# Global Sourcing

ECON 871

# Introduction

**Goal for Today:** Think about global sourcing decisions—i.e., how firms decide where to buy their inputs from.

A few motivating facts:

- Extensive margins (firms, products) account for most of the cross-country variation in U.S. imports and exports.
- Much more focus on extensive margins of *exporting*—how firms decide whether to export or not (think, Melitz)—than the extensive margins of importing.
- Most of world trade (roughly 2/3) is in intermediate inputs, which means these importing decisions may be of aggregate importance.

# Introduction

**Goal for Today:** Think about global sourcing decisions—i.e., how firms decide where to buy their inputs from.

More topically... a lot of chatter these days about rebuilding supply chains.

- **Reshoring**—domesticating supply chains.
- **Friendshoring**—importing inputs, but only from "low-risk" sources.
- This week, Biden Administration announced the creation of the "Council on Supply Chain Resilience"
- Useful to have a framework to think about how distortionary these policies will be.

# Introduction

We're going to work through the model in Antras, Fort and Tintelnot (2017) (AFT), which is a model of how firms make decisions of **where** (extensive) to source inputs from and **how much** (intensive) to buy of each input.

**Main Challenges:**

- Standard models of exporting (think, multi-country Melitz), assume that **firms have constant marginal costs**, that are unaffected by trade decisions.
- But, firms import intermediate inputs precisely to affect (lower) their marginal costs.
- Creates **interdependencies across markets**. Firm's must jointly decide:
  - Which country to import each input from.
  - How much of each input to buy.

# Antras et al. (2017) Environment

- $J$ countries.
- Each country has a measure of $L_j$ consumers/workers.
- Consumers have CES preferences over differentiated varieties of **manufactured goods**, with elasticity of substitution $\sigma > 1$.

$$U_{Mi} = \left( \int_{\omega \in \Omega_i} q_i(\omega)^{(\sigma-1)/\sigma} d\omega \right)^{\sigma/(\sigma-1)}$$

- Gives rise to standard demand for each variety $\omega$ in country $i$:

$$q_i(\omega) = E_i P_i^{\sigma-1} p_i(\omega)^{-\sigma}$$

- Useful later to define a (manufacturing) market demand term for market $i$:

$$B_i \equiv \frac{1}{\sigma} \left( \frac{\sigma}{\sigma - 1} \right)^{1-\sigma} E_i P_i^{\sigma-1}$$

# Antras et al. (2017) Environment

**Final-Goods Sector (Non-Traded, Consumption Goods)**:

- Measure of $N_i$ producers in each country $i \in J$.
- Heterogeneous firms, characterized by productivity $\varphi$.
- Monopolistic competition and free entry.
- Produced using a CES bundle of intermediate inputs.

**Intermediates (Traded)**:

- The (CES) bundle of intermediates containes a continuum of measure one of firm-specific inputs.
- Inputs are imperfectly substitutable, with elasticity of substitution $\rho$.
- Name of the game is determining where each input should come from, and how much.

# Sourcing Strategy

**Sourcing Strategy:** A final good producer based in country $i$ can only acquire the capability to offshore in $j$ after paying fixed cost $f_{ij}$ (in units of labor).

- Denote $\mathcal{J}_i(\varphi) \in J$ the **set of countries** for which a firm based in $i$ with productivity $\varphi$ has paid the associated fixed cost of offshoring, $w_i f_{ij}$.
- $\mathcal{J}_i(\varphi)$ = "*global sourcing strategy*" of the firm.
- Intuitively, can think of this as bringing the EK model *inside the firm*.
  - One hitch is the fixed cost—can only access an input if you pay the fixed cost to offshore in $j$.

# Intermediates Sector

There is a competitive fringe of intermediate goods suppliers who sell at prices equal to marginal cost.

- Competitive fringe of suppliers (sell at marginal cost).
- Let $a_j(v, \rho)$ be the unit labor requirement associated with the production of firm $\varphi$'s intermediate good $\nu \in [0, 1]$ in country $j$.
- Iceberg trade cost $\tau_{ij}$ of shipping intermediates from $j$ to $i$.
- The cost at which firms from $i$ can procure input $\nu$ from country $j$ is then given by:

$$\tau_{ij} a_j(v, \varphi) w_j$$

# Sourcing Decision

As in EK, **firms will choose to buy from the least cost source**.

