Input Sourcing and Multinational Production

Stefania Garetto
What this Paper is About

- A large portion of international trade flows happens within firms’ boundaries:
  - in the year 2000, 50% of U.S. imports and 32% of exports happened between parents and affiliates of multinational firms\(^1\).

- Antrás (2003): intrafirm imports arise due to incomplete contracts between firms and suppliers.

- This paper: intrafirm imports arise due to **TECHNOLOGY HETEROGENEITY** and to the implications of **IMPERFECT COMPETITION** on **PRICES**.

\(^1\) Bernard, Jensen and Schott (2007).
A firm can either insource or outsource input production. Two forces drive this decision:

1. TECHNOLOGY HETEROGENEITY: by outsourcing, a firm can exploit a supplier’s better technology;

2. IMPERFECT COMPETITION: by outsourcing, a firm has to pay a mark-up price (depending on the degree of competition in the market).
Main Idea

- A firm can either insource or outsource input production.
  
  Two forces drive this decision:

  1. **TECHNOLOGY HETEROGENEITY**: by outsourcing, a firm can exploit a supplier’s better technology;
  
  2. **IMPERFECT COMPETITION**: by outsourcing, a firm has to pay a mark-up price (depending on the degree of competition in the market).

- Intrafirm transactions happen between a firm and itself:
  
  1. the parent’s technology is transferred to its affiliates;
  
  2. intrafirm transactions are priced at marginal cost (transfer pricing).
• Unified **general equilibrium** framework: firms can trade **and** set plants abroad to produce.

• Theory of **optimal pricing** in presence of multinationals.
  ○ “pro-competition effect” of multinational firms.

• **Quantitative exercise:**
  ○ Gains from trade **versus** gains from vertical FDI/intrafirm trade;
  ○ Quantitative relevance of productivity differences **versus** market structure in shaping firms’ decisions.
Related Literature

- On input sourcing and multinational production:

- On technology heterogeneity shaping world production:

- On the gains from trade and multinational production:
  Rodríguez-Clare (2007), Ramondo and Rodríguez-Clare (2009),
  Burstein and Monge-Naranjo (2009)
Setup of the Model

- a homogeneous final good produced with labor and a continuum of differentiated inputs;

- 2 types of firms: final good producers and input producers (or suppliers);

- monopolistic competition across suppliers:
  \[ \Downarrow \]
  a supplier produces one unit of input with labor \( z \sim \psi(z) \), and sells it at price \( p(z) \);

- perfectly competitive final good producers use labor and inputs:
  \[ \Downarrow \]
  for each input, decide whether to **OUTSOURCE** it or to **INTEGRATE** production;
  \[ \Downarrow \]
  sourcing decision based on the lowest cost option: for each input, in-house unit labor requirement \( x \sim \phi(x) \).
The Inputs Space
The Inputs Space

Introduction

Closed Economy
- Setup
- Firm's Problem
- Prices
- Equilibrium

Open Economy

Welfare Analysis

Conclusions
The Inputs Space: the Firm’s Problem

Introduction

Closed Economy
- Setup
- Firm’s Problem
- Prices
- Equilibrium

Open Economy

Welfare Analysis

Conclusions
The Inputs Space: Optimal Sourcing

**Introduction**

- Closed Economy
  - Setup
  - Firm’s Problem
  - Prices
  - Equilibrium

- Open Economy

- Welfare Analysis

- Conclusions
The Final Good Producer’s Problem

\( q(x, z) \) is the quantity produced of an input for which the potential buyer has unit cost \( x \) and the supplier has unit cost \( z \) and charges a price \( p(z) \).

