Global Sourcing and Multinational Activity: A Unified Approach

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Motivation

- Trade flows are dominated by very large firms
- The largest trading firms tend to be multinational enterprises (MNEs)
- MNEs' foreign sourcing and global production decisions are likely related, but studied separately
  - Data limitations
  - Theory gets too complicated too quickly (especially, multi-country models)
- We lack a unified framework to study the effects of policy changes on global production
  - Tariffs affect trade costs *and* MNEs' global production decisions

Main Contributions

- Newly linked Bureau of Economic Analysis and US Census data
  - Aggregate importance of MNEs
  - Some salient feature of MNEs margins of trade and their global operations
  - Document strong relationship between importing and FDI
- Framework to analyze firms' *joint* FDI and foreign sourcing decisions
  - Key novel feature: firm-level global sourcing strategy (shared by all plants)
  - Pin down intensive and extensive margins of global sourcing and global production
  - In an extension, we also consider the extensive margin of exporting (not today)
- Applications (via stylized examples)
  - Non-monotonic effects of tariffs on final goods and on inputs on US manufacturing

We exploit newly-linked 2007 US Census-BEA data

- Data from the US Census Bureau
  - Longitudinal Business Database: universe private, non-farm employer establishments
  - All Economic Censuses: sales and inputs
  - Longitudinal Foreign Trade Transactions: imports and exports (we exclude oil)
  - Company Organization Survey (COS): firm ownership information

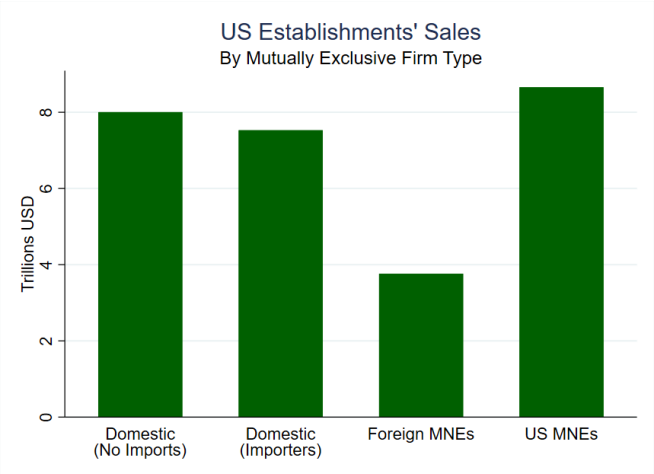
- BEA data on direct investment and multinational enterprises (MNEs)
  - BEA US Direct Investment Abroad (outward FDI, BE-11)
  - BEA Foreign Direct Investment in the United States (inward FDI, BE-12)

- Combine data via 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

New firm definitions using the combined data

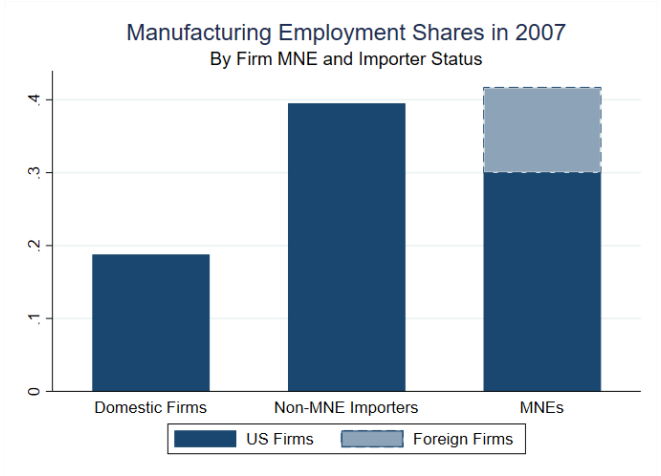
- US MNE:
  - Has majority-owned foreign affiliates (*FAs*)
  - We focus on firms with majority-owned foreign manufacturing affiliates (*FMAs*)
- Foreign-owned MNE:
  - Majority-owned by a foreign firm according to BEA
  - For firms with majority-owned *FA* activity, also use Census employment and ownership data
- Domestic firm:
  - Non-MNE firm that does not import (Domestic)
  - Non-MNE firm that imports (Domestic Importer)
- Manufacturing firm: firm with one or more manufacturing plants in United States

