Global Sourcing and Multinational Activity: A Unified Approach

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December, 13 2019

Trade Wars

One View

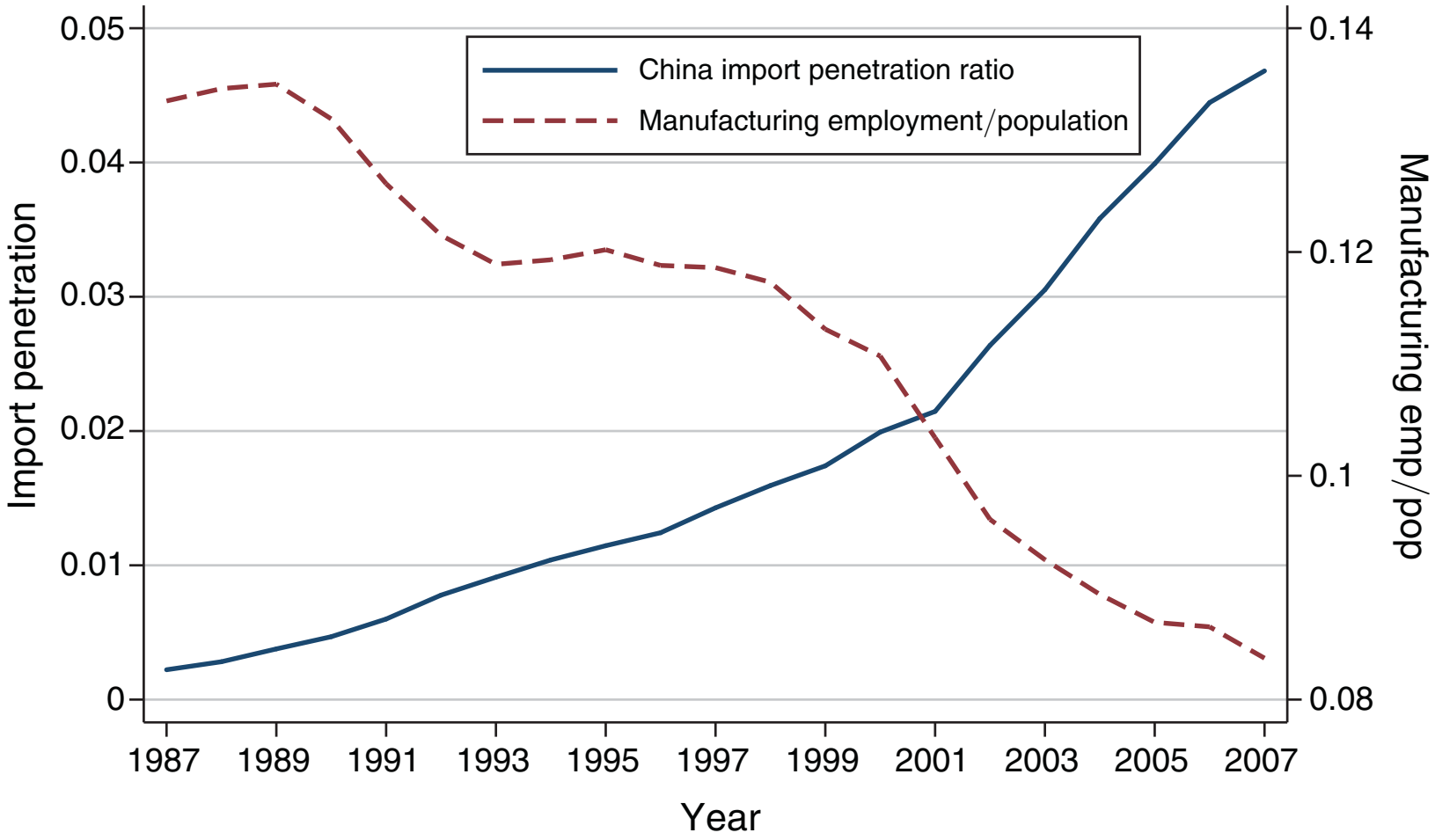
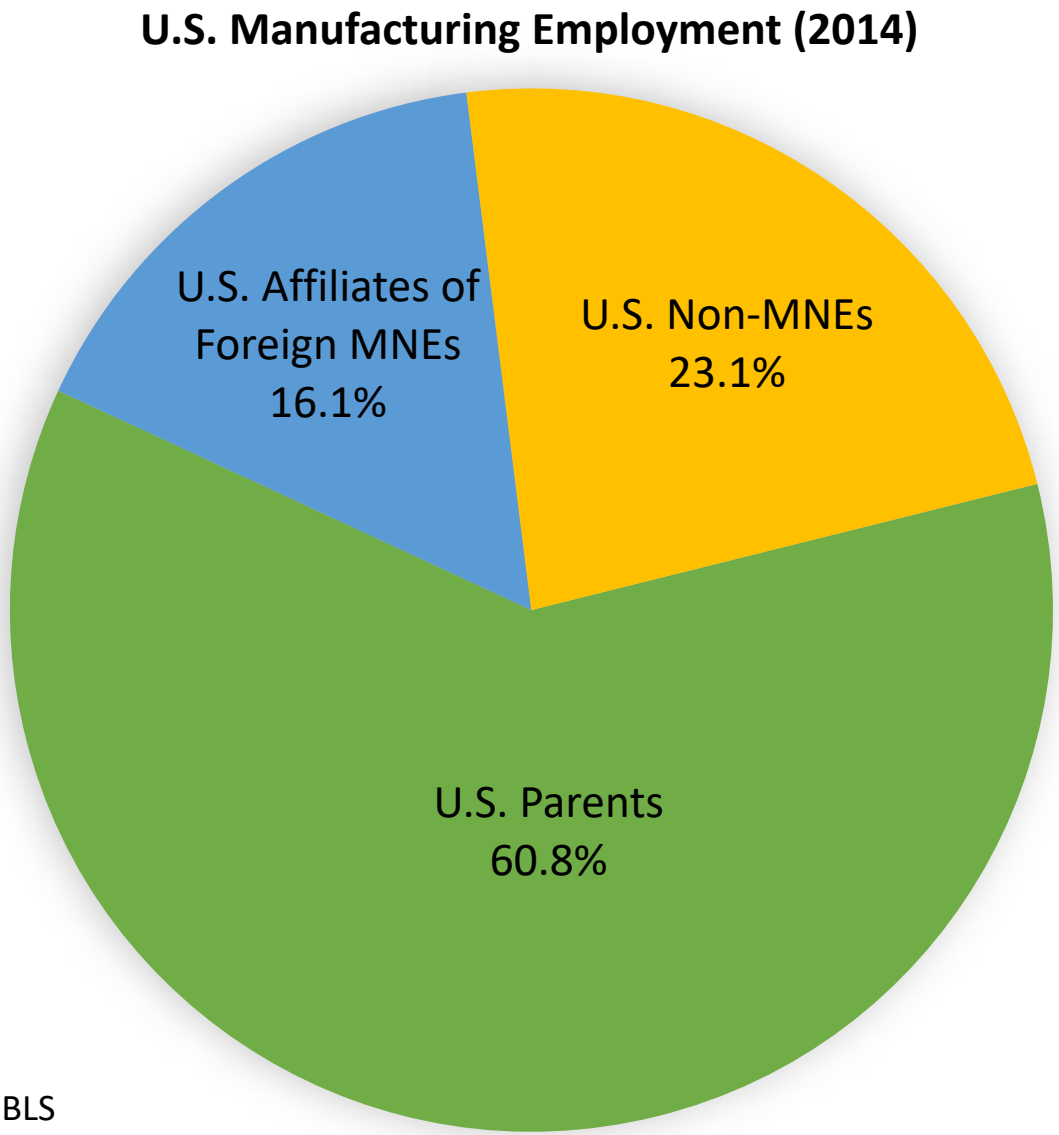


FIGURE 1. IMPORT PENETRATION RATIO FOR US IMPORTS FROM CHINA (*left scale*), AND SHARE OF US WORKING-AGE POPULATION EMPLOYED IN MANUFACTURING (*right scale*)