The final good producer solves:

\[
\min_{q(x, z)} \int_0^\infty \int_0^\infty \min\{x, p(z)\} q(x, z) \phi(x) \psi(z) \, dx \, dz \\
\text{s.t.} \quad \left[ \int_0^\infty \int_0^\infty q(x, z)^{1-1/\eta} \phi(x) \psi(z) \, dx \, dz \right]^{\eta/(\eta-1)} \geq q
\]

where \( \eta > 1 \) and the wages are normalized to 1.
Demand and Price Indexes

The final good producer’s problem has solution:

\[ q^I(x, p(z)) = \left( \frac{x}{p} \right)^{-\eta} q \quad \forall (x, z) \in \{(x, z) : x \leq p(z)\} \]  

\[ q^T(x, p(z)) = \left( \frac{p(z)}{p} \right)^{-\eta} q \quad \forall (x, z) \in \{(x, z) : x \geq p(z)\} \]  

where \( p \) is the aggregate price index:

\[ p = \left[ p_I^{1-\eta} + p_T^{1-\eta} \right]^{1/(1-\eta)} \]  

\[ p_I = \left[ \int_0^\infty \int_0^{p(z)} x^{1-\eta} \phi(x) \psi(z) dx dz \right]^{1/(1-\eta)} \]  

\[ p_T = \left[ \int_0^\infty p(z)^{1-\eta} \left[ 1 - \Phi(p(z)) \right] \psi(z) dz \right]^{1/(1-\eta)} \]
The Supplier’s Problem

A supplier with draw $z$ chooses the optimal price $p(z)$ such to maximize its expected profits:

$$\max_{p(z)} \left[ p(z) - z \right] \int_{p(z)}^{\infty} q^T(x, p(z)) \phi(x) dx.$$

where $q^T(p(z))$ is given by (2).

The first order condition is:

$$[p(z) - z] \underbrace{q^T(x, p(z)) \phi(p(z)) - \frac{\partial q^T(x, p(z))}{\partial p(z)} [1 - \Phi(p(z))]}_{\text{extensive margin}} - \underbrace{\frac{\partial q^T(x, p(z))}{\partial p(z)} [1 - \Phi(p(z))]}_{\text{intensive margin}} = \ldots$$

$$\ldots = \int_{p(z)}^{\infty} q^T(x, p(z)) \phi(x) dx$$

[1 - \Phi(p(z))]"
Pricing Rule

$$p(z) = \left[ 1 - \frac{1}{\eta + \frac{\phi(p(z))}{1 - \Phi(p(z))p(z)}} \right]^{-1} z. \quad (6)$$

For $$\phi(x) = \lambda e^{-\lambda x}$$:

![Diagram showing pricing strategy and mark-up over marginal cost](image-url)

$$\frac{\partial p(z)}{\partial \eta} < 0$$  $$\frac{\partial p(z)}{\partial \lambda} < 0$$
Equilibrium in the Final Good Market

- Final good production function: \( c = q^{\alpha}l_f^{1-\alpha} \);
- Population constraint: \( L = l_i + l_f \);
- Linear input production technology implies: \( l_i = kq \);
  ↓
- Solve population constraint as a linear equation in \( q \), then compute \( l_i \) and \( l_f \).

Intrafirm share of input sourcing:

\[
S_I = \left( \frac{p_I}{p} \right)^{1-\eta} = \left[ 1 + \frac{\int_0^\infty \int_0^{p(z)} x^{1-\eta} \phi(x) \psi(z) dx dz}{\int_0^\infty p(z)^{1-\eta} \left[ 1 - \Phi(p(z)) \right] \psi(z) dz} \right]^{-1}
\]
Open Economy: Setup

- $N$ countries;
- country-specific distributions $\phi_i(x_i)$ and $\psi_i(z_i)$;
- each final good producer in each country decides whether to OUTSOURCE or to INSOURCE each input, and WHERE;
- suppliers in each country can sell worldwide;
  \[\downarrow\]
- sourcing decision based on the lowest cost option ($2N$ available).

REMARKS:

1. **Foreign integration (FDI)** ⇒ a final good producer transfers its domestic technology $x_i$ to the destination country, but hires local workers at local wages.

2. Final good producers cannot enter the inputs market ⇒ FDI is only VERTICAL (no export platforms).
The Final Good Producer’s Problem

- $z = (z_1, z_2, \ldots, z_N)$ and $\psi(z) = \prod_{j=1}^{N} \psi_j(z_j)$;
- $w_i =$ wage level in country $i$;
- $t_{ij} =$ iceberg cost of trade between countries $i$ and $j$ ($t_{ij} \geq 1$);
- $\tau_{ij} =$ iceberg cost for a firm from $i$ to insource an input in $j$ ($\tau_{ij} \geq 1$).

