Multinational Production and Comparative Advantage

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Multinational Production (MP) and Sectoral Productivity

**Question**: Does MP affect the pattern of specialization of an economy?

**Observation**:
- MP represents a large fraction of output, employment and trade
- The fraction of MP on output is significantly heterogeneous across sectors
- MP and sectoral productivity are negatively correlated
MP has Significant Sectoral Variability

Bilateral-sector level MP data for 35 OECD and non-OECD European countries, nine manufacturing sectors and one non-tradable sector.
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MP is correlated with sectoral productivity

Negative Correlation Between (MP/output) and Relative TFP

- Foreign affiliate sales are higher in sectors where the host economy is relatively less productive.

**MP and Total Factor Productivity**

![Graph showing the correlation between MP and Total Factor Productivity](image)

- Coef = -3.306762, t = -4.24, Partial Correlation = -0.4076***
Can MP Affect Relative Productivity Across Sectors?

- Multinationals bring knowhow, innovative knowledge, and managerial skills.
- MP reduces differences in relative productivity across sectors
  - MP induces larger transfer of technology in sectors where the host country is relatively less productive
Effect of Comparative Advantage on MP allocation

Relative Technology

Low MP

High MP

Locals’ productivity

Sectors

S1 S2 S3 S4 S5 S6 S7
Effect of MP on Comparative Advantage

- Small technology transfer
- Large technology transfer
- Local productivity
- (Locals + Multinationals) productivity
Assembles an industry-level dataset of bilateral foreign affiliates’ sales to document some empirical regularities

Incorporates a sectoral dimension into a multi-country model of trade and MP:
- Estimates productivities at the sectoral level for domestic and all producers in the economy
- Derives analytical implications for welfare
- Conducts counterfactual exercises to evaluate the effects of MP
- Unisectoral models of Trade and MP are silent with respect to the interaction between MP and comparative advantage
The increase in real income following an opening to multinational activity is 15 percentage points higher compared to the case where MP is homogeneous across sectors (27% compared to 12%)

The increase in real income following a trade liberalization is about half of what it would be if MP does not affect comparative advantage (10% compared to 19.4%)
Preview of Results

- The increase in real income following an opening to multinational activity is 15 percentage points higher compared to the case where MP is homogeneous across sectors (27% compared to 12%)

- The increase in real income following a trade liberalization is about half of what it would be if MP does not affect comparative advantage (10% compared to 19.4%)
Contribution to Related Literature

- Uni-sector MP-trade models:
  - Ramondo and Rodriguez-Clare (2011); Shikher (2011)
  - Arkolakis, Ramondo, Rodriguez-Clare and Yeaple (2012)
  - Alfaro and Chen (2012, 2011)

- Multi-sector trade-only models:

- Horizontal MP and technology transfer:
Roadmap

- Presents a GE model of trade and MP that incorporates the sectoral dimension.

- Estimates productivity parameters of local producers and overall economy for each country-sector pair.

- Evaluates the welfare implications of the effect of MP on comparative advantage.
A Multi-Sector Trade-MP Model

Environment

- $N$ countries: source ($s$), host ($h$) and destination market ($m$)

- $J$ tradable sectors and one ($J + 1$) non-tradable sector
  - Each sector has a continuum of varieties $\omega = [0, 1]$

- MP by source country $s$ in host country $h$ occurs when a technology from $s$ is used in $h$ to produce variety $\omega$.
  - Trade: Country produces from their own market to sell to a foreign market $s = h$.
  - MP: Country produces at the destination market $h = m$.
  - Export Platforms: Country $s$ produces in $h$ to sell from there to destination market $m$. 
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A Multi-Sector Trade-MP Model

Environment

- Using technology to produce in a foreign country entails a cost:
  - Iceberg MP costs: \( g_{hs}^j > 1 \), and \( g_{ss}^j = 1 \)

- Trade across countries is costly:
  - Iceberg trade costs: \( d_{nh}^j > 1 \), and \( d_{hh}^j = 1 \)

- Factors of Production: capital (K), labor (L)

- Productivity of each country-sector pair is described by:
  \[
  z_s^j (\omega) \equiv \{ z_{1s}^j (\omega) , z_{2s}^j (\omega) , ..., z_{Ns}^j (\omega) \} \quad \forall i, j = 1 : N
  \]
Production Structure