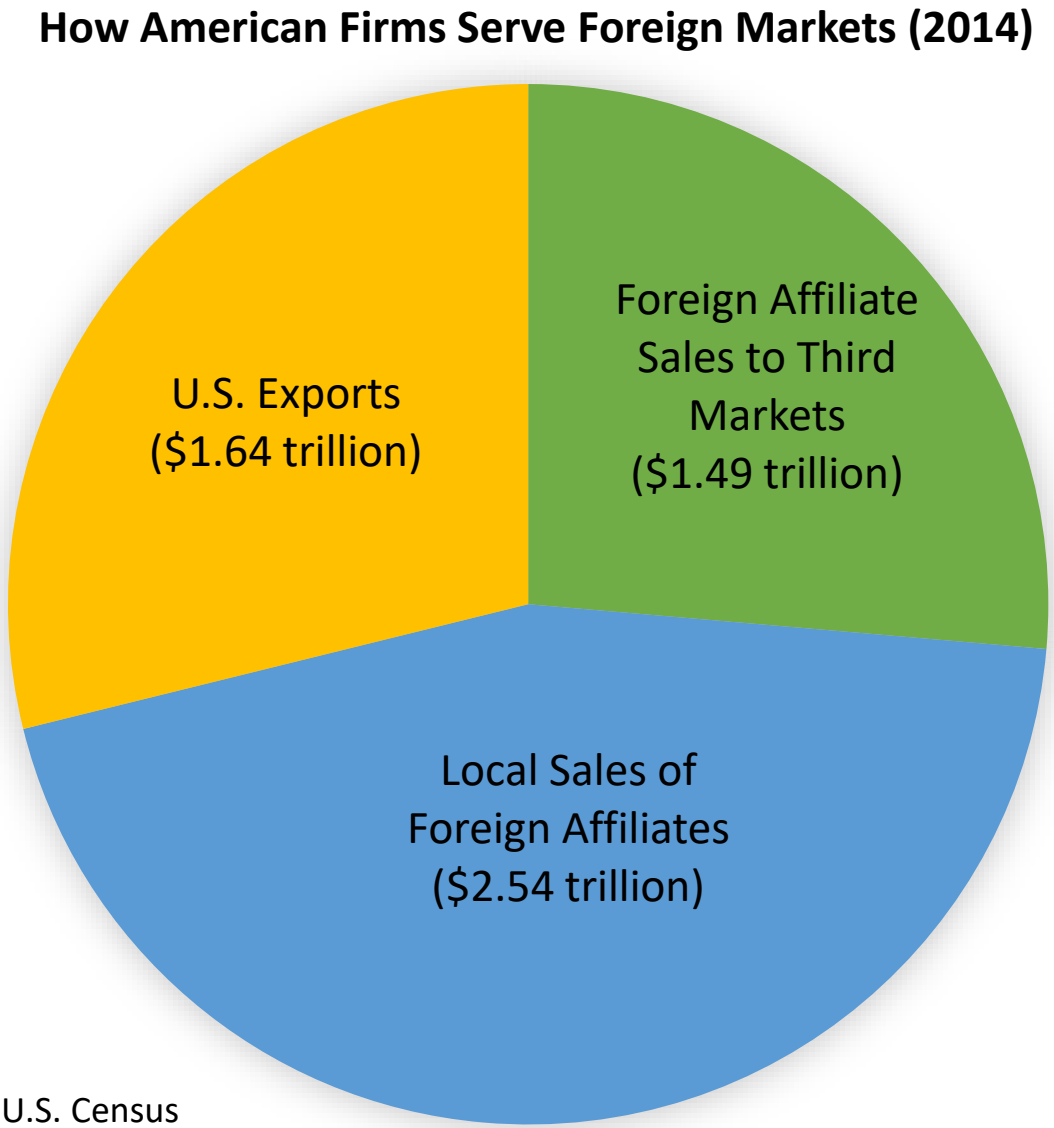
Another View

Some Key Considerations: Manufacturing Employment



Source: BEA and BLS

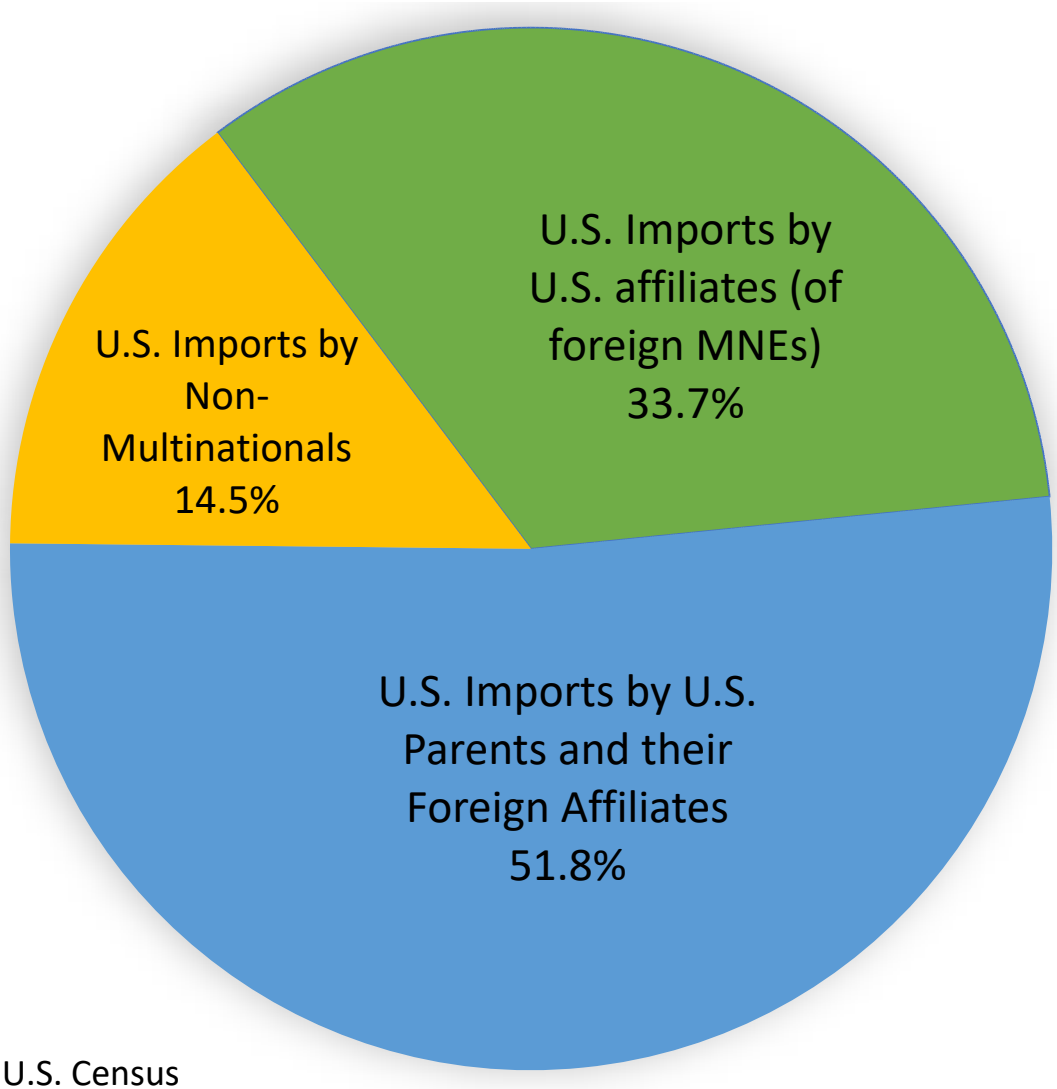
Some Key Considerations: Global Assembly



Source: BEA and U.S. Census

Some Key Considerations: Global Sourcing

U.S. Imports by Type of Manufacturing Firm (2007)



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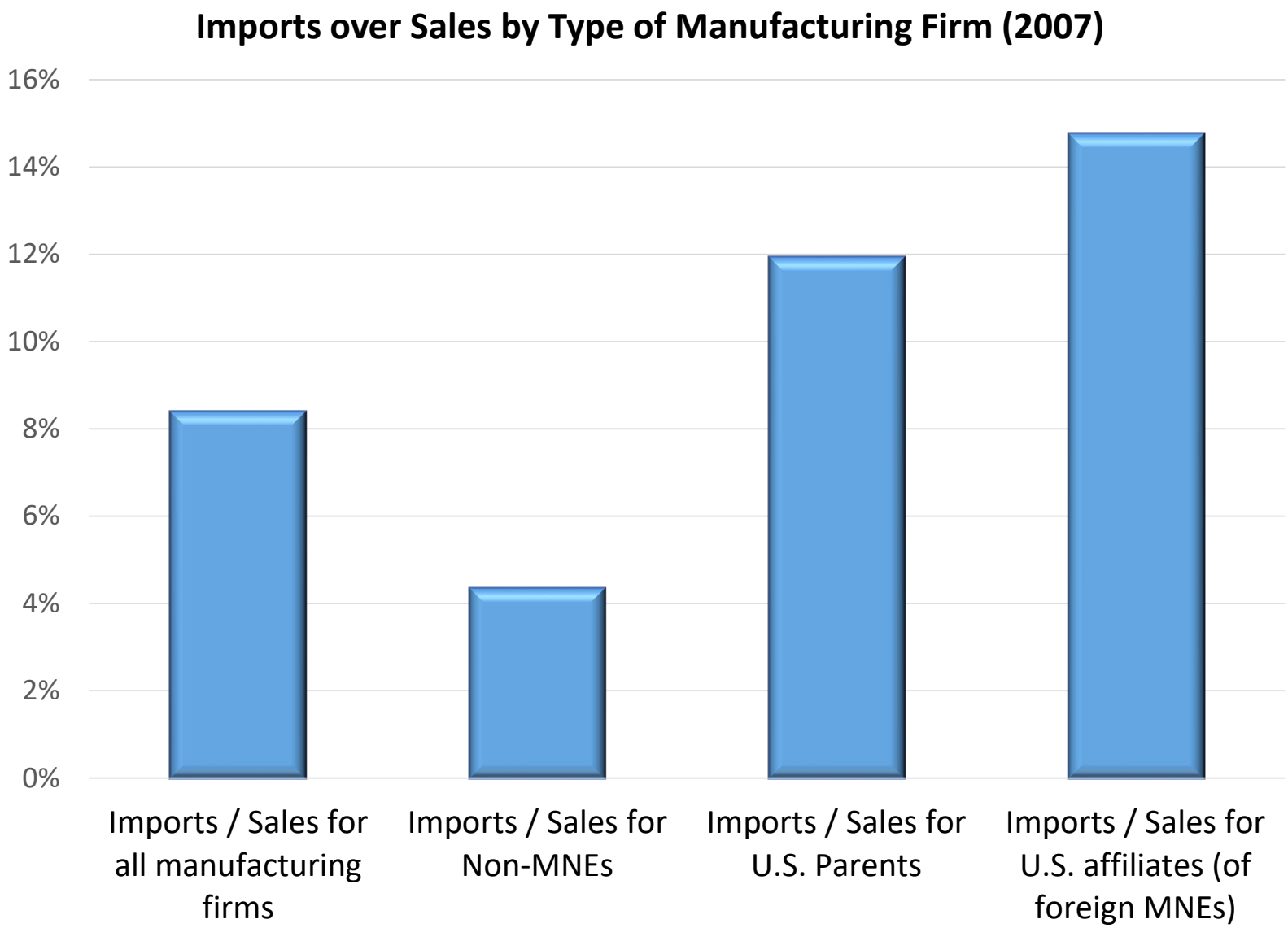
Some Key Considerations: Global Sourcing