A final good producer in country $i$ solves:

$$\min_{q_i(x_i, z)} \int_{\mathbb{R}_+^N} \int_{0}^{\infty} c_i(x_i, z) q_i(x_i, z) \phi_i(x_i) \psi(z) dx_i dz$$

s.t. $\left[ \int_{\mathbb{R}_+^N} \int_{0}^{\infty} q_i(x_i, z)^{1-1/\eta} \phi_i(x_i) \psi(z) dx_i dz \right]^{\eta/(\eta-1)} \geq q_i$

where:

$$c_i(x_i, z) = \min_j \{ \tau_{ij} w_j x_i, p_{ij}(z_j) \}.$$
The final good producer’s problem has solution:

\[ q_i(x_i, z) = \left( \frac{m_i x_i}{p_i} \right)^{-\eta} q_i \quad \forall (x_i, z) \text{ s.t. } c_i(x_i, z) = m_i x_i \]

\[ q^T_i(x_i, z) = \left( \frac{p_{ij}(z_j)}{p_i} \right)^{-\eta} q_i \quad \forall (x_i, z) \text{ s.t. } c_i(x_i, z) = p_{ij}(z_j) \]

where \( m_i \equiv \min_k \{ \tau_{ik} w_k \} \) and:

\[ p_i = \left[ (p^I_i)^{1-\eta} + \sum_{j=1}^{N} (p^T_{ij})^{1-\eta} \right]^{1/(1-\eta)} \]

\[ p^I_i = \left[ \int_{B^I_i} [m_i x_i]^{1-\eta} \phi_i(x_i) \psi(z) dx_i dz \right]^{1/(1-\eta)} \]

\[ p^T_{ij} = \left[ \int_{B^T_{ij}} [p_{ij}(z_j)]^{1-\eta} \phi_i(x_i) \psi(z) dx_i dz \right]^{1/(1-\eta)} \]
Demand and Price Indexes

The final good producer’s problem has solution:

\[ q^I_i(x_i, z) = \left( \frac{m_i x_i}{p_i} \right)^{-\eta} q_i \quad \forall (x_i, z) \text{ s.t. } c_i(x_i, z) = m_i x_i \]

\[ q^T_i(x_i, z) = \left( \frac{p_{ij}(z_j)}{p_i} \right)^{-\eta} q_i \quad \forall (x_i, z) \text{ s.t. } c_i(x_i, z) = p_{ij}(z_j) \]

where \( m_i \equiv \min_k \{ \tau_{ik} w_k \} \) and:

\[ p_i = \left[ (p^I_i)^{1-\eta} + \sum_{j=1}^{N} (p^T_{ij})^{1-\eta} \right]^{1/(1-\eta)} \]

\[ p^I_i = \left[ \int_{B^I_i} [m_i x_i]^{1-\eta} \phi_i(x_i) \psi(z) dx_i dz \right]^{1/(1-\eta)} \]

\[ p^T_{ij} = \left[ \int_{B^T_{ij}} [p_{ij}(z_j)]^{1-\eta} \phi_i(x_i) \psi(z) dx_i dz \right]^{1/(1-\eta)} \]
A supplier in country \( j \) chooses the optimal price \( p_{ij}(z_j) \) to charge in country \( i \) to:

\[
\max_{p_{ij}(z_j)} \left[ p_{ij}(z_j) - t_{ij} w_j z_j \right] \left( \frac{p_{ij}(z_j)}{p_i} \right)^{-\eta} q_i A_{ij}(p_{ij}(z_j))
\]

where \( A_{ij}(p_{ij}(z_j)) \) is the mass of buyers from \( i \) buying good \((x_i, z)\) from a supplier from \( j \):

\[
A_{ij}(p_{ij}(z_j)) = \left[ 1 - \Phi_i \left( \frac{p_{ij}(z_j)}{m_i} \right) \right] \cdot \prod_{k \neq j} \left[ 1 - F_{ik}(p_{ij}(z_j)) \right] \cdot \prod_{k \neq j} \left[ 1 - F_{ik}(z_k) \right] \cdot \prod_{k \neq j} \left[ 1 - F_{ik}(z_k) \right]
\]

