THE MARGINS OF GLOBAL SOURCING: THEORY AND EVIDENCE FROM U.S. FIRMS

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Disclaimer: This work is unofficial and thus has not undergone the review accorded to official Census Bureau publications. All results have been reviewed to ensure that no confidential information is disclosed. The views expressed in the paper are those of the authors and not necessarily those of the U.S. Census Bureau.
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- Extensive margins of exporting are much better understood than extensive margins of importing
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- Firms source multiple inputs from multiple countries
- Extensive margins (firms, products) account for most of the cross-country variation in U.S. imports and exports
- Extensive margins of exporting are much better understood than extensive margins of importing
- Yet two-thirds of world trade is intermediate inputs
  - Potential for importers’ decisions to be key determinant of trade
2007 Importer Sales Premia by Number of Source Countries

![Graph showing the trend of importer sales premia from 2007 by the number of source countries.

- **Premium 2002**
- **Premium with product controls**

The graph plots the minimum number of countries from which a firm sources against the premium. There is a clear upward trend, indicating an increasing premium as the number of source countries increases.
Country Rank by Importers vs. Total Imports

The diagram illustrates the rank of countries based on their imports and the number of firms. The countries ranked by imports are CAN, CHN, DEU, GBR, TWN, ITA, JPN, MEX, FRA, and KOR. The countries ranked by the number of firms are the same, but the ranking order is different.
Challenges for a Multi-Input, Multi-Country Model of Global Sourcing

- Export models generally assume constant marginal costs
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- Importing inputs naturally affects the marginal cost of the firm
- Import entry decisions are thus interdependent across markets
- Interdependencies across markets complicate the firm’s decision
  - Which countries should a firm invest in importing from?
  - From which particular country should each input be bought?
  - How much of each input should be purchased?
MAIN CONTRIBUTIONS

- Develop a quantifiable multi-country sourcing model
  - Closed-form solution for intensive margin of sourcing
  - Characterization of firms’ extensive margin sourcing decisions
  - Countries differ along two dimensions
  - Eaton and Kortum (2002) and Chaney (2008) are special cases
**Main Contributions**

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  - Apply theoretical insights and IO algorithm to estimate model
  - Estimate fixed costs of sourcing
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- Study effects of shocks to global sourcing
  - Heterogeneous impact across firm size distribution
  - Distinguish net vs. gross changes in sourcing / employment
  - Reduced form evidence consistent with these predictions
**Related Literature**

- **Empirical evidence on firm sourcing**

- **Importing, firm efficiency, and markups**

- **Multi-country sourcing**
  Head, Ries, Jing (2010); Blaum, Lelarge, and Peters (2013, 2014); Bernard, Moxnes, Ulltveit-Moe (2014)

- **Firm-level interdependencies in MP and/or exporting**
Model
**ENVIRONMENT**

- $J$ countries
- Measure of $L_j$ consumers / workers
- Dixit-Stiglitz preferences over manufacturing varieties, elasticity of substitution $\sigma > 1$ (later introduce non-manufacturing sector)
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- Measure of $L_j$ consumers / workers
- Dixit-Stiglitz preferences over manufacturing varieties, elasticity of substitution $\sigma > 1$ (later introduce non-manufacturing sector)
- Final good sector producing these varieties:
  - Measure $N_j$ of heterogeneous firms (pinned down by free entry)
  - Non-tradable final output
  - Monopolistic competition
**Environment**

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- Dixit-Stiglitz preferences over manufacturing varieties, elasticity of substitution $\sigma > 1$ (later introduce non-manufacturing sector)

- Final good sector producing these varieties:
  - Measure $N_j$ of heterogeneous firms (pinned down by free entry)
  - Non-tradable final output
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- Intermediate good sector
  - Each firm uses a unit measure of (firm-specific) intermediate inputs
  - Trade cost $\tau_{ij}$ to import from country $j$ by country $i$
  - Perfect competition $\implies$ Marginal-cost pricing of inputs
Production Technology

- Final good requires assembly of a bundle of intermediates
- Marginal cost of final good producer, $\varphi$:

$$c_i \left( \{j(v)\}_{v=0}^{1}, \varphi \right) = \frac{1}{\varphi} \left( \int_0^1 \left( p_i(v, j(v), \varphi) \right)^{1-\rho} dv \right)^{1/(1-\rho)}$$
Production Technology

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$$
c_i \left( \{ j(v) \}_{v=0}^{1}, \varphi \right) = \frac{1}{\varphi} \left( \int_{0}^{1} (\tau_{ij(v)} a_{j(v)}(v, \varphi) w_{j(v)})^{1-\rho} dv \right)^{1/(1-\rho)},
$$
**Production Technology**

- Final good requires assembly of a bundle of intermediates
- Marginal cost of final good producer, $\phi$:

\[
c_i \left( \{ j(v) \}_{v=0}^1, \varphi \right) = \frac{1}{\varphi} \left( \int_0^1 (\tau_{ij(v)} a_{j(v)}(v, \varphi) w_{j(v)})^{1-\rho} dv \right)^{1/(1-\rho)},
\]

- Productivity $1/a_{j(v, \varphi)}$ for a given location $j$ drawn from Fréchet distribution:

\[
\Pr(a_j(v, \varphi) \geq a) = e^{-T_j a^\theta}, \quad \text{with } T_j > 0.
\]
**Production Technology**

- Final good requires assembly of a bundle of intermediates
- Marginal cost of final good producer, $\varphi$:

$$
c_i \left( \{ j (v) \} _{v=0}^1, \varphi \right) = \frac{1}{\varphi} \left( \int_0^1 \left( \tau_{ij(v)} a_{j(v)} (v, \varphi) w_{j(v)} \right)^{1-\rho} dv \right) ^{1/(1-\rho)},
$$

- Productivity $1/a_j (v, \varphi)$ for a given location $j$ drawn from Fréchet distribution:

$$
Pr(a_j (v, \varphi) \geq a) = e^{-T_j a^\theta}, \text{ with } T_j > 0.
$$

- Country-specific fixed cost of offshoring $w_{ij}$
FIRM’S PROBLEM

Firm chooses:

