The Extensive Margin of Intrafirm Trade

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Nov 2010
Motivation

- Antràs (2003) was the first to document that there are distinct patterns in the data on the share of U.S. imports that are intrafirm.
Motivation

Fact: In a cross-section of 22 manufacturing industries, intrafirm imports as % share of total U.S. imports is found to be larger, the higher the R&D intensity of the industry.

For Example:

- Chemical MNC import products from affiliated foreign plants, whereas textile or agricultural machinery MNC import from independent foreign plants.
$y = 0.4474x + 3.6023$
$R^2 = 0.3711$
Motivation

- This paper breaks up total intrafirm imports into two parts,
  \[
  \text{Intrafirm Imports} = \text{Number of Foreign Affiliates} \times \text{Average Imports per Affiliate.}
  \]
- I find that the number matters more.
Motivation

- Fact: In the same dataset, number of foreign affiliates is larger the higher the R&D intensity of the industry, whereas the R&D intensity has no statistically significant impact on the average imports per affiliate.

- For Example:
  - Chemical MNC set up majority-owned foreign affiliates more than twice in number than either textile or agricultural machinery MNC.
  - Chemical MNC import higher volume of products per affiliate than textile MNC, but lower volume of products per affiliate than agricultural machinery MNC.
The graph shows a scatter plot titled "No. of U.S. HQ's Foreign Affiliates & Relative HQ Intensity". The x-axis represents the log of (R&D / Employment), and the y-axis represents the log of (Number of Affiliates). The equation of the trend line is given as $y = 0.2655x + 6.2423$ with $R^2 = 0.2217$. This indicates a moderate relationship between the number of U.S. headquarters foreign affiliates and the relative headquarters intensity.
$y = 0.182x - 2.64$

$R^2 = 0.0759$
The endogenous choice of number of affiliates can be rationalized in a theoretical framework that combines 3 ingredients:

- A multiproduct setup: each product line needs manufactured parts from a plant and HQ services from the firm
- Antràs’ property-rights model: benefits of integration outweigh its costs only in HQ-services-intensive firm
- Melitz’s productivity heterogeneity applied to plant level:
  1. endogenous selection of foreign plants to export marketplace
  2. integration of high productive plants
The Model in Words

- A single-brand multiproduct MNC consists of one HQ firm and a spectrum of plants.
- Under the same brand, each final-product requires two specially designed intermediate inputs.
- Different plants bring different productivity draws into final-good production.
- Contract incompleteness leads to ex-ante underinvestment in intermediate inputs.
- After inputs have been produced, plants unite to bargain with the HQ over sales revenue allocation.
Introduction

The Model in Words

- Three possible organizational forms chosen by the HQ:
  1. integrating all plants
  2. outsource from all plants
  3. a mix of integration and outsourcing

- Ownership represents rights to seize some manufactured parts, which affects the outside options of the HQ and plants.

- Inefficiency in manufactured parts is relatively higher under integration than under outsourcing, and conversely for HQ services.

- This implies that HQ will choose outsourcing only when manufactured parts is relatively important in production.

- When the mixed strategy is chosen, HQ selects the fewest number of affiliates to minimize integration costs.
The Model in Words

- In a partial equilibrium open economy, manufactured parts are traded across borders, but final-products are nontradable.
- The coexistence of beachhead export costs and productivity heterogeneity implies endogenous selection of exporters.
- Export plants not only have higher productivity than domestic plants on average, but also lead to the invention of new products.
- With access to exporters, domestic HQ redraw boundaries:
  - a fraction of domestic affiliates are rearranged as independent plants to make spaces for foreign competent affiliates.
The Closed-Economy Model

Preferences

- A representative consumer faces a continuum of brands $i$,

$$Q = \left( \int_{i=0}^{1} q(i) \frac{\theta-1}{\theta} \, di \right)^{\frac{\theta}{\theta-1}}, \theta > 1.$$  

- Each brand $i$ consists of a basket $\Omega$ of varieties $j$,

$$q(i) = \left( \int_{j \in \Omega} q_j(i) \frac{\sigma-1}{\sigma} \, dj \right)^{\frac{\sigma}{\sigma-1}}, \sigma > 1.$$
The Closed-Economy Model