and \( F_{ij}(p_{ij}(z_j)) \) denotes the CDF of the distribution of the prices \( p_{ij}(z_j) \).
F.O.B prices \( (p_{ij}(z_j)/t_{ij}) \), for \( \phi_i(x_i) = \lambda_i e^{-\lambda_i x_i} \), \( \psi_j(z_j) = \mu_j e^{-\mu_j z_j} \):

\[
\frac{\partial p_{ij}(z_j)}{\partial \eta} < 0 \\
\frac{\partial p_{ij}(z_j)}{\partial m_i} > 0 \\
\frac{\partial p_{ij}(z_j)}{\partial t_{ik}} > 0, \quad \forall k \neq j \\
\frac{\partial p_{ij}(z_j)}{\partial \mu_k} < 0, \quad \forall k
\]
General Equilibrium

Final good production function:
\[ c_i = q_i^\alpha (l_i^f)^{1-\alpha} \quad \forall i = 1, \ldots N. \]

Population constraint:
\[ L_i = l_i^f + \sum_{j=1}^{N} (l_{ji}^I + l_{ji}^T) \quad \forall i = 1, \ldots N. \]

Linear production technologies imply:
\[ L_i = \frac{(1 - \alpha)p_i}{\alpha w_i} q_i + \sum_{j=1}^{N} (k_{ji}^I q_j + k_{ji}^T q_j) \quad \text{for } i = 1, \ldots N \]

(linear system of \( N \) equations in the \( N \) unknowns \( \{q_i\}_{i=1}^{N} \)).

Market clearing:
\[ r_i c_i = L_i w_i + \int_0^\infty \pi_i(z_i) \psi_i(z_i) dz_i \quad \forall i = 1, \ldots N. \]

\( r_i \) \( c_i \) total expenditure
\( L_i \) \( w_i \) labor income
\( \int_0^\infty \pi_i(z_i) \psi_i(z_i) dz_i \) total profits
Two-country world – Home ($H$) and Foreign ($F$). Look for $w_H/w_F$ s.t.:

$$ED_H = L_H w_H + \int_0^\infty \pi_H(z_H) \psi_H(z_H) dz_H - r_H c_H = 0.$$
Insourcing: Changes of Location

Introduction

Closed Economy

- Setup
- Firm’s Problem
- Prices
- General Equilibrium

Open Economy

- Setup
- Firm’s Problem
- Prices
- General Equilibrium

Welfare Analysis

Conclusions

- \( w_H \in (0, \frac{w_F}{\tau}) \) \Rightarrow both countries integrate in \( H \);
- \( w_H \in \left( \frac{w_F}{\tau}, \tau w_F \right) \Rightarrow both countries integrate domestically;
- \( w_H \in (\tau w_F, \infty) \Rightarrow both countries integrate in \( F \).\)
The Gains from Multinational Sourcing

Calibrate the model to:

- Compute the **gains from foreign insourcing**:
  - Disentangle the gains from arm’s length trade from the gains from FDI/intrafirm trade;
  - Assess the quantitative importance of productivity and technology *versus* competition and market structure.

- Gains from foreign insourcing arise because:
  - Firms from the origin country match **high productivity** with the **low wages** of the host country;
  - Consumers in the host country experience an **increase in relative wages**;
  - **Prices decrease** due to increased competition among suppliers.
Calibration

<table>
<thead>
<tr>
<th>parameter</th>
<th>value</th>
<th>definition</th>
<th>source</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \alpha )</td>
<td>0.25</td>
<td>1 - labor share in non-tradeables</td>
<td>Alvarez and Lucas (2007)</td>
</tr>
<tr>
<td>( \eta )</td>
<td>1.8 (1.2)</td>
<td>elasticity of substitution</td>
<td>model restrictions</td>
</tr>
<tr>
<td>( t )</td>
<td>1.1</td>
<td>iceberg trade cost</td>
<td></td>
</tr>
<tr>
<td>( \tau )</td>
<td>2.65 (2.66)</td>
<td>iceberg FDI cost</td>
<td></td>
</tr>
<tr>
<td>( L_{us}/L_{row} )</td>
<td>0.16</td>
<td>relative labor in efficiency units</td>
<td>to match data</td>
</tr>
<tr>
<td>( \mu_{us}/\mu_{row} )</td>
<td>1.92 (1.77)</td>
<td>suppliers’ relative productivity</td>
<td></td>
</tr>
<tr>
<td>( \lambda_{us}/\lambda_{row} )</td>
<td>1.92 (1.77)</td>
<td>buyers’ relative productivity</td>
<td></td>
</tr>
</tbody>
</table>
**Calibration (contd.)**

