Supply chain uncertainty and diversification

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Supply chain disruption risk and firms' sentiments

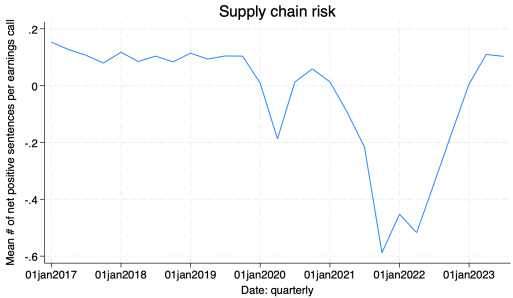

Figure 1: Average sentiment

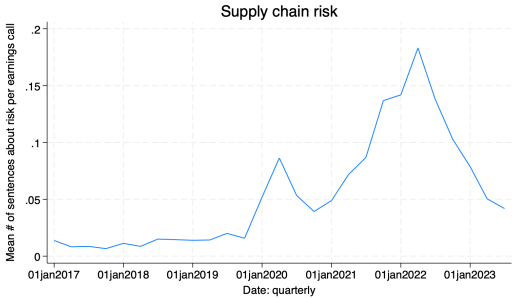

Figure 2: Average risk

- Hassan et al. (2023): Text-based measures on earning calls dedicated to the event of interest: *"Supply chain risk"*
  - Sentiment: perceived impact on the **mean** of the firm's economic outlook
  - Risk: perceived impact on the **variance** of the firm's economic outlook

Research question and results

- How does supply chain uncertainty affect firms' sourcing decision?
  - Would firms be sourcing from foreign countries to diversify against this risk? Or will they be re-shoring instead?
  - Would firms import from cheaper or less risky/riskier countries?

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  - Counterfactual analysis: changes in uncertainty and impact on firms sourcing, both on the *extensive* and *intensive* margin

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  - Counterfactual analysis: changes in uncertainty and impact on firms sourcing, both on the *extensive* and *intensive* margin
- Preview of the results:
  - Theoretically, ambiguous effect of risks
    - Firm-level uncertainty affects sourcing capability: option-value effect
    - Aggregate risk affects market demand: hedging effect
  - Increase in uncertainty increases foreign sourcing via both margins: Option value effect dominates hedging effect
  - Mean-preserving uncertainty was not the only mechanism at play during the post-Covid-19 trade disruption events

Related Literature

- Sourcing models
  - Antràs and Helpman (2004), Antràs and Helpman (2006), Antràs, Fort, and Tintelnot (2017), Bernard and Moxnes (2018)
    - Study supply chain disruption risk in multi-country sourcing model
- Uncertainty in trade
  - Theory: Grossman, Helpman, and L'Huillier (2023), Grossman, Helpman, and Sabal (2023), Gervais (2021, 2018)
    - Multi-country model allows for sourcing interdependencies and to separate effect of cost and uncertainty, aggregate and idiosyncratic.
    - Structural estimation with micro data and counterfactual analysis
  - Tariff policy uncertainty: Handley et al. (2020), Handley and Limão (2017), Charoenwong et al. (2023)
    - General framework for policy, supply-chain risk, and trade shocks
  - Trade disruption shocks Carreras-Valle (2021), Castro-Vincenzi (2022), Lafrogne-Joussier et al. (2022)
    - Analyze uncertainty and firm's sourcing choice using structural model
  - Empirical literature on propagation through trade networks: Caselli et al. (2020), Boehm et al. (2019), Carvalho et al. (2021), LaBelle et al. (2021), D'Aguanno et al. (2021)
    - Study of firms' joint sourcing and diversification decision

Model: Set-up and timeline

- Multi-country sourcing model inspired from Antràs, Fort, and Tintelnot (2017)
  - I countries. Origin: i, Destination: j.
  - Final-good producers in j, with productivity φ, produce a single variety – with monopolistic competition – using a unit measure of intermediate inputs
  - Sourcing from set of countries $\mathcal{I}_j(\varphi)$
  - Trade from intermediate good firms in countries $i \in I$, perfect competition, productivity follows Fréchet distribution with shape θ: $\mathbb{P}(a_i(\nu, \varphi) \geq a) = e^{-T_i a^{\theta}}$

