Static and Dynamic Gains from Importing Intermediate Inputs: Theory and Evidence

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Motivation: Importing and Productivity

- 18.87% of plants; 28.42% of inputs used in production was imported.

- The imported inputs directly enter the production process
  \( \Rightarrow \) have a direct impact on production and productivity
Motivation: Importing and Productivity

Table 4: Mean of Value Added Per Worker: Importers and Non-importers (1,000 Colombia Peso)

<table>
<thead>
<tr>
<th>Industry Name</th>
<th>Non-importers</th>
<th>Importers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Ind Chemicals</td>
<td>333.47</td>
<td>442.22</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>86.25</td>
<td>210.10</td>
</tr>
<tr>
<td>Plastics</td>
<td>88.81</td>
<td>142.21</td>
</tr>
<tr>
<td>Leather Shoes</td>
<td>84.41</td>
<td>113.07</td>
</tr>
<tr>
<td>Printing &amp; Publishing</td>
<td>77.87</td>
<td>126.03</td>
</tr>
<tr>
<td>Clothing</td>
<td>91.67</td>
<td>99.61</td>
</tr>
<tr>
<td>All six Industries</td>
<td>115.37</td>
<td>177.30</td>
</tr>
</tbody>
</table>

Possible Explanations

1. Self selection

2. Importing may have a positive effect on productivity.
Possible Explanations

1. Self selection

2. Importing may have a positive effect on productivity.
   (1) Higher quality per dollar
   (2) More variety
   (3) Dynamic productivity effect
      - Channels: exposure to foreign technology, technical support from foreign suppliers, more open-minded management.
Literature

- Literature studying the gains from importing

- Contribution of my work
  1. Incorporate dynamic productivity effect of importing; decompose the total gains from importing: static + dynamic
  2. Control for self selection of firms into importing by endogenizing firms' dynamic importing decision.
Preview of Main Results

- I construct a dynamic model to characterize firms’ decision on whether to import intermediate inputs. In the model:
  - **Importing decision is endogenous:** productivity, along with other factors, determines firms’ importing decision.
  - **Productivity is endogenous:** the importing decision, in turn, affects firms' future productivity dynamically.

- Estimate this dynamic model structurally using micro data

- I find:
  1. Obvious selection: larger firms and more productive firms are more likely to import.
  2. Gains from importing are large (1%-22% increase of firm value).
  3. Dynamic productivity effect is the major source of gains from importing.
Plan

- Data
- Model
- Estimation Procedure
- Estimation Results
- Selection
- Gains from Importing
- Conclusion
Data

- Plant-level data from Colombia during 1977-1989: basic industrial chemicals, pharmaceuticals, plastics, clothing, leather shoes, printing & publishing

- Panel data. Cover all plants with 10 or more employees.

- Variables: value of output, domestic input, imported input, labor, capital, investment, and some other firm characteristics.
Turnover and Persistence of Importing Status

- Turnover: 10% of the importers are new; 12.6% quit importing
- Persistence:

<table>
<thead>
<tr>
<th>Table 3: Transition Probability of Importing Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date t</td>
</tr>
<tr>
<td>Import</td>
</tr>
<tr>
<td>Not Import</td>
</tr>
</tbody>
</table>
The Model


- Production:

\[
Q_{jt} = \exp(\omega_{jt}) \left[ L_{jt}^{\alpha_l} M_{jt}^{\alpha_m} K_{jt}^{\alpha_k} \right]
\]

with \( M_{jt} = \left[ M_{jdt}^{\theta-1} + (AM_{jft})^{\theta-1} \right]^{\frac{\theta}{\theta-1}} \)

- Demand:

\[
Q_{jt}^D = \Phi_t P_{jt}^\eta
\]
Timing

1. At the beginning of each date, each firm observes its own state $s_{jt} = \{K_{jt}, \omega_{jt}, d_{jt}\}$.
2. Choose static input $(L_{jt}, M_{jtd}, M_{jtf})$ and output price $(P_{jt})$ to maximize its static profit for this period;
3. Observe two new import cost shocks $(C_{sjt}, C_{ft})$, i.i.d across $j$ and $t$.
4. Choose importing status for next period $(d_{jt+1})$ and investment $(i_{jt})$.