Trade and FDI iceberg costs, labor force in efficiency units, and relative productivity:

\[ t = 1.1 \]  \hspace{2cm} \textit{U.S. intrafirm import share} = 13.5\%

\[ \tau = 2.65 \]  \hspace{2cm} \textit{U.S. import/GDP} = 13.3\%

\[ \frac{L_{us}}{L_{row}} = 0.16 \]  \hspace{2cm} \textit{U.S. GDP/World GDP} = 30\%

\[ \frac{\mu_{us}}{\mu_{row}} = 1.92 \]  \hspace{2cm} \textit{U.S. GDP per worker/ROW GDP per worker}^2 = 2.22

(Assume \( \lambda_{us}/\lambda_{row} = \mu_{us}/\mu_{row} \). All data are for the year 2004).

\[ \text{(GDP per worker)}^2_{row} = \sum_{i \neq us} \left( \frac{GDP_i}{\text{labor force}_i} \times \frac{\text{imports}_{us, i}}{\text{imports}_{us, row}} \right). \]
The Gains from Insourcing

\[
\text{welfare gain} = \left( \frac{\text{consumption in calibrated model}}{\text{consumption in model without integration}} - 1 \right) \times 100
\]

<table>
<thead>
<tr>
<th></th>
<th>baseline calibration</th>
<th>FDI reform</th>
<th>higher market power</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>((\eta = 1.8,)</td>
<td>((\eta = 1.8,)</td>
<td>((\eta' = 1.2,)</td>
</tr>
<tr>
<td></td>
<td>(\tau = 2.65))</td>
<td>(\tau' = 1.82))</td>
<td>(\tau = 2.66))</td>
</tr>
<tr>
<td>U.S. welfare gains (%)</td>
<td>4.87</td>
<td>6.95</td>
<td>13.29</td>
</tr>
<tr>
<td>of which:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>domestic integration</td>
<td>4.16</td>
<td>0</td>
<td>11.35</td>
</tr>
<tr>
<td>foreign integration</td>
<td>0.71</td>
<td>6.95</td>
<td>1.94</td>
</tr>
<tr>
<td>of which:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>productivity effect</td>
<td>4.63</td>
<td>6.41</td>
<td>4.41</td>
</tr>
<tr>
<td>competition effect</td>
<td>0.24</td>
<td>0.54</td>
<td>8.88</td>
</tr>
<tr>
<td>intrafirm import share (%)</td>
<td>13.7</td>
<td>62.52</td>
<td>13.7</td>
</tr>
<tr>
<td>(\Delta%) in av. dom. mark-up</td>
<td>-8.2</td>
<td>-8.74</td>
<td>-42.33</td>
</tr>
</tbody>
</table>
The Gains from Insourcing (contd.)

<table>
<thead>
<tr>
<th></th>
<th>baseline calibration ($\eta = 1.8$, $\tau = 2.65$)</th>
<th>FDI reform ($\eta = 1.8$, $\tau' = 1.82$)</th>
<th>higher market power ($\eta' = 1.2$, $\tau = 2.66$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROW welfare gains (%)</td>
<td>12.39</td>
<td>14.87</td>
<td>23.1</td>
</tr>
<tr>
<td>of which:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>domestic integration</td>
<td>11.84</td>
<td>11.84</td>
<td>22.58</td>
</tr>
<tr>
<td>foreign integration</td>
<td>0.55</td>
<td>3.33</td>
<td>0.52</td>
</tr>
<tr>
<td>of which:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>productivity effect</td>
<td>11.76</td>
<td>14.35</td>
<td>14.37</td>
</tr>
<tr>
<td>competition effect</td>
<td>0.63</td>
<td>0.52</td>
<td>8.73</td>
</tr>
<tr>
<td>$\Delta$% in av. dom. mark-up</td>
<td>-8.3</td>
<td>-8.25</td>
<td>-42.99</td>
</tr>
</tbody>
</table>
Gains from Trade and FDI