MNEs are few in number, but they are LARGE



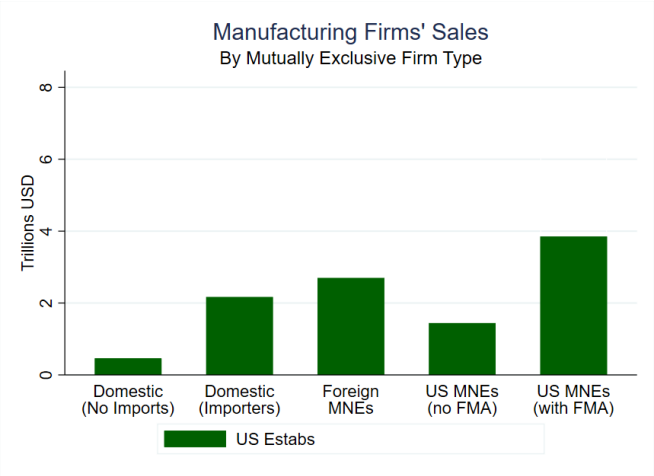
- There are 7.8K foreign MNEs (0.17%) that cover 6% of employment and 13% of sales
- There are 2.8k US MNEs (0.06%) that cover 19% of employment and 31% of sales

MNEs dominate US manufacturing activity (employment)



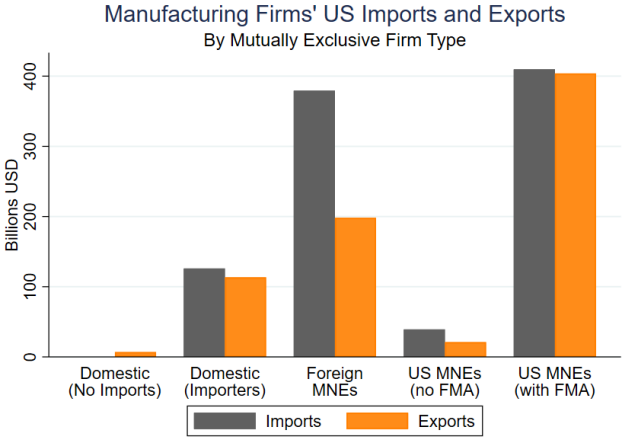
- US MNEs (1,550) and Foreign MNEs (2,200) account for 41% of US manuf. employment

MNEs dominate US manufacturing activity (sales)



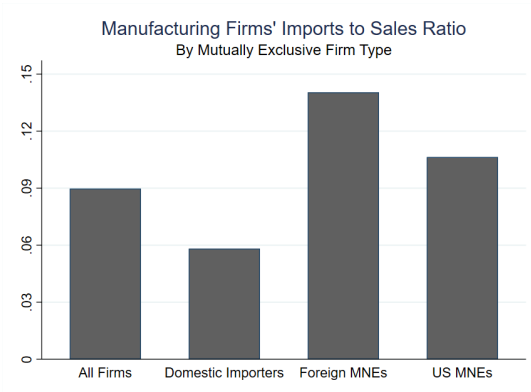
- US MNEs (1,550) and Foreign MNEs (2,200) account for 74% of manuf firms' sales

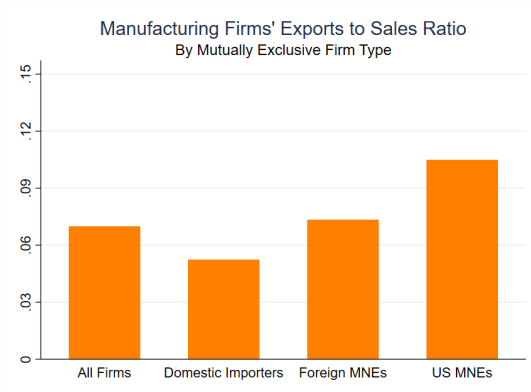
MNEs with US manufacturing activity dominate trade flows



- MNEs with US manuf estabs account for 58% of US imports and 66% of exports
- MNEs account for 87% of **manufacturing** firms' imports and 84% of their exports

MNEs are more import and export intensive





- Foreign-owned MNEs are most import intensive; US MNEs are most export intensive