- Evolution of state variables

\[
K_{jt+1} = (1 - \delta_k)K_{jt} + i_{jt}
\]
\[
\omega_{jt+1} = g_0 + g_\omega \omega_{jt} + g_d d_{jt} + \epsilon_{jt+1}, \epsilon_{jt+1} \sim N(0, \sigma_\epsilon^2)
\]
\[
d_{jt+1} = 1, \text{ if pay the sunk/fixed cost } (C_{sjt}, C_{ft})
\]
The firm chooses $L_{jt}, M_{jtd}, M_{jtf}$, and $P_{jt}$ to maximize period profit.

$$\ln R_{jt} = \sum_{\tau} \gamma_{\tau} D_{t} + r_{k} \ln K_{jt} + r_{\omega} \omega_{jt} + r_{d} d_{jt}$$  \hspace{1cm} (1)$$

where $r_{k}, r_{d},$ and $r_{w}$ are functions of demand parameters and production parameters.

Total variable cost

$$C_{jt} = \frac{1 + \eta}{\eta} (\alpha_{l} + \alpha_{m}) R_{jt}$$  \hspace{1cm} (2)$$
Dynamic choice of importing status

Plant j’s value before it observes the current-date fixed cost/sunk cost

\[ V(s_{jt}) = \pi(s_{jt}) + \int \int \max_{d_{jt+1}} \left\{ V^1(s_{jt}) - d_{jt} C^f_{jt} - (1 - d_{jt}) C^s_{jt}, V^0(s_{jt}) \right\} dF^s dF^f \]

where

\[ V^1(s_{jt}) = \delta \max_{i_{jt}} \int V(s_{jt+1}, d_{jt+1} = 1) dF (\omega_{jt+1} | \omega_{jt}, d_{jt}) \]

\[ V^0(s_{jt}) = \delta \max_{i_{jt}} \int V(s_{jt+1}, d_{jt+1} = 0) dF (\omega_{jt+1} | \omega_{jt}, d_{jt}) \]
Idea for Identification

Parameters to be estimated: $\alpha_l, \alpha_m, \alpha_k, A, \theta; \eta; g_\omega, g_d, \sigma_\xi^2; F^s, F^f$.

- $\alpha_l, \alpha_m, \alpha_k, A, \theta, \eta; g(\cdot, \cdot), \sigma_\xi^2$ identified from plants' static decision
  - $\alpha_l, \alpha_m, \alpha_k, \eta, g_\omega, \sigma_\xi^2$: non-importers' static decision.
  - $g_d$: comparison of productivity growth for importers and non-importers.
  - $A, \theta$: relative usage of domestic and imported inputs for importers.

- $F^s, F^f$: identified from the conditional choice probability (CCP) of importing
  - Idea: sunk/fixed costs determines the turnover of importing status, so we can infer the distribution of sunk/fixed costs from the observed importing decisions.
Estimation: Stage 1

- Stage 1 estimates production parameters \((\alpha_l, \alpha_m, \alpha_k, A, \theta)\) and productivity evolution parameters \((g_\omega, g_d, \sigma^2_\varepsilon)\);

\[
q_{jt} = \alpha_l l_{jt} + \alpha_m \frac{\theta}{\theta - 1} \ln \left[ M_{j\theta d\theta}^{\theta-1} + (AM_{jft})^{\theta-1} d_{jt} \right] + \alpha_k k_{jt} + \omega_{jt} + \zeta_{jt}
\]

\[
q_{jt} = \alpha_l l_{jt} + \alpha_m \frac{\theta}{\theta - 1} \ln \left[ M_{j\theta d\theta}^{\theta-1} + (AM_{jft})^{\theta-1} d_{jt} \right] + \phi(i_{jt}, k_{jt}, d_{jt+1}) + \zeta_{jt}
\]

- From \(\phi(i_{jt}, k_{jt}, d_{jt+1}) = \alpha_k k_{jt} + \omega_{jt}, \quad \omega_{jt} = g(\omega_{jt-1}, d_{jt-1}) + \varepsilon_{jt}\)

\[
\hat{\phi}_{jt} = \alpha_k k_{jt} + g(\hat{\phi}_{jt-1} - \alpha_k k_{jt-1}, d_{jt-1}) + \varepsilon_{jt} + \zeta_{jt}
\]

- Recover productivity: \(\hat{\omega}_{jt} = \hat{\phi}_{jt} - \hat{\alpha}_k k_{jt}\)
Stage 2: Demand Elasticity