- Production function:

$$Q_{mhs}^j(\omega) = \left[ (L_h^j)^{\alpha_j} (K_h^j)^{1-\alpha_j} \right]^{\beta_j} \left[ \prod_{k=1}^{J+1} (Q_s^k)^{\gamma_{kj}} \right]^{1-\beta_j} \left( \frac{z_{hs}^j(\omega)}{g_{hs}^j} \right),$$

$$\Rightarrow p_{mhs}^j(\omega) = \left( \frac{c_h^j g_{hs}^j}{z_{hs}^j(\omega)} \right) d_{mh}^j$$

where:

$$c_h^j = \left[ (w_h^j)^{\alpha_j} (r_h^j)^{1-\alpha_j} \right]^{\beta_j} \left[ \prod_{k=1}^{J+1} (p_h^k)^{\gamma_{kj}} \right]^{1-\beta_j}.$$
Seller $s$ will choose the location $h$ to reach country $m$ with the lowest possible price

$$p^j_{ms}(\omega) = \min \{ p^j_{m1s}(\omega), p^j_{m2s}(\omega), ..., p^j_{mNs}(\omega) \}$$

Consumers in $m$ will choose to buy from the source technology country $s$ that offers the cheapest price

$$p^j_m(\omega) = \min \{ p^j_{m1}(\omega), p^j_{m2}(\omega), ..., p^j_{mN}(\omega) \}$$
Hence, the probability that country \((m)\) imports sector \((j)\) goods from country \((h)\) using country \((s)\) technologies is described as:

\[
\pi^j_{mhs} = \frac{T^j_s (\Delta^j_{ms})^{-\theta_j}}{\sum_s T^j_s (\Delta^j_{ms})^{-\theta_j}} \cdot \frac{(\delta^j_{mhs})^{-\theta_j}}{\sum_h (\delta^j_{mhs})^{-\theta_j}}.
\]

where \(\Delta^j_{ms} = \left(\sum_h (\delta^j_{mhs})^{-\theta_j}\right)^{-\frac{1}{\theta_j}}\) and \(\delta^j_{mhs} = d^j_{mh} c^j_h g^j_{hs}\).
Trade Shares: $\pi_{mh}^j$

- Summing up $\pi_{mhs}^j$ across source countries $s$

\[
\pi_{mh}^j = \sum_{s=1}^{N} \pi_{mhs}^j
\]

\[
\frac{X_{mh}^j}{X_m^j} = \pi_{mh}^j = \frac{\tilde{T}_h^j (c_{h}^j d_{mh}^j)^{-\theta}}{\sum_{k=1}^{N} \tilde{T}_k^j (c_{k}^j d_{mk}^j)^{-\theta}}
\]

Where $\tilde{T}_h^j$ is the effective technology:

\[
\tilde{T}_h^j = T_1^j g_1^j -\theta + T_2^j g_2^j -\theta + \ldots + T_N^j g_N^j -\theta
\]
MP Shares: $y_{hs}^j$

- MP sales: summing up $\pi_{mhs}^j X_m^j$ across destination countries $m$; where $X_m^j = p_m^j Q_m^j$

\[
I_{hs}^j = \sum_{m=1}^{N} \pi_{mhs}^j X_m^j
\]

\[
I_{hs}^j = \frac{T_{s}^j \left(g_{hs}^j c_h^j\right)^{-\theta}}{(p_{h}^j)^{-\theta}} \frac{(X_h)^2}{X_{hh}}
\]

- MP shares are given by:

\[
y_{hs}^j = \frac{I_{hs}^j}{\sum_s I_{hs}^j} = \frac{I_{hs}^j}{I_{h}^j} = \frac{T_{s}^j \left(g_{hs}^j\right)^{-\theta}}{\tilde{T}_{h}^j}
\]
Given the set of prices \( \{ w_h, r_h, P_h, \{ p_{j}^h \}_{j=1}^{J+1} \}_{h=1}^{N} \), production is allocated across countries and sectors as follows:

\[
p_{h}^{j} Q_{h}^{j} = p_{h}^{j} Y_{h}^{j} + \sum_{k=1}^{J+1} (1 - \beta_{k}) \gamma_{j,k} \left( \sum_{m=1}^{N} \sum_{s=1}^{N} \pi_{mhs}^{k} p_{m}^{k} Q_{m}^{k} \right)
\]