MNEs feature significantly richer extensive margins of import and export

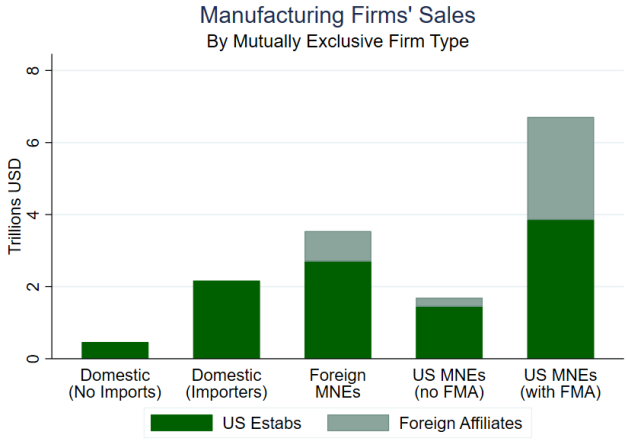
Panel A: Import Patterns

Firm Type	No. of Import Countries	Share of Importers	Share of Imports	Number of Import Countries Average	Number of Import Countries Median
Domestic	1	0.47	0.01	1	1
	2+	0.48	0.17	4	**3**
Foreign-Owned MNEs	1	0.00	0.00	1	1
	2+	0.03	0.40	12	**8**
US MNEs	1	0.00	0.00	1	1
	2+	0.02	0.43	21	**17**

Panel B: Export Patterns

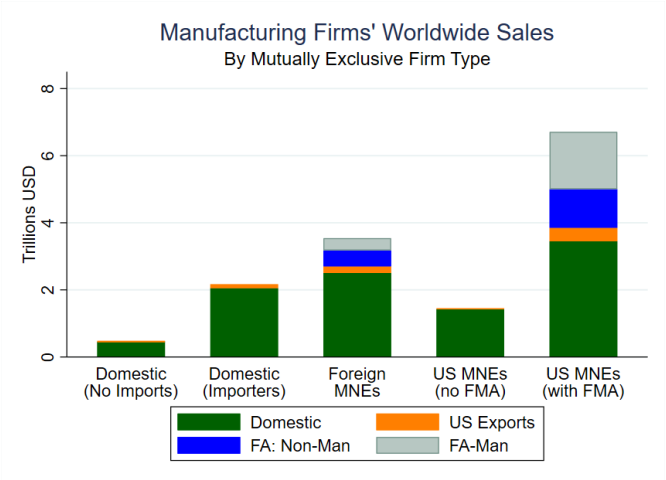
Firm Type	No. of Export Countries	Share of Exporters	Share of Exports	Number of Export Countries Average	Number of Export Countries Median
Domestic	1	0.44	0.01	1	1
	2+	0.52	0.18	8	**4**
Foreign-Owned MNEs	1	0.00	0.00	1	1
	2+	0.03	0.27	19	**10**
US MNEs	1	0.00	0.00	1	1
	2+	0.02	0.54	40	**35**

FA sales of US MNEs are LARGE and close to their US establishment sales



- US manuf MNEs' foreign affiliate sales equal 74% of their US establishments' sales

In fact, US MNEs sell abroad overwhelmingly via FA sales!



- US manuf MNEs' FA sales are four times larger than these US establishments' exports

Estimate relationship between importing and foreign affiliate activity

$$
\begin{aligned}
Pr(y_{frc} = 1|X) = \quad & \beta_D log(distance_c) + log(GDP_c) + \beta_L Language_c + \beta_C Contiguous_c + \\
& \beta_A Affiliate_{fc} + \beta_{AR} AffiliateRegion_{fr} + \\
& \beta_F Foreign_{fc} + \beta_{FR} ForeignRegion_{fr} + \gamma_f + \gamma_r
\end{aligned}
$$

- $y_{frc} = 1$ if firm f imports from country c in region r
- Standard gravity variables (distance, GDP, common language, contiguity)
- $Affiliate_{fc}$ is an indicators for whether firm has an affiliate in country c
- $AffiliateRegion_{fr}$ is an indicator for whether firm has an affiliate in the same region
- $Foreign_{fc}$ is indicator for whether firm is foreign owned by country
- $ForeignRegion_{fr}$ is an indicator for whether firm is foreign owned a country in the region

Extensive margin of imports is related to country MNE activity

Dependent variable is an indicator for whether firm f imports from country c in region r

	(1)	(2)	(3)	(4)	(5)	(6)
Common Language$_c$	0.002	0.001	0.001	0.001		
	(0.008)	(0.008)	(0.008)	(0.008)		
$log(distance_c)$	-0.017	-0.006	-0.006	-0.006		
	(0.013)	(0.009)	(0.009)	(0.009)		
$log(GDP_c)$	0.015***	0.014***	0.014***	0.014***		
	(0.003)	(0.003)	(0.002)	(0.002)		
Contiguous$_c$		0.133***	0.128***	0.129***		
		(0.013)	(0.013)	(0.013)		
Affiliate$_{fc}$			0.550***	0.582***	0.501***	0.536***
			(0.028)	(0.031)	(0.025)	(0.028)
Foreign-Owned$_{fc}$			0.726***	0.735***	0.669***	0.678***
			(0.046)	(0.047)	(0.047)	(0.047)
Affiliate in Region$_{fr}$				0.069***		0.074***
				(0.015)		(0.015)
Foreign in Region$_{fr}$				0.086***		0.090***
				(0.020)		(0.021)
Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes
Region FEs	Yes	Yes	Yes	Yes	No	No
Country FEs	No	No	No	No	Yes	Yes
Adj. R2	0.194	0.197	0.215	0.216	0.278	0.28
Observations (000s)	6,330	6,330	6,330	6,330	6,330	6,330

Standard errors two-way clustered by firm and by country. ** p<0.05, *** p<0.01.