- Sourcing strategy $\mathcal{J}_i(\varphi) \subseteq \{1, \ldots, J\}$
- Source country $j(v) \in \mathcal{J}_i(\varphi)$ for each intermediate $v$
- Price of final good

Sourcing strategy thus determines set of countries from which firm can buy inputs

For all other countries $j \notin \mathcal{J}_i(\varphi)$, it is as if $a_j(v, \varphi) = +\infty$
**FIRM BEHAVIOR CONDITIONAL ON SOURCING STRATEGY**

- Share of intermediate input purchases sourced from any country $j$:

\[
\chi_{ij}(\varphi) = \frac{T_j (\tau_{ij} w_j)^{-\theta}}{\Theta_i(\varphi)} \quad \text{if } j \in \mathcal{J}_i(\varphi)
\]
Firm behavior conditional on sourcing strategy

- Share of intermediate input purchases sourced from any country $j$:

  $$ \chi_{ij}(\varphi) = \frac{T_j (\tau_{ij} w_j)^{-\theta}}{\Theta_i(\varphi)} \quad \text{if } j \in J_i(\varphi) $$

- Sourcing capability:

  $$ \Theta_i(\varphi) \equiv \sum_{k \in J_i(\varphi)} T_k (\tau_{ik} w_k)^{-\theta} $$
Firm behavior conditional on sourcing strategy

- Share of intermediate input purchases sourced from any country $j$:

$$
\chi_{ij} (\varphi) = \frac{T_j (\tau_{ij} w_j)^{-\theta}}{\Theta_i (\varphi)} \quad \text{if } j \in \mathcal{J}_i (\varphi)
$$

- Sourcing capability:

$$
\Theta_i (\varphi) \equiv \sum_{k \in \mathcal{J}_i (\varphi)} T_k (\tau_{ik} w_k)^{-\theta}
$$

- Marginal cost:

$$
c_i (\varphi) = \frac{1}{\varphi} (\gamma \Theta_i (\varphi))^{-1/\theta}
$$
**Optimal Sourcing Strategy**

- General profit function:

\[
\max_{I_{ij} \in \{0, 1\}_{j=1}^J} c_i(\varphi, \{I_{ij} \in \{0, 1\}_{j=1}^J\})^{1-\sigma} B_i - w_i \sum_{j=1}^J I_{ij} f_{ij}
\]
**Optimal Sourcing Strategy**

- With cost function plugged in:

$$\max_{I_{ij} \in \{0,1\}^J} \varphi^{\sigma - 1} \left( \gamma \sum_{j=1}^{J} I_{ij} \frac{T_j (\tau_{ij} w_j)^{-\theta}}{\sigma - 1} \right)^{(\sigma - 1)/\theta} B_i - w_i \sum_{j=1}^{J} I_{ij} f_{ij}$$
**Optimal Sourcing Strategy**

\[
\max_{I_{ij} \in \{0,1\}} \quad \varphi^{\sigma-1} \left( \gamma \sum_{j=1}^{J} I_{ij} T_j (\tau_{ij} w_j)^{-\theta} \right)^{(\sigma-1)/\theta} \quad B_i - w_i \sum_{j=1}^{J} I_{ij} f_{ij}
\]

- Profits are supermodular in \( \varphi \) and \( \sum_{j=1}^{J} I_{ij} T_j (\tau_{ij} w_j)^{-\theta} \)

- **Proposition:** The solution \( I_{ij} (\varphi) \in \{0,1\} \) to the optimal sourcing problem is such that a firm’s sourcing capability
  \[
  \Theta_i (\varphi) \equiv \sum_{j=1}^{J} I_{ij} (\varphi) T_j (\tau_{ij} w_j)^{-\theta}
  \]
  is nondecreasing in \( \varphi \)

- Implications for size distribution of firms
Optimal Sourcing Strategy

\[
\max_{I_{ij} \in \{0,1\}_j} \phi^{\sigma-1} \left( \gamma \sum_{j=1}^{J} I_{ij} T_j (\tau_{ij} w_j)^{-\theta} \right)^{(\sigma-1)/\theta} B_i - w_i \sum_{j=1}^{J} I_{ij} f_{ij}
\]

- Complements case: \( \frac{\sigma-1}{\theta} > 1 \)
- Substitutes case: \( \frac{\sigma-1}{\theta} < 1 \)
**Optimal Sourcing Strategy**

\[
\max_{I_{ij} \in \{0,1\}^J} \varphi^{\sigma-1} \left( \gamma \sum_{j=1}^J I_{ij} T_j (\tau_{ij} w_j)^{-\theta} \right)^{(\sigma-1)/\theta} \quad B_i - w_i \sum_{j=1}^J I_{ij} f_{ij}
\]

- Complements case: \(\frac{\sigma-1}{\theta} > 1\)

- **Proposition:** Whenever \((\sigma - 1)/\theta > 1\), the solution \(I_{ij}(\varphi) \in \{0, 1\}^J\) to the optimal sourcing problem satisfies \(J_i(\varphi_L) \subseteq J_i(\varphi_H)\) for \(\varphi_H \geq \varphi_L\), where \(J_i(\varphi) = \{j : I_{ij}(\varphi) = 1\}\).