Demands

- The demand for brand $i$ is:
  \[ q(i) = QP^\theta p(i)^{-\theta}. \]
- The demand for final-good variety $j$ under brand $i$ is:
  \[ q_j(i) = QP^\theta p(i)^{\sigma-\theta} p_j(i)^{-\sigma}. \]
- $P$ is the price index for consumption composite $Q$, $p(i)$ is the price index for brand output $q(i)$, and $p_j(i)$ is the unit price of variety output $q_j(i)$. 
The Closed-Economy Model

Revenues

- Sales revenue for entire brand $i$ is:

  $$ R(i) = p(i)q(i). $$

- Sales revenue for a single variety $j$ under brand $i$ is:

  $$ R_j(i) = p_j(i)q_j(i). $$
The Closed-Economy Model

Production

- Symmetric brands, drop $i$.
- The production of variety $j$ involves two parties:
  - one HQ owns the entire brand and provides HQ services $\{ h_j \}_{j \in \Omega}$
  - one plant $M_j$ draws productivity $z_j$ and provides manufactured parts $m_j$
The Closed-Economy Model

Production

- The technology is a Cobb-Douglas assembly of two inputs,

\[ q_j = z_j \left( \frac{h_j}{\eta_h} \right)^{\eta_h} \left( \frac{m_j}{\eta_m} \right)^{\eta_m}, \quad \eta_h \in [0, 1], \quad \eta_m = 1 - \eta_h. \]

- \( \eta_h \) and \( \eta_m \) are, respectively, the intensity parameters for \( h_j \) and \( m_j \).

- Therefore, this particular brand is called the HQ services intense brand if \( \eta_h \) is large.

- Productivity \( z_j \) is drawn by \( M_j \) from a known distribution \( G(z) \) with support \([z_{\text{min}}, z_{\text{max}}]\).
The Closed-Economy Model

Costs

- The HQ services must be supplied by the HQ, and the manufactured parts must be supplied by the plant.
- HQ services can be produced with a variable cost $c_h$ per unit of $h_j$, and manufactured parts can be produced with a variable cost $c_m$ per unit of $m_j$.
- The fixed fee to integrate any one manufacturing plant is $f_i$. There is however no such costs for outsourcing, $f_O = 0$. 
The Closed-Economy Model
Contract Incompleteness

- Contracts are incomplete: investments and revenues are not verifiable, the only item can be contracted upon is the ownership structure.
- The HQ and the plants’ union will bargain over the surplus of the relationship ex post.
- Assume the generalized Nash bargaining leaves the HQ with a fraction $\beta$ of the ex-post gains from co-production.
- The ex-post division of the surplus results in ex-ante under-investment
The Closed-Economy Model

Ownership Structure

- The HQ must decide:
  1. What level of ex-post bargaining power to build up
  2. Which plants to integrate

- As in Grossman and Hart (1986), the ownership structure affects the ex-post division of surplus through its effect on each party’s outside option.

- Manufacturing plant $M_j$:
  - It is assumed that the manufactured parts are complete specific to variety $j$, thereby the outside option for $M_j$ is 0 regardless of ownership structure.
The Closed-Economy Model

Ownership Structure

- The HQ:
  - Integrated single affiliate: HQ can fire $M_j$’s manager in case of contractual breakdown, seize the manufactured parts and produce $\delta$ fraction of final variety $q_j$ at a lower productivity.
  - Non-integrated single affiliate: $M_j$ is a stand-alone plant and HQ’s outside option is also 0 because a contractual breach leaves $H$ with no time to react and attract another supplier.
  - Mixed strategy $k$ affiliates: HQ seize manufactured parts from all integrated affiliates, and produce $\varepsilon_k$ fraction of brand output $q$, which translates into sales revenue of $\varepsilon_k^{\frac{\theta-1}{\theta}} R$. 
The Closed-Economy Model

Bargaining Results

The payoffs in the generalized Nash bargaining game are as follows:

<table>
<thead>
<tr>
<th>Scenario</th>
<th>HQ</th>
<th>Suppliers’ Union</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrate all</td>
<td>$\delta^{\theta-1}<em>\theta R + \beta (1 - \delta^{\theta-1}</em>\theta) R$</td>
<td>$(1 - \beta) \left(1 - \delta^{\theta-1}_\theta \right) R$</td>
</tr>
<tr>
<td>Outsource from all</td>
<td>$\beta R$</td>
<td>$(1 - \beta) R$</td>
</tr>
<tr>
<td>Integrate up to $M_k$</td>
<td>$\varepsilon^{\theta-1}_k R + \beta (1 - \varepsilon^{\theta-1}_k) R$</td>
<td>$(1 - \beta) \left(1 - \varepsilon^{\theta-1}_k \right) R$</td>
</tr>
</tbody>
</table>
The Closed-Economy Model

Timing

- $\forall j$, the HQ enters into a cooperation agreement with any one plant among a large number of \textit{identical} candidates, and refers to the selected as $M_j$.
- A $\Omega$ set of $M_j$ find out their productivity draws separately, and found plants’ union $M$ to fight for a more favorable bargaining result.
- The HQ chooses ex-ante bargaining powers.
- The HQ chooses which plants to integrate.
- The HQ and $M$ simultaneously choose their optimal investments in intermediate inputs $\{h_j\}_{j\in\Omega}$ and $\{m_j\}_{j\in\Omega}$, respectively.
The Closed-Economy Model

Timing

- Bargain over the incoming $R$ begins, the HQ proposes a dividing scheme which keeps $\beta_h$ fraction to itself, and offers the rest to $M$.
- If $M$ rejects, $M$ gets nothing while the HQ seizes a fraction of $q_j$ from each integrated $M_j$.
- If $M$ accepts the offer, then $M$ transports $\{m_j\}_{j \in \Omega}$ to the HQ, where $q_j$ amount of variety $j$ is assembled, $\forall j$.
- Revenue $R$ is collected, then divided according to the offer.
- $M$ distributes its share of profit, $\beta_m R$, to all $M_j$ in a pro rata share of their contributions—$\beta_m R_j$ to plant $M_j$, $\forall j$. 
The Closed-Economy Model

Investment Choices

- Given the optimal $\beta_h$ and $\{m_j\}_{j \in \Omega}$, the HQ maximizes,

$$\max_{\{h_j\}_{j \in \Omega}} \beta_h R - c_h \int_{j \in \Omega} h_j dj.$$ 

- Similarly, $M$ maximizes its share profit given $\beta_h$ and $\{h_j\}_{j \in \Omega}$,

$$\max_{\{m_j\}_{j \in \Omega}} \beta_m R - c_m \int_{j \in \Omega} m_j dj.$$
The Closed-Economy Model
Ownership Choices I

- The HQ chooses $\beta_h$ to maximize ex-ante total profit,

$$\max_{\beta_h} \left[ R - c_h \int_{j \in \Omega} h_j \, dj - c_m \int_{j \in \Omega} m_j \, dj, \right.$$  
$$s.t. \text{ optimal investments in } \{h_j, m_j\}_{j \in \Omega}$$

- If the HQ can choose $\beta_h$ freely from the $[0, 1]$ interval, then there is an unique analytical expression for the optimal share of revenue, $\beta_h^* (\eta_h)$.

- Define implicitly,

$$\begin{cases} 
\beta_h^* (\eta_h^L) = \beta; \\
\beta_h^* (\eta_h^H) = \delta^{\frac{\theta - 1}{\theta}} + \beta (1 - \delta^{\frac{\theta - 1}{\theta}}) .
\end{cases}$$
The Closed-Economy Model

Ownership Choices I
The Closed-Economy Model

Ownership Choices II

- Given $\beta^*_h$, the HQ picks out the fewest number of affiliates that minimizes the total costs incurred in integration,

$$\min f_i \times \text{number of integrated plants}.$$ 

- Rank all plants under the same brand from high to low according to their productivity draws on interval $[0, \Omega]$, i.e., $z_j \geq z_k$, $\forall j < k$ and $j, k \in \Omega$.

- The HQ integrate all plants lie on $[0, k]$ and outsource from others.
The Closed-Economy Model
Ownership Choices III

- The HQ of brand $i$ will adopt the organizational form depending upon its intensity parameter of HQ services.

