The Margins of Global Sourcing: Theory and Evidence from U.S. Firms

Pol Antràs[1] Teresa Fort [2] Felix Tintelnot[3]

[1]Harvard University

[2]Tuck School at Dartmouth

[3]University of Chicago

Johns Hopkins University, SAIS

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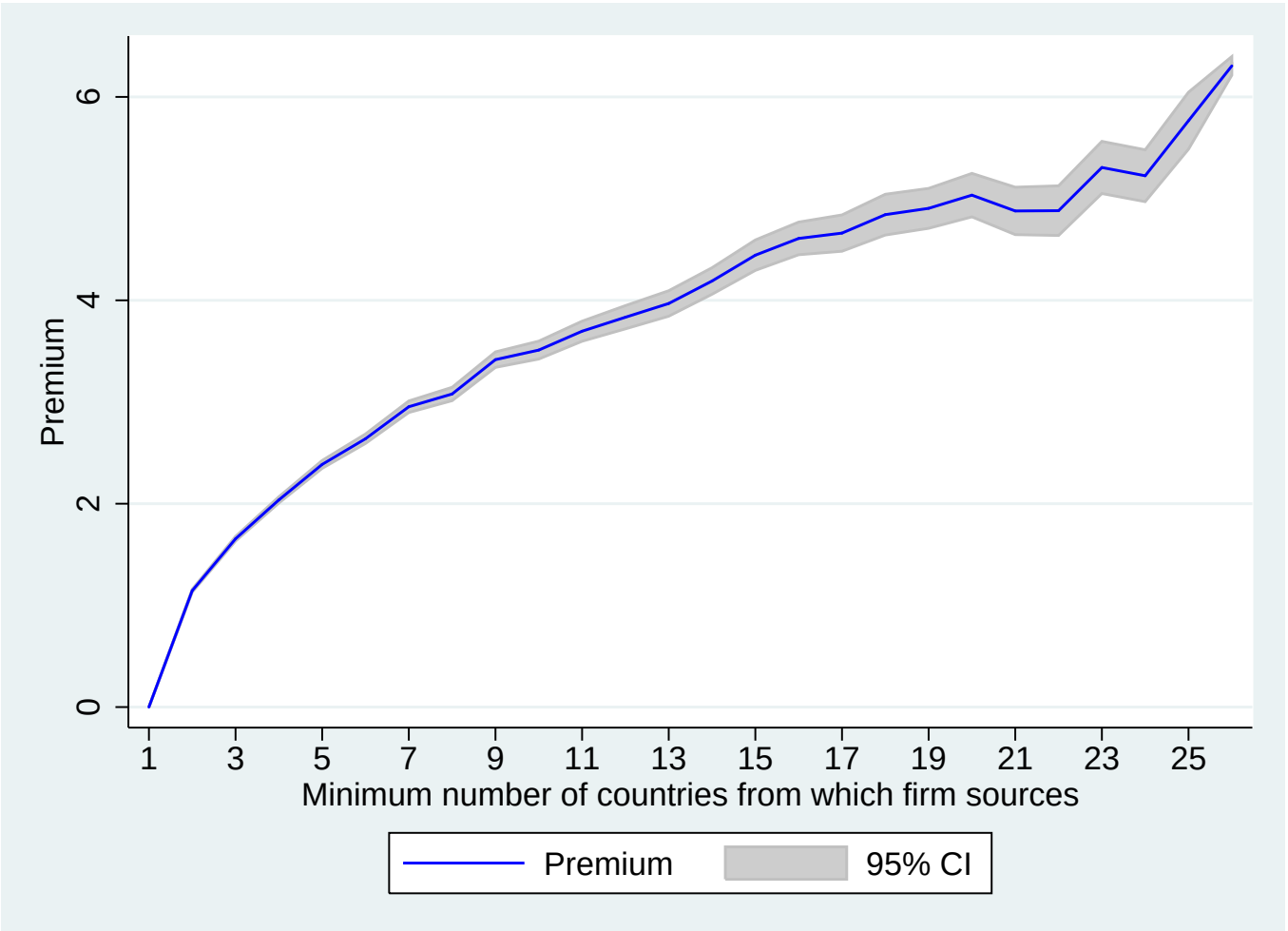
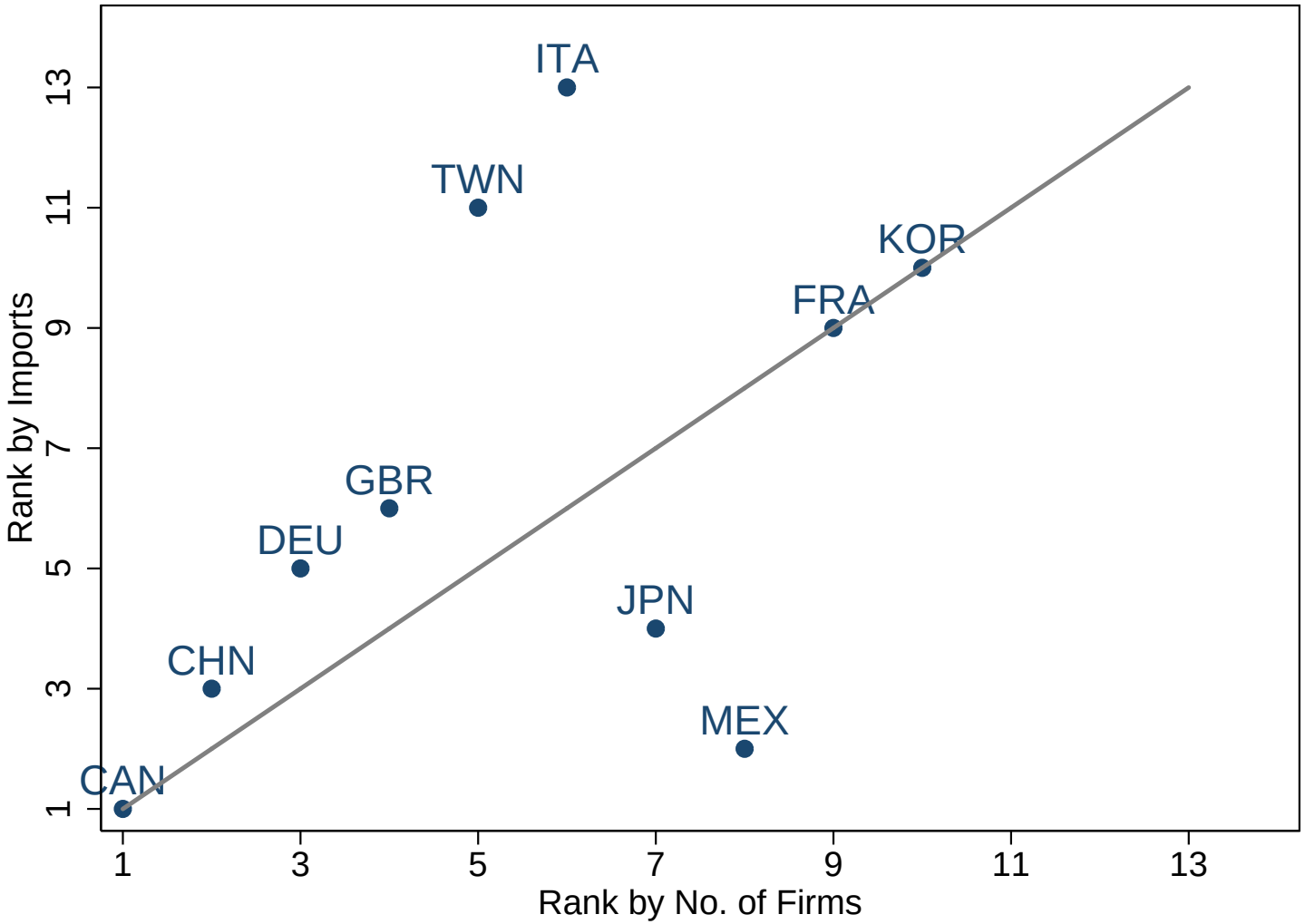
- Extensive margins (firms, products) account for most of the cross-country variation in U.S. imports and exports
- Extensive margins of exporting are much better understood than extensive margins of importing
- Yet two-thirds of world trade is intermediate inputs
    - Potential for importers' decisions to be key determinant of trade