<table>
<thead>
<tr>
<th></th>
<th>U.S.</th>
<th>ROW</th>
</tr>
</thead>
<tbody>
<tr>
<td>autarky</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>costless trade and no FDI</td>
<td>1.13</td>
<td>1.05</td>
</tr>
<tr>
<td>costless trade and costless FDI</td>
<td>1.23</td>
<td>1.06</td>
</tr>
</tbody>
</table>

- **U.S. gains from trade:**
  - 10% (Alvarez and Lucas (2007)), 17% (Eaton and Kortum (2002)).

- **U.S. gains from “openness”:**
  - \(\approx 10\%\) (Rodríguez-Clare (2007)), 9% (Burstein and Monge-Naranjo (2007)).
Conclusions

- New GE framework to think about firms’ sourcing decisions:
  location + organizational structure driven by technology heterogeneity and imperfect competition.

- This theory contributes to understanding:
  - the **effect of multinational firms on competition**: optimal pricing of tradeables;
  - the **determinants of intrafirm trade**: market structure and cost advantages;
  - the **gains from intrafirm trade**.
Why is Intrafirm Trade so Important?

- Intrafirm trade is the by-product of a firm setting a plant in another country.
  Understanding intrafirm trade helps to understand:
  - the nature/structure/operations of multinational firms;
  - the relationship between trade and foreign direct investment.

- Intrafirm transactions are priced differently than arm’s length transactions\(^3\):
  - transfer prices and arm’s length prices respond differently to changes in the economy
    \[\downarrow\]
    different pass-through of changes in marginal costs, transportation costs or exchange rates.

---

\(^3\)Bernard, Jensen and Schott (2006).
Input Differentiation and Intrafirm Trade

Given $\alpha$, $\eta$, $L_i$, $\lambda_i$, $\mu_i$, $t_{ij}$, $\tau_{ij} \forall j$, the intrafirm share of imports of country $i$ is:

$$
\sigma_i = \left[ 1 + \sum_{j \neq i} \int_{B_{ij}^T} [p_{ij}(z_j)]^{1-\eta} \phi_i(x) \psi(z) dx_i dz \right]^{-1}
$$

$$(\text{where } m_i = \tau_{ij} w_j \text{ for } j \neq i).$$

**Proposition 1**: $\frac{\partial \sigma_i}{\partial \eta} < 0$.

Higher differentiation across inputs ("low" $\eta$)
$\downarrow$
higher “outside” prices: $\frac{\partial p_{ij}(z_j)}{\partial \eta} < 0 \ \forall j$
$\downarrow$
higher incentive to do intrafirm sourcing.
Data

\[
\ln(\sigma_{st}) = \beta_0 + \beta_1 D^\eta_s + \varepsilon_{st}
\]

- \(\sigma_{st}\) ≡ **Intrafirm share of import**: imports of U.S. parents from their foreign affiliates/ total U.S. imports (29 manufacturing BEA sectors for 4 years).

- \(D^\eta_s\) ≡ **Input differentiation variable**: from Broda and Weinstein (2006)’s estimates of (3-digit SITC) sector elasticities \(\eta_i\):

\[
D_{SITC_{s}}^\eta = \begin{cases} 
1 & \text{if } \eta_s < \text{median}(\eta_s); \\
0 & \text{if } \eta_s \geq \text{median}(\eta_s).
\end{cases}
\]

Aggregate into BEA manufacturing industries:

\[
D_{BEA_{s}}^\eta = \sum_{SITC_{s} \in BEA_{s}} \frac{\text{import}_{SITC_{s}}}{\text{import}_{BEA_{s}}} \times D_{SITC_{s}}^\eta
\]

\((D^\eta_{BEA_{s}} \in [0, 1]\) and assigns value 0 to commodities and value 1 to highly differentiated products).
## Sector Differentiation Variable