This means the price firm $\varphi$ from country $i$ actually pays for $\nu$ is:

$$z_i(v, \varphi; \mathcal{J}_i(\varphi)) = \min_{j \in \mathcal{J}_i(\varphi)} \{\tau_{ij} a_j(v, \varphi) w_j\}$$

With this, we can write the **marginal cost** for firm $\varphi$ based in country $i$ of producing a unit of the final good variety as:

$$c_i(\varphi) = \frac{1}{\varphi} \left( \int_0^1 z_i(v, \varphi; \mathcal{J}_i(\varphi))^{1-\rho} dv \right)^{\frac{1}{1-\rho}}$$

# Sourcing Decision

As in EK, assume the **firm-specific intermediate input efficiencies** $1/a_j(v,\varphi)$ are drawn from a Frechet distribution:

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

- $T_j$ governs the state of technology in country $j$ (absolute advantage).
- $\theta$ governs the variability of productivity draws across inputs (comparative advantage within the range of intermediates across countries).

# The Firm Problem

Each firm chooses the following...

- A **sourcing strategy** $\mathcal{J}_i(\varphi) \subset \{1, ..., J\}$.
- A source country $j(\nu) \in \mathcal{J}_i(\varphi)$ for each intermediate $\nu$.
- Quantity of each input $j(\nu)$ to purchase.
- The price of the final good.

# Solving the Model

AFT solves for the equilibrium in three steps:

1. Characterize optimal firm behavior *conditional* on a given sourcing strategy $\mathcal{J}_i(\varphi)$.

2. Characterize choice of sourcing strategy.

3. Aggregate across firms to solve for general equilibrium.

We will go through (1) and (2). For (3), see paper if you are interested.

# Firm Behavior | Sourcing Strategy

For a firm, $\varphi$, based in country $i$, **the share of intermediate input purchases sourced from any country** $j$ will be given by:

$$\chi_{ij}(\varphi) = \begin{cases} \frac{T_j(\tau_{ij}w_j)^{-\theta}}{\Theta_i(\varphi)} & \text{if } j \in \mathcal{J}_i(\varphi) \\ 0 & \text{if } j \notin \mathcal{J}_i(\varphi) \end{cases}$$

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

This should look familiar.

- Same derivation from EK which gave us share of country $i$'s imports from $j$. (Or probability of purchasing from $j$.)
- Comes from properties of the Frechet distribution.

# Firm Behavior | Sourcing Strategy

Some terminology. From the last slide:

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

- The numerator, $T_j(\tau_{ij} w_j)^{-\theta}$ is the **sourcing potential of country** $j$ from the perspective of firm in $i$.
  On average, how cheap is it for firms in $i$ to buy from country $j$
  - If $j$ is remote, has high wages or bad technology $\rightarrow$ worse sourcing potential.

- The denominator, $\Theta_i(\varphi) \equiv \sum_{k \in \mathcal{J}_i(\varphi)} T_k(\tau_{ik} w_k)^{-\theta}$ is the **sourcing capability** of firm $\varphi$ in $i$.
  Given a sourcing strategy, how cheap is it for firm $\varphi$ to buy from all countries everywhere.
  - If $i$ is really remote, worse sourcing capability.

# Firm Behavior | Sourcing Strategy

After choosing the least-cost source of supply for each input, $\nu$, we can express the **overall marginal cost** faced by firm $\varphi$ based in country $i$ as:

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

where $\gamma = \left[\Gamma\left(\frac{\theta+1-\rho}{\theta}\right)\right]^{\theta/(1-\rho)}$ and $\Gamma$ is the gamma function.

- Derivation is "cumbersome," but same one we went through to derive price index in EK.
- Idea – marginal cost of a firm is going to be a function of its sourcing capability.
- **Key insight:** adding an extra location to $\mathcal{J}_i(\varphi)$ increases the sourcing capability of a firm and necessarily lowers the expected price paid for all varieties $\nu$.

  Grants the firm an additional cost draw for all varieties $\nu \in [0, 1]$

# Firm Behavior — Sourcing Strategy

Finally, we can write down **firm profits conditional on a sourcing strategy as**:

$$\pi_i(\varphi) = \varphi^{\sigma-1} \left(\gamma \Theta_i(\varphi)\right)^{(\sigma-1)/\theta} B_i - w_i \sum_{j \in \mathcal{J}_i(\varphi)} f_{ij}$$

- Where $B_i \equiv \frac{1}{\sigma}\left(\frac{\sigma}{\sigma-1}\right)^{1-\sigma} E_i P_i^{\sigma-1}$ is a market demand equation for market $i$ that we defined earlier.