2007 Importer Sales Premia by Number of Source Countries



▸ Premia2002 ▸ Premia with product controls

Country Rank by Importers vs. Total Imports



▸ Table

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- 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
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- Study effects of shocks to global sourcing
  - changes to aggregate trade patterns
  - heterogeneous impact across firm size distribution
  - distinction between net and gross changes in sourcing / employment

Related literature

- Empirical evidence on firm sourcing

  Bernard, Jensen, Redding, and Schott (2007, 2009); Bernard, Blanchard, Van Beveren, Vandebussche (2012); Fort (2014)

- Importing, firm efficiency, and markups

  Amiti and Konings (2007), Halpern, Koren, and Szeidl (2011), De Loecker, Goldberg, Khandelwal, and Pavcnik (2012), Gopinath and Neiman (2013), Amiti, Itskhoki, and Konings (2013), Garetto (2013)

- 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

  Tintelnot (2014), Morales, Sheu, and Zahler (2014), Yeaple (2003)

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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  - Monopolistic competition
- Intermediate good sector
  - Each firm uses a unit measure of (firm-specific) intermediate inputs
  - Trade cost τ_{ij} to import from country j by country i
  - Perfect competition $\Longrightarrow$ Marginal-cost pricing of inputs

Production Technology

- Final good requires the assembly of a bundle of intermediates
- Marginal cost of final good producer, φ:

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

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

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

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- Country-specific fixed cost of offshoring $w_i f_{ij}$

Firm's problem

- Firm chooses:
  - Sourcing strategy $\mathcal{J}_i(\varphi) \subseteq \{1, ..., J\}$
  - 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:

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

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- 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:

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

Optimal Sourcing Strategy

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

- Profits are supermodular in φ and $\sum_{j=1}^{J} I_{ij}T_j\left(\tau_{ij}w_j\right)^{-\theta}$
- Proposition: The solution $I_{ij}\left(\varphi\right)\in\{0,1\}_{j=1}^{J}$ to the optimal sourcing problem is such that a firm's sourcing capability $\Theta_i\left(\varphi\right)\equiv\sum_{j=1}^{J} I_{ij}\left(\varphi\right)T_j\left(\tau_{ij}w_j\right)^{-\theta}$ is nondecreasing in φ
- Implications for size distribution of firms

Optimal Sourcing Strategy

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

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

Optimal Sourcing Strategy

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

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

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

- Hierarchies in the complements case

Industry and General Equilibrium

- Consumers spend constant share η on manufacturing sector.

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

▸ Universal Importing ▸ General Case ▸ Independent Entry Decisions

Brief Discussion of Assumptions

- Model has many moving pieces
- Q1: Wouldn't it be simpler to have a single-input model?
- Q2: Wouldn't it be simpler to adopt an Armington model?

Multiple countries and inputs

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

	Mean	Std. Dev.	25th Ptile	Median	95th Ptile
Country Count	3.26	5.09	1	2	11
Product Count	11.91	48.89	1	3	41

- Although extreme, the continuum of inputs assumption helps a lot

Countries Per Product

- Number of countries per HS10 products imported by a firm

	Firm Level		
	Mean	Median	Max
Mean	1.11	1.00	1.61
Median	1.03	1.00	1.00
95%tile	1.78	1.00	4.00

- Not much evidence of differentiation by country of origin

▸ Export counts ▸ 3+ countries

Estimation

Data

- 2007 data from the U.S. Census Bureau
  - Economic Censuses
  - Import transactions data
- Sample is all manufacturing firms (around 250,000 firms)
  - Include firms with non-manufacturing activity
  - 23% of employment and 38% of sales
  - 65% of (non-mining) imports
  - A quarter of these firms imports
- Structural Estimation
  - Limit analysis to countries with 200+ U.S. importers
  - 64 countries and the U.S.