- FA in same region raises prob. of importing by 7pp (US MNEs) and 9pp (Foreign MNEs)

Intensive margin of imports is related to country MNE activity

Dependent variable is $log(imports_{frc})$

	(1)	(2)	(3)	(4)	(5)	(6)
Common Language$_c$	-0.264***	-0.252**	-0.272**	-0.269**		
	(0.101)	(0.110)	(0.113)	(0.113)		
$log(distance_c)$	-0.719***	-0.157	-0.105	-0.107		
	(0.191)	(0.347)	(0.386)	(0.385)		
$log(GDP_c)$	0.392***	0.377***	0.326***	0.331***		
	(0.050)	(0.054)	(0.058)	(0.058)		
Contiguous$_c$		0.874**	0.898**	0.885**		
		(0.378)	(0.411)	(0.411)		
Affiliate$_{fc}$			2.265***	2.363***	2.224***	2.331***
			(0.127)	(0.112)	(0.123)	(0.110)
Foreign-Owned$_{fc}$			3.399***	3.545***	3.617***	3.765***
			(0.165)	(0.177)	(0.227)	(0.223)
Affiliate in Region$_{fr}$				0.162		0.181
				(0.115)		(0.113)
Foreign in Region$_{fr}$				0.468***		0.480***
				(0.156)		(0.160)
Firm FEs	Yes	Yes	Yes	Yes	Yes	Yes
Region FEs	Yes	Yes	Yes	Yes	No	No
Country FEs	No	No	No	No	Yes	Yes
Adj. R2	0.233	0.234	0.268	0.269	0.282	0.283
Observations	177,000	177,000	177,000	177,000	177,000	177,000

Standard errors two-way clustered by firm and by country. ** p<0.05, *** p<0.01.

- More mixed results for intensive margin (no effect for US MNEs of FA in same region)

Overview of the theory

- Unified framework with global assembly and global sourcing
  - Combines Tintelnot (2017) with Antràs, Fort and Tintelnot (2017)
- Single downstream manufacturing sector with scale economies and free entry
  - CES preferences, firm heterogeneity, and monopolistic competition downstream (Melitz' 03)
  - CES technology, cost heterogeneity, and perfect competition upstream (Eaton-Kortum' 02)
  - J countries with differing trade costs, wages, and productivities
- A final-good producer in the model:
  1. Pays fixed cost to enter a headquarter country and learn its core productivity
  1. Decides whether to pay additional fixed cost to 'go global' (to market goods worldwide)
  2. Chooses countries in which to produce final goods and learns productivity per good
  3. Chooses countries from which to source inputs and learns marginal cost of each input
  4. Assembly plants source each input from cheapest source
  5. Consumers purchase each good from cheapest assembly plant

Firm's sourcing and assembly decisions are interrelated

- Adding an assembly location entails a fixed cost, but it also:
  - reduces the trade costs of selling to some markets (export-platform FDI)
  - allows the firm to obtain additional productivity draws ('learn from locals', Armington)
  - pairs of assembly locations can be complements or substitutes (cannibalization versus complementarity effects)
- Adding a new source of inputs entails a fixed cost, but it also:
  - reduces the costs of procuring some inputs
  - allows the firm to obtain additional productivity draws (reduces costs and expands scale)
  - pairs of sourcing locations can be complements or substitutes (largely as in AFT' 17)
- A new force leading to complementarity between both extensive margins
  - richer sourcing strategy reduces marginal costs, makes richer assembly strategy + appealing
  - richer assembly strategy increases firm sales, makes richer sourcing strategy + appealing

Key Equations from Formal Model

- Preferences over manufacturing are nested CES aggregator

$$U_{Mi} = \left(\int_{\varphi \in \Omega_i} \left(\int_0^1 q_i(\varphi, \omega)^{(\sigma_w - 1)/\sigma_w} \, d\omega \right)^{\frac{\sigma_w}{\sigma_w - 1} \frac{(\sigma - 1)}{\sigma}} d\varphi \right)^{\sigma/(\sigma-1)}, \quad \sigma_w, \sigma > 1.$$