**Key Tradeoff:** Increasing $\Theta_i(\varphi)$, by adding countries to sourcing strategy vs paying more fixed costs.

# Optimal Sourcing Strategy

Next, we want to characterize each firm's optimal sourcing strategy.

- Combinatorial problem.
- Firm must choose set $\mathcal{J}_i(\varphi) \in J$ of locations to maximize profits $\pi_i(\varphi)$.

Firm profits, from last slide, can be rewritten:

$$\max_{I_{ij} \in \{0,1\}_{j=1}^{J}} \pi_i(\varphi, I_{i1}, I_{i2}, ..., I_{ij})$$

$$= \varphi^{\sigma-1} \left( \gamma \sum_{j=1}^{J} I_{ij} T_j (\tau_{ij} w_j)^{-\theta} \right)^{(\sigma-1)/\theta} B_i - w_i \sum_{i=1}^{J} I_{ij} f_{ij}$$

Where $I_{ij} = 1$ if $j \in \mathcal{J}_i(\varphi)$, and 0 otherwise.

# Optimal Sourcing Strategy

Problem on the last slide is hard to solve. Why?

- Brute force way would be to calculate profits for each combination of locations and choose the strategy that yields the highest profits.
  - **Problem:** There are $2^J$ possible sourcing strategies. Infeasible for "real world" calibrations.
  - **Side Note:** "Friendshoring" could be like constraining firms to choose sourcing strategy $\mathcal{J}_i^{\text{Friend}}(\varphi) \in J^{\text{Friends}}$. Or maybe need forward-looking firms who take risk into account in costs?
- Instead AFT rely on a few properties of the profit function to solve this using an algorithm from a paper by Jia (2008).

# Key Properties

**Proposition 1:** The solution to the optimal sourcing problem is such that:

(a) A firm's sourcing capability, $\Theta_i(\varphi)$, is *non-decreasing in* $\varphi$.
More productive firms choose a larger sourcing capability (either select into more countries **or** select into *better* countries).

(b) If $(\sigma - 1)/\theta \geq 1$, then $\mathcal{J}_i(\varphi_L) \subset \mathcal{J}_i(\varphi_H)$ for $\varphi_H > \varphi_L$.
This says that the *cardinality* of the sourcing capability is non-decreasing in $\varphi$ when:

1. Demand is relatively elastic (**high** $\sigma$) so profits respond to reduction in costs.
2. Input efficiency levels are heterogeneous across markets (**low** $\theta$) so you achieve a high reduction in costs from adding an extra country into the set.

# Optimal Sourcing Strategy

That more productive/larger firms have larger sourcing strategies appears to hold in the data.