The optimal sectoral factor allocations in country \( h \) and tradable sector \( j \) must thus satisfy:

\[
\sum_{m=1}^{N} \sum_{s=1}^{N} \pi_{mhs}^{j} p_{m}^{j} Q_{m}^{j} = \frac{w_{h} L_{h}^{j}}{\alpha_{j} \beta_{j}} = \frac{r_{h} K_{h}^{j}}{(1 - \alpha_{j}) \beta_{j}}.
\]
Analytical predictions

Simplifying assumptions

- Cobb Douglas preferences and equal expenditure shares

- A mirror image of the fundamental productivity across sectors and countries: $T_1^a = T_2^b$ and $T_1^b = T_2^a$

- Country 2 has comparative advantage in sector $a$:

  $$T_2^a > T_2^b$$

- Symmetry in trade and MP barriers

- The above assumptions ensure that wages are equal in both countries, $w_1 = w_2 = 1$
Welfare Analysis: Gains from Trade

- Welfare: an expression for real wage

\[ W_s = \frac{w_s}{(p_a^s p_b^s)^{1/2}} = \Gamma^{-1} \left( \frac{T_a T_b}{T_a T_b} \right)^{1/2} \left( \pi_a \pi_b \right)^{1/2} \left( \frac{\pi_a \pi_b}{\pi_a \pi_b} \right)^{1/2} \left( \frac{y_s y_s}{y_s y_s} \right)^{1/2} \]

- Gains from trade: \( (\pi_a \pi_b)^{-1/2\theta} \)

\[ GT_s = \frac{W_{sd>0}}{W_{sd \to \infty}} = \left( \frac{\left( \tilde{T}_a / T_a \right) \left( \tilde{T}_b / T_b \right)}{\sum_{j=a,b} \left( 1 + (d g^j)^{-\theta} \right) + \frac{T_{i \neq j}}{T_i} (g^j - \theta + d^{-\theta})} \right)^{-1/2\theta} \]
Welfare Analysis: Gains from MP

- Welfare: an expression for real wage

\[ W_s = \frac{w_s}{(p_s^a p_s^b)^{\frac{1}{2}}} = \Gamma^{-1} \left( T_s^a T_s^b \right)^{\frac{1}{2\theta}} \left( \pi_{ss}^a \pi_{ss}^b \right)^{-\frac{1}{2\theta}} \left( y_{ss}^a y_{ss}^b \right)^{-\frac{1}{2\theta}} \]

- Gains from MP:

\[ GMP_s = \frac{W_s^{g>0}}{W_s^{g\to\infty}} = \left[ \sum_{j=a,b} \left( 1 + \frac{T_{1}^{\neq j}}{T_1^j} d^{-\theta} \right) \right]^{-\frac{1}{2\theta}} \]
MP is disproportionately allocated in comparative disadvantage sectors

**Proposition 1**

In a two-country, two-sector world economy, the lower the technology of country 1 in sector a (country 1’s comparative disadvantage sector) relative to sector b, the higher the probability that firms from country 2 will produce in sector a relative to sector b in country 1.
The higher the heterogeneity of MP across sectors, the higher the gains from MP

Proposition 2

The higher the heterogeneity of MP across sectors, the higher the gains from MP. When the share of domestically produced goods is the same across sectors \((y_{hh}^a = y_{hh}^b)\), the gains from MP attain a minimum. Therefore, uni-sectoral trade-MP models understate the actual gains from MP as long as \(y_{hh}^a \neq y_{hh}^b\)
Gains from trade are lower the more heterogeneous the technology upgrade across sectors

**Proposition 3**

*The more heterogeneous the technology upgrade across sectors toward comparative disadvantage sectors, the lower the dispersion of effective technologies and the lower the gains from trade*
Figure: Proportional Technology Transfer
Bilateral MP Data: Sectoral Dimension

- **Coverage:**
  - 35 declaring countries
  - 9 manufacturing and 6 non-manufacturing sectors

- **Variables:**
  - Sales, employment and number of establishments

- **Unit of Analysis:**
  - Each observation is a (origin-location-sector) triplet, averaged over the period 2003-2007

- **Sources:**
  - OECD (Statistics on Measuring Globalization and IDIS)
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Estimating Model’s Parameters
Trade and MP Gravity Equations