- Marginal cost in assembly plant k is constant and given by:

$$c_k(\varphi, \omega) = \underbrace{\frac{1}{\varphi}}_{\text{Core productivity}} \underbrace{\frac{1}{z_k(\varphi, \omega)}}_{\text{Assembly productivity}} \underbrace{(w_k)^{1-\alpha}}_{\text{Assembly labor costs}} \left(\int_0^1 \underbrace{\left(\tau^s_{jk(v)} a_{j(v)}(v, \varphi) w_{j(v)} \right)^{1-\rho}}_{\text{Marginal cost of input v}} dv \right)^{\alpha/(1-\rho)}$$

$$Pr(a_j(v, \varphi) \geq a) = e^{-T_j^s a^{\theta^s}}; \qquad Pr(1/z_k(\varphi, \omega) \geq a) = e^{-T_k^a a^{\theta^a}}.$$

Optimal Assembly and Sourcing Strategies

- Define $\xi^a_{ki} = T^a_k \left(\tau^a_{ki}\right)^{-\theta^a} \left(w_k\right)^{-(1-\alpha)\theta^a}$ and $\xi^s_{jk} = T^s_j \left(\tau^s_{jk} w_j\right)^{-\theta^s}$
- Firm chooses $\mathcal{I}^a_k \in \{0,1\}^J$ and $\mathcal{I}^s_j \in \{0,1\}^J$ to solve

$$\max \ \pi_h(\varphi) = \kappa\varphi^{\sigma-1} \sum_{i\in J} E_i P_i^{\sigma-1} \left(\sum_{k\in J} \mathcal{I}^a_k \cdot \xi^a_{ki} \left(\sum_{j\in J} \mathcal{I}^s_j \cdot \xi^s_{jk} \right)^{\frac{\alpha\theta^a}{\theta^s}} \right)^{\frac{(\sigma-1)}{\theta^a}} - \sum_{j\in J} \mathcal{I}^s_j \cdot w_h f^s_{hj} - \sum_{k\in J} \mathcal{I}^a_k \cdot w_h f^a_{hk} - w_h f^g_h,$$

- This is a $2^{J\times 2}$ problem; even for $J = 20$, this is roughly 10^{12}
- Can we exploit some properties of the profit function? (as in Antràs, Fort and Tintelnot, 2017)

Some Properties of the Profit Function

Lemma

The profit function $\pi_h(\varphi, \mathcal{J}_h(\varphi), \mathcal{K}_h(\varphi))$ *features:*

1. *increasing differences in* $\left(\mathcal{I}_k^a, \mathcal{I}_{k'}^a\right)$ *for* $k, k' \in \{1, ..., J\}$ *and* $k \neq k'$ *when* $\sigma - 1 > \theta^a$*, and decreasing differences in* $\left(\mathcal{I}_k^a, \mathcal{I}_{k'}^a\right)$ *for* $k, k' \in \{1, ..., J\}$ *and* $k \neq k'$ *when* $\sigma - 1 < \theta^a$*;*
2. *increasing differences in* $\left(\mathcal{I}_j^s, \mathcal{I}_{j'}^s\right)$ *for* $j, j' \in \{1, ..., J\}$ *when* $\sigma - 1 \geq \theta^a > \theta^s/\alpha$*, and decreasing differences in* $\left(\mathcal{I}_j^s, \mathcal{I}_{j'}^s\right)$ *for* $j, j' \in \{1, ..., J\}$ *when* $\sigma - 1 < \theta^a < \theta^s/\alpha$*;*
3. *increasing differences in* $\left(\mathcal{I}_k^a, \mathcal{I}_j^s\right)$ *for* $k \in \{1, ..., J\}$ *and* $j \in \{1, ..., J\}$ *when* $\sigma - 1 \geq \theta^a$*.*

- In words:
  - pairs of assembly locations can be substitutes or complements
  - pairs of sourcing locations can be substitutes or complements
  - pairs of assembly and sourcing locations can be (but need not be) complements
  - profit function does not typically feature 'single crossing' property

General Results

Proposition

The optimal assembly and sourcing strategies imply that the vector of a firm's global production capabilities is such that $\sum_{i \in J} \left(\Psi_{hi}\left(\varphi\right)\right)^{(\sigma-1)/\theta^a} E_i P_i^{\sigma-1}$ *is nondecreasing in* φ.

- More productive firms choose a vector of global production capabilities that translates into magnified differences in world sales.