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, κ, and residual demand
  - Simulated method of moments + Jia's (2008) algorithm

$$\Pi(\mathcal{J},\varphi,f_{ij}^n) = \varphi^{\sigma-1}\left(\sum_{j=1}^{j\in\mathcal{J}} T_j(\tau_{ij}w_j)^{-\theta}\right)^{(\sigma-1)/\theta} \widetilde{B} - \sum_{j\in\mathcal{J}} f_{ij}^n$$

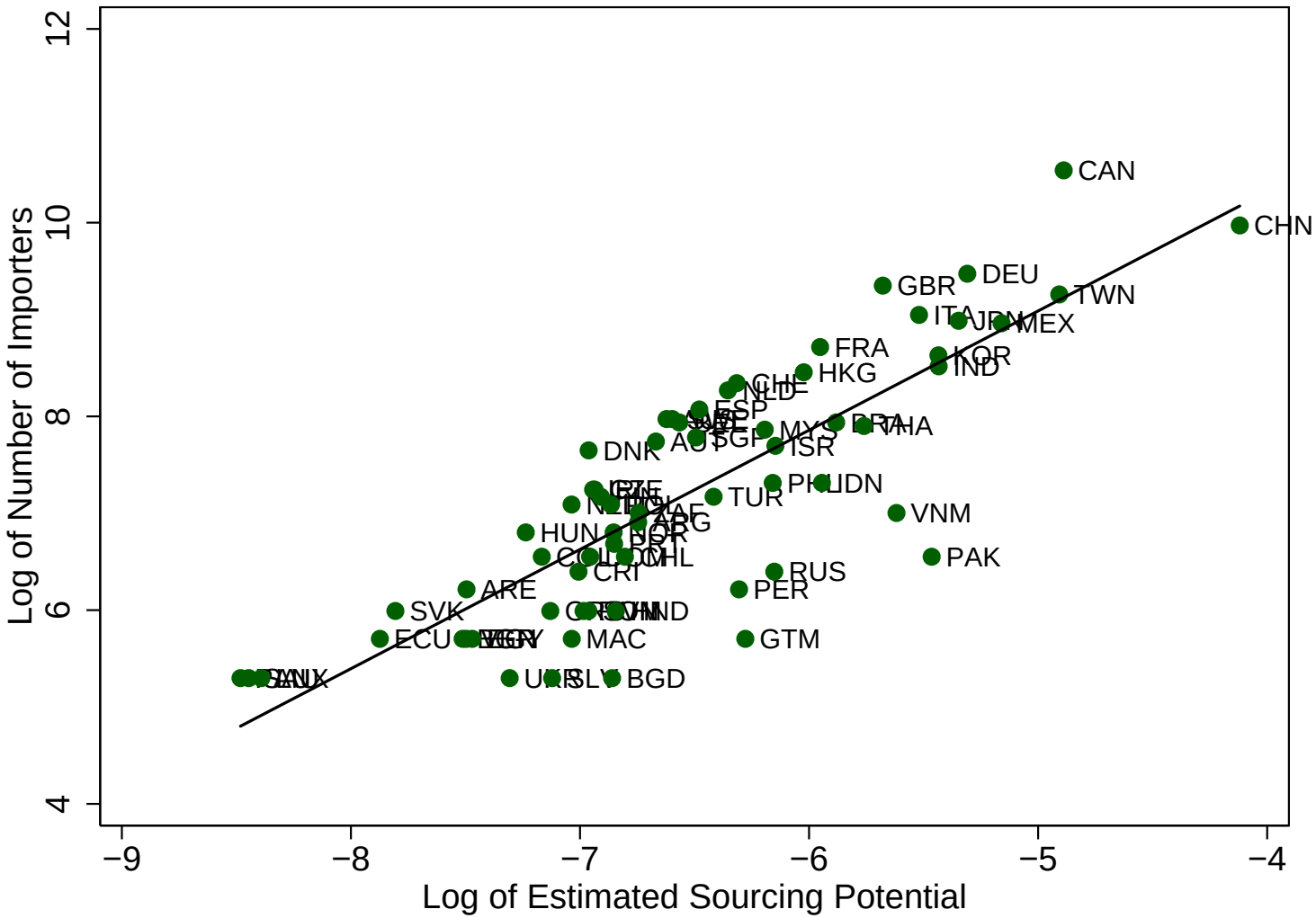
Step 1 Step 2 Step 3

Step 1: Estimate country sourcing potential

- Define country potential $\xi_j = T_j \left(\tau_{ij} w_j\right)^{-\theta}$
- Normalize firm share from j: $\chi^n_{ij} / \chi^n_{ii} = \frac{T_j (\tau_{ij} w_j)^{-\theta}}{\Theta^n_i} / \frac{T_i (\tau_{ii} w_i)^{-\theta}}{\Theta^n_i}$
- Log-Linearize: $\log \chi^n_{ij} - \log \chi^n_{ii} = \log \xi_j + \epsilon^n_j$
- Estimate via OLS

▸ Measuring input shares ▸ pottable

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

$$\begin{aligned}\log \hat{\xi}_j =& \beta_r \log \text{R\&D}_j + \beta_k \log \text{capital}_j + \beta_C \text{control corruption}_j \\ &+ \beta_n \log \text{no of firms} - \theta \log w_j \\ &- \theta \left(\log \beta_c + \beta_d \log \text{distance}_{ij} + \text{language}_{ij} \log \beta_l \right) + \iota_j\end{aligned}$$