Proposition

1. **Outsource from all if** $\eta_h(i) \in [0, \eta^L_h(i)]$;

2. **Integrate all if** $\eta_h(i) \in [\eta^H_h(i), 1]$;

3. **Integrate up to** $M_k$ **if** $\eta_h(i) \in (\eta^L_h(i), \eta^H_h(i))$. 
The Open-Economy Model

- The world consists of two countries—home and foreign.
- Assume only manufactured parts are traded across borders, whereas varieties are nontradable.
- A new domestic variety under brand \( i \) with its manufactured parts supplied by a foreign plant is denoted as \( j' \in \Omega' \). The manufactured parts for variety \( j' \) are produced by a foreign plant, \( M_{j'} \), with a variable cost \( c'_{m} < c_{m} \) per unit of \( m_{j'} \).
- The basket of final-products becomes \( \Omega \cup \Omega' \).
The Open-Economy Model

- Foreign plants face two types of costs when ship their manufactured parts to the home country—a fixed cost to start exporting, $f$, and a unit export cost, $\tau$.
- It is only after the realization of productivity draws that foreign manufacturers decide whether to export based on the below free entry condition:

$$\beta_m R_{j'} - (\tau + c'_m) m_{j'} \geq f.$$  

- A decrease in exporting costs $\tau$ and/or entry fee $f$ raises the total amount of intrafirm imports through increasing the number of foreign affiliates.
The Open-Economy Model
The Open-Economy Model

- $\beta^*_h$ stays unchanged $\Rightarrow \varepsilon_k = \varepsilon_{k'}$
- Therefore, we must have $k' < k$ in order to make the above equation satisfied.
- The total number of integrated plants is shrinking through substituting one high productive foreign affiliate for several relatively low productive domestic affiliates.
- The HQ lowers expenditures on integration, but at the same time maintains its desired bargaining power.
- Higher HQ services intensity $\Rightarrow$ higher $\beta^*_h$ $\Rightarrow$ more productive foreign plants are integrated as affiliates.
Empirical Studies

Theoretical Predictions

The HQ acquires a larger NUMBER of foreign affiliates in
- HQ–service-intensive industries.
- countries with lower trade barriers.
Empirical Studies

Data Description

Two cross-sectional dataset of the year 2007, looking across industries and countries, respectively.

- 114 industries with NAICS 4-digit classification by industry of affiliate.
- 109 foreign countries that import to the U.S. within a firm’s boundaries.
- Source: BEA financial and operating dataset on U.S.-headquartered multinational companies and U.S. census bureau data on intrafirm imports to U.S.
Empirical Studies

Conceptual Issues

- The model is one where only intermediate inputs are traded.
- The trade data includes both intermediate inputs and final goods.
- Does this matter?
Empirical Studies

Conceptual Issues

- The model studies brands within an industry.
- The data is across industries.
- Does this matter?
Empirical Studies
Looking Across Industries

- **Dependent Variables**
  - $\ln(\text{No. of Affiliates}_i)$: Number of foreign affiliates owned by U.S. HQ in industry $i$ from the rest of the world
  - $\ln(\text{Intrafirm Imports}_i)$: the intrafirm U.S. imports shipped by foreign affiliates to their U.S. parent firms as % share of total U.S. imports in industry $i$
Empirical Studies
Looking Across Industries

- **Explanatory Variables**
  - $\ln\left(\frac{K_i}{L_i}\right), \ln\left(\frac{RD_i}{L_i}\right)$: capital and R&D expenditures divided by compensation of employees
  - $\ln\left(\frac{M_i}{L_i}\right)$: expenses on materials such as property, plant, and equipment divided by compensation of employees
  - $\ln\left(\frac{Q_i}{L_i}\right)$: affiliate sales divided by compensation of employees, measures the average affiliate’s productivity
Empirical Studies

Estimation Equations

\[
\ln(\text{No. of Affiliates}_i) = \alpha_0 + \alpha_1 \ln\left(\frac{K_i}{L_i}\right) + \alpha_2 \ln\left(\frac{R&D_i}{L_i}\right) \\
\quad + \alpha_3 \ln\left(\frac{M_i}{L_i}\right) + \alpha_4 \ln\left(\frac{Q_i}{L_i}\right) + \epsilon_i
\]

\[
\ln(\text{Intrafirm Imports}_i) = \rho_0 + \rho_1 \ln\left(\frac{K_i}{L_i}\right) + \rho_2 \ln\left(\frac{R&D_i}{L_i}\right) \\
\quad + \rho_3 \ln\left(\frac{M_i}{L_i}\right) + \rho_4 \ln\left(\frac{Q_i}{L_i}\right) + u_i,
\]
## Empirical Studies