Trade Gravity Equation

\[
\ln \left( \frac{X_{mh}^j}{X_{mm}^j} \right) = \ln \left( \tilde{T}_h^j \left( c_h^j \right)^{-\theta} \right) - \ln \left( \tilde{T}_m^j \left( c_m^j \right)^{-\theta} \right) - \theta \ln (d_{mh}^j)
\]

exporter fixed effect
importer fixed effect
bilateral observables

Trade barriers are defined as:

\[
\ln (d_{mh}^j) = d_k^j + b_{mh}^j + CU_{mh}^j + RTA_{mh}^j + exporter_r^j + v_{mh}^j
\]

Two Step Procedure
MP Gravity Equation

\[ \ln \left( \frac{I^j_{hs}}{I^j_{hh}} \right) = \ln(T^j_s) - \ln(T^j_h) - \theta \ln(g^j_{hs}) \]

- source fixed effect
- host fixed effect
- bilateral observables

MP barriers are defined as:

\[ \ln(g^j_{hs}) = d^j_k + b^s_{hs} + CU^j_{hs} + RTA^j_{hs} + source^j_s + \mu^j_{hs} \]
Recall that effective technology parameters are given by

\[
\begin{bmatrix}
\tilde{T}_{1j} \\
\tilde{T}_{2j} \\
.. \\
.. \\
\tilde{T}_{Nj}
\end{bmatrix}
= 
\begin{bmatrix}
g_{11}^j & g_{12}^j & .. & .. & g_{1N}^j \\
g_{21}^j & g_{22}^j & .. & .. & g_{2N}^j \\
.. & .. & .. & .. & .. \\
.. & .. & .. & .. & .. \\
g_{N1}^j & g_{N2}^j & .. & .. & g_{NN}^j
\end{bmatrix}
\times
\begin{bmatrix}
T_{1j} \\
T_{2j} \\
.. \\
.. \\
T_{Nj}
\end{bmatrix}
\]

Given \( \tilde{T}_{sj} \) and \( h_{si}^j \), we can solve for the fundamental productivity \( T_{ij} \) using the above system of equations for each sector \( j \).
<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔCV</td>
<td>-0.19</td>
</tr>
<tr>
<td>ΔT</td>
<td>0.09</td>
</tr>
<tr>
<td>ΔCV</td>
<td>-0.29</td>
</tr>
<tr>
<td>ΔT</td>
<td>0.17</td>
</tr>
<tr>
<td>ΔCV</td>
<td>-0.25</td>
</tr>
<tr>
<td>ΔT</td>
<td>0.14</td>
</tr>
</tbody>
</table>
MP Technology Transfer

Canada

Portugal

Sweden

Japan

Relative Productivity vs. Sectors Sorted by initial T

Legend:
- Local
- Locals + Foreign
$\ln \left( \tilde{T}_h^j \right)^{1/\theta} - \ln \left( T_h^j \right)^{1/\theta} = \beta_0 + \beta_1 \ln \left( T_h^j \right)^{1/\theta} + \gamma_h + \delta_j + \epsilon_{hj}$
## The Fit of the Baseline Model with the Data

<table>
<thead>
<tr>
<th></th>
<th>Model</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wages</strong></td>
<td></td>
<td></td>
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<tr>
<td>Mean</td>
<td>0.761</td>
<td>0.650</td>
</tr>
<tr>
<td>Median</td>
<td>0.790</td>
<td>0.710</td>
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<tr>
<td>corr(model, data)</td>
<td>0.920</td>
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</tr>
<tr>
<td><strong>Imports/GDP</strong></td>
<td></td>
<td></td>
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<tr>
<td>Mean</td>
<td>0.364</td>
<td>0.359</td>
</tr>
<tr>
<td>Median</td>
<td>0.342</td>
<td>0.291</td>
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<tr>
<td>corr(model, data)</td>
<td>0.829</td>
<td></td>
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<tr>
<td><strong>Inward MP/Production</strong></td>
<td></td>
<td></td>
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<tr>
<td>Mean</td>
<td>0.338</td>
<td>0.269</td>
</tr>
<tr>
<td>Median</td>
<td>0.302</td>
<td>0.258</td>
</tr>
<tr>
<td>corr(model, data)</td>
<td>0.758</td>
<td></td>
</tr>
</tbody>
</table>
Proportional Technology Transfer