Step 2b: Estimate dispersion of productivities

	$\log \xi$			log aggregate import		
	OLS	IV	IV	OLS	IV	IV
HC adjusted wage	-0.51***	**-2.01***	**-1.71**	-0.55	**-4.50**	**-4.56**
	(0.18)	(0.72)	(0.68)	(0.39)	(1.79)	(1.92)
log distance	-0.34*	-0.83**	-0.57**	-1.03**	-2.32***	-1.73**
	(0.19)	(0.35)	(0.28)	(0.41)	(0.86)	(0.79)
common language	0.26	0.20	0.19	0.44	0.27	0.48
	(0.21)	(0.31)	(0.28)	(0.46)	(0.76)	(0.78)
log R&D	0.40***	0.52***	0.54***	0.71***	1.02***	1.30***
	(0.05)	(0.09)	(0.13)	(0.10)	(0.21)	(0.36)
log KL	-0.17	0.61	0.44	-0.30	1.76*	1.64
	(0.17)	(0.43)	(0.38)	(0.38)	(1.07)	(1.05)
Control of corruption	0.11	0.70**	0.59*	0.31	1.86**	1.82**
	(0.15)	(0.34)	(0.31)	(0.33)	(0.85)	(0.86)
log no. of firms			-0.01			-0.37
			(0.14)			(0.39)
Constant	-3.60***	-6.60***	-5.97***	12.22***	4.32	6.98
	(0.89)	(1.87)	(1.55)	(1.96)	(4.61)	(4.35)
Observations	58	58	56	58	58	56

Implications of first two steps

- Sourcing from all countries, relative to only domestic sourcing
  - 7-10 percent lower input costs
  - 24-32 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 5 parameters via Simulated Method of Moments
  - Firm-country-specific fixed costs (distance, lang, cons, disp)
  - Residual demand

- Use 67 moments
  - Share of importing firms
  - Share of firms that sources from each country
  - Share of firms sourcing less than 50^{th} percentile from the U.S.

- Solve firm's problem
  - 2^{65} or about 10^{19} possible choices
  - Exploit complementarities in profit function
  - Build on algorithm in Jia (2008)

▸ Parameters

Marginal benefit of country j

- Profits of a sourcing strategy $\mathcal{J}$ for a firm
  - given productivity φ and fixed cost f_{ij}^n

$$\Pi\left(\mathcal{J}, \varphi, f_{ij}^n\right) = \varphi^{\sigma-1} B\left(\left(\gamma \Theta_i\left(\mathcal{J}\right)\right)^{(\sigma-1)/\theta}\right) - \sum_{j \in \mathcal{J}} f_{ij}^n,$$

- Marginal benefit of adding country j given φ and $\mathcal{J} \setminus j$

$$\varphi^{\sigma-1} \gamma^{(\sigma-1)/\theta} B\left(\Theta_i\left(\mathcal{J}\right)^{(\sigma-1)/\theta} - \Theta_i\left(\mathcal{J} \setminus j\right)^{(\sigma-1)/\theta}\right) - f_{ij}^n$$

Solve firm's problem using Jia (2008) algorithm

- Define mapping $V : \{0,1\}^N \to \{0,1\}^N$
  - $V_j(\mathcal{J}) = 1$ if marginal benefit of j given $\mathcal{J}$ is positive
- Increasing differences in profit function imply $V()$ is an increasing function
- Start from set $\mathcal{J}^0$ and use iterative application of V-operator to obtain lower bound for sourcing strategy
- Start from set $\mathcal{J}^1$ and use iterative application of V-operator to obtain upper bound for sourcing strategy
- If bounds do not overlap, evaluate all combinations between them

▸ Statistics on Performance

Parameter Estimates

B	0.123
β_c^f	0.011
β_d^f	0.340
β_l^f	0.611
β_{disp}^f	0.859

- Fixed costs 40 percent lower if common language
- Fixed costs increasing in distance with elasticity of .34 percent
- Median fixed cost estimates range from 9,000 to 28,000 USD

▸ Share of Importers

Counterfactual

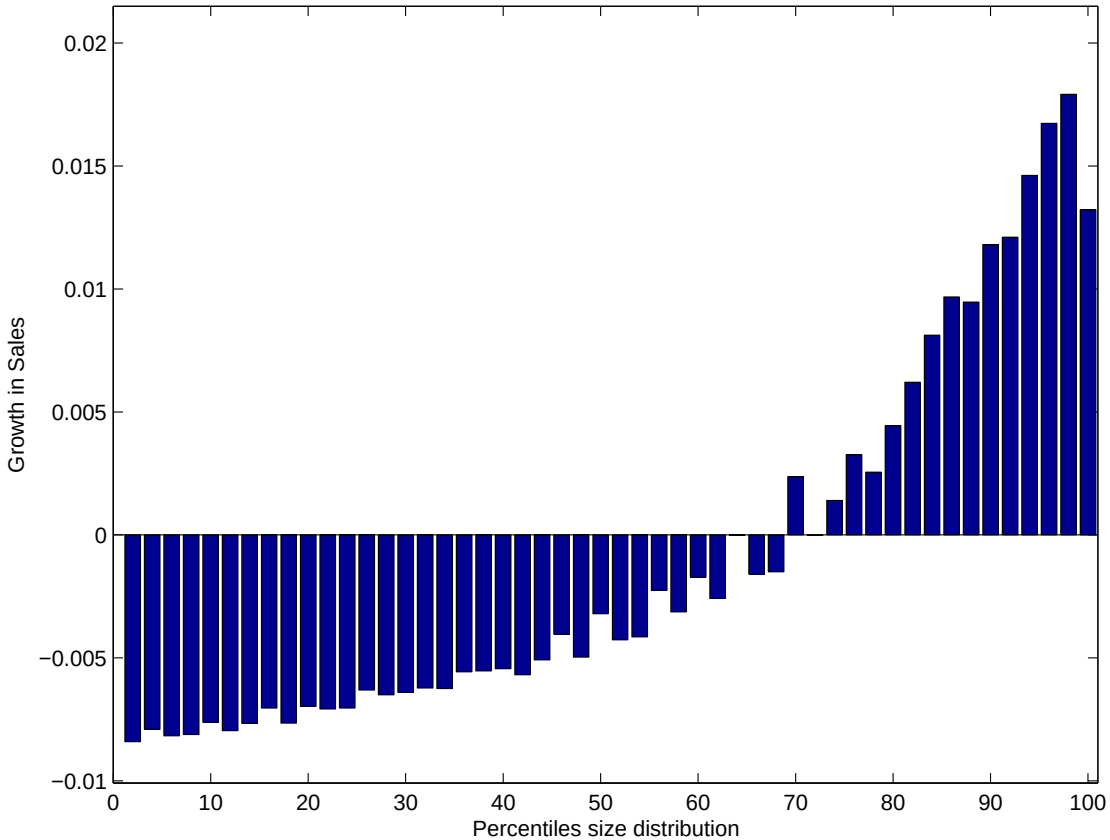
- 100% shock to China's sourcing potential
- Resolve for the equilibrium price index and the mass of entering firms
- Compare
  - Baseline
  - Alternative parameter values that imply univeral importing or independent entry decisions
- Focus on
  - Third market effects and sourcing from the U.S.
  - Gross versus net changes in sourcing
  - Size distribution