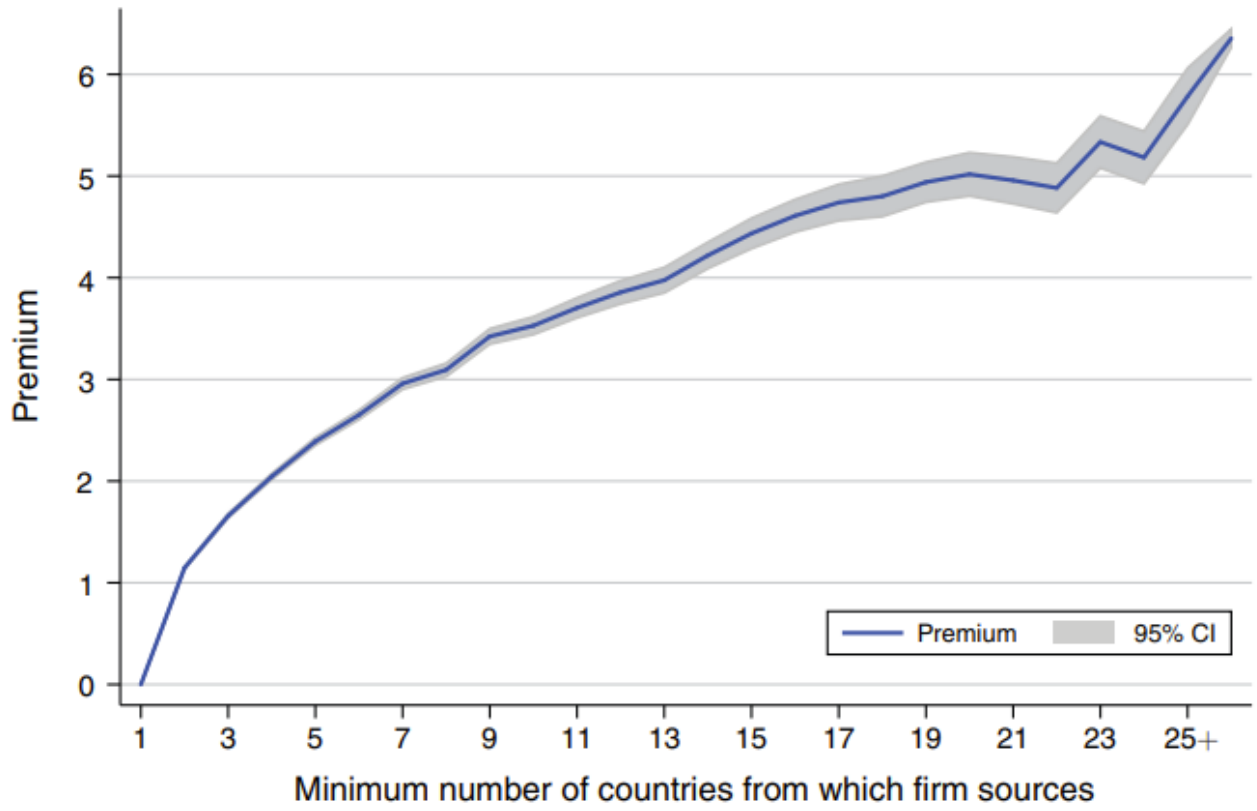


FIGURE 1. SALES PREMIA AND MINIMUM NUMBER OF SOURCING COUNTRIES IN 2007

# Optimal Sourcing Strategy

Proposition 1 also implies that there should be a "pecking order" of sources—a strict hierarchical order in which countries a firm adds to its sourcing strategy.

- Tends to be violated in the data — often see less productive firms sourcing from countries from which more productive firms do not source.
- Possible explanation: fixed costs of sourcing ($f'_{ij}s$) might be heterogeneous across firms.
- However, they do show that 36 percent of firms do follow a "pecking order," which is more than you would expect if firms selected into importing randomly.

# Optimal Sourcing Strategy

36 percent of firms follow a “pecking order.”

TABLE 3—US FIRMS IMPORTING FROM STRINGS OF TOP TEN COUNTRIES

| String | Data | | Random entry | |
|---|---|---|---|---|
| | Firms | Percent of importers | Firms | Percent of importers |
| CA | 17,980 | 29.82 | 6,760 | 11.21 |
| CA-CH | 2,210 | 3.67 | 3,730 | 6.19 |
| CA-CH-DE | 340 | 0.56 | 1,030 | 1.71 |
| CA-CH-DE-GB | 150 | 0.25 | 240 | 0.40 |
| CA-CH-DE-GB-TW | 80 | 0.13 | 50 | 0.08 |
| CA-CH-DE-GB-TW-IT | 30 | 0.05 | 10 | 0.02 |
| CA-CH-DE-GB-TW-IT-JP | 30 | 0.05 | 0 | 0.00 |
| CA-CH-DE-GB-TW-IT-JP-MX | 50 | 0.08 | 0 | 0.00 |
| CA-CH-DE-GB-TW-IT-JP-MX-FR | 160 | 0.27 | 0 | 0.00 |
| CA-CH-DE-GB-TW-IT-JP-MX-FR-KR | 650 | 1.08 | 0 | 0.00 |
| TOTAL following pecking order | 21,680 | 36.0 | 11,820 | 19.6 |

*Notes:* The string CA means importing from Canada but no other among the top ten; CA-CH means importing from Canada and China but no other; and so forth. Percent of importers shows percent of each category relative to all firms that import from top ten countries.

# Optimal Sourcing Strategy

**Proposition 2:** For all $j \in \{1, ..., J\}$, define the mapping $V_{i,j}(\varphi, \mathcal{J})$ to take a value of one whenever including country $j$ in the sourcing strategy $\mathcal{J}$ raises firm-level profits $\pi_i(\varphi, \mathcal{J})$, and to take a value of zero otherwise. Then, whenever $(\sigma - 1)/\theta \geq 1$: $V_{i,j}(\varphi, \mathcal{J}') \geq V_{i,j}(\varphi, \mathcal{J})$ for $\mathcal{J} \subset \mathcal{J}'$.

- This is a bit of a mouthful.
- Going to be the basis for using the algorithm from Jia (2008).
- Let's walk through the details.

# Optimal Sourcing Strategy

Start from a sourcing strategy $\underline{\mathcal{J}}$, which contains 0 countries.