- Hierarchies in extensive margin decisions
- Increasing differences in the profit function
Firm sourcing from country $j$ holding $B_i$ fixed

\[ M_{ij}(\varphi) = (\sigma - 1)B_i\varphi^\sigma(\gamma\Theta_i(\varphi))\left(\frac{\sigma - 1}{\theta}\right) \frac{T_j(\tau_{ij}w_j)^{-\theta}}{\Theta_i(\varphi)} \]
**Firm sourcing from country j holding \( B_i \) fixed**

- Firm sourcing from country \( j \)

\[
M_{ij}(\varphi) = C \varphi^{\sigma - 1} (\Theta_i(\varphi))^{\left(\frac{\sigma - 1}{\theta}\right)} \frac{T_j(\tau_{ij}w_j)^{-\theta}}{\Theta_i(\varphi)}
\]
Firm sourcing from country $j$ holding $B_i$ fixed

- Firm sourcing from country $j$ and a shock to country $k$

$$M_{ij}(\varphi) = C\varphi^{\sigma-1}T_j(\tau_{ij}w_j)^{-\theta}(\Theta_i(\varphi))^{(\sigma-1)/(\theta)}$$

- Scale effect
- Substitution effect
Firm sourcing from country $j$ holding $B_i$ fixed

- Firm sourcing from country $j$ and a shock to country $k$

\[
M_{ij}(\varphi) = \tilde{C}_j \varphi^{\sigma - 1} (\Theta_i(\varphi)) \left( \frac{\sigma - 1}{\theta} \right) - 1
\]
Firm sourcing from country $j$ holding $B_i$ fixed

- Firm sourcing from country $j$ and a shock to country $k$

\[ M_{ij} (\varphi) = \tilde{C}_j \varphi^{\sigma - 1} (\Theta_i (\varphi)) \left( \frac{\sigma - 1}{\theta} - 1 \right) \]

- Complements case: \( \frac{\sigma - 1}{\theta} > 1 \)
Firm sourcing from country $j$ holding $B_i$ fixed

- Firm sourcing from country $j$ and a shock to country $k$

$$M_{ij}(\varphi) = \tilde{C}_j \varphi^{\sigma-1} (\Theta_i(\varphi)) \left( \frac{\sigma-1}{\theta} - 1 \right)$$

- Complements case: $\frac{\sigma-1}{\theta} > 1$

- Holding $B_i$ constant, increase in sourcing capability ($\Theta_i$) weakly increases:
  - foreign sourcing
  - domestic sourcing
Industry and General Equilibrium

- Consumers spend constant share $\eta$ on manufacturing sector.
- Workers are perfectly mobile across sectors (other sector pins down wage level)
- Industry Equilibrium is characterized by:
  - Fixed point for the market potential, $B_i$
  - Free entry condition

Proposition: Given a positive wage vector, solution for $B_i$ and $N_i$ is unique
Gravity

- Special case 1: Universal importing
  - Aggregate trade flows as in Eaton and Kortum (2002)
  - Extensive margin effect at the product level

- Special case 2: Independent entry decisions \((\sigma - 1)/\theta = 1\) and core efficiency Pareto)
  - Aggregate trade flows as in Chaney (2008)
  - Extensive margin effect at product and firm level

- General case
  - Extensive margin effect at product and firm level
  - Third market effects
Estimation
DATA

- 1997 and 2007 firm sourcing from U.S. Census Bureau
  - Economic Censuses
  - Import transactions data
  - All firms with positive manufacturing activity

- Structural Estimation
  - Limit analysis to countries with 200+ U.S. importers
  - 66 countries and the U.S.
  - Country data from World Bank, CEPII, and Penn World Tables

- Counterfactual comparisons to actual data
  - Panel of manufacturing firms in 1997 and 2007
  - UN Comtrade data
  - 1997 BEA Input-Output tables
**Road Map for Estimation**

- **Step 1:** Back out sourcing potential from firm-level input shares
  - Recovered from country fixed effects in normalized share regressions

- **Step 2:** Estimate demand elasticity and productivity dispersion
  - Project fixed effect on human-capital adjusted labor cost

- **Step 3:** Estimate fixed costs of sourcing and residual demand
  - Simulated method of moments + Jia’s (2008) algorithm

\[ \Pi(\mathcal{J}, \varphi, f_{ij}^n) = \varphi^{\sigma-1} \left( \sum_{j=1}^{\mathcal{J}} T_j (\tau_{ij} w_j)^{-\theta} \right) \]
Step 1: Estimate country sourcing potential

- Define country potential $\xi_j = T_j (\tau_{ij} w_j)^{-\theta}$

- Normalize firm share from $j$: $\chi_{ij}^n / \chi_{ii}^n = \frac{T_j (\tau_{ij} w_j)^{-\theta}}{\Theta_i^n} / \frac{T_i (\tau_{ii} w_i)^{-\theta}}{\Theta_i^n}$

- Log-Linearize: $\log \chi_{ij}^n - \log \chi_{ii}^n = \log \xi_j + \epsilon_j^n$

- Estimate via OLS

Measuring input shares
Sourcing potential versus number of firms

Aggregate Imports
Step 2: Estimate elasticity of demand and dispersion of productivities

- Estimate elasticity of demand using model’s predicted mark-up
  - Median manufacturing firm’s mark-up is 1.35
  - Implies $\sigma = 3.85$

- Project $\hat{\xi}_j = T_j (\tau_{ij} w_j)^{-\theta}$ on country variables
  - Wages (human capital adjusted)
  - Country controls for technology and bilateral trade frictions
  - Instrument using population

\[
\log \hat{\xi}_j = \beta_r \log R&D_j + \beta_k \log \text{capital}_j + \beta_C \text{control corruption}_j \\
+ \beta_n \log \text{no of firms} - \theta \log w_j \\
- \theta (\log \beta_c + \beta_d \log \text{distance}_{ij} + \text{language}_{ij} \log \beta_l) + \iota_j
\]
### Step 2b: Estimate Dispersion of Productivities