Baseline

Chinese import status	Change sourcing from US	Change Sourcing from other countries	Share of firms
Entrants	1.010	1.023	0.143
Exiters	NaN	NaN	0.000
Continuers	0.999	0.998	0.098
Others	0.989	0.970	0.759

- Aggregate sourcing from the U.S. is reduced by 1.06 percent
- For every 10 domestic manufacturing jobs destroyed, 1 new job is created.

Baseline - Size distribution and price index



- Price index falls by .4 %.

Alternative parameters: Universal importing

- No fixed costs of foreign sourcing

Chinese import status	Change sourcing from US	Change Sourcing from other countries	Share of firms
Entrants	NaN	NaN	0.000
Exiters	NaN	NaN	0.000
Continuers	0.991	0.991	1.000
Others	NaN	NaN	0.000

- All type of firms descrease sourcing from the U.S. and from third markets by the same amount

Alternative parameters: Independent entry decisions

- Set $\theta = \sigma - 1$

Chinese import status	Change sourcing from US	Change Sourcing from other countries	Share of firms
Entrants	0.996	0.990	0.150
Exiters	NaN	NaN	0.000
Continuers	0.996	0.995	0.092
Others	0.996	0.989	0.758

- All firms decrease sourcing from the U.S. by the same amount
- No gross increases of sourcing

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

$$M_{ij} = \tau_{ij}^{-\theta} \frac{Ei}{\Theta_i} \frac{Q_j}{\sum_k \tau_{kj}^{-\theta} \frac{E_k}{\Theta_k}}$$

- Familiar from Eaton and Kortum (2002)
- Trade elasticity is given by θ
- Extensive margin effect at the *product-level*

▸ BACK

Gravity - general case

- General case

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

  where

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

- Λ_{ij} yields
  - Extensive margin effect at the *firm-level* in addition to the *product-level*
  - Third market effects

▸ BACK

Gravity - independent entry decisions

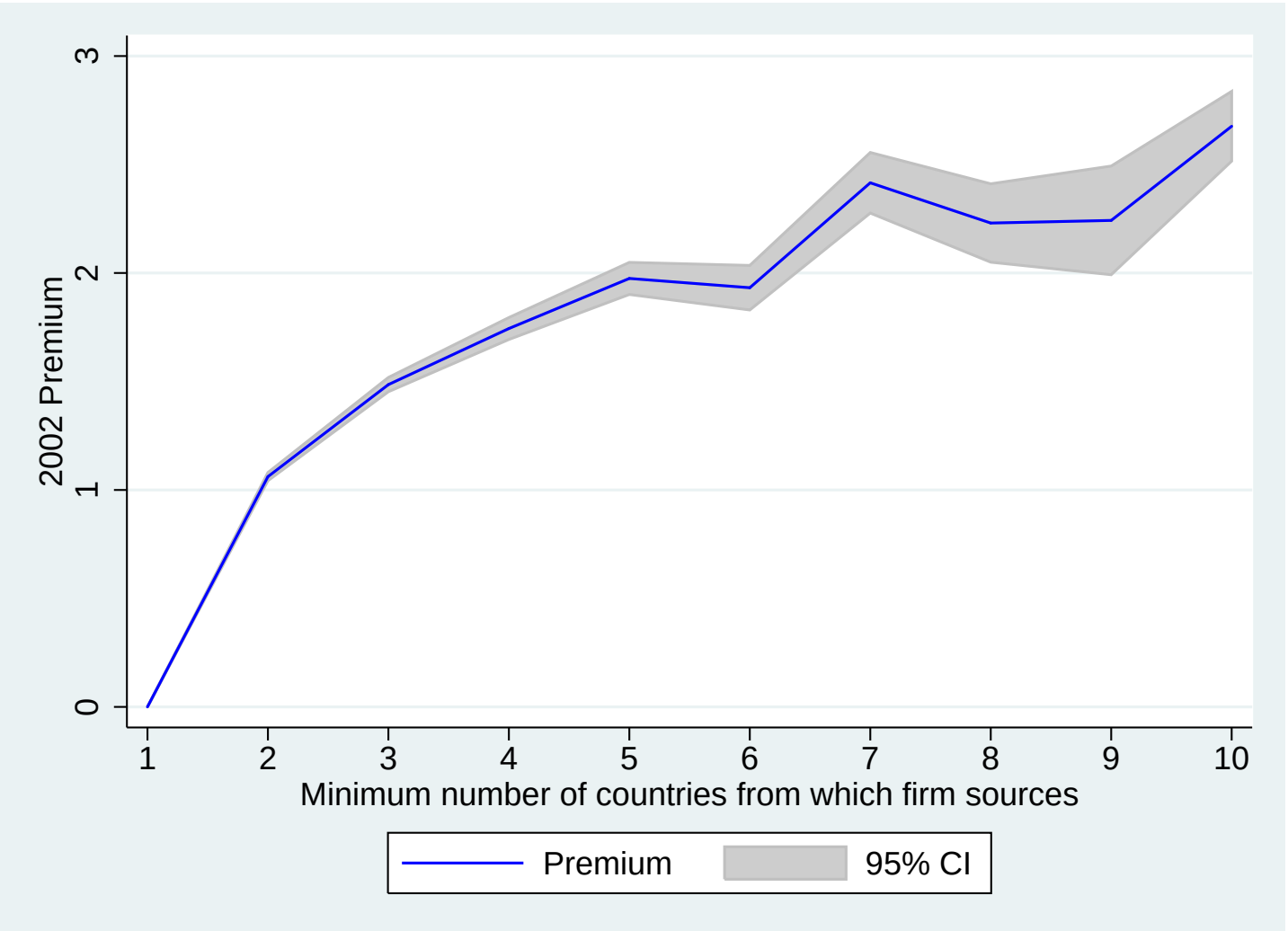
- Special case 2: $(\sigma - 1)/\theta = 1$ and core efficiency Pareto