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  - Supply chain risk from i to j for firm φ: aggregate and idiosyncratic shock

$$p_{ij}(\nu, \varphi) \equiv \tau_{ij}\ \bar{\gamma}_{ij}\ \tilde{\gamma}_{ij(\varphi)}\ w_i$$

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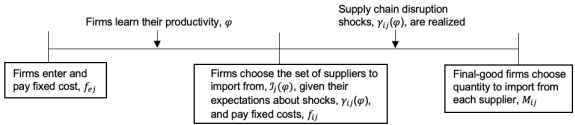
$$p_{ij}(\nu,\varphi) \equiv \tau_{ij}\ \bar{\gamma}_{ij}\ \tilde{\gamma}_{ij}(\varphi)\ w_i$$

  - Household consumes final goods as a CES bundle with elasticity σ
- Three-stages firms decisions



Model: Firm Behavior Conditional on Sourcing Strategy, $\mathcal{I}_j(\varphi)$

- Share of intermediate input purchases for realized shocks:

$$\mathcal{X}_{ij}(\varphi, \boldsymbol{\gamma}) = \frac{T_i(\tau_{ij}\,\bar{\gamma}_{ij}\,\tilde{\gamma}_{ij(\varphi)}\,w_i)^{-\theta}}{\Theta_j(\varphi, \bar{\gamma}_{ij}\tilde{\gamma}_{ij(\varphi)})} \text{ if } i \in \mathcal{I}_j$$

$\Rightarrow$ $T_i(\tau_{ij}\bar{\gamma}_{ij}\tilde{\gamma}_{ij(\varphi)}w_i)^{-\theta}$: *sourcing potential* of country i from the point of view of firm φ in country j

$\Rightarrow$ $\Theta_j(\varphi, \bar{\gamma}_{ij}\tilde{\gamma}_{ij(\varphi)}) \equiv \sum_{k\in\mathcal{I}_j(\varphi)} T_k(\tau_{kj}\bar{\gamma}_{kj}\tilde{\gamma}_{kj(\varphi)}w_k)^{-\theta}$: *sourcing capability* of firm φ in country j

$\Rightarrow$ *Ex-post* Eaton and Kortum, within the firm

Model: Choice of Set of Countries to Import from, $\mathcal{I}_j(\varphi)$

- Choice of $\mathcal{I}$ using ex-ante profits, with $\mathcal{I}_j(\varphi) = \{i : \mathbb{1}_{ij} = 1\}$:

$$\max_{\mathbb{1}_{ij} \in \{0,1\}^I_{i=1}} \mathbb{E}(\pi_j(\varphi,\gamma)) = \mathbb{E}\left(\underbrace{\varphi^{\sigma-1}}_{\text{prod}} \underbrace{\left(\eta \sum_{i=1}^{I} \mathbb{1}_{ij} T_i \left(\tau_{ij} \bar{\gamma}_{ij} \tilde{\gamma}_{ij(\varphi)} w_i \right)^{-\theta} \right)}_{\substack{\text{sourcing capability} \\ \Theta_j(\varphi,\gamma(\varphi))}}^{\frac{\sigma-1}{\theta}} \underbrace{B_j(\bar{\gamma})}_{\substack{\text{market} \\ \text{demand}}} \right) - w_j \sum_{i=1}^{I} \mathbb{1}_{ij} f_{ij}$$

- With market demand in j defined as

$$B_j(\bar{\gamma}) \equiv \frac{1}{\sigma} \left(\frac{\sigma}{\sigma - 1} \right)^{1-\sigma} E_j P_j(\bar{\gamma})^{\sigma-1}$$