- **Lower bound of the sourcing strategy** is obtained by adding each country one-by-one, and keeping those for which the marginal benefit of adding the country is positive.
- If, for country $j$, $V_{i,j}(\varphi, \mathcal{J}) = 1$ when $\mathcal{J}$ is the null set, then $j$ must be in $\mathcal{J}_i(\varphi)$.

Then, consider the set $\bar{\mathcal{J}}$, which countains all countries.

- **Upper bound of the sourcing strategy** is obtained by removing countries one-by-one. If removing $j$ does not reduce profits, $j$ is not in the optimal sourcing strategy.
- If $V_{i,j}(\varphi, \mathcal{J}) = 0$ when $\mathcal{J}$ includes all countries except for $j$, then $j$ cannot possibly be in $\mathcal{J}_i(\varphi)$.

# Optimal Sourcing Strategy

Hopefully upper and lower bounds defined on the last slide converge.

- If not, only need to compare combinations between the two bounds, rather than $2^J$.
- Not guaranteed to work — could still end up with a large number of choices between the two bounds.
- In practice, approach leads to completely overlapping pairs most of the time.

# Optimal Sourcing Strategy

**Proposition 3:** Holding constant the market demand level $B_i$, whenever $(\sigma - 1)/\theta \geq 1$, an increase in the sourcing potential $T_j(\tau_{ij} w_j)^{-\theta}$ or a reduction in the fixed cost $f_j$ of *any country* $j$, (weakly) increases the input purchases by firms in $i$ *not only from* $j$*, but also from other countries*.

- Productivity shock or reduction in bilateral trade costs with country $j$ will not only increase input purchases from $j$, but from everywhere else.
- Holding market demand constant is not innocuous – requires holding the aggregate price index, $P_i$, constant, which is unlikely.

# Optimal Sourcing Strategy

Antras et al. (2017) provide some suggestive evidence that proposition 3 holds in the data:

- In response to the "China Shock," a range of U.S. firms select into sourcing from China.
- On average, these firms increase input purchases **not only from China, but also from the United States and third-party countries**.
- Illustrative of interdependencies across markets. If sourcing choices were independent, China shock would induce more sourcing from China, but not third-country effects.

# AFT Recap

Paper provides a framework for thinking about firm sourcing in a multi-country world.

- See paper if you are interested in rest of structural estimation and aggregation.
- Highlights importance of interdependencies in firms' extensive margin decisions.
- Framework for solving a computationally difficult problem.
- My take—interesting implications for current discussion on reshaping supply chains.
- A few notes/extensions to wrap up.

# Spiders vs Snakes

AFT applies to “spiders” not “snakes.”

- Spider—think Boeing.
- Snakes—think semi-conductors.
- Follow up work by Antràs and De Gortari (2020) on how to model “snakes.”
  - Here, the decision is sequential: good must go through (a) then (b) then (c) etc.

# Related Frameworks—"Two-Sided Matching"

Models we've covered throughout the semester have been firms making decisions about export destinations/input sources.

Set of papers considering frameworks in which firms match with other firms, rather than with countries.

- Bernard, Moxnes and Ulltveit-Moe (2018) features a model where firms are deciding which countries to export to, but fixed costs of exporting are **relationship-specific**.
  - Have to pay these costs to transact with a new customer, *even if already selling to other customers in the same market*.

- Similar framework for input sourcing decision Dhyne, Kikkawa, Mogstad and Tintelnot (2021) where fixed costs of sourcing apply at the supplier level rather than the country level.

# Related Frameworks—"Stochastic Formation"

Parallel literature has taken tools from the network theory literature to develop **stochastic models of endogenous firm-to-firm production network formation**.

- Eaton et al. (2022)—final good producers get randomly matched with heterogeneous suppliers.
  - If they can produce input cheaper themselves, don't outsource.
- Oberfield (2018)—buyer-seller specific (match-specific) productivities.
  - Buyers chooses best match among pool of potential suppliers.
  - Generates large differences in productivity and size across firms.

# Horizontal and Export-Platform FDI

Finally, related set of models in which only final goods are produced and are done so with local factors of production, however...

- Firms can set up foreign assembly plants to service foreign consumers at a lower marginal cost. (Also called “export platforms.”)
- Instead of choosing a set of countries to source inputs from, a firm activates a set of locations to produce in.
- Then, firms decide from which assembly plant to sell to consumers in all potential destinations.
- **Tradeoff:** Fixed cost of setting up plants vs variable cost of transporting goods.
- **Key Papers:** Tintelnot (2017), Antràs, Fadeev, Fort and Tintelnot (2022)

# Horizontal and Export-Platform FDI

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