Proposition

There exists a threshold productivity φ_h^**, such that only firms headquartered in h with* $\varphi > \varphi_h^*$ *find it optimal to become global firms.*

- There is selection into 'going global'.

Case with Pervasive Complementarities

- Assume $\sigma - 1 \geq \theta^a > \theta^s/\alpha$.

Proposition

Whenever $\sigma - 1 \geq \theta^a \geq \theta^s/\alpha$, *we necessarily have that* $\mathcal{J}_h(\varphi_L) \subseteq \mathcal{J}_h(\varphi_H)$ *and* $\mathcal{K}_h(\varphi_L) \subseteq \mathcal{K}_h(\varphi_H)$ *for* $\varphi_H \geq \varphi_L$, *where* $\mathcal{J}_i(\varphi) = \left\{j : \mathcal{I}^s_{hj} = 1\right\}$ *and* $\mathcal{K}_i(\varphi) = \{k : \mathcal{I}^a_{hk}(\varphi) = 1\}$.

- Model delivers a strict hierarchical order in the extensive margin of global sourcing and of global assembly
  - Weaker version: more productive firms select into more sourcing and assembly locations
- Not robust to heterogeneous fixed costs, but iterative algorithm (Jia'08, AFT'17) still implementable in that case
  - Never implementable with cannibalization effects

Zooming in on the Assembly-Sourcing Complementarity

- Assume $\sigma - 1 = \theta^a = \theta^s/\alpha$
- Firm will find the addition of j' profitable whenever

$$\kappa\varphi^{\sigma-1}\sum_{i\in J}B_i\sum_{k\in\mathcal{K}_h(\varphi)}T^a_k\left(\tau^a_{ki}\right)^{-\theta^a}\left(w_k\right)^{-(1-\alpha)\theta^a}T^s_{j'}\left(\tau^s_{j'k}w_{j'}\right)^{-\theta^s} > w_h f^s_{hj'},$$

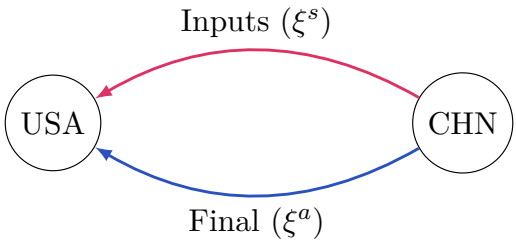
- Further isolate the role of geography:

$$\kappa\varphi^{\sigma-1}G^aG^s\sum_{k\in\mathcal{K}_h(\varphi)}\sum_{i\in J}B_i\left(\tau^a_{ki}\right)^{-\theta^a}\left(\tau^s_{j'k}\right)^{-\theta^s} > w_h f^s_h. \tag{1}$$

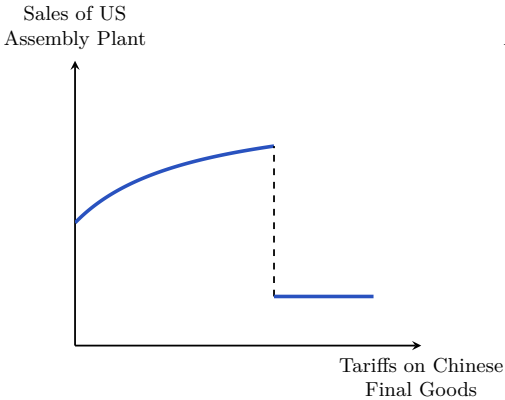
- Whether an input source j' is activated or not depends on a market-access-weighted 'distance' of this source market j' from all the firm's assembly plants
- This is in line with our reduced-form results (although we predict that **only** extensive margin should be active, this is not robust to including 'headquarter gravity')

The Effect of Tariffs: Illustrative Example

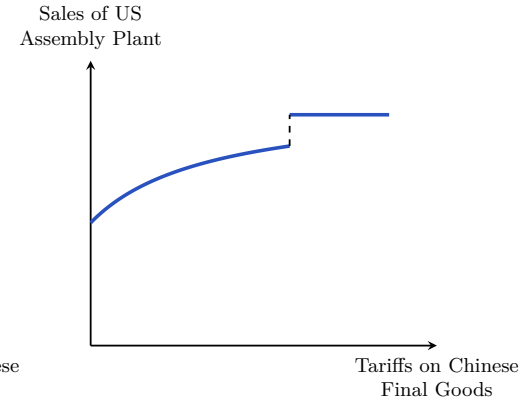
1. Two countries: USA and China
2. Firm's goods are only demanded in the US, so $E_{ch}P_{ch}^{\sigma-1} = 0$.
3. Fixed costs of assembly are zero in both countries, so $\mathcal{K}_h(\varphi) = \{US, Ch\}$.
4. Fixed costs of sourcing in the US are 0, so $\{US\} \in \mathcal{J}_h(\varphi)$.
5. The US does not export intermediate inputs to China, or $\xi^s_{us,ch} = 0$.
6. Pairs of assembly locations are substitutes $\sigma - 1 < \theta^a$, while pairs of sourcing locations are independent $\theta^a = \theta^s/\alpha$.