$\Rightarrow$ Effect through price index Price index

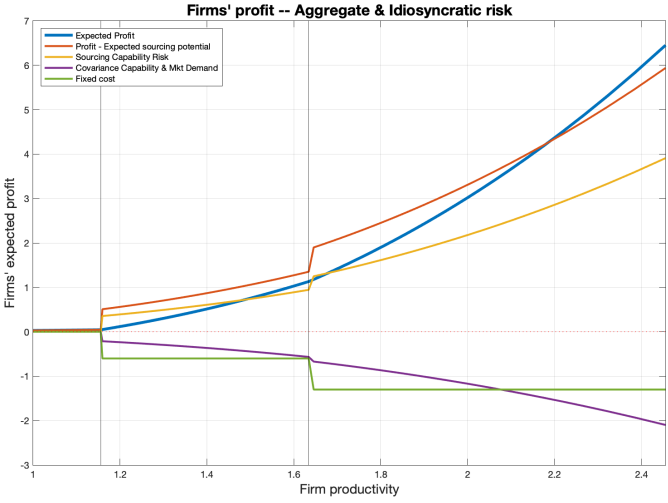
Decomposition: What determines profits?

- The firms maximizes expected profit for their sourcing decision

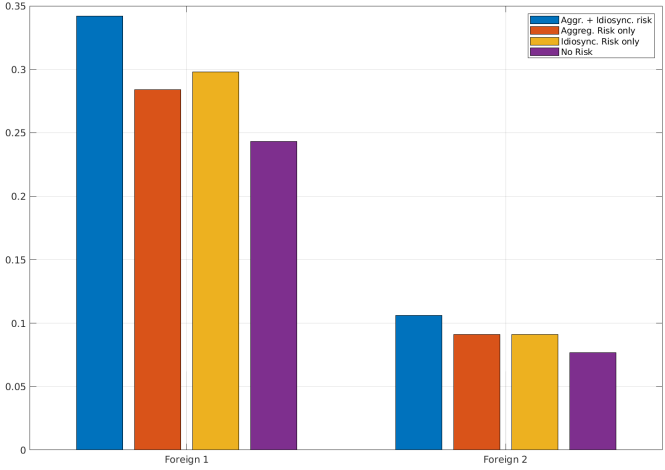
$$\mathbb{E}\big[\pi(\varphi,\gamma)\big] = \varphi^{\sigma-1}\Big(\underbrace{\Theta_H(\varphi,\mathbb{E}[\gamma])^{\frac{\sigma-1}{\theta}}}_{\text{Sourcing capability for expected shock}} + \underbrace{\mathbb{E}\big[\Theta_H(\varphi,\gamma)^{\frac{\sigma-1}{\theta}} - \Theta_H(\varphi,\mathbb{E}[\gamma])^{\frac{\sigma-1}{\theta}}\big]}_{\text{Risk effect on capability}}\Big) \times \underbrace{\mathbb{E}(B_H(\bar{\gamma}))}_{\text{Expected market demand}}$$

$$+ \varphi^{\sigma-1} \underbrace{Cov(\Theta_H(\varphi,\gamma)^{\frac{\sigma-1}{\theta}}, B_H(\bar{\gamma}))}_{\text{Covariance btw sourcing capability \& market demand}} - \underbrace{w_j \sum_{i\in\mathcal{I}(\varphi)} f_{ij}}_{\text{Fixed cost of sourcing}}$$

Profit Decomposition – 3 Countries Example



Profit and Firm sourcing



Data Description

- Proprietary administrative data from the Central Bank of Chile:
  - **Customs** country-to-firm level data: import unit values, quantities, origin countries, and product categories
  - **Tax Form 29:** sales and materials purchases
  - **Unemployment Funds:** employer-employee level data.
  - Quarterly panel from 2012 to 2023.
- Publicly available data (yearly):
  - (i) CEPII gravity data set (population weighted distance, and common language): 2003-2021.
  - (ii) World Bank WGI (control of corruption): 2003-2021.

Structural Estimation: Step 1, Average Sourcing Potential

We want to estimate the parameters and risk $\bar{\gamma}_{ij}, \tilde{\gamma}^n_{ij}, f^n_{ij}$.

- Take θ and σ from Antràs et al. (2017), so $\theta = 1.789$ and $\sigma = 3.85$, $\Rightarrow\ (\sigma - 1)/\theta = 1.593 > 1$
- Use model-derived relationship:

$$\log \