Counterfactual 1: Gains from Trade

Figure: Counterfactual 2: Proportional Technology Transfer
Gains from MP: in a multisector framework

Counterfactual 1: Gains from MP

**Table: Gains From MP**

<table>
<thead>
<tr>
<th></th>
<th>Median</th>
<th>Mean</th>
<th>Std.Dev</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MP Gains (Multisector) (%)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Counterfactual Vs</td>
<td>15.59</td>
<td>27.01</td>
<td>0.29</td>
<td>9.58</td>
<td>93.48</td>
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<tr>
<td>Baseline</td>
<td></td>
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<tr>
<td><strong>MP Gains (Uni-sector) (%)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Counterfactual Vs</td>
<td>8.42</td>
<td>12.03</td>
<td>0.17</td>
<td>0.02</td>
<td>79.35</td>
</tr>
<tr>
<td>Baseline</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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</table>
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<table>
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<tr>
<th>Gains from Trade (%)</th>
<th>Mean</th>
<th>Median</th>
<th>Std.Dev</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual Gains</td>
<td>10.39</td>
<td>9.28</td>
<td>0.05</td>
<td>1.19</td>
<td>24.53</td>
</tr>
<tr>
<td>Counterfactual</td>
<td>19.05</td>
<td>17.42</td>
<td>0.08</td>
<td>9.18</td>
<td>33.81</td>
</tr>
</tbody>
</table>
Infinity barriers to MP in non-tradable sectors

Counterfactual 3: welfare effect

Table: MP in non-tradables

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td><strong>Welfare Change (%)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Counterfactual Vs Baseline</td>
<td>4.69</td>
<td>6.53</td>
<td>0.05</td>
<td>1.54</td>
<td>12.33</td>
</tr>
<tr>
<td>** Tradable Price Index (%)**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Counterfactual Vs Baseline</td>
<td>1.87</td>
<td>1.62</td>
<td>0.04</td>
<td>0.63</td>
<td>2.13</td>
</tr>
</tbody>
</table>
Conclusion

- This paper documents a new empirical regularity: A negative relationship between MP and comparative advantage.
- It shows that MP weakens countries comparative advantage.
- It shows that uni-sectoral models systematically overstate the gains from trade and understate the gains from MP.
Comments

- Counterfactuals: present four separate scenarios:
  - uni-sectoral model with trade and MP
  - multi-sectoral model with trade without MP
  - multi-sectoral model with MP without trade
  - multi-sectoral model with MP and trade (*this paper*)

- Evaluating Gains from Openness
- The role of sectoral heterogeneity in a model of trade and MP
- Show the results are isomorphic to M&A or greenfield
- External validation
- Estimate the parameters jointly using all moments
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- multi-sectoral model with trade without MP
- multi-sectoral model with MP without trade
- multi-sectoral model with MP and trade (*this paper*)

Evaluating Gains from Openness

The role of sectoral heterogeneity in a model of trade and MP

Show the results are isomorphic to M&A or greenfield

External validation

Estimate the parameters jointly using all moments
Appendix
Preferences

- Consumers in country $m$ maximize utility subject to the budget constraint:

$$U_m = \left( \sum_{j=1}^{J} \omega_j \frac{1}{\eta} (Y_j^m)^{\frac{n-1}{n}} \right)^{\frac{n}{\eta-1} \xi_m} (Y_{J+1}^m)^{1-\xi_m},$$

s.t.

$$\sum_{j=1}^{J+1} p_j^m Y_j^m = w_m L_m + r_m K_m$$

- $P_m$ - price level in country $m$ is given by:

$$P_m = B_m \left( \sum_{j=1}^{J} \omega_j (p_j^m)^{1-\eta} \right)^{\frac{1}{1-\eta} \xi_m} (p_{J+1}^m)^{1-\xi_m},$$
Productivity vectors are drawn independently across varieties \( \omega \) in sector \( j \) and origin country \( i \) from a multivariate Frechet distribution

\[
F_s^j(z) = \exp \left[-T_s^j \left( \sum_{h=1}^{N} (z_{hs}^j)^{-\theta_j} \right) \right].
\]

Productivity differences are characterized by:

1. Inter-industry heterogeneity or relative technology differences in fundamental productivity across industries \((T_s^j=a/T_s^j=b)\)
2. Intra-industry heterogeneity, governed by \(\theta^j\)
Fact 2: MP Heterogeneity