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

- Trade elasticity as in Chaney (2008)
- Extensive margin effect
- No third market effects

▸ BACK

2002 Sales Premia for 2002 non-importers



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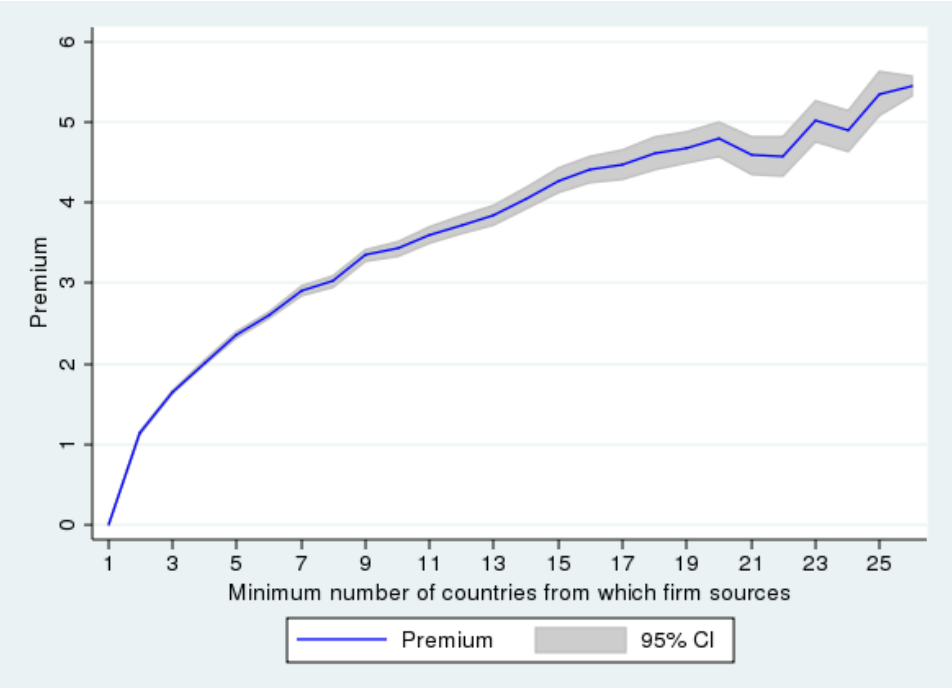
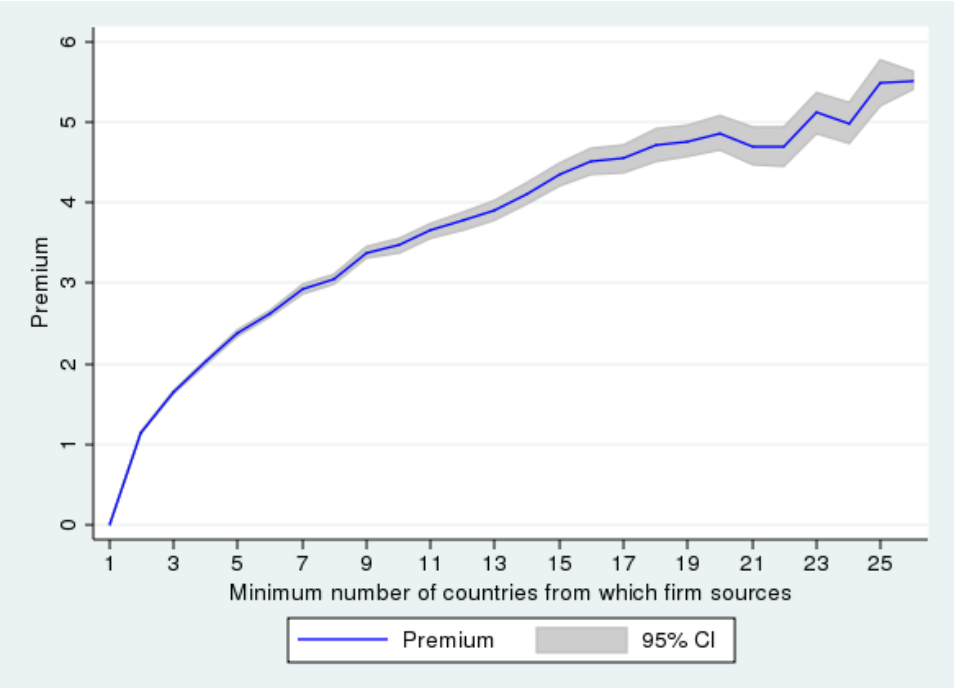
2007 Sales Premia with product controls