<table>
<thead>
<tr>
<th></th>
<th>log $\xi$</th>
<th>log aggregate imports</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OLS</td>
<td>IV</td>
</tr>
<tr>
<td>log HC adjusted wage</td>
<td>-0.537***</td>
<td>-1.789**</td>
</tr>
<tr>
<td></td>
<td>(0.184)</td>
<td>(0.696)</td>
</tr>
<tr>
<td>log distance</td>
<td>-0.341*</td>
<td>-0.621**</td>
</tr>
<tr>
<td></td>
<td>(0.197)</td>
<td>(0.294)</td>
</tr>
<tr>
<td>log R&amp;D</td>
<td>0.352***</td>
<td>0.524***</td>
</tr>
<tr>
<td></td>
<td>(0.068)</td>
<td>(0.125)</td>
</tr>
<tr>
<td>log capital/worker</td>
<td>-0.184</td>
<td>0.425</td>
</tr>
<tr>
<td></td>
<td>(0.175)</td>
<td>(0.390)</td>
</tr>
<tr>
<td>common language</td>
<td>0.105</td>
<td>0.146</td>
</tr>
<tr>
<td></td>
<td>(0.223)</td>
<td>(0.289)</td>
</tr>
<tr>
<td>control corrupt</td>
<td>0.156</td>
<td>0.621**</td>
</tr>
<tr>
<td></td>
<td>(0.151)</td>
<td>(0.312)</td>
</tr>
<tr>
<td>log no. of firms</td>
<td>0.108</td>
<td>-0.020</td>
</tr>
<tr>
<td></td>
<td>(0.086)</td>
<td>(0.130)</td>
</tr>
<tr>
<td>Constant</td>
<td>-7.250***</td>
<td>-11.068***</td>
</tr>
<tr>
<td></td>
<td>(0.922)</td>
<td>(2.323)</td>
</tr>
<tr>
<td>Observations</td>
<td>57</td>
<td>57</td>
</tr>
</tbody>
</table>

**Notes:**
- **OLS** and **IV** refer to Ordinary Least Squares and Instrumental Variables, respectively.
- *******, *****, and ** indicate significance levels at 1%, 5%, and 10%, respectively.
- Standard errors are in parentheses beneath the estimated coefficients.
Implications of first two steps

- Sourcing from all countries, relative to only domestic sourcing
  - 9 percent lower input costs
  - 33 percent larger sales

- Robust result: $\frac{\sigma - 1}{\theta} > 1$
  - Complements case from model
  - Increasing differences of the profit function in the sourcing set
**Step 3: Estimate fixed costs and residual demand**

- Fix the shape parameter of Pareto distribution $\kappa = 4.5$
- Estimate 6 parameters via Simulated Method of Moments
  - Firm-country-specific fixed costs (cons, distance, lang, corrupt, disp)
  - Residual demand
- Use 68 moments
  - Share of importing firms
  - Share of firms that sources from each foreign country
  - Share of firms sourcing less than $50^{th}$ percentile from the U.S.
- Solve firm’s problem
  - $2^{67}$ or about $10^{20}$ possible choices
  - Exploit complementarities in profit function
  - Build on algorithm in Jia (2008)
**Solve firm’s problem using Jia (2008) algorithm**

- Define mapping $V: \{0, 1\}^N \rightarrow \{0, 1\}^N$
  - $V_j(J) = 1$ if marginal benefit of $j$ given $J$ is positive

- Increasing differences in profit function imply $V()$ is an increasing function

- Start from set $J^0$ and use iterative application of V-operator to obtain lower bound for sourcing strategy

- Start from set $J^1$ and use iterative application of V-operator to obtain upper bound for sourcing strategy

- If bounds do not overlap, evaluate all combinations between them
### Parameter Estimates

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>0.127</td>
</tr>
<tr>
<td>$\beta_f^C$</td>
<td>0.021</td>
</tr>
<tr>
<td>$\beta_f^d$</td>
<td>0.146</td>
</tr>
<tr>
<td>$\beta_f^l$</td>
<td>0.893</td>
</tr>
<tr>
<td>$\beta_f^C$</td>
<td>-0.408</td>
</tr>
<tr>
<td>$\beta_f^{disp}$</td>
<td>0.829</td>
</tr>
</tbody>
</table>

- Fixed costs 11 percent lower if common language
- Fixed costs increase in distance with elasticity of .15
- Fixed costs decrease with control of corruption
- Median fixed cost estimates range from 9,000 to 46,000 USD
SOURCING POTENTIAL VS. FIXED COST ESTIMATES

Sourcing Potential vs. Fixed Cost Estimates

Introduction
Model Estimation
Counterfactual
Conclusion
MODEL FIT (I)

Share of importers by country (targeted moment)

Share of aggregate foreign sourcing by country (non-targeted moment)
## Model fit (II)

<table>
<thead>
<tr>
<th>String</th>
<th>Data</th>
<th>Baseline Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>29.82</td>
<td>29.62</td>
</tr>
<tr>
<td>CA-CH</td>
<td>3.67</td>
<td>3.97</td>
</tr>
<tr>
<td>CA-CH-DE</td>
<td>0.56</td>
<td>0.74</td>
</tr>
<tr>
<td>CA-CH-DE-GB</td>
<td>0.25</td>
<td>0.17</td>
</tr>
<tr>
<td>CA-CH-DE-GB-TW</td>
<td>0.13</td>
<td>0.11</td>
</tr>
<tr>
<td>CA-CH-DE-GB-TW-IT</td>
<td>0.05</td>
<td>0.03</td>
</tr>
<tr>
<td>CA-CH-DE-GB-TW-IT-JP</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td>CA-CH-DE-GB-TW-IT-JP-MX</td>
<td>0.08</td>
<td>0.09</td>
</tr>
<tr>
<td>CA-CH-DE-GB-TW-IT-JP-MX-FR</td>
<td>0.27</td>
<td>0.15</td>
</tr>
<tr>
<td>CA-CH-DE-GB-TW-IT-JP-MX-FR-KR</td>
<td>1.08</td>
<td>0.84</td>
</tr>
</tbody>
</table>

*Notes:* This Table depicts the percentage of importers following a particular sourcing pattern. The first row shows the percentage of firms only importing from Canada, the second row shows the percentage of firms only importing from Canada and China, and so forth (irrespective of firm sourcing outside these top 10 countries).
COUNTERFACTUAL

- Negative shock to China’s sourcing potential to match 1997 share of China importers (38% of its 2007 level)
- Resolve for equilibrium price index and mass of new firms
- Calculate impact from going back to 2007 sourcing potential values

