The Organization of Production and Trade

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May 2009
Observation: Trade Integration

- Rising globalization in trade, \( [(\text{export}+\text{import})/2]/\text{GDP} \) (IFS data):

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<tr>
<td>Germany</td>
<td>14.5</td>
<td>16.5</td>
<td>21.6</td>
<td>24.0</td>
<td>33.5</td>
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<tr>
<td>Japan</td>
<td>8.8</td>
<td>8.3</td>
<td>11.8</td>
<td>8.4</td>
<td>10.1</td>
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Observation: production disintegration

- Rising production fragmentation, Hummels-Ishii-Yi (2001)

VS index of imported input content of export goods (dashline):
Main Issues

- Is vertical integration more efficient than middle product trade?
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- What are the key factors inducing outsourcing in equilibrium when full integration is an alternative?
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- Peng-Thisse-Wang (2006) constructs a dynamic general equilibrium framework to characterize vertical integration with perfectly mobile skilled labor
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    - better match with local preferences and sufficient local capital (Riezman-Wang 2008)
Purpose of this Paper

- Develop a unified framework to identify necessary and sufficient conditions for the emergence of a particular organizational structure – *separation* with middle-product trade, *vertical integration* or *global sourcing*
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  - Important to incorporate both comparative advantage and other organizational costs, especially for calibration analysis
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  - Configuration \(O\): \(U\) is a multinational, produces the middle product, offers it with blue print to the LDC subcontractor, who takes over the downstream manufacturing component
Organizational Costs

- Cost advantages/disadvantages under different organizational structure:

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<tr>
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<th>Upstream CST Cost $\sigma^S$</th>
<th>Downstream Diversification Cost $\nu$</th>
<th>Subcontractor Defect Cost $\delta$</th>
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Under outsourcing, international monitoring or law enforcement is difficult, so product defection implies:

Revenue = $POXO$ with probability $(1 - \delta)$

0 with probability $\delta$
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  $$\text{Revenue} = \begin{cases} 
  P^O X^O & \text{with probability } (1 - \delta) \\
  0 & \text{with probability } \delta 
  \end{cases}$$
Main Decisions

- The game tree:

\[
\begin{align*}
\text{separation} & \quad q, X \quad (S) \\
\text{integration} & \quad X \quad (I) \\
\text{v-merger} & \quad \text{outsourcing} \quad X, V \quad (c_0, c_1) \\
& \quad C \text{ rejects} \quad (I) \\
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  - $U$ makes a take-it-or-leave-it offer to $C$ with a mixed contract $c_0 + c_1 P O X O$
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Profit Functions

- $\omega = \frac{w_L}{w_H} = w_L^*(1 - \zeta^i) < 1$, $\kappa^U = 1 / (\gamma A_0^U)^2$, $\kappa^D = 1 / (A_0^D)^2$
- $a^i = \frac{1}{1 - \sigma^i} \kappa^U + \kappa^D$, $b^i = \frac{1}{\gamma} \left[ \frac{1}{\theta} + (1 - \zeta^i) \omega \right]$

\[
\begin{align*}
\Pi^U &= q \frac{X}{\gamma} - \left( a^S - \kappa^D \right) X^2 + b^S X + F^U \\
\Pi^D &= PX - \left\{ \kappa^D X^2 + \frac{1}{\gamma} \left[ q + (1 - \zeta^S) \omega \right] X + F^D \right\} \\
\Pi^I &= PX - \left\{ a^I X^2 + \left[ b^I + \frac{\omega}{\gamma(1 - \nu)} \right] X + F^U + F^D \right\} \\
\Pi^O_l &= -c_0 - \left[ a^O X^2 + b^O X + F^U \right] \\
\Pi^C_l &= c_0 - \left( \frac{(1 - \zeta^O)\omega}{\gamma} X + F^D \right) \\
\Pi^O_h &= (1 - c_1) PX + \Pi^O_l \\
\Pi^C_h &= c_1 PX + \Pi^C_l
\end{align*}
\]
World demand for the consumable:

\[ P = \left( \frac{X}{D_0} \right)^{-\frac{1}{\epsilon}} \]

where \( D_0 > 0 \) and \( \epsilon > 1 \)
We solve the optimization problem backward.
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3rd stage: assuming that the upstream and downstream firms merge and to outsourcing final assembling, the optimal terms of contract $V(c_0, c_1)$ at a contracted output quantity $X$ is determined
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- 1st stage: given the organizational outcome determined in stage 2, the upstream and downstream firms determine whether to merge
Stage 3: optimal outsourcing contract

- Subcontractor’s outside option $= \Pi_C^0 > 0$ and risk-neutral expected utility:

$$U^C = (1-\delta)\Pi_C^h + \delta\Pi_C^l$$
Stage 3: optimal outsourcing contract