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>$D_{BEAS}^\eta$</th>
<th>Code</th>
<th>Description</th>
<th>$D_{BEAS}^\eta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Grain, Mill and Bakery Prod.</td>
<td>0</td>
<td>21</td>
<td>Construction, Mining, etc.</td>
<td>0.4979</td>
</tr>
<tr>
<td>2</td>
<td>Beverages</td>
<td>0</td>
<td>22</td>
<td>Computer and Office Equip.</td>
<td>0.4092</td>
</tr>
<tr>
<td>4</td>
<td>Other Food and Kindred Prod.</td>
<td>0.4303</td>
<td>23</td>
<td>Other Nonelectric Machinery</td>
<td>0.6464</td>
</tr>
<tr>
<td>5</td>
<td>Apparel and Other Textile Prod.</td>
<td>0.4938</td>
<td>24</td>
<td>Household Appliances</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Pulp, Paper and Boardmills</td>
<td>0</td>
<td>25</td>
<td>Household Audio and Video</td>
<td>0.8958</td>
</tr>
<tr>
<td>9</td>
<td>Printing and Publishing</td>
<td>1</td>
<td>26</td>
<td>Electronic Components</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>Drugs</td>
<td>1</td>
<td>27</td>
<td>Other Electrical Machinery</td>
<td>0.3919</td>
</tr>
<tr>
<td>11</td>
<td>Soaps, Cleaners and Toilet Gds</td>
<td>0.7006</td>
<td>28</td>
<td>Motor Vehicles and Equip.</td>
<td>0.6503</td>
</tr>
<tr>
<td>12</td>
<td>Agricultural Chemicals</td>
<td>0.2304</td>
<td>29</td>
<td>Other Transportation Equip.</td>
<td>0.2657</td>
</tr>
<tr>
<td>13</td>
<td>Industrial Chemicals and Synt.</td>
<td>0.4891</td>
<td>30</td>
<td>Lumber, Wood, Furniture</td>
<td>0.5101</td>
</tr>
<tr>
<td>14</td>
<td>Other Chemicals</td>
<td>1</td>
<td>31</td>
<td>Glass Products</td>
<td>0.5518</td>
</tr>
<tr>
<td>15</td>
<td>Rubber Prod.</td>
<td>0.8827</td>
<td>32</td>
<td>Stone, Clay, Concrete, Gypsum</td>
<td>0.8330</td>
</tr>
<tr>
<td>16</td>
<td>Miscellaneous Plastic Prod.</td>
<td>0</td>
<td>33</td>
<td>Instruments and Apparatus</td>
<td>0.9650</td>
</tr>
<tr>
<td>19</td>
<td>Fabricated Metal Prod.</td>
<td>0.4464</td>
<td>34</td>
<td>Other Manufacturing</td>
<td>0.5131</td>
</tr>
<tr>
<td>20</td>
<td>Farm and Garden Machinery</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Results

\[ \ln(\sigma_{st}) = \beta_0 + \beta_1 D_s^n + \varepsilon_{st} \]

Data for 29 BEA manufacturing sectors, for 4 years (Source: BEA, BW (2006))
\[ \ln(\sigma_{st}) = \beta_0 + \beta_1 D_s^\eta + \beta_2 \ln(K_{st}/L_{st}) + \varepsilon_{st} \]

<table>
<thead>
<tr>
<th>Dep. Var: ( \ln(\sigma_{st}) )</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>( D_s^\eta )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.474***</td>
<td>1.474***</td>
<td>1.478***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.251)</td>
<td>(0.434)</td>
<td>(0.442)</td>
<td></td>
</tr>
<tr>
<td>( \ln(K_{st}/L_{st}) )</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.829***</td>
<td>1.005***</td>
<td>1.005***</td>
<td>1.018***</td>
</tr>
<tr>
<td></td>
<td>(0.159)</td>
<td>(0.143)</td>
<td>(0.246)</td>
<td>(0.255)</td>
</tr>
<tr>
<td>clustered errors</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>year fixed effects</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>adj. ( R^2 )</td>
<td>0.185</td>
<td>0.370</td>
<td>0.381</td>
<td>0.385</td>
</tr>
<tr>
<td>No. of obs.</td>
<td>116</td>
<td>116</td>
<td>116</td>
<td>116</td>
</tr>
<tr>
<td>No. of clusters</td>
<td>29</td>
<td>29</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>