- Compare baseline model predictions to models with alternative parameter values that imply:
  - Universal importing
  - Independent entry decisions
  - Common fixed costs

- Focus on
  - Third market effects and sourcing from the U.S.
  - Gross versus net changes in sourcing
  - Size distribution
## Baseline

<table>
<thead>
<tr>
<th>Chinese import status</th>
<th>Change sourcing from US</th>
<th>Change Sourcing from other countries</th>
<th>Share of firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrants</td>
<td>1.008</td>
<td>1.015</td>
<td>0.066</td>
</tr>
<tr>
<td>Continuers</td>
<td>1.002</td>
<td>1.002</td>
<td>0.019</td>
</tr>
<tr>
<td>Others</td>
<td>0.994</td>
<td>0.986</td>
<td>0.915</td>
</tr>
</tbody>
</table>

- Aggregate sourcing from the U.S. is reduced by 0.60 percent
- For every 10 domestic manufacturing jobs destroyed, 2 new jobs are created
Baseline - Size distribution and price index

- Price index falls by .2%.
**Alternative parameters: Universal importing**

- No fixed costs of foreign sourcing

<table>
<thead>
<tr>
<th>Chinese import status</th>
<th>Change sourcing from US</th>
<th>Change Sourcing from other countries</th>
<th>Share of firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrants</td>
<td>-</td>
<td>-</td>
<td>0.000</td>
</tr>
<tr>
<td>Continuers</td>
<td>0.988</td>
<td>0.988</td>
<td>1.000</td>
</tr>
<tr>
<td>Others</td>
<td>-</td>
<td>-</td>
<td>0.000</td>
</tr>
</tbody>
</table>

- All type of firms decrease sourcing from the U.S. and from third markets by the same amount
Alternative parameters: Independent entry decisions

- Set $\theta = \sigma - 1$

<table>
<thead>
<tr>
<th>Chinese import status</th>
<th>Change sourcing from US</th>
<th>Change Sourcing from other countries</th>
<th>Share of firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrants</td>
<td>0.997</td>
<td>0.993</td>
<td>0.067</td>
</tr>
<tr>
<td>Continuers</td>
<td>0.997</td>
<td>0.995</td>
<td>0.019</td>
</tr>
<tr>
<td>Others</td>
<td>0.997</td>
<td>0.991</td>
<td>0.914</td>
</tr>
</tbody>
</table>

- All firms decrease sourcing from the U.S. by the same amount
- No gross increases of sourcing
# Alternative Parameters: Common Fixed Costs

<table>
<thead>
<tr>
<th>Chinese import status</th>
<th>Change sourcing from US</th>
<th>Change Sourcing from other countries</th>
<th>Share of firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrants</td>
<td>1.004</td>
<td>1.060</td>
<td>0.143</td>
</tr>
<tr>
<td>Continuers</td>
<td>0.998</td>
<td>0.997</td>
<td>0.041</td>
</tr>
<tr>
<td>Others</td>
<td>0.990</td>
<td>-</td>
<td>0.817</td>
</tr>
</tbody>
</table>

- Perfect pecking order restricts extensive margin responses
Reduced-form comparison to the data

- Model predicts increased domestic and third market sourcing by China importers

\[ \Delta y_n = \beta_0 + \beta_{Ch} \Delta China_n + \varepsilon_n \]

- \( \Delta China_n = \frac{\text{Imports}_{n2007}^{Ch} - \text{Imports}_{n1997}^{Ch}}{\left(\text{Imports}_{n2007}^{Ch} + \text{Imports}_{n1997}^{Ch}\right)/2} \)

- \( \Delta y_n \) is 1997 to 2007 change in firm \( n \)'s:
  - log domestic inputs
  - DHS growth rate of non-China imports
  - log number of non-China source countries
IV ESTIMATION OF CHINA SOURCING DECISION

- Identify changes in firm-level sourcing from China using shock to Chinese comparative advantage in inputs of industry $h$

\[ China_{ht}^{input} = \sum_{m \in h} s_m \frac{EUimports_{mt}^{China}}{EUimports_{mt}^{World/US}} \]

- $s_m$ is expenditure share of inputs from industry $m$ in industry $h$

- Firm-level shock based on firm’s industries

\[ shock_n^{input} = \Delta \sum_{h \in n} s_{nh} China_{ht}^{input} \]

- Change from 1997 to 2007

- $s_{nh}$ is industry $h$’s share of firm $n$’s manufacturing sales in 1997
# Estimates of the China Shock on Firm Sourcing

Dependent variable is change from 1997 to 2007 in firm $n$:

<table>
<thead>
<tr>
<th></th>
<th>Domestic inputs</th>
<th>No. of countries</th>
<th>Foreign inputs</th>
<th>Domestic inputs</th>
<th>No. of countries</th>
<th>Foreign inputs</th>
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<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>OLS</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>China, DHS</td>
<td>0.084***</td>
<td>0.255***</td>
<td>0.360***</td>
<td>0.934***</td>
<td>0.553***</td>
<td>0.654***</td>
</tr>
<tr>
<td></td>
<td>(0.012)</td>
<td>(0.007)</td>
<td>(0.013)</td>
<td>(0.258)</td>
<td>(0.080)</td>
<td>(0.197)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.069***</td>
<td>0.144***</td>
<td>0.315***</td>
<td>-0.064</td>
<td>0.097***</td>
<td>0.269***</td>
</tr>
<tr>
<td></td>
<td>(0.023)</td>
<td>(0.013)</td>
<td>(0.026)</td>
<td>(0.047)</td>
<td>(0.017)</td>
<td>(0.044)</td>
</tr>
<tr>
<td>Adj. $R^2$</td>
<td>0.00</td>
<td>0.11</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>IV</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>China, DHS</td>
<td>0.934***</td>
<td>0.553***</td>
<td>0.654***</td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td></td>
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<td>(0.017)</td>
<td>(0.044)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>N</strong></td>
<td>127,400</td>
<td>127,400</td>
<td>127,400</td>
<td>127,400</td>
<td>127,400</td>
<td>127,400</td>
</tr>
</tbody>
</table>