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$$c_0 \geq \frac{(1 - \zeta^O)\omega}{\gamma}X - (1 - \delta)c_1PX + (F^D + \Pi_0^C)$$
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- Outsourcer’s optimization problem:

$$\max_{\{c_0, c_1, X\}} U^O = (1 - \delta) \left(1 - e^{-\alpha\Pi_h^O}\right) + \delta \left(1 - e^{-\alpha\Pi_l^O}\right)$$

s.t. Final good demand and C’s IR
Stage 3: optimal outsourcing contract

\[ \frac{\partial U^O}{\partial c_1} > 0 \Rightarrow c_1 = 1 \]
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- Since $U$ makes a take-it-or-leave-it offer to $D$, acquisition payment: $S^O = \Pi^D$
Stage 2: integration versus outsourcing

- Optimization problem under integration:

\[
\max_X \Pi^I = \left( \frac{X}{D_0} \right)^{-1/\epsilon} X - a^I(X)^2 - \left[ b^I + \frac{\omega}{\gamma(1-\nu)} \right] X - \left( F^U + F^D \right)
\]
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- Acquisition payment: \( S^I = \Pi^D \)
Stage 1: merge Versus separation

- Downstream $D$’s Optimization problem under separation:

$$\max_X \Pi^D = \left( \frac{X}{D_0} \right)^{-1/\epsilon} X - \left[ \kappa^D X^2 + \frac{q + \left( 1 - \zeta^S \right) \omega}{\gamma} X + F^D \right]$$

$=>$ downward-sloping demand for $X^S = K(q)$
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=> downward-sloping demand for $X^S = K(q)$

- Upstream $U$’s optimization (taking $K(q)$ as given):

$$\max_q \Pi^U = \frac{qK(q)}{\gamma} - \left\{ \frac{\kappa^U}{1 - \sigma^S} [K(q)]^2 + b^S K(q) + F^U \right\}$$

=> fixed point mapping for $X^S$ supply and pricing:

$X^S = R^S (X^S)$ and $q = Q(X^S)$
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$\Rightarrow$ fixed point mapping for $X^S$ supply and pricing: 
$X^S = R^S(X^S)$ and $q = Q(X^S)$

- The total surplus accrued from middle-product trade =  
$\Pi^U(X^S) + \Pi^D(X^S)$
Equilibrium

1. Equilibrium

2. $U$ and $D$ determines whether to merge
3. Multinational $U$ determines whether to outsource
4. $C$ determines whether to accept $U$’s contract
5. equilibrium configuration is determined by (noting $\Pi^D(X^S) = S^I = S^O$),

<table>
<thead>
<tr>
<th>Necessary/Sufficient Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S$ $\Pi^U(X^S) + \Pi^D(X^S) &gt; \max{\Pi^I(X^I), \Pi^O(X^O)}$</td>
</tr>
<tr>
<td>$I$ $\Pi^I(X^I) &gt; \max{\Pi^U(X^S) + \Pi^D(X^S), \Pi^O(X^O)}$</td>
</tr>
<tr>
<td>$O$ $\Pi^O(X^O) &gt; \max{\Pi^U(X^S) + \Pi^D(X^S), \Pi^I(X^I)}$</td>
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</table>
Middle Product Market Equilibrium

- Higher CST cost lowers middle product output, raises price
Middle Product Market Equilibrium

- Higher CST cost lowers middle product output, raises price
- Greater labor-cost saving raises middle product output, has ambiguous effect on price
Optimal Outsourcing Contract

Optimal Contract: upfront payment to outsourcer, full revenue share to subcontractor
Optimized Profits
Final Demand and Producer Profits

- Optimized profits:

\[ \Pi^O = (1-\delta) \frac{1}{\epsilon} PX + a^O X^2 - \Pi^C_0 - F^U - F^D \]
\[ \Pi^I = \frac{1}{\epsilon} PX + a^I X^2 - F^U - F^D \]
\[ \Pi^U + \Pi^D = \left( 2 - \frac{1}{\epsilon} \right) \frac{1}{\epsilon} PX + \left( a^S + 2\kappa^D \right) X^2 - F^U - F^D \]

- Higher final good demand elasticity lowers producer profits under any configuration.
- Such negative effect is larger under O and I than under S, due to direct insulation and price adjustment effects.
- When a final good has many competing substitutes, the organizational structure is more likely to be S rather than mO and I.
Optimized Profits Compared

- For every $X > 0$, $\Pi^U + \Pi^D > \Pi^I > \Pi^O$, and all are strictly increasing.

- Higher communication/search/trade cost ($\sigma^S$),
  - lowers $X$ supply and aggregate surplus accrued middle product trade $\Pi^U + \Pi^D$,
  - grants separation more disadvantageous.

- Higher subcontractor’s outside option ($\Pi^C_0$)
  - lowers outsourcing profit $\Pi^O$,
  - reduces the benefit of outsourcing.