- 2-1: given the estimates of $\alpha_l$ and $\alpha_m$, estimate demand elasticity($\eta$) from variable cost and revenue data.

\[
C_{jt} = \frac{1 + \eta}{\eta} (\hat{\alpha}_l + \hat{\alpha}_m) R_{jt} + \zeta_{jt}
\]

- 2-2: construct the revenue functions from equation (1), and profit function

\[
\ln R_{jt} = \sum_{\tau} \gamma_{\tau} D_t + \hat{r}_k \ln K_{jt} + \hat{r}_\omega \omega_{jt} + \hat{r}_d d_{jt} + \zeta_{jt}
\]

\[
\pi_{jt} = \left[ 1 - \frac{1 + \hat{\eta}}{\hat{\eta}} (\hat{\alpha}_l + \hat{\alpha}_m) \right] R_{jt}
\]
Stage 3: Distribution of Costs

Estimate $F^s, F^f$ using MLE, based on conditional choice probability (CCP) of importing

- Assume: iid $C^s_{jt} \sim EXP(\lambda_s), C^f_{jt} \sim EXP(\lambda_f)$
- Probability to import:

$$L^1_{jt} = \Pr \{d_{jt+1} = 1 \mid s_{jt}\}$$

$$= \Pr \{d_{jt} C^f_{jt} + (1 - d_{jt}) C^s_{jt} \leq V^1(s_{jt}) - V^0(s_{jt}) \mid s_{jt}\}$$

- Likelihood function:

$$L = \prod_{j=1:N} L_j = \prod_{t=1:N} \prod_{t=1:T} L_{jt}$$

where $L_{jt} = d_{jt+1} L^1_{jt} + (1 - d_{jt+1})(1 - L^1_{jt})$. 

"Gains from Importing"

Hongsong Zhang, Penn State University
• Major difficulty: \( V^1(s_{jt}) \) and \( V^0(s_{jt}) \) are unknown. They can be computed from equations (3) – (5). (value function iteration)
Computation Algorithm

Discretize the state space $S$ into $S'$ with $N$ grid points.

1. Pick a parameter $\lambda^0 = \left(\lambda_S^0, \lambda_f^0\right) \in \Gamma$ (parameter space).

2. Given $\lambda^0$, compute value function $V(S')$ defined in equation (1);
   2.1 Pick an starting value function $V_0(S')$;
   2.2 Compute the choice-specific value function $V^1(S')$ and $V^0(S')$ from equations (2), and (3).
   2.3 Use $\pi(S')$, $V^1(S')$ and $V^0(S')$ to update the value function to $V_1(S')$;
   2.4 Iterate until $|V_{i+1}(S') - V_i(S')|$ small.

3. For given $\lambda^0$, compute the likelihood: $L(\lambda^0)$

Pick $\lambda^* = \arg\max_{\lambda \in \Gamma} L(\lambda)$ (MLE).


## Estimation Results

### Table 5: Parameters in Production Function

<table>
<thead>
<tr>
<th>Industry</th>
<th>B.I. Chemicals</th>
<th>Pharmaceuticals</th>
<th>Plastics</th>
<th>L. Shoes</th>
<th>Print &amp; Pub</th>
<th>Clothing</th>
</tr>
</thead>
<tbody>
<tr>
<td>L-share ($\alpha_l$)</td>
<td>0.4260</td>
<td>0.3466</td>
<td>0.3034</td>
<td>0.4736</td>
<td>0.4956</td>
<td>0.5510</td>
</tr>
<tr>
<td></td>
<td>(0.0024)</td>
<td>(0.0026)</td>
<td>(0.0013)</td>
<td>(0.0012)</td>
<td>(0.0006)</td>
<td>(0.0003)</td>
</tr>
<tr>
<td>M-share ($\alpha_m$)</td>
<td>0.3420</td>
<td>0.5774</td>
<td>0.6253</td>
<td>0.4015</td>
<td>0.4283</td>
<td>0.3666</td>
</tr>
<tr>
<td></td>
<td>(0.0011)</td>
<td>(0.0019)</td>
<td>(0.0006)</td>
<td>(0.0006)</td>
<td>(0.0003)</td>
<td>(0.0001)</td>
</tr>
<tr>
<td>K-share ($\alpha_k$)</td>
<td>0.1247</td>
<td>0.0723</td>
<td>0.0537</td>
<td>0.0854</td>
<td>0.0911</td>
<td>0.0537</td>
</tr>
<tr>
<td></td>
<td>(0.0096)</td>
<td>(0.0036)</td>
<td>(0.0014)</td>
<td>(0.0020)</td>
<td>(0.0002)</td>
<td>(0.0014)</td>
</tr>
<tr>
<td>Quality (A)</td>
<td>1.0006</td>
<td>0.9255</td>
<td>1.0903</td>
<td>1.0001</td>
<td>0.9317</td>
<td>0.9995</td>
</tr>
<tr>
<td></td>
<td>(0.4611)</td>
<td>(0.0828)</td>
<td>(0.0233)</td>
<td>(0.5430)</td>
<td>(0.0359)</td>
<td>(0.1013)</td>
</tr>
<tr>
<td>Elasticity ($\theta$)</td>
<td>5.0069</td>
<td>9.6690</td>
<td>21.5337</td>
<td>2.7108</td>
<td>22.3194</td>
<td>9.2140</td>
</tr>
<tr>
<td></td>
<td>(0.1287)</td>
<td>(0.0897)</td>
<td>(0.0577)</td>
<td>(0.3821)</td>
<td>(0.0479)</td>
<td>(0.5232)</td>
</tr>
</tbody>
</table>