(a) Controlling for number of imported goods



(b) Controlling for number of exported goods

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Measuring Input Shares

- $Inputs^n = Sales^n - ValueAdded^n + ProductionWorkerWages^n$
  - Manufacturing and wholesale coverage
  - Highly correlated with traditional input measures for manufacturing

- $\chi_{ij}^n = M_j^n / Inputs^n$
  - 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

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Top 10 Countries Source Countries

	Rank by: Firms	Rank by: Value	Number of Firms	Value of Imports
Canada	1	1	37,800	145,700
China	2	3	21,400	121,980
Germany	3	5	13,000	62,930
United Kingdom	4	6	11,500	30,750
Taiwan	5	11	10,500	16,630
Italy	6	13	8,500	13,230
Japan	7	4	8,000	112,250
Mexico	8	2	7,800	125,960
France	9	9	6,100	22,980
Korea, South	10	10	5,600	20,390

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Firm-level instrument

- Ideally, want the importance of each product in firm production
  - Use HS-IO tables and firm industry to get product weights?
  - Firm-specific if firms span multiple industries or switch over time
  - Works for all firms
- Alternative strategy for importers
  - Use import product share in pre-sample
  - Firm-specific, time invariant share
  - Time variation comes from China product-level shocks
- Similar product-level test
  - Effect of shock to product k on sourcing strategy
  - Sample is all firms already importing a product (not from China)
  - $Pr(y_{ijkt}|X_{ijt} = 1) = M_{i,China,t-1} + Sales_{it} + Controls$
  - Where $y_{ijkt} = 1$ if firm switches its import of product k to China
  - Also assess how this change affects other sourcing decisions

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Why depart from Armington?

- Number of countries per HS10 products traded by a firm

	Firm Level Imports			Firm Level Exports		
	Mean	Median	Max	Mean	Median	Max
Mean	1.11	1.00	1.61	1.66	1.27	4.67
Median	1.03	1.00	1.00	1.00	1.00	1.00
95%tile	1.78	1.00	4.00	4.00	2.00	20.00

- Generally higher counts for exports

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Why depart from Armington?

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

	Firm Level Imports			Firm Level Exports		
	Mean	Median	Max	Mean	Median	Max
Mean	1.28	1.05	3.18	2.26	1.48	8.25
Median	1.19	1.00	2.00	1.73	1.00	4.00
95%tile	1.96	1.00	9.00	5.17	3.00	30.00

- Same basic pattern for firms that trade with at least 3 countries

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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

Number of observations	200,000
Number of importing firms	64,600
Mean Squared Error	2.64
Range of foreign $\log \xi_j$	- 4.12 to -8.42
Sum of foreign ξ_j	0.137

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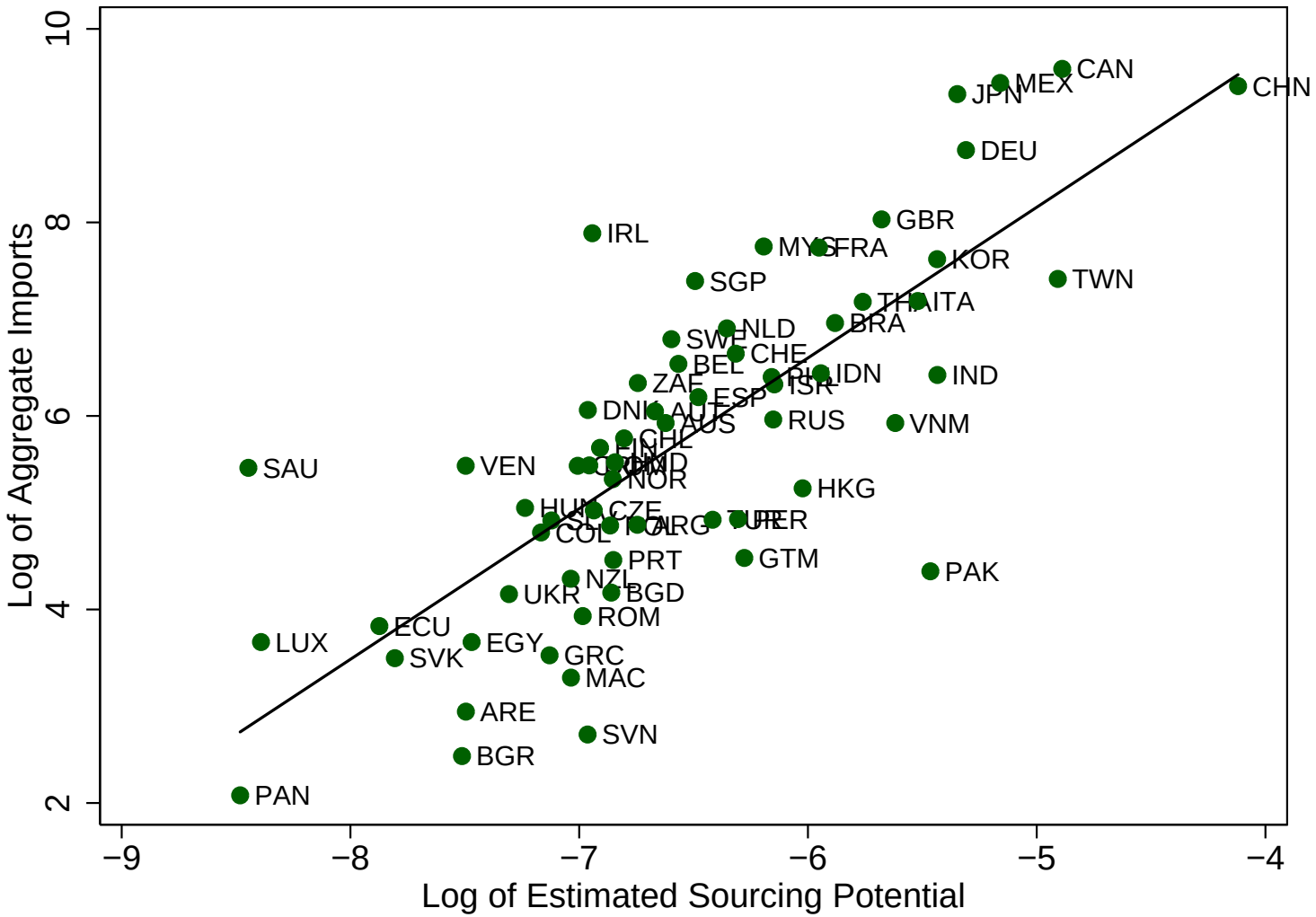
Sourcing potential versus aggregate imports