First Stage Statistics

<table>
<thead>
<tr>
<th></th>
<th>Coeff (se)</th>
<th>KP Fstat</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OLS</strong></td>
<td>2.691***</td>
<td>28.51</td>
</tr>
<tr>
<td></td>
<td>(0.504)</td>
<td></td>
</tr>
</tbody>
</table>

Notes: All variables are changes or growth rates from 1997 to 2007. Standard errors are in parentheses and clustered by 439 NAICS industries. N rounded for disclosure avoidance.
CONCLUSION

- New framework for firm sourcing in a multi-country world
  - Interdependencies in firms’ extensive margin decisions
  - Distinguish between country potential and fixed costs

- Counterfactual implications
  - Third market effects
  - Heterogeneous effects across firms
  - Gross changes versus net changes

- Framework and methodology can be applied to other problems
Back-up
Gravity - Universal Importing

- Special case 1: Very low fixed cost of offshoring

\[ M_{ij} = \tau_{ij} \theta E_i \Theta_i \sum_k \tau_{kj} \theta E_k \Theta_k \]

- Familiar from Eaton and Kortum (2002)

- Trade elasticity is given by \( \theta \)

- Extensive margin effect at the product-level
**Gravity - General Case**

- General case

\[ M_{ij} = \tau_{ij}^{-\theta} \Lambda_{ij} \frac{E_i}{P_i^{1-\sigma}/N_i} \sum_k \tau_{kj}^{-\theta} \Lambda_{kj} \frac{Q_j}{P_j^{1-\sigma}/N_j} \]

where

\[ \Lambda_{ij} = \int_{\tilde{\varphi}_{ij}}^\infty I_{ij}(\varphi) \left( \Theta_i(\varphi) \right)^{(\sigma-1-\theta)/\theta} \varphi^{\sigma-1} dG_i(\varphi), \]

- \( \Lambda_{ij} \) yields
  - Extensive margin effect at the *firm-level* in addition to the *product-level*
  - Third market effects
**Gravity - Independent Entry Decisions**

- Special case 2: \((\sigma - 1)/\theta = 1\) and core efficiency Pareto

\[
M_{ij} = \tau_{ij}^{-\kappa} f_{ij}^{1-\kappa/(\sigma-1)} \Psi_i \frac{E_i}{P_i^{-\kappa}} \frac{Q_j}{\sum_k \tau_{kj}^{-\kappa} f_{kj}^{1-\kappa/(\sigma-1)} \Psi_k \frac{E_k}{P_k^{-\kappa}}},
\]

- Trade elasticity as in Chaney (2008)
- Extensive margin effect
- No third market effects
2002 Sales Premia for 2002 non-importers
2007 Sales Premia with Product Controls

(a) Controlling for number of imported goods

(b) Controlling for number of exported goods
Measuring Input Shares

- \( \text{Inputs}^n = \text{Sales}^n - \text{ValueAdded}^n + \text{ProductionWorkerWages}^n \)
  - Manufacturing and wholesale coverage
  - Highly correlated with traditional input measures for manufacturing

- \( \chi_{ij}^n = M_j^n / \text{Inputs}^n \)
  - Use imports from \( j \) to measure inputs sourced from \( j \)
  - Domestic sourcing is the residual
  - Imports are zero if country is not in the firm’s sourcing strategy
**Top 10 Countries Source Countries**

<table>
<thead>
<tr>
<th>Rank by:</th>
<th>Number of Firms</th>
<th>Value of Imports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firms</td>
<td>Value</td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>1</td>
<td>37,800</td>
</tr>
<tr>
<td>China</td>
<td>2</td>
<td>21,400</td>
</tr>
<tr>
<td>Germany</td>
<td>3</td>
<td>13,000</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>4</td>
<td>11,500</td>
</tr>
<tr>
<td>Taiwan</td>
<td>5</td>
<td>10,500</td>
</tr>
<tr>
<td>Italy</td>
<td>6</td>
<td>8,500</td>
</tr>
<tr>
<td>Japan</td>
<td>7</td>
<td>8,000</td>
</tr>
<tr>
<td>Mexico</td>
<td>8</td>
<td>7,800</td>
</tr>
<tr>
<td>France</td>
<td>9</td>
<td>6,100</td>
</tr>
<tr>
<td>Korea, South</td>
<td>10</td>
<td>5,600</td>
</tr>
</tbody>
</table>
Estimates of the China Shock on Firm Sourcing Controlling for Import Penetration

Dependent variable is percent change from 1997 to 2007 in firm:

<table>
<thead>
<tr>
<th></th>
<th>Domestic inputs</th>
<th>No. of countries</th>
<th>Foreign inputs</th>
<th>Domestic inputs</th>
<th>No. of countries</th>
<th>Foreign inputs</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>OLS</td>
<td>IV</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>China, DHS</td>
<td>0.085***</td>
<td>0.255***</td>
<td>0.360***</td>
<td>1.368***</td>
<td>0.660***</td>
<td>0.788***</td>
</tr>
<tr>
<td></td>
<td>(0.012)</td>
<td>(0.007)</td>
<td>(0.012)</td>
<td>(0.424)</td>
<td>(0.098)</td>
<td>(0.243)</td>
</tr>
<tr>
<td>Import penetration</td>
<td>-0.103</td>
<td>0.039</td>
<td>-0.010</td>
<td>-1.019**</td>
<td>-0.250***</td>
<td>-0.316*</td>
</tr>
<tr>
<td></td>
<td>(0.196)</td>
<td>(0.079)</td>
<td>(0.144)</td>
<td>(0.511)</td>
<td>(0.090)</td>
<td>(0.190)</td>
</tr>
<tr>
<td>constant</td>
<td>0.074***</td>
<td>0.142***</td>
<td>0.315***</td>
<td>-0.084</td>
<td>0.093***</td>
<td>0.263***</td>
</tr>
<tr>
<td></td>
<td>(0.027)</td>
<td>(0.015)</td>
<td>(0.031)</td>
<td>(0.055)</td>
<td>(0.017)</td>
<td>(0.044)</td>
</tr>
<tr>
<td>Adj.R2</td>
<td>0.00</td>
<td>0.11</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>127,400</td>
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<td>127,400</td>
<td>127,400</td>
<td>127,400</td>
<td>127,400</td>
</tr>
</tbody>
</table>