MP Sectoral Heterogeneity

<table>
<thead>
<tr>
<th>a. France</th>
<th>b. United Kingdom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machinery</td>
<td>Transport Equipment</td>
</tr>
<tr>
<td>Metals</td>
<td>Non-metallic</td>
</tr>
<tr>
<td>Chemicals</td>
<td>Machinery</td>
</tr>
<tr>
<td>Non-metallic</td>
<td>Chemicals</td>
</tr>
<tr>
<td>Furniture</td>
<td>Food</td>
</tr>
<tr>
<td>Wood</td>
<td>Furniture</td>
</tr>
<tr>
<td>Transport Equipment</td>
<td>Metals</td>
</tr>
<tr>
<td>Food</td>
<td>Wood</td>
</tr>
<tr>
<td>Textiles</td>
<td>Textiles</td>
</tr>
</tbody>
</table>

Share of MP on output (%)
Fact 2: MP Heterogeneity: Across Countries within a Sector
Fact 1: MP Relative to Output

Inward Multinational Production

Production

Iceland
New Zealand
Japan
Greece
Belgium-Luxembourg
Australia
Switzerland
Denmark
USA
Finland
Norway
Italy
Ireland
Spain
Portugal
Germany
Netherlands
France
Austria
Sweden
United Kingdom
Canada
Fact 1: MP Relative Exports (U.S.)

US Multinational Production
As a share of US exports

- Japan
- Mexico
- India
- Canada
- Israel
- Turkey
- China
- Denmark
- South Africa
- Finland
- Austria
- Australia
- France
- Netherlands
- Germany
- Portugal
- Switzerland
- Italy
- United Kingdom
- Poland
- Spain
- Hungary
- Ireland
- Sweden

MP relevance
Alviarez (Sauder)  MP and Comparative Advantage
### MP and Sectoral Productivity

<table>
<thead>
<tr>
<th></th>
<th>Employment</th>
<th>Sales</th>
<th>Value Added</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BEA</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rel. Productivity</td>
<td>-3.71***</td>
<td>-1.98**</td>
<td>-2.12**</td>
</tr>
<tr>
<td>Obs.</td>
<td>1,089</td>
<td>1,089</td>
<td>1,353</td>
</tr>
<tr>
<td><strong>OECD</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rel. Productivity</td>
<td>-1.39***</td>
<td>-1.05***</td>
<td>-1.08***</td>
</tr>
<tr>
<td>Obs.</td>
<td>1,260</td>
<td>1,366</td>
<td>1,100</td>
</tr>
</tbody>
</table>

Note: Standard errors are cluster at the country level. All regressions have country and year fixed effects.
MP and Comparative Advantage

\[ MP_{sales}^j_n = \alpha + \beta \cdot TFP^j_n + \delta_n + \gamma_j + \epsilon^j_n \]

- MP sales are normalized by output in country \( n \) and sector \( j \)
- *Total Factor Productivity* \((TFP^j_n)\) is measured relative to the frontier in sector \( j \)
- \( \delta_n \) and \( \gamma_n \) denotes country and sector fixed effects
- robust to \( TFP \) correction by selection in open economies, and alternative measures of MP

Robustness
MP and Comparative Advantage

Domestic Sales of US Foreign Affiliates

Share of MP on output vs. Technology

coeff = -2.614, (robust) se = .8251, t = -3.17
MP and Comparative Advantage

Value Added of US Foreign Affiliates

Share of MP on output vs. Technology

coeff = -4.220, (robust) se = .8389, t = -5.03
Proof: Let's define the ratio of probabilities \( \frac{\pi_{112}^a}{\pi_{112}^b} \) that country 2 produce in country 1 as:

\[
\frac{\pi_{112}^a}{\pi_{112}^b} = \frac{T_2^a}{T_2^b} \left[ \frac{T_2^b}{T_1^a} (h^{-\theta} + d^{-\theta})^{-\frac{1}{\theta}} + \frac{T_1^b}{T_1^a} \left[ 1 + (hd)^{-\theta} \right]^{-\frac{1}{\theta}} \right]
\]

\[
\frac{\partial}{\partial T_1^a} \left( \frac{\pi_{112}^a}{\pi_{112}^b} \right) < 0
\]

\[
\frac{\partial}{\partial T_2^a} \left( \frac{\pi_{112}^a}{\pi_{112}^b} \right) > 0
\]
Given $T^j_s$ (obtained from the gravity equation fixed effects) and $h^j_{si}$, we can calculate the effective productivity $\tilde{T}^j_i$ for each sector $j$

\[
\tilde{T}^j_1 = T^j_1 h^j_{11} - \theta + T^j_2 h^j_{12} - \theta \\
\tilde{T}^j_2 = T^j_1 h^j_{21} - \theta + T^j_2 h^j_{22} - \theta
\]
Estimating Model’s Parameters

