td>
<td>Reference</td>
</tr>
<tr>
<td># of inequalities</td>
<td>4600</td>
<td></td>
</tr>
<tr>
<td>% satisfied</td>
<td>75.4</td>
<td></td>
</tr>
</tbody>
</table>
Distance frictions
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
- Negative correlation b/w upstream distance parameter and agglomeration

<table>
<thead>
<tr>
<th>Ellison and Glaeser’s (1997) agglomeration index</th>
<th>$\beta^{\text{up}}_{\text{distance}}$</th>
<th>$\beta^{\text{down}}_{\text{distance}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.42</td>
<td>0.17</td>
<td></td>
</tr>
</tbody>
</table>

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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