Notes: (1) The standard errors are in the parentheses. (2) I also control for age and ownership dummy in this regression.
Productivity Evolution

Table 6: Productivity Evolution Process

<table>
<thead>
<tr>
<th>Industry</th>
<th>Chemicals</th>
<th>Pharmaceuticals</th>
<th>Plastics</th>
<th>L.Shoes</th>
<th>Print&amp;Pub</th>
<th>Clothing</th>
</tr>
</thead>
<tbody>
<tr>
<td>$g_0$</td>
<td>0.5583</td>
<td>0.2743</td>
<td>0.3085</td>
<td>0.5481</td>
<td>0.6390</td>
<td>0.4593</td>
</tr>
<tr>
<td></td>
<td>(0.9385)</td>
<td>(0.9876)</td>
<td>(0.5828)</td>
<td>(0.9686)</td>
<td>(0.0320)</td>
<td>(0.3650)</td>
</tr>
<tr>
<td>$g_ω$</td>
<td>0.8240</td>
<td>0.7719</td>
<td>0.7919</td>
<td>0.6954</td>
<td>0.3154</td>
<td>0.7202</td>
</tr>
<tr>
<td></td>
<td>(0.1169)</td>
<td>(0.5460)</td>
<td>(0.2666)</td>
<td>(0.2548)</td>
<td>(0.0128)</td>
<td>(0.1111)</td>
</tr>
<tr>
<td>$g_d$</td>
<td>0.0150</td>
<td>0.0213</td>
<td>0.0115</td>
<td>0.0205</td>
<td>0.0277</td>
<td>0.0026</td>
</tr>
<tr>
<td></td>
<td>(0.0072)</td>
<td>(0.0128)</td>
<td>(0.0035)</td>
<td>(0.0157)</td>
<td>(0.0012)</td>
<td>(0.0070)</td>
</tr>
<tr>
<td>$σ_ω$</td>
<td>0.0994</td>
<td>0.0621</td>
<td>0.0402</td>
<td>0.0588</td>
<td>0.1307</td>
<td>0.0472</td>
</tr>
</tbody>
</table>

Notes: (1) Standard errors in parentheses. (2) I control for export in the regression.

$$\omega_{jt} = \frac{g_0}{\omega} + g_ω \omega_{jt-1} + g_d d_{jt-1} + \varepsilon_{jt}$$

Robustness check.
## Distribution of Fixed and Sunk Costs

Table 8: Distribution of Sunk and Fixed Cost (MLE)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( \log \lambda_s )</td>
<td>17.1686</td>
<td>17.2725</td>
<td>18.5566</td>
<td>19.6835</td>
<td>16.5361</td>
<td>18.4536</td>
</tr>
<tr>
<td></td>
<td>(0.2410)</td>
<td>(0.2619)</td>
<td>(0.1917)</td>
<td>(0.3880)</td>
<td>(0.1455)</td>
<td>(0.1956)</td>
</tr>
<tr>
<td>( \log \lambda_f )</td>
<td>14.4476</td>
<td>14.1224</td>
<td>15.0534</td>
<td>15.2471</td>
<td>12.7986</td>
<td>13.4990</td>
</tr>
<tr>
<td></td>
<td>(0.0599)</td>
<td>(0.0596)</td>
<td>(0.0324)</td>
<td>(0.0628)</td>
<td>(0.0237)</td>
<td>(0.1022)</td>
</tr>
</tbody>
</table>