Generalize Method of Moments

- Given \( h_{si}^j \) and \( d_{si}^j \), \( T_i^j \) are chosen to minimize:

\[
\min_{T_i^j} \left[ (1 - R^T) + (1 - R^{MP}) \right]
\]

where \( R^T \) and \( R^{MP} \) are given by:

\[
R^T \equiv 1 - \frac{\sum_{i,n; n \neq i} \left[ \tilde{X}_{ni}^j, data - \tilde{X}_{ni}^j, model \right]^2}{\sum_{i,n; n \neq i} \left( \tilde{X}_{ni}^j, data \right)^2}
\]

\[
R^{MP} \equiv 1 - \frac{\sum_{i,n; n \neq i} \left[ \tilde{I}_{ni}^j, data - \tilde{I}_{ni}^j, model \right]^2}{\sum_{i,n; n \neq i} \left( \tilde{I}_{ni}^j, data \right)^2}
\]
Effective technology: two step procedure

- The importer fixed effect

\[ S_n^j = \frac{\tilde{T}_n^j}{\tilde{T}_{us}^j} \left( \frac{c_n^j}{c_{us}^j} \right)^{-\theta} \]

- The share of spending going to home-produced goods

\[ \frac{X_{nn}^j}{X_{us}^j} = \tilde{T}_n^j \left( \frac{c_n^j}{p_n^j} \right)^{-\theta} \]

- Dividing it by US, we have:

\[ \frac{X_{nn}^j / X_n^j}{X_{us,us}^j / X_{us}^j} = \frac{\tilde{T}_n^j}{\tilde{T}_{us}^j} \left( \frac{c_n^j}{c_{us}^j} \right)^{-\theta} \left( \frac{p_n^j}{p_{us}^j} \right)^{-\theta} = S_n^j \left( \frac{p_{us}^j}{p_n^j} \right)^{-\theta} \]
The ratio of price levels in sector j relative to US becomes

\[ \frac{p_j^j}{p_j^{us}} = \left( \frac{X_{nn}^j}{X_{nn}^n} \frac{1}{X_{us,us}^j / X_{us}^j S_n^j} \right)^{\frac{1}{\theta}} \]

The cost of the input bundles relative to the U.S can be written as:

\[ \frac{c_n^j}{c_{us}^j} = \left( \frac{w_n^j}{w_u^j} \right)^{\alpha_j \beta_j} \left( \frac{\gamma_n^j}{\gamma_{us}^j} \right)^{(1-\alpha_j)\beta_j} \left( \prod_{k=1}^{J+1} \left( \frac{p_n^k}{p_{us}^k} \right)^{\gamma_{k,j}} \right)^{1-\beta_j} \]
Productivity vectors are drawn independently across sector varieties $\omega$ in sector $j$ and origin country $i$ from univariate Frechet marginals combined by a copula.

$$F_{i}^{j}(z) = exp \left\{ -T_{i}^{j} \left[ (z_{1i}^{j}(\omega))^{-\frac{\theta_{j}}{1-\rho_{j}}} + (z_{2i}^{j}(\omega))^{-\frac{\theta_{j}}{1-\rho_{j}}} \right]^{1-\rho_{j}} \right\}$$

There are three levels of heterogeneity in this model:

1. Inter-industry heterogeneity or relative technology differences in fundamental productivity across industries $T_{i}^{1}/T_{i}^{2}$
2. Intra-industry heterogeneity, governed by $\theta$
3. Correlation between draws from different locations $\rho$. 
Preferences

- Two-tier preferences:
  