- Overall, when subcontractor’s default risk and outside option are sufficiently low, the labor diversification loss is moderate and the communication/search/trade cost is sufficiently high
  - $O$ is the most preferred
  - $S$ is the least preferred.
Indifference Boundaries

Partition the projected \(((1 - \delta), \nu)\) space into \(S, I\) and \(O\) with 3 pairwise indifference boundaries:
In response to an increase in $\sigma^S$ or a decrease in $\zeta^S$

- IS brdy up, OS brdy left, IO brdy unchanged
- $S$ shrinks, $I$ and $O$ expand
Comparative Statics II

- In response to higher $\Pi_0^C$, higher $\sigma^O$, or lower $\zeta^O$
  - $IS$ brdy unchanged, $OS$ brdy right, $IO$ brdy up
  - *direct effect* in stage 2: $O$ shrinks to $O_1 \cup O_2$, $I$ expands to $I \cup O_3 \cup O_4 \cup O_5$, $S$ unchanged
  - *indirect effect* in stage 1 ($O$ more profitable in stage 2): $O$ shrinks to $O_1$, $S$ expands to $S \cup O_2$
  - *spillover effect* in stage 1 ($I$ more profitable in stage 2): $I$ shrinks to $I \cup O_4 \cup O_5$, $S$ expands to $S \cup O_2 \cup O_3$

- Increase in pure outsourcing cost can create a spillover effect on the trade-off between $S$ and $I$
In response to an increase in $\theta$

- IS brdy ambiguous, OS brdy left, IO brdy down
- $O$ always expands, $I$ and $S$ may shrink or expand
Welfare Analysis

- Consider the simplest case with $\Pi^C_0 = 0$: world welfare = upstream/downstream firm payoffs + consumer surplus
- Downward-sloping final good demand $\Rightarrow$ consumer surplus is positively related to output
- Case shown above: $O$ leads to both higher firm payoffs and higher output (thus higher consumer surplus) $\Rightarrow$ $O$ arises in equilibrium and achieves highest welfare
- In general, equilibrium configuration need not be optimal
- Example:
  - $\sigma$ is sufficiently high to cause a downward shift in $\Pi^O$ so that $I$ emerges in equilibrium
  - $\zeta$ is sufficiently high to offset the $\sigma$-effect to leave $R^O$ unchanged
  - equilibrium output of middle and final products are still the highest under $O$
  - $O$ generates less firm payoffs than $I$, but yields higher consumer surplus
Calibration

- Key observations:
  - total trade cost in unit values = 10-30%
  - labor saving in the South = 10-30%
  - price elasticities of demands for manufactured goods $\in [1, 3]$
  - integration cost = 12% (D'Aveni-Ravenscraft 1994)
  - defect rate = 5%
  - non-production/production wage differential = 1.6 (Machin-van Reenen 1998)
  - ratio of designing labor in the North to the South = 5
  - ratio of total workers in the North to the South = 12.5
  - non-production employment share = 30% (Machin-van Reenen 1998)
  - percentage of high-skilled workers = 48% (Sachs-Shatz 1996)
  - value of intermediate goods exported to the South = 45 (Yi 2003)

- Normalization: $X^D = L^U = 1$
## Calibrated Parameter Values

<table>
<thead>
<tr>
<th></th>
<th>( \sigma^S = 0.2, \zeta^S = 0.25, \sigma^O = 0.1, \zeta^O = \frac{1}{3} )</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>( \Pi^C_0 = 5, \delta = 0.05, \nu = 0.12 )</td>
</tr>
<tr>
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<td>( A^U_0 = 35.819, A^D_0 = 2.944, \theta = 70.298, \gamma = 0.0411 )</td>
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<tr>
<td></td>
<td>( F^U = 20, F^D = 10, \omega = 0.625, D_0 = 12767, \epsilon = 2 )</td>
</tr>
<tr>
<td><strong>U.S.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Japan</strong></td>
<td>( \zeta^S = 0.25 \cdot 0.75, \zeta^O = \frac{1}{3} \cdot 0.75, \nu = 0.12 \cdot \frac{2}{3} )</td>
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</tr>
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\( \sigma \): Standard deviation, \( \zeta \): Correlation coefficient, \( \Pi \): Marginal utility, \( \Pi^C \): Marginal cost of capital, \( A \): Asset value, \( \theta \): Technology coefficient, \( \gamma \): Impact parameter, \( F \): Flow, \( D \): Depreciation, \( \epsilon \): Elasticity of demand, \( \nu \): Wage rate.
Calibrated Equilibria
Conclusions

Main Findings:

outsourcing is the most and separation the least preferred if subcontractor's defect and bargaining strength are low, labor diversification loss is moderate, and CST cost is high. The potential availability of one organizational structure can change the trade-off of the other structures (presence of spillover effect in response to changes in pure outsourcing costs). Equilibrium need not be optimal. Extensions: generalize production technologies/organizational costs, quantitative welfare assessments.
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