The Effect of Tariffs: Illustrative Example



(a) Firm-level Sourcing Strategy



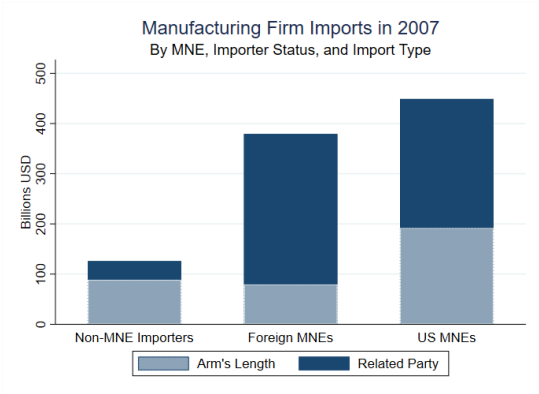
(b) Plant-level Sourcing Strategy

- Higher tariffs initially boost US assembly, but Chinese assembly eventually shuts down
- The latter never happens with plant-level global sourcing decisions

Conclusions

- Multinational firms are dominant players in domestic employment, output, and trade
- MNEs' foreign sourcing and production decisions are interrelated
- This carries important implications for how the geography of manufacturing activity responds to trade policy

MNEs trade A LOT at arm's-length



- MNE operations not only relevant for intrafirm trade

Formal Model: Endowments and Preferences

- J countries indexed by i when consuming, by k when assemblying, by j when providing inputs, and by h when hosting headquarters (entry)
- Fixed (equipped) labor force L_j for $j \in \{1, ..., J\}$, wage w_j
- Endogenous measure Ω_i of manufacturing firms (index φ) selling final goods in country i
- Each firm sells a unit measure of varieties (index ω)
- Consumers worldwide spend a share η of income on manufacturing goods
- Preferences over manufacturing are nested CES aggregator

$$U_{Mi} = \left(\int_{\varphi \in \Omega_i} \left(\int_0^1 q_i(\varphi, \omega)^{(\sigma_w - 1)/\sigma_w} \, \mathrm{d}\omega \right)^{\frac{\sigma_w}{\sigma_w - 1} \frac{(\sigma - 1)}{\sigma}} \mathrm{d}\varphi \right)^{\sigma/(\sigma - 1)}, \quad \sigma_w, \sigma > 1.$$

  - allow different substitutability within σ_w and across σ firms' varieties

Technology and Market Structure

- Non-manufacturing sector is perfectly competitive and operates under a constant-returns-to scale technology in labor
- Manufacturing sector is monopolistically competitive; free entry
- Manufacturing varieties are produced under IRS due to various fixed costs
  - fixed cost of entry: $w_h f_h^e$ to open headquarters in h
  - fixed cost of 'going global': $w_h f_h^g$ to market goods worldwide
  - fixed cost of assembly: $w_h f_{hk}^a$ to assemble in country k
  - fixed cost of sourcing: $w_h f_{hj}^s$ to be able to buy inputs from j
- **Global Assembly Strategy** $\mathcal{K}_h(\varphi)$**:** set of countries k for which a firm headquartered in h has paid $w_h f_{hk}^a$
- **Global Sourcing Strategy** $\mathcal{J}_h(\varphi)$**:** set of countries j for which a firm headquartered in h has paid $w_h f_{hj}^s$
  - Note: *any* assembly plant $k \in \mathcal{K}_h(\varphi)$ can use inputs from $j \in \mathcal{J}_h(\varphi)$

Technology and Market Structure

- Marginal cost in assembly plant k is constant and given by:

$$c_k(\varphi,\omega) = \underbrace{\frac{1}{\varphi}}_{\text{Core productivity}} \underbrace{\frac{1}{z_k(\varphi,\omega)}}_{\text{Assembly productivity}} \underbrace{(w_k)^{1-\alpha}}_{\text{Assembly labor costs}} \left(\int_0^1 \underbrace{\left(\tau^s_{jk(v)} a_{j(v)}(v,\varphi)\, w_{j(v)}\right)^{1-\rho}}_{\text{Marginal cost of input v}} dv \right)^{\alpha/(1-\rho)}$$