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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 β_{disp}^f
- No domestic fixed cost of sourcing
- $\delta = \left[B, \beta_c^f, \beta_d^f, \beta_l^f, \beta_{\text{disp}}^f\right]$
- Simulate more than 2 million firms

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Moments

1. The share of importing firms

2. The share of firms that sources from each country

3. The share of firms in each input quantile for each country
   - Quantiles defined by the qth percentile of inputs in data
   - Where $q = (25, 50, 90)$

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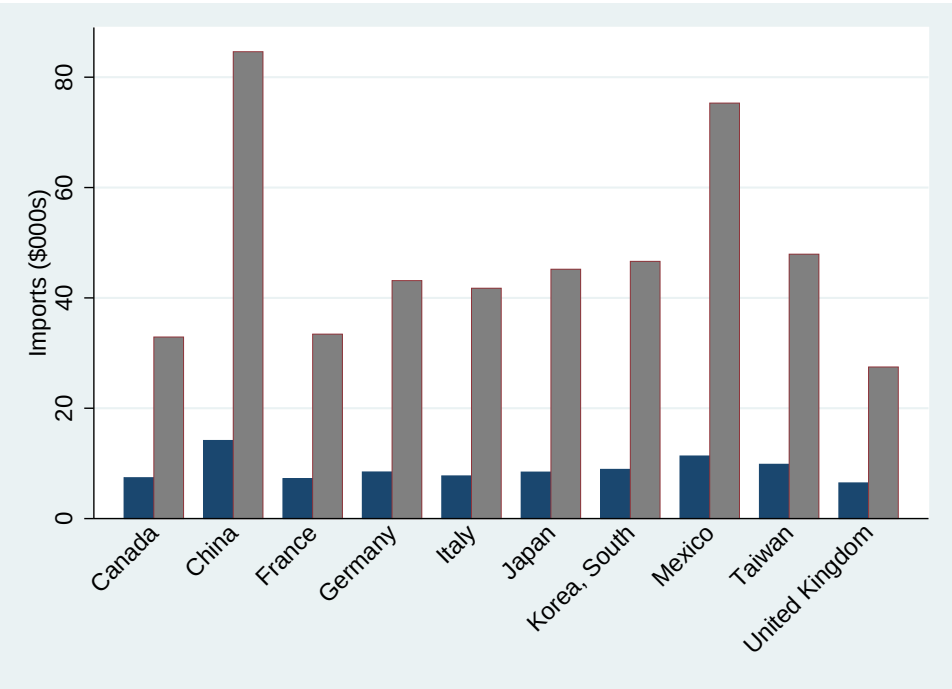
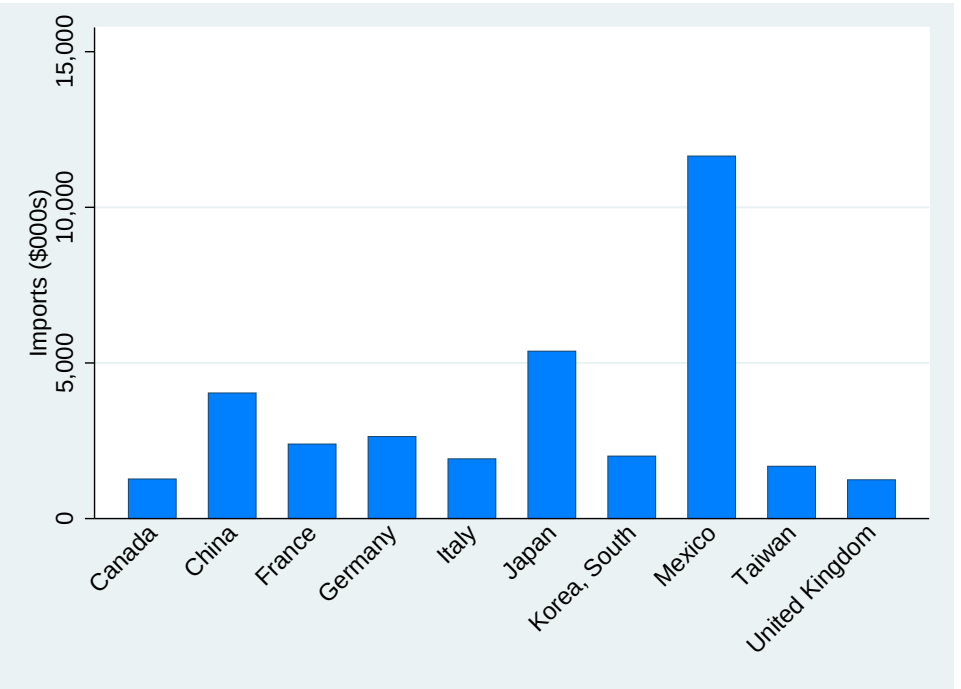
Import Percentiles by Country



(a) 25th and 50th



(b) 90th

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Statistics on Jia Algorithm Performance

Cardinality of difference in bounds	0	1	2	3	4	5	6	7	8	9-25	≥ 26
Number of occasions	9959361735	0	374149	22523	1514	72	6	1	0	0	0

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Share of importers by country