### OLS Results

<table>
<thead>
<tr>
<th>Indep. Var.</th>
<th>Dep. Var.</th>
<th>In (Intrafirm Imports&lt;sub&gt;i&lt;/sub&gt;)</th>
<th>In (No. of Affiliates&lt;sub&gt;i&lt;/sub&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\ln \left( \frac{K_i}{L_i} \right)$</td>
<td></td>
<td>0.102</td>
<td>0.676**</td>
</tr>
<tr>
<td>$\ln \left( \frac{R^D_i}{L_i} \right)$</td>
<td></td>
<td>0.342</td>
<td>0.262**</td>
</tr>
<tr>
<td>$\ln \left( \frac{M_i}{L_i} \right)$</td>
<td></td>
<td>$-0.286$</td>
<td>$-0.839$***</td>
</tr>
<tr>
<td>$\ln \left( \frac{Q_i}{L_i} \right)$</td>
<td></td>
<td>0.372</td>
<td>0.317**</td>
</tr>
</tbody>
</table>

| No. of Obs. | 30 | 114 |
| Adj. $R^2$  | 0.15 | 0.22 |
Empirical Studies
Looking Across Countries

- Dependent Variables
  - $\ln(\text{No. of Affiliates}_c)$: the overall number of foreign affiliates operating in country $c$ owned by U.S. HQ
  - $\ln(\text{Related Party Imports}_c)$: the related party imports as percentage shares of total imports from all foreign affiliates in country $c$ to their parent firms in the U.S.
Empirical Studies

Looking Across Countries

Explanatory Variables

- \( \ln(\tau_c) \): exporting costs per standard container shipped out of country \( c \) (Doing Business Data: Trading Across Borders)
- \( \ln(f_c) \): expenses to start a business in country \( c \) (Doing Business Data: Starting a business), to proxy the fixed fee of entering into exporting marketplace
- \( \ln(Enf_c) \): contract enforcement costs in country \( c \) (Doing Business Data: Enforcing Contracts)
- \( \ln\left(\frac{L_c}{K_c}\right) \): foreign affiliate’s compensation on employees divided by capital expenditures, measures labor costs in country \( c \)
Empirical Studies

Estimation Equations

\[ \ln(\text{No. of Affiliates}_c) = \alpha_0' + \alpha_1' \ln(\tau_c) + \alpha_2' \ln(f_c) \]
\[ + \alpha_3' \ln(\text{Enf}_c) + \alpha_4' \ln\left(\frac{L_c}{K_c}\right) + \epsilon'_c \]

\[ \ln(\text{Related Party Imports}_c) = \rho_0' + \rho_1' \ln(\tau_c) + \rho_2' \ln(f_c) \]
\[ + \rho_3' \ln(\text{Enf}_c) + \rho_4' \ln\left(\frac{L_c}{K_c}\right) + \nu'_c \]
## Empirical Studies

### Results

<table>
<thead>
<tr>
<th>Indep. Var.</th>
<th>( \ln(\text{Related Party Imports}_c) )</th>
<th>( \ln(\text{No. of Affiliates}_c) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \ln(\tau_c) )</td>
<td>-0.126</td>
<td>-0.208**</td>
</tr>
<tr>
<td>( \ln(f_c) )</td>
<td>-0.281**</td>
<td>-0.388***</td>
</tr>
<tr>
<td>( \ln(\text{Enf}_c) )</td>
<td>-0.228**</td>
<td>-0.113</td>
</tr>
<tr>
<td>( \ln\left(\frac{L_c}{K_c}\right) )</td>
<td>-0.094</td>
<td>-0.17</td>
</tr>
</tbody>
</table>

| No. of Obs | 109 | 109 |
| Adj. \( R^2 \) | 0.22 | 0.29 |
Empirical Studies

Conclusion

- Across industries, higher extensive margin in industries with higher HQ services intensity.
- Across countries, higher extensive margin in countries with lower trade barriers.
- Volume of intrafirm imports is a combination of extensive margin and intensive margin, in which the extensive margin plays a much more important part.