First Stage Statistics: Coeff (se) 2.089*** (0.520)  KP Fstat 16.13

Notes: Standard errors are in parentheses and clustered by 439 NAICS industries. N rounded for disclosure avoidance.
# Estimates of the China Shock on Firm Sourcing

Instrumenting for Import Penetration

Dependent variable is percent change from 1997 to 2007 in firm:

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<tr>
<th></th>
<th>Domestic inputs</th>
<th>No. of countries</th>
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<td>0.085***</td>
<td>0.255***</td>
<td>0.360***</td>
<td>1.010***</td>
<td>0.867***</td>
<td>1.245***</td>
</tr>
<tr>
<td></td>
<td>(0.012)</td>
<td>(0.007)</td>
<td>(0.012)</td>
<td>(0.318)</td>
<td>(0.112)</td>
<td>(0.261)</td>
</tr>
<tr>
<td>Import Penetration</td>
<td>-0.103</td>
<td>0.039</td>
<td>-0.010</td>
<td>-0.179</td>
<td>-0.736***</td>
<td>-1.388***</td>
</tr>
<tr>
<td></td>
<td>(0.196)</td>
<td>(0.079)</td>
<td>(0.144)</td>
<td>(0.558)</td>
<td>(0.182)</td>
<td>(0.393)</td>
</tr>
<tr>
<td>constant</td>
<td>0.074***</td>
<td>0.142***</td>
<td>0.315***</td>
<td>-0.068</td>
<td>0.083***</td>
<td>0.242***</td>
</tr>
<tr>
<td></td>
<td>(0.027)</td>
<td>(0.015)</td>
<td>(0.031)</td>
<td>(0.050)</td>
<td>(0.017)</td>
<td>(0.042)</td>
</tr>
<tr>
<td>Adj.R2</td>
<td>0.00</td>
<td>0.11</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>127,400</td>
<td>127,400</td>
<td>127,400</td>
<td>127,400</td>
<td>127,400</td>
<td>127,400</td>
</tr>
</tbody>
</table>

First Stage Statistics  

<table>
<thead>
<tr>
<th></th>
<th>Coeff (se)</th>
<th>KP Fstat</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.810***</td>
<td>7.72</td>
</tr>
<tr>
<td></td>
<td>(0.670)</td>
<td></td>
</tr>
</tbody>
</table>

Notes: Standard errors are in parentheses and clustered by 439 NAICS industries. N rounded for disclosure avoidance.
**Estimates of the China Shock on Firm Sourcing, for New China Importers**

Dependent variable is percent change from 1997 to 2007 in firm:

<table>
<thead>
<tr>
<th></th>
<th>Domestic inputs</th>
<th>No. of countries</th>
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<th>Domestic inputs</th>
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<tr>
<td></td>
<td>OLS</td>
<td></td>
<td></td>
<td>IV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New China importer</td>
<td>0.173***</td>
<td>0.553***</td>
<td>0.774***</td>
<td>2.261***</td>
<td>1.208***</td>
<td>1.426***</td>
</tr>
<tr>
<td></td>
<td>(0.027)</td>
<td>(0.015)</td>
<td>(0.027)</td>
<td>(0.557)</td>
<td>(0.170)</td>
<td>(0.425)</td>
</tr>
<tr>
<td>constant</td>
<td>0.069***</td>
<td>0.143***</td>
<td>0.313***</td>
<td>-0.062</td>
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<td></td>
<td>(0.023)</td>
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<td>(0.017)</td>
<td>(0.045)</td>
</tr>
<tr>
<td>Adj.R2</td>
<td>0.00</td>
<td>0.11</td>
<td>0.05</td>
<td>-0.30</td>
<td>-0.04</td>
<td>0.01</td>
</tr>
<tr>
<td>N</td>
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<td>127,400</td>
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First Stage Statistics

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<tr>
<td></td>
<td>1.233***</td>
<td>(0.237)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>27.11</td>
</tr>
</tbody>
</table>

Notes: Standard errors are in parentheses and clustered by 439 NAICS industries. N rounded for disclosure avoidance.
**FIRST STAGE STATISTICS**

Dependent variable is change from 1997 to 2007 in firm

<table>
<thead>
<tr>
<th></th>
<th>Domestic inputs</th>
<th>No. of countries</th>
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<td>(0.047)</td>
<td>(0.017)</td>
<td>(0.044)</td>
</tr>
<tr>
<td>Adj. R²</td>
<td>0.00</td>
<td>0.11</td>
<td>0.05</td>
<td>127,400</td>
<td>127,400</td>
<td>127,400</td>
</tr>
<tr>
<td>N</td>
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<td>127,400</td>
<td>127,400</td>
<td>127,400</td>
<td>127,400</td>
<td>127,400</td>
</tr>
<tr>
<td>AR F stat</td>
<td>12.98</td>
<td>12.05</td>
<td>5.17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AR pval</td>
<td>0.000</td>
<td>0.001</td>
<td>0.023</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AR χ² stat</td>
<td>13.01</td>
<td>12.07</td>
<td>5.18</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AR pval</td>
<td>0.000</td>
<td>0.001</td>
<td>0.023</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First Stage Statistics</td>
<td>Coeff (se) 2.691*** (0.504)</td>
<td>KP Fstat 28.51</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: Standard errors are in parentheses and clustered by 439 NAICS industries. N rounded for disclosure avoidance.
MULTIPLE COUNTRIES AND INPUTS

- Count of distinct source locations and products imported by a firm

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>25th Ptile</th>
<th>Median</th>
<th>95th Ptile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Country Count</td>
<td>3.26</td>
<td>5.09</td>
<td>1</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>Product Count</td>
<td>11.91</td>
<td>48.89</td>
<td>1</td>
<td>3</td>
<td>41</td>
</tr>
</tbody>
</table>