Notes: Standard deviation in parentheses.
Self Selection: New Importer

Begin importing if: \[ C_{jt}^s \leq V^1(s_{jt} \mid d_{jt} = 0) - V^0(s_{jt} \mid d_{jt} = 0) \]

- More productive/larger firms tend to start importing.

**Figure:** Thresholds for new importing: Fixed Costs, Productivity, and Firm Size.
Self Selection: Old Importer

Stop importing if: \( C_{jt}^f \leq V^1(s_{jt} \mid d_{jt} = 1) - V^0(s_{jt} \mid d_{jt} = 1) \)

- More productive/larger firms tend to continue importing.

Figure: Thresholds for Continuing Importing: Fixed Costs, Productivity, and Firm Size.
Importing Probability: New Importer VS Old Importer

"Gains from Importing"

Hongsong Zhang, Penn State University
Gains from Importing

- Total Gain:

\[ \text{Total Gain} = V(s_{jt0}) - V_{aut}(\omega_{jt}, K_{jt}) \]  

where \( s_{jt0} = (\omega_{jt}, K_{jt}, d_{jt} = 0) \).

- Decomposition:

\[ \text{Dynamic Effect} = V(s_{jt0}) - V(s_{jt0} \mid g_d = 0) \]  

\[ \text{Static Effect} = V(s_{jt0} \mid g_d = 0) - V_{aut}(\omega_{jt}, K_{jt}) \]
Total Gains

Table 9: Total Gains From Importing

<table>
<thead>
<tr>
<th>Industry Name</th>
<th>Pctg. Gain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Ind Chemicals</td>
<td>14.47%</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>22.28%</td>
</tr>
<tr>
<td>Plastics</td>
<td>16.25%</td>
</tr>
<tr>
<td>Leather Shoes</td>
<td>6.17%</td>
</tr>
<tr>
<td>Printing&amp;Publishing</td>
<td>4.50%</td>
</tr>
<tr>
<td>Clothing</td>
<td>0.87%</td>
</tr>
</tbody>
</table>

Notes: "Pctg. Gain" refers to the percentage gain of firm value from importing. It is defined as (total gain)/V(sjt0).
Sources of the Gains: Dynamic & Static Effects

Table 10: Dynamic and Static Effects from Importing

<table>
<thead>
<tr>
<th>Industry Name</th>
<th>Dynamic Effect</th>
<th>Static Effect</th>
<th>Total E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Ind Chemicals</td>
<td>13.94%</td>
<td>0.53%</td>
<td>14.47%</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>21.82%</td>
<td>0.47%</td>
<td>22.28%</td>
</tr>
<tr>
<td>Plastics</td>
<td>15.76%</td>
<td>0.49%</td>
<td>16.25%</td>
</tr>
<tr>
<td>Leather Shoes</td>
<td>5.35%</td>
<td>0.82%</td>
<td>6.17%</td>
</tr>
<tr>
<td>Printing&amp;Publishing</td>
<td>4.46%</td>
<td>0.03%</td>
<td>4.50%</td>
</tr>
<tr>
<td>Clothing</td>
<td>0.75%</td>
<td>0.12%</td>
<td>0.87%</td>
</tr>
</tbody>
</table>
Conclusion and Future Work

1. *Incorporate* dynamic productivity effect of importing into consideration; *decompose* the total gains from importing: static effect + dynamic effect

   (1) Total gains from importing are large. (Increase firm value by 0.87%-22%)
   (2) Dynamic productivity effect is the major source of gains from importing. (85% total gain; 1.5% annual productivity)

2. *Control for* self selection of firms into importing by endogenizing firms’ dynamic importing decision. Based on a dynamic structural model which is estimated using micro data.

   (3) Self selection: more productive/larger plants are more likely to import intermediate materials.
1. Location Choice: origin country of import affects the size/sources of gains (work in progress)

2. Import & Export: understand the dynamics of import and export (work in progress)

3. R&D and importing