- Iceberg trade costs τ^s_{jk} and τ^a_{ki}
- Probabilistic formulation of assembly and input productivities:

$$\Pr(a_j(v,\varphi) \geq a) = e^{-T^s_j a^{\theta^s}}, \quad \text{with } T^s_j > 0$$

$$\Pr(1/z_k(\varphi,\omega) \geq a) = e^{-T^a_k a^{\theta^a}}, \quad \text{with } T^a_k > 0$$

Firm Behavior for Fixed Assembly and Sourcing Strategies

- Share of intermediate input purchases sourced by an assembly plant in $k \in \mathcal{K}_h(\varphi)$ from any country j is

$$\chi_{hjk}(\varphi) = \frac{T_j^s \left(\tau_{jk}^s w_j\right)^{-\theta^s}}{\Theta_{hk}(\varphi)} \quad \text{if } j \in \mathcal{J}_h(\varphi) \tag{2}$$

  and $\chi_{hjk}(\varphi) = 0$ otherwise, where

$$\Theta_{hk}(\varphi) \equiv \sum_{j' \in \mathcal{J}_h(\varphi)} T_{j'}^s \left(\tau_{j'k}^s w_{j'}\right)^{-\theta^s}. \tag{3}$$

- $T_j^s \left(\tau_{jk}^s w_j\right)^{-\theta^s}$ captures the sourcing potential of country j from the point of view of assembly plants in k
- $\Theta_{hk}(\varphi)$ summarizes the sourcing capability of an assembly plant in k producing goods for a firm φ headquartered in h

Firm Behavior for Fixed Assembly and Sourcing Strategies

- Share of firm φ's sales in market i originating from assembly plants in k is given by:

$$\mu_{hki} = \frac{T_k^a \left(\tau_{ki}^a\right)^{-\theta^a} \left(w_k\right)^{-(1-\alpha)\theta^a} \left(\Theta_{hk}\left(\varphi\right)\right)^{\alpha\theta^a/\theta^s}}{\Psi_{hi}}$$

with

$$\Psi_{hi}\left(\varphi\right) = \sum_{k' \in \mathcal{K}_h(\varphi)} T_{k'}^a \left(\tau_{k'i}^a\right)^{-\theta^a} \left(w_{k'}\right)^{-(1-\alpha)\theta^a} \left(\Theta_{hk'}\left(\varphi\right)\right)^{\alpha\theta^a/\theta^s}.$$

- $T_k^a \left(\tau_{ki}^a\right)^{-\theta^a} \left(w_k\right)^{-(1-\alpha)\theta^a}$ captures assembly cost potential of country k when selling to country i
- $\Psi_{hi}\left(\varphi\right)$ summarizes the global production capability of a firm φ headquartered in country h when selling in i.

Firm Behavior for Fixed Assembly and Sourcing Strategies

- Price index at which firm φ based in h sells its unit measure of varieties in market i:

$$p_{hi}(\varphi) = \frac{\sigma}{\sigma - 1} \frac{1}{\varphi} \left(\zeta \Psi_{hi}(\varphi)\right)^{-1/\theta^a},$$

  and firm sales in i are $\left(p_{hi}(\varphi)\right)^{1-\sigma} E_i P_i^{\sigma-1}$

- Assembly plant k overall sales are

$$s_{hk}(\varphi) = \widetilde{\zeta} \varphi^{\sigma-1} \sum_{i \in J} \mu_{hki} \times \left(\Psi_{hi}(\varphi)\right)^{(\sigma-1)/\theta^a} E_i P_i^{\sigma-1}$$

- Firm's operating profits conditional on $\mathcal{J}_h(\varphi)$ and $\mathcal{K}_h(\varphi)$ are

$$\pi_h(\varphi) = \frac{1}{\sigma} \widetilde{\zeta} \varphi^{\sigma-1} \sum_{i \in J} \left(\Psi_{hi}(\varphi)\right)^{(\sigma-1)/\theta^a} E_i P_i^{\sigma-1}$$

Closing the Model: Industry and General Equilibrium

- Free entry implies $E_i = w_i L_i$
- Consumers spend constant share η on manufacturing sector
- Assume non-manufacturing sector pins down wages and (for now) assume that wage is independent of manufacturing equilibrium
  - e.g., non-manufacturing goods are freely traded and produced in i
  - all general equilibrium action is on allocation of labor to manufacturing and on price index, rather than on wages
- Industry Equilibrium is characterized by:
  - fixed point for vector of price indices P_i
  - free entry condition
- Assume balanced trade (can easily accommodate trade imbalances)