Some Takeaways

- Global Assembly and Global Sourcing are **prominent** features of (U.S.) manufacturing

- These firm strategies appear to be **interdependent**:
  - global sourcing decisions shaped by global assembly strategy
  - global assembly decisions shaped by global sourcing strategy

Some Takeaways

- Global Assembly and Global Sourcing are **prominent** features of (U.S.) manufacturing
- These firm strategies appear to be **interdependent**:
  - global sourcing decisions shaped by global assembly strategy
  - global assembly decisions shaped by global sourcing strategy
- These interdependencies are likely to complicate the response of the geography of world manufacturing to increases in trade barriers
  - Tariff-jumping FDI (assembly) versus putting sand in the wheels of GVCs (global sourcing)
- Will Trump tariffs invigorate U.S. manufacturing?

Our Contribution/Goals

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- **Today:** Outline model and estimation strategy and show some preliminary quantitative results

A New Linked U.S. Census-BEA Dataset

- 2007 Census data
  - Longitudinal Business Database: private non-farm employer establishments
  - Economic Censuses: Sales and inputs Import and Export transactions of merchandise goods (LFTTD)
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- Combine datasets using EINs and name and address matching
  - Census generally maps more EINs and activity to a unique firm
  - Use COS to distinguish US versus majority-owned foreign firms

Theoretical Framework: Non-Technical Overview

- Marriage of the global assembly framework in Tintelnot (2017) with the global sourcing framework in Antràs, Fort and Tintelnot (2017)
- Single manufacturing sector: J countries, CES preferences, scale economies, trade costs, monopolistic competition, and free entry
  - Krugman' 80, Melitz '03, Eaton and Kortum' 02 are all special cases

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  4. Final goods and inputs are differentiated by country of origin: 'variety' gains from fragmentation

Main Forces Shaping Extensive Margin

- Adding an assembly location entails a fixed cost, but it also:
  - reduces the trade costs of selling to some markets
  - allows the firm to obtain an additional differentiated variety
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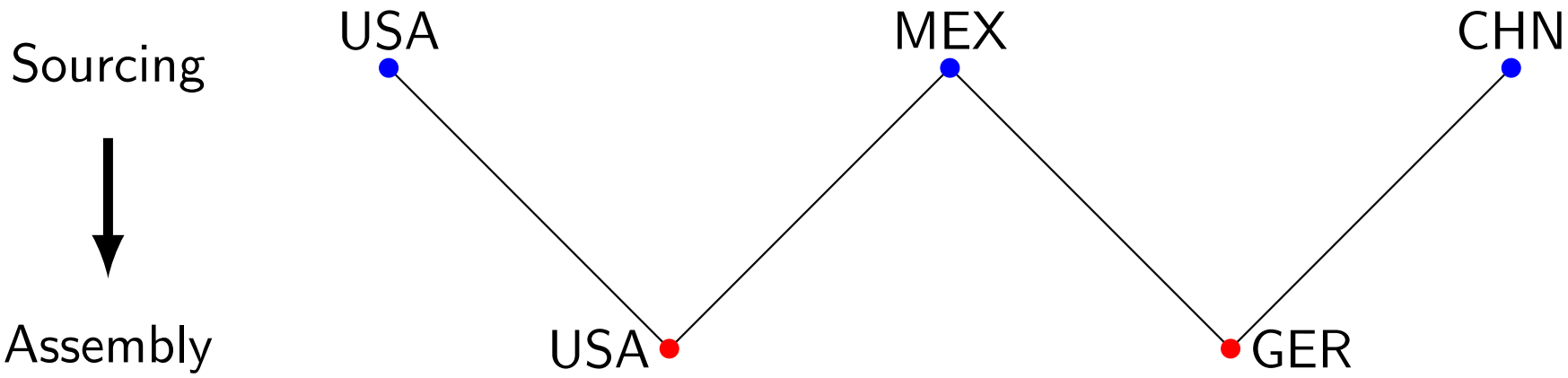
- A force towards complementarity between both extensive margins
  - richer sourcing strategy reduces marginal costs and makes richer assembly strategy more appealing
  - richer assembly strategy increases overall firm sales and makes richer sourcing strategy more appealing

Formal Model. Global Sourcing. Fixed Extensive Margin



- Denote the sets of sourcing countries $\Delta_{usa} = \{USA, MEX\}$ and $\Delta_{ger} = \{MEX, CHN\}$;

- Production of a variety in location $\ell \in \{USA, GER\}$ is

$$y_\ell = \text{Productivity}_\ell \cdot \left(\begin{array}{c} \text{Assembly} \\ \text{Labor in } \ell \end{array} \right)^{\alpha} \cdot \left(\begin{array}{c} \text{Armington CES} \\ \text{Bundle of Inputs} \end{array} \right)^{1-\alpha}$$

$$\begin{array}{c} \text{Armington CES} \\ \text{Bundle of Inputs} \end{array} = \frac{1}{1-\alpha} \left[\sum_{k \in \Delta_\ell} \left(q_k / \gamma_k \right)^{\frac{\mu-1}{\mu}} \right]^{\frac{\mu}{\mu-1}}$$

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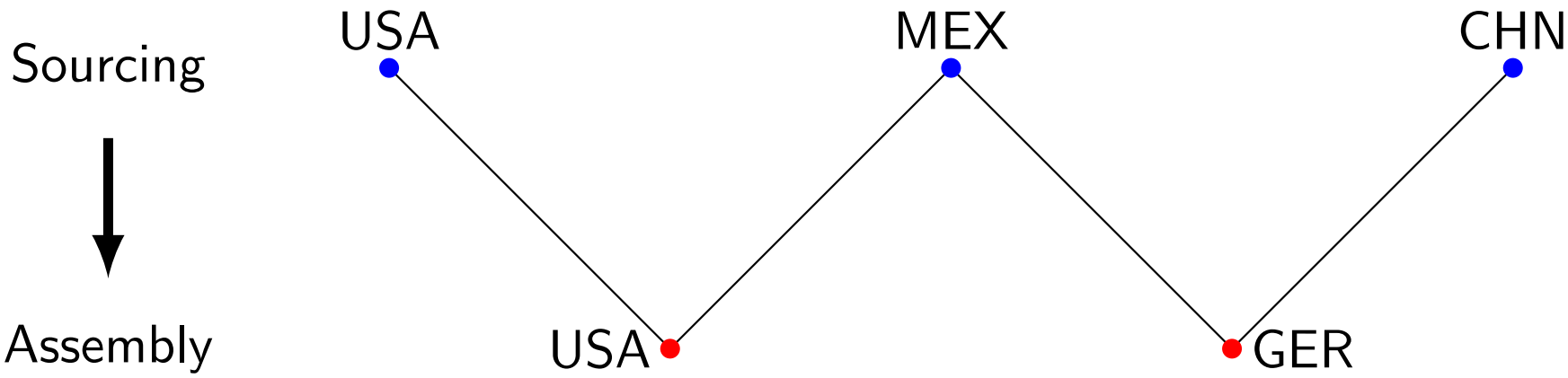


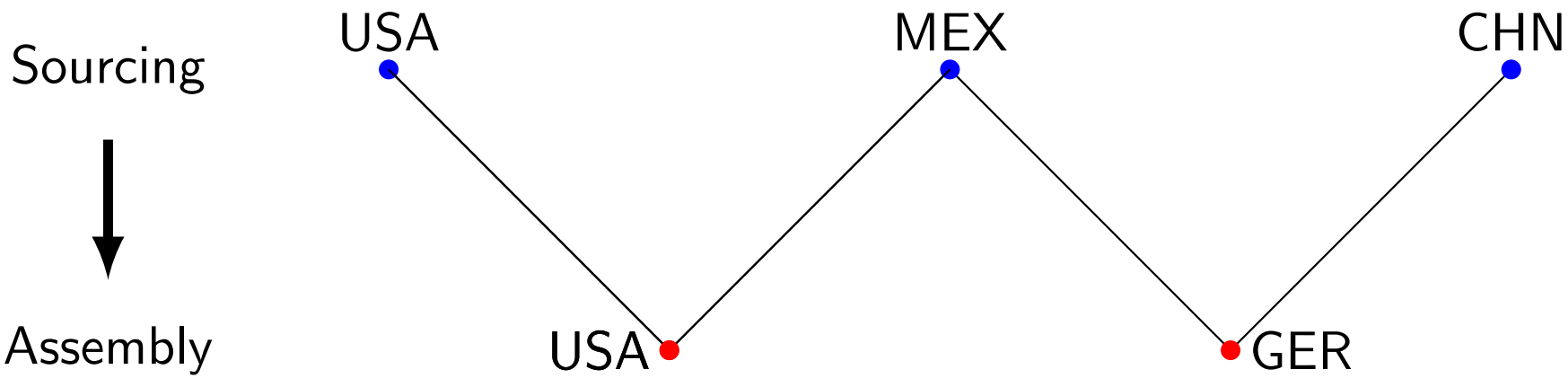
- Denote the sets of sourcing countries $\Delta_{usa} = \{USA, MEX\}$ and $\Delta_{ger} = \{MEX, CHN\}$;

- Marginal costs in assembly $\ell \in \{USA, GER\}$:

$$\text{MC}_\ell = \text{Productivity}^{-1} \cdot \left(\begin{array}{c} \text{Price of} \\ \text{Labor in } \ell \end{array} \right)^{\alpha} \cdot \left(\begin{array}{c} \text{Price Index} \\ \text{for Inputs in } \ell \end{array} \right)^{1-\alpha}$$

$$\boxed{\text{MC}_\ell = \varphi^{-1} \cdot (w_\ell)^{\alpha} \cdot \left(\sum_{k \in \Delta_\ell} (\gamma_k w_k \tau_{k,\ell})^{1-\mu} \right)^{\frac{1-\alpha}{1-\mu}}}$$

Firm-Level Trade Flows of Inputs



- Sourcing Sets for USA $\Delta_{usa} = \{USA, MEX\}$ and for GER $\Delta_{ger} = \{MEX, CHN\}$, for assembly location $\ell \in \{USA, GER\}$:

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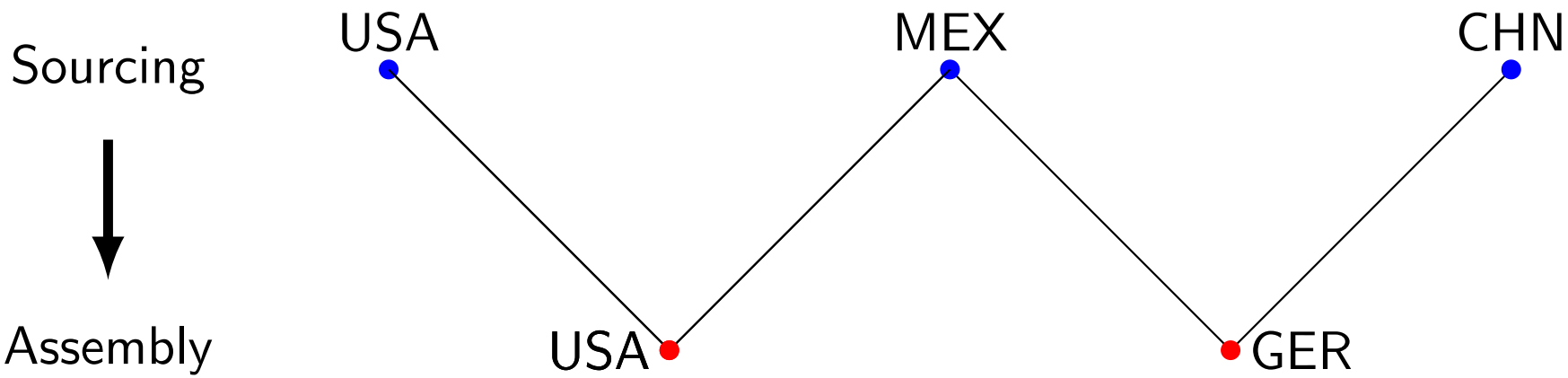

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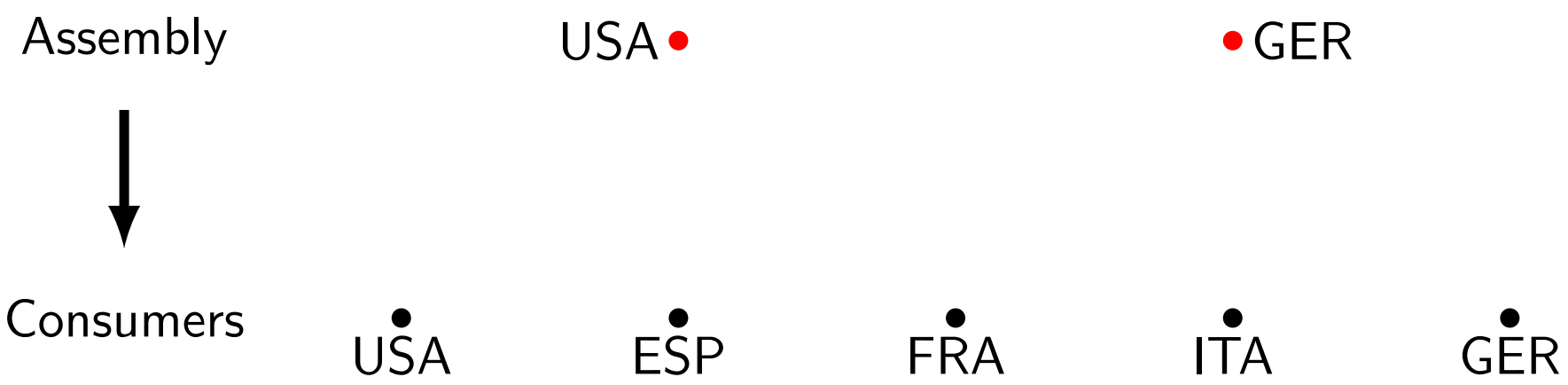
$$\text{Inputs Share from } k \text{ to } \ell = \frac{(\gamma_k w_k \cdot \tau_{k,\ell})^{1-\mu}}{\sum_{j \in \Delta_\ell} (\gamma_j w_j \cdot \tau_{j,\ell})^{1-\mu}}$$

Final Demand. Assembly. Double CES Demand



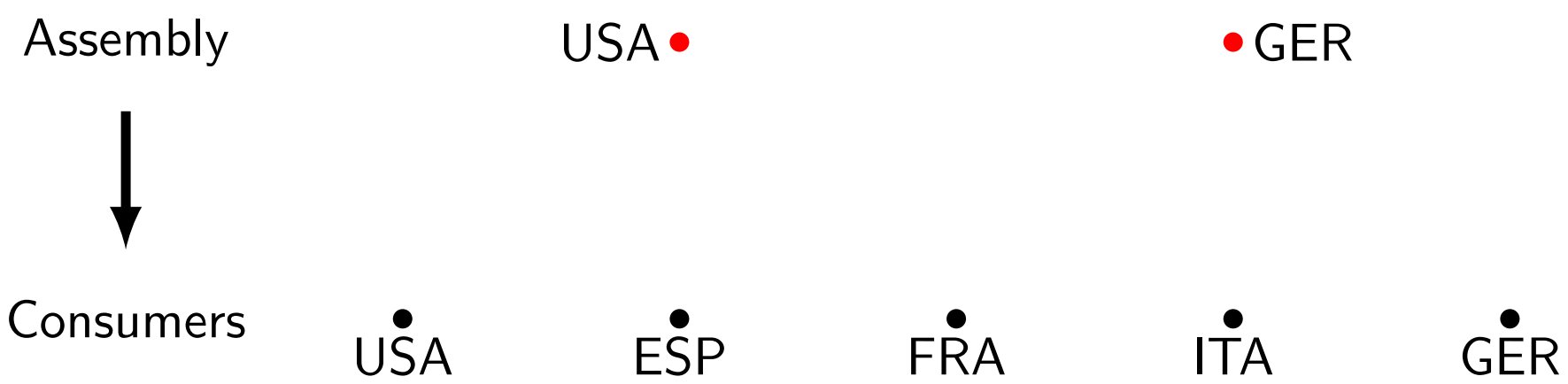
- CES Demand across firms in market m

$$\left[\int_{\psi\in Firms_m} Q_{\psi,m}^{\frac{\sigma-1}{\sigma}} \mathrm{d}\psi\right]^{\frac{\sigma}{\sigma-1}} \Rightarrow \text{Firm-level Sales: } \boxed{S_{\psi,m} = \frac{p_{\psi,m}^{1-\sigma}}{P_m^{1-\sigma}} E_m}$$

- CES demand within a firm ψ across varieties from $\ell \in \{USA, GER\}$

$$Q_\psi = \left[\sum_{\ell\in\{USA,GER\}} \beta_\ell^{\frac{1}{\rho}} Q_{\psi,\ell}^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}} \Rightarrow \text{Variety-level Sales: } \boxed{S_{\psi,\ell,m} = \frac{p_{\psi,\ell}^{1-\rho}}{p_{\psi,m}^{1-\rho}} \beta_\ell S_{\psi,m}}$$

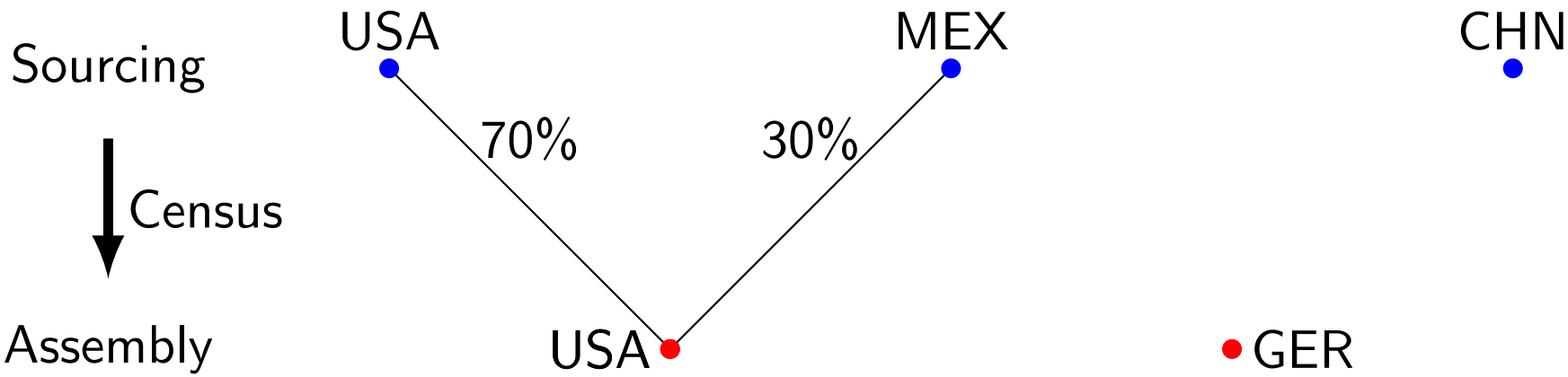
Firm-Level Trade Flows of Final Goods



- Assembly Set $\mathcal{Z} = \{USA, GER\}$

$$\text{Share of Sales from } \ell \text{ to } m = \frac{\beta_\ell \cdot \left(w_\ell^\alpha \cdot \tau_{\ell,m}\right)^{1-\rho} \cdot \left(\sum_{j \in \Delta} \left(\gamma_j w_j \tau_{j,\ell}\right)^{1-\mu}\right)^{(1-\alpha)\frac{1-\rho}{1-\mu}}}{\sum_{n \in \mathcal{Z}} \beta_n \cdot \left(w_n^\alpha \cdot \tau_{n,m}\right)^{1-\rho} \cdot \left(\sum_{j \in \Delta} \left(\gamma_j w_j \tau_{j,n}\right)^{1-\mu}\right)^{(1-\alpha)\frac{1-\rho}{1-\mu}}}$$

Census Data



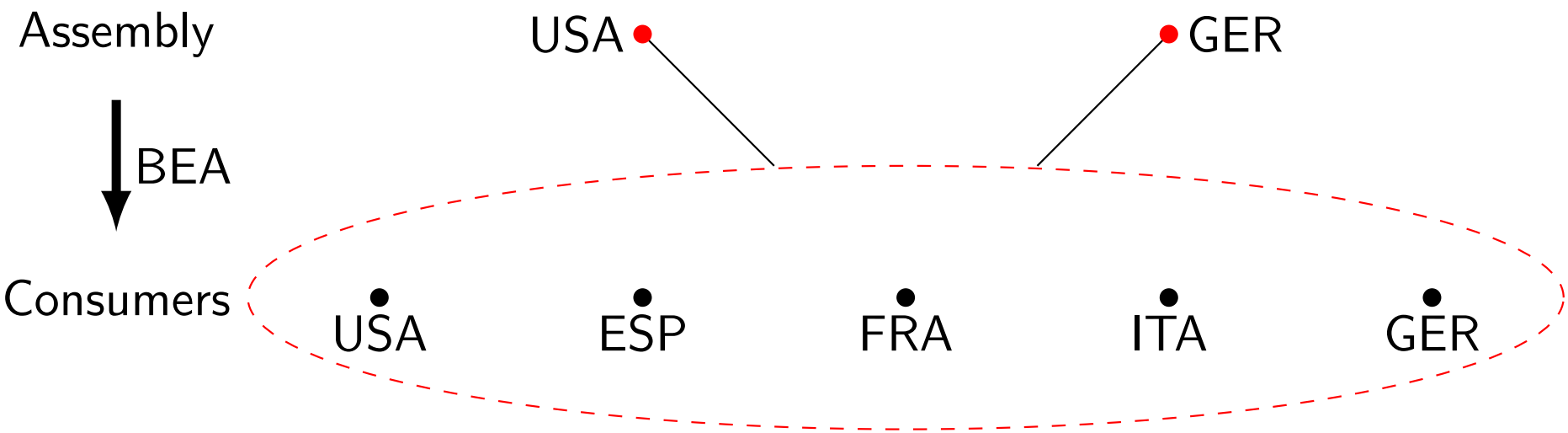
- Normalize $\left(T_{usa} w_{usa} \cdot \tau_{usa,usa}\right)^{1-\mu} = 1$

$$\frac{\left(\gamma_{mex} w_{mex} \cdot \tau_{mex,usa}\right)^{1-\mu}}{1 + \left(\gamma_{mex} w_{mex} \cdot \tau_{mex,usa}\right)^{1-\mu}} = 0.3 \text{ and } \frac{1}{1 + \left(\gamma_{mex} w_{mex} \cdot \tau_{mex,usa}\right)^{1-\mu}} = 0.7$$

$$\Rightarrow \left(\gamma_{mex} w_{mex} \cdot \tau_{mex,usa}\right)^{1-\mu} = \frac{3}{7}$$

- U.S. Census data allows to recover sourcing potentials $\left(\gamma_k w_k \tau_{k,usa}\right)^{1-\mu}$ for USA;

BEA Data



- BEA data allows us to recover for each firm and assembly location ℓ:

$$\beta_\ell \cdot w_\ell^\alpha \left(\text{Price of Inputs}_\ell\right)^{1-\alpha} = \beta_\ell \cdot w_\ell^\alpha \cdot \left[\sum_{k \in \Delta_\ell} \left(\gamma_k w_k \cdot \tau_{k,\ell}\right)^{1-\mu}\right]^{\frac{1-\alpha}{1-\mu}}$$

- Higher relative sales of location ℓ reflect:
  - Higher demand β_ℓ;
  - Lower wages w_ℓ;
  - Lower input prices;

Census + BEA Data

- Census $\Rightarrow$ Price of Inputs$_{usa}$ for any sourcing set Δ:

$$\text{Price of Inputs}_{usa}(\Delta) = \left[\sum_{k\in\Delta} \gamma_k w_k \cdot \tau_{k,usa}\right]^{\frac{1}{1-\mu}}$$

- BEA $\Rightarrow \beta_\ell w_\ell^\alpha \cdot (\text{Price of Inputs}_\ell(\Delta_\ell))^{1-\alpha}$ for all assembly plants ℓ;
- **Assumption:** All affiliates of one MNE have the same sourcing set

$$\Delta_\ell = \Delta_{usa}$$

- Additional Estimates: proxies for trade costs $\hat{\tau}_{k,\ell}$;
- Allows us to separate $\beta_\ell w_\ell^\alpha$ and $(\text{Price of Inputs}_\ell)^{1-\alpha}$:

$$\text{Price of Inputs}_\ell = \left[\sum_{k\in\Delta_\ell} (\gamma_k w_k \cdot \tau_{k,\ell})^{1-\mu}\right]^{\frac{1}{1-\mu}} \approx \left[\sum_{k\in\Delta_{usa}} (\gamma_k w_k \cdot \hat{\tau}_{k,\ell})^{1-\mu}\right]^{\frac{1}{1-\mu}}$$

Summary on the Intensive Margin

- Census and BEA data allows to construct operating profits for any sourcing set Δ and assembly set $\mathcal{Z}$:

$$\pi^o(\varphi, \Delta, \mathcal{Z}) =$$

$$\sigma^{-1}\varphi^{\sigma-1} \cdot \sum_{m=1}^{J} \left[\sum_{\ell \in \mathcal{Z}} \beta_\ell \cdot \left(w_\ell^\alpha \cdot \tau_{\ell,m}\right)^{1-\rho} \cdot \left(\sum_{k \in \Delta} \left(\gamma_k w_k \tau_{k,\ell}\right)^{1-\mu} \right)^{(1-\alpha)\cdot\frac{1-\rho}{1-\mu}} \right]^{\frac{1-\sigma}{1-\rho}} \cdot \frac{E_m}{P_m^{1-\sigma}}$$

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- How do firms choose sourcing set Δ and assembly set $\mathcal{Z}$?

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$$\sigma^{-1}\varphi^{\sigma-1} \cdot \sum_{m=1}^{J} \left[\sum_{\ell=1}^{J} \mathbb{I}_\ell^a \cdot \beta_\ell \cdot \left(w_\ell^\alpha \cdot \tau_{\ell,m}\right)^{1-\rho} \cdot \left(\sum_{k=1}^{J} \mathbb{I}_k^s \cdot \left(\gamma_k w_k \tau_{k,\ell}\right)^{1-\mu} \right)^{(1-\alpha)\cdot\frac{1-\rho}{1-\mu}} \right]^{\frac{1-\sigma}{1-\rho}} \cdot \frac{E_m}{P_m^{1-\sigma}}$$

$$- \sum_{k=1}^{J} \mathbb{I}_k^s \cdot f_k^s - \sum_{\ell=1}^{J} \mathbb{I}_\ell^a \cdot f_\ell^a \longrightarrow \max_{(\mathbb{I}^s, \mathbb{I}^a) \in \{0,1\}^{2J}}$$

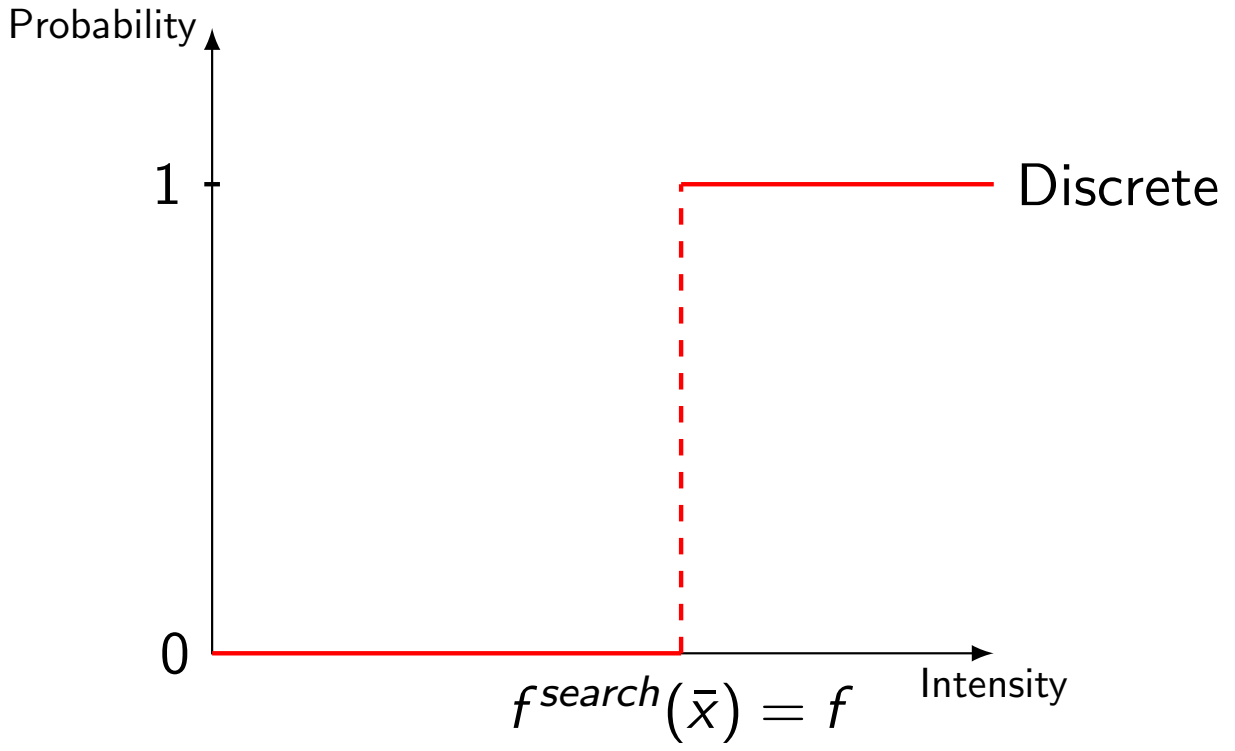
Probabilistic (Search) Framework

- **The Idea:**

  Turn the discrete problem into continuous one using randomization

- For example, for sourcing

$$\{\text{Fixed Costs: } f_k^s \to \mathbb{I}_k^s = 1\} \Rightarrow \{\text{Search Costs: } f_k^s(x_k) \to \mathbb{P}\left(\mathbb{I}_k^s = 1 | x_k\right)\}$$



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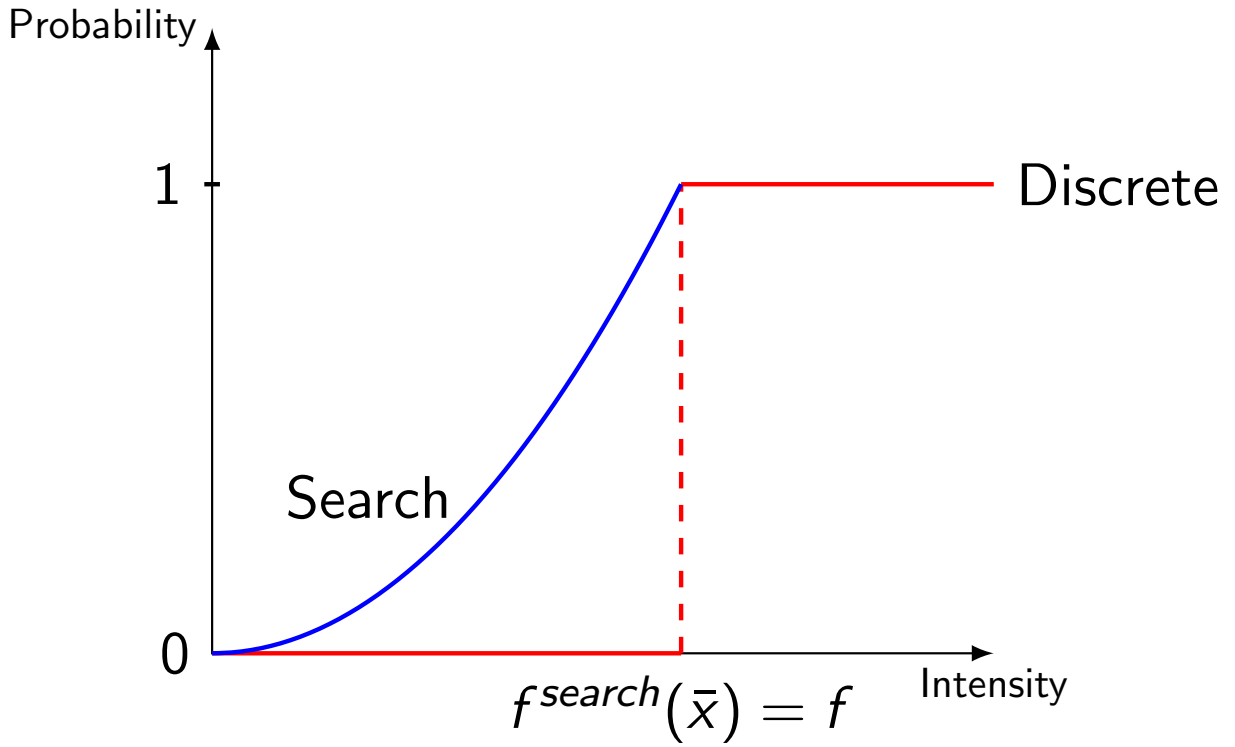

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- High-dimensional discrete optimization $\rightarrow$ High-dimensional expectation

$$\left\{ \max_{\mathbb{I}} \pi(\mathbb{I}) \text{ over } \mathbb{I} \in \{0,1\}^{2J} \right\} \Rightarrow \left\{ \max_{x} \mathbb{E}\left[\pi|x\right] \text{ over } x \in [0,1]^{2J} \right\}$$

where

$$\mathbb{E}\left[\pi|x\right] = \sum_{\mathbb{I}\in\{0,1\}^{2J}} \mathbb{P}\left(\mathbb{I}|x\right) \cdot \pi^{o}(\mathbb{I}) - \sum_{l} f_{l}^{a}(x_{l}) - \sum_{k} f_{k}^{s}(x_{k})$$

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- How to compute expectation? Still the sum over 2^{2J} ...
  - Simulations break the curse of dimensionality.

Search. Implementation

- Denote the expected operating profit

$$\mathbb{E}\left[\pi^o|x\right] = \sum_{\mathbb{I}\in\{0,1\}^{2J}} \mathbb{P}\left(\mathbb{I}|x\right)\cdot\pi^o(\mathbb{I})$$

- Denote by $p(x_i^t) = \mathbb{P}\left(\mathbb{I}_i^t = 1|x_i^t\right)$ for $t \in \{a, s\}$, and $i \in J$;

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Search. Implementation

- Denote the expected operating profit

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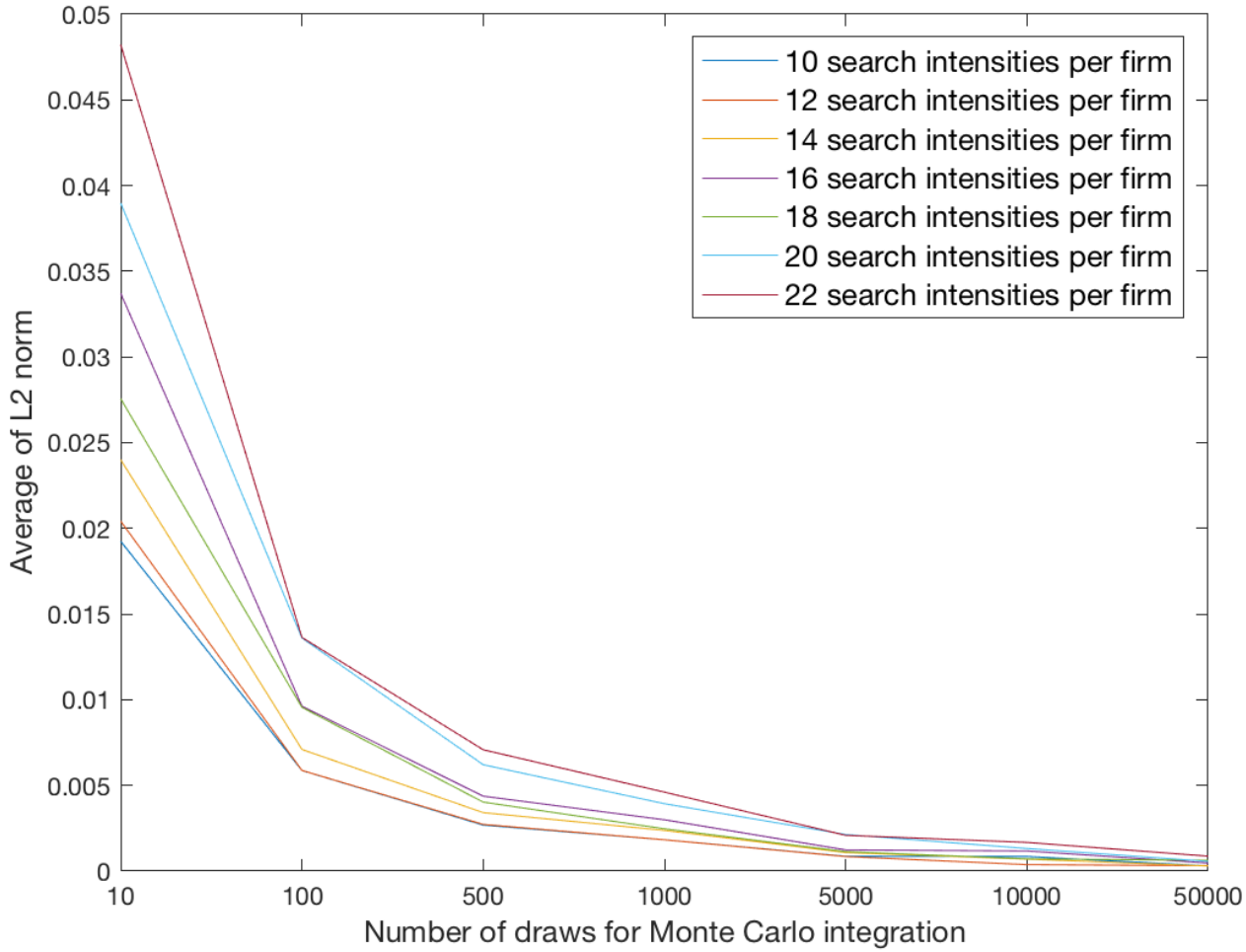
- First Order Condition for country ℓ in assembly

$$p'\left(x_\ell^a\right)\cdot\left(\underbrace{\mathbb{E}\left[\pi^o|x,\mathbb{I}_\ell^a=1\right]-\mathbb{E}\left[\pi^o|x,\mathbb{I}_\ell^a=0\right]}_{\text{Simulations}}\right) = \frac{\mathrm{d}}{\mathrm{d}x_\ell^a} f_\ell^a\left(x_\ell^a\right)$$

- Expected Marginal Operating Profit = Marginal Search Costs;
- Similar for other countries in assembly and sourcing;

A Preview



- Can use Chernoff bounds to evaluate errors in simulations for larger number of countries

Empirical Strategy. Extensive Margin

- **Intensive Margin (roughly):** Information about $\pi^o(\varphi, \Delta, \mathcal{Z})$ for any Δ, $\mathcal{Z}$;
- **Extensive Margin:** Estimate the **levels** $\tilde{f} = \{f_\ell^a, f_k^s\}_{k,\ell}$ of search costs

$$\text{MLE: } \mathcal{L}\left(\tilde{f}\right) = \prod_{\psi \in \text{Firms}} \mathbb{P}\left(\overbrace{\Delta(\psi), \mathcal{Z}(\psi)}^{\text{Data}} | x^*(\psi) \right) \to \max_{\tilde{f}}$$

$$\text{s.t. } x^*(\psi) = \arg\max_x \left\{ \mathbb{E}\left[\pi^o(\psi)|x\right] - \sum_\ell f_\ell^a \cdot f(x_\ell^a) - \sum_k f_k^s \cdot f(x_k^s) \right\}$$

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- **Full MLE:** includes intensive and extensive margins together:

$$\left\{ \underbrace{\mathbb{P}(\Delta, \mathcal{Z})}_{\tilde{f}}, \underbrace{\left\{ (\gamma_k w_k \cdot \tau_{k\ell})^{1-\mu} \right\}_{k \in \Delta}}_{\log \mathcal{N}}, \underbrace{\left\{ \beta_\ell \left(w_\ell^\alpha \right)^{1-\rho} \right\}_{\ell \in \mathcal{Z}}}_{\log \mathcal{N}}, \underbrace{\varphi}_{\text{Pareto}} \right\}$$

A Rough Exercise

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- We can extend it to include transport costs, asymmetric wages and asymmetric technologies

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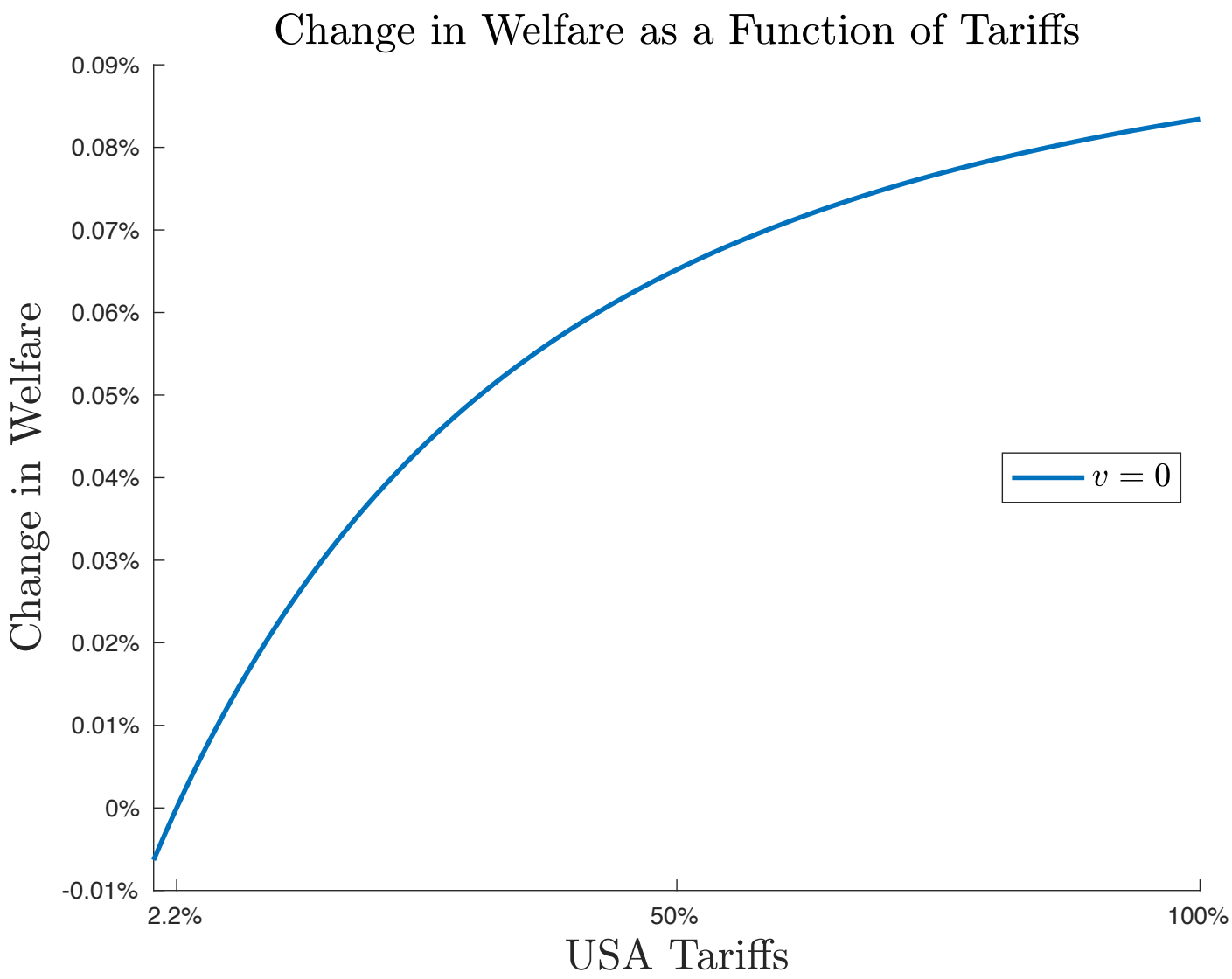
- Can evaluate the quantitative importance of input tariff incidence for welfare implications of rising tariffs
- Assume incidence υ on inputs

Effects of Tariffs on Welfare



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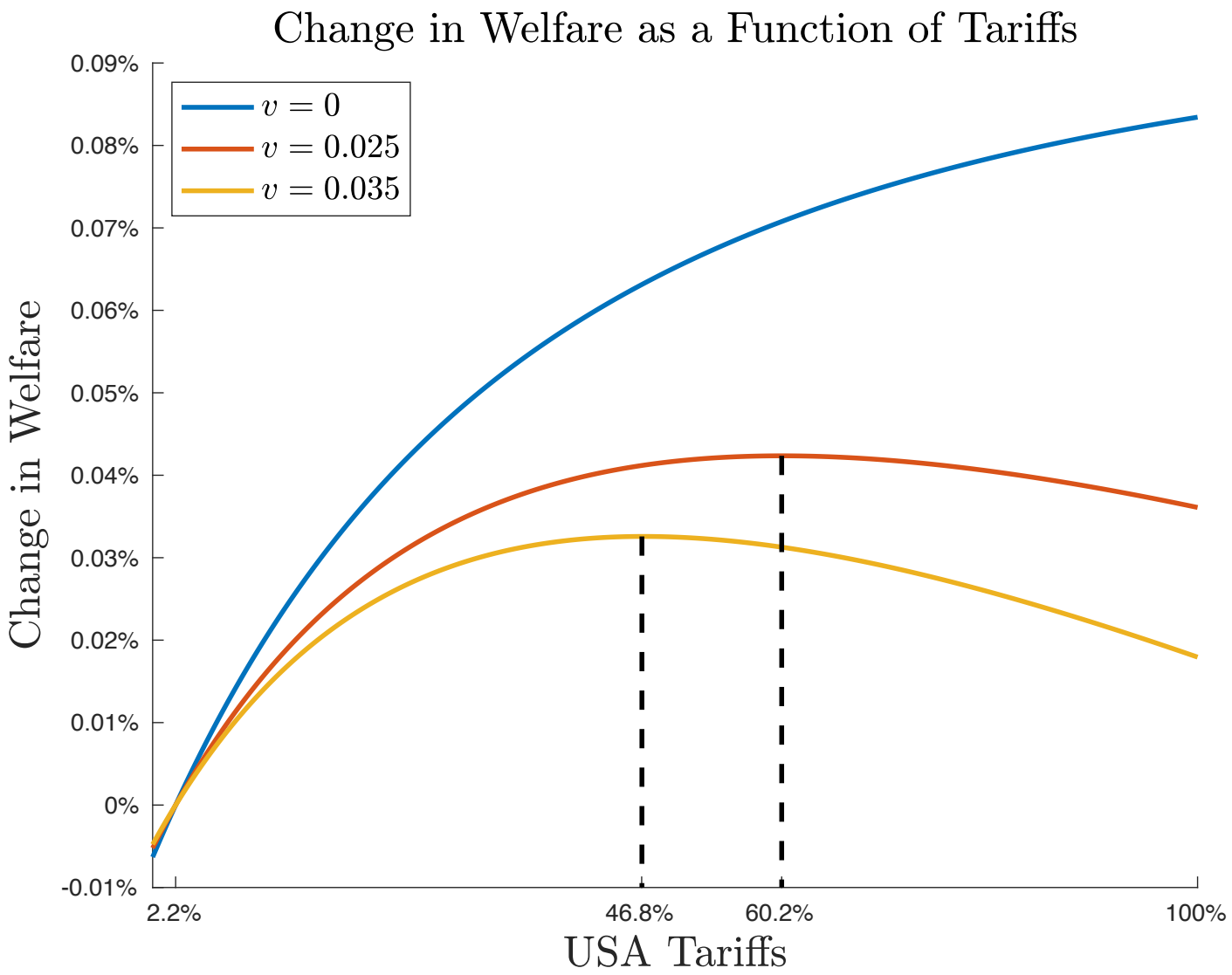

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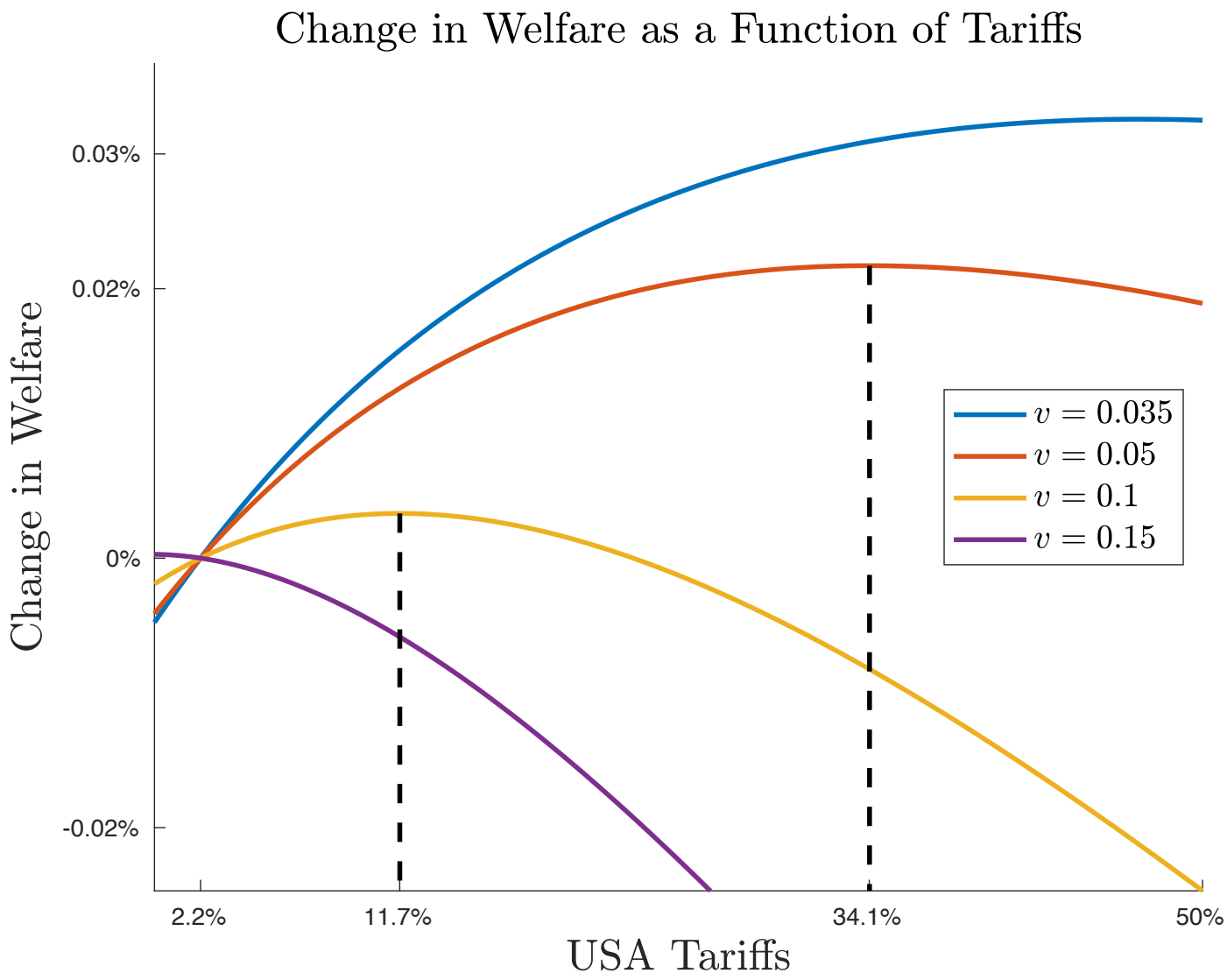

Effects of Tariffs and Tariff Wars on Welfare

TABLE 1
WELFARE ESTIMATES

Incidence	20% unilateral	20% trade war	50% unilateral	50% trade war
$v = 0$	0.036%	0.015%	0.065%	0.000%
$v = 0.05$	0.019%	−0.003%	0.019%	−0.045%
$v = 0.10$	0.001%	−0.020%	−0.025%	−0.089%
$v = 0.15$	−0.015%	−0.036%	−0.066%	−0.129%
$v = 1$	−0.249%	−0.268%	−0.516%	−0.572%

Summary

- Construct a quantitative trade model of global assembly and sourcing:
  - Global Firms;
- Provide a method for solving extensive margin:
  - The changing geography of production;
- Construct the new data set: linked Census and BEA:
  - Structural estimation of the model;
- Perform counterfactuals in GE setting:
  - Suggestions for trade policy.