- Although extreme, the continuum of inputs assumption helps a lot
**FIRM-LEVEL IMPORT STATISTICS**

- Number of imported HS10 products per country
- Number of countries per imported HS10 product

<table>
<thead>
<tr>
<th>Products Per Country</th>
<th>Countries Per Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm-level</td>
<td>Firm-level</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
</tr>
<tr>
<td>Mean</td>
<td>2.78</td>
</tr>
<tr>
<td>Median</td>
<td>2.00</td>
</tr>
<tr>
<td>95%tile</td>
<td>8.23</td>
</tr>
</tbody>
</table>

- Not much evidence of differentiation by country of origin
Firm-level import and export statistics

- Number of countries per HS6 products traded by a firm

<table>
<thead>
<tr>
<th></th>
<th>Firm Level Imports</th>
<th>Firm Level Exports</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Median</td>
</tr>
<tr>
<td>Mean</td>
<td>1.15</td>
<td>1.05</td>
</tr>
<tr>
<td>Median</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>95%tile</td>
<td>1.93</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Notes: Table reports statistics on the firm-level mean, median, and maximum of the number of countries from which a firm imports or exports the same HS6 product.

- Generally higher counts for exports
WHY DEPART FROM ARMINGTON?

- Number of countries per HS10 products traded by a firm, for firms that trade with at least 3 countries

<table>
<thead>
<tr>
<th></th>
<th>Firm Level Imports</th>
<th></th>
<th>Firm Level Exports</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Median</td>
<td>Max</td>
<td>Mean</td>
</tr>
<tr>
<td>Mean</td>
<td>1.28</td>
<td>1.05</td>
<td>3.18</td>
<td>2.26</td>
</tr>
<tr>
<td>Median</td>
<td>1.19</td>
<td>1.00</td>
<td>2.00</td>
<td>1.73</td>
</tr>
<tr>
<td>95%tile</td>
<td>1.96</td>
<td>1.00</td>
<td>9.00</td>
<td>5.17</td>
</tr>
</tbody>
</table>

- Same basic pattern for firms that trade with at least 3 countries
# Hierarchies in Firm Sourcing Patterns

**Table:** U.S. firms importing from strings of top 10 countries

<table>
<thead>
<tr>
<th>String</th>
<th>Firms</th>
<th>% of Importers</th>
<th>Firms</th>
<th>% of Importers</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>17,980</td>
<td>29.82</td>
<td>6,760</td>
<td>11.21</td>
</tr>
<tr>
<td>CA-CH</td>
<td>2,210</td>
<td>3.67</td>
<td>3,730</td>
<td>6.19</td>
</tr>
<tr>
<td>CA-CH-DE</td>
<td>340</td>
<td>0.56</td>
<td>1,030</td>
<td>1.71</td>
</tr>
<tr>
<td>CA-CH-DE-GB</td>
<td>150</td>
<td>0.25</td>
<td>240</td>
<td>0.40</td>
</tr>
<tr>
<td>CA-CH-DE-GB-TW</td>
<td>80</td>
<td>0.13</td>
<td>50</td>
<td>0.08</td>
</tr>
<tr>
<td>CA-CH-DE-GB-TW-IT</td>
<td>30</td>
<td>0.05</td>
<td>10</td>
<td>0.02</td>
</tr>
<tr>
<td>CA-CH-DE-GB-TW-IT-JP</td>
<td>30</td>
<td>0.05</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>CA-CH-DE-GB-TW-IT-JP-MX</td>
<td>50</td>
<td>0.08</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>CA-CH-DE-GB-TW-IT-JP-MX-FR</td>
<td>160</td>
<td>0.27</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>CA-CH-DE-GB-TW-IT-JP-MX-FR-KR</td>
<td>650</td>
<td>1.08</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>TOTAL Following Pecking Order</strong></td>
<td><strong>21,680</strong></td>
<td><strong>36.0</strong></td>
<td><strong>11,820</strong></td>
<td><strong>19.6</strong></td>
</tr>
</tbody>
</table>

*Notes:* The string CA means importing from Canada but no other among the top 10; CA-CH means importing from Canada and China but no other, and so forth. % of Importers shows percent of each category relative to all firms that import from top 10 countries.
**Estimation of countries’ sourcing potential**

- Estimate via OLS

\[
\log \chi_{ij}^n - \log \chi_{ii}^n = \log \xi_j + \log \epsilon_j^n
\]

- Summary statistics for sourcing appeal estimation

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of observations</td>
<td>200,000</td>
</tr>
<tr>
<td>Number of importing firms</td>
<td>64,600</td>
</tr>
<tr>
<td>Mean Squared Error</td>
<td>2.64</td>
</tr>
<tr>
<td>Range of foreign log (\xi_j)</td>
<td>-4.12 to -8.42</td>
</tr>
<tr>
<td>Sum of foreign (\xi_j)</td>
<td>0.137</td>
</tr>
</tbody>
</table>
SOURCING POTENTIAL VERSUS AGGREGATE IMPORTS
**PARAMETERS**

- \( f_{ij}^n \) distributed log-normal
  - Scale parameter: \( \log \beta_c^f + \beta_d^f \log \text{distance}_{ij} + \log \beta_l^f \text{language}_{ij} \)
  - Dispersion parameter \( \beta_{\text{disp}}^f \)

- No domestic fixed cost of sourcing

- \( \delta = [B, \beta_c^f, \beta_d^f, \beta_l^f, \beta_{\text{disp}}^f] \)

- Simulate more than 2 million firms
Statistics on Jia Algorithm Performance

<table>
<thead>
<tr>
<th>Cardinality of difference in bounds</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9-25</th>
<th>≥ 26</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of occasions</td>
<td>9959361735</td>
<td>0</td>
<td>374149</td>
<td>22523</td>
<td>1514</td>
<td>72</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>