  - First tier: Cobb-Douglas ($\xi_n$) on aggregate tradable sectors $Y^j_n$
    
    $$Y_n = (Y^n_a)^{\xi_n} (Y^n_b)^{1-\xi_n}$$

  - Second tier: CES ($\epsilon_n$) on varieties $Y^j_n (\omega)$
    
    $$Y^j_n = \left( \int_0^1 Y^j_n (\omega)^{\frac{\epsilon_j-1}{\epsilon_j}} d\omega \right)^{\frac{\epsilon_j}{\epsilon_j-1}}$$

  - And the actual price in sector $j$, country $n$ is given by:
    
    $$P^j_n = B_n (p_{n1})^{\xi_n} (p_{n2})^{1-\xi_n}$$
## MP and trade barriers

### Table: Estimated trade $d_{ns}^j$ and $h_{si}^j$

<table>
<thead>
<tr>
<th>Sector</th>
<th>Trade</th>
<th>MP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food</td>
<td>2.64</td>
<td>2.75</td>
</tr>
<tr>
<td>Textiles</td>
<td>2.13</td>
<td>2.64</td>
</tr>
<tr>
<td>Wood</td>
<td>2.65</td>
<td>2.16</td>
</tr>
<tr>
<td>Chemicals</td>
<td>2.28</td>
<td>3.14</td>
</tr>
<tr>
<td>Non-metallic</td>
<td>2.75</td>
<td>2.25</td>
</tr>
<tr>
<td>Metals</td>
<td>2.39</td>
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<tr>
<td>Machinery</td>
<td>1.98</td>
<td>2.91</td>
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<tr>
<td>Transport</td>
<td>2.37</td>
<td>3.76</td>
</tr>
<tr>
<td>Furniture</td>
<td>2.15</td>
<td>2.07</td>
</tr>
<tr>
<td>Average Change</td>
<td>Relative Change</td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>-----------------</td>
<td></td>
</tr>
<tr>
<td><strong>Top 10: Largest Change Countries</strong></td>
<td><strong>Top 10: Largest Change Countries</strong></td>
<td></td>
</tr>
<tr>
<td>Czech Rep.</td>
<td>0.41</td>
<td>Poland</td>
</tr>
<tr>
<td>Poland</td>
<td>0.35</td>
<td>Czech Rep</td>
</tr>
<tr>
<td>Lithuania</td>
<td>0.30</td>
<td>Spain</td>
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<tr>
<td>Hungary</td>
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<td>Portugal</td>
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<tr>
<td>Austria</td>
<td>0.24</td>
<td>Canada</td>
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<tr>
<td>Netherlands</td>
<td>0.22</td>
<td>Austria</td>
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<tr>
<td>Slovakia</td>
<td>0.22</td>
<td>Italy</td>
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<tr>
<td>Portugal</td>
<td>0.22</td>
<td>Turkey</td>
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<td>Sweden</td>
<td>0.20</td>
<td>Russia</td>
</tr>
<tr>
<td>Canada</td>
<td>0.17</td>
<td>Sweden</td>
</tr>
<tr>
<td>Turkey</td>
<td>0.14</td>
<td>Slovenia</td>
</tr>
<tr>
<td>Average Change</td>
<td>Relative Change</td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>-----------------</td>
<td></td>
</tr>
<tr>
<td>Bottom 10: Smallest Change Countries</td>
<td>Bottom 10: Smallest Change Countries</td>
<td></td>
</tr>
<tr>
<td>Finland 0.09</td>
<td>Japan -0.14</td>
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<tr>
<td>France 0.07</td>
<td>Belgium -0.08</td>
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<tr>
<td>Switzerland 0.06</td>
<td>Denmark -0.07</td>
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<td>Denmark 0.04</td>
<td>Greece -0.06</td>
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</tr>
<tr>
<td>Norway 0.04</td>
<td>United Kingdom -0.06</td>
<td></td>
</tr>
<tr>
<td>New Zealand 0.04</td>
<td>Norway -0.04</td>
<td></td>
</tr>
<tr>
<td>Australia 0.03</td>
<td>Latvia 0.05</td>
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<td>Belgium 0.02</td>
<td>Germany 0.08</td>
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<td>Greece 0.01</td>
<td>France 0.14</td>
<td></td>
</tr>
<tr>
<td>Israel 0.01</td>
<td>Bulgaria 0.14</td>
<td></td>
</tr>
</tbody>
</table>
Model’s correlation of MP sales and $T_s^j$
MP in comparative disadvantage sectors

Negative correlation between (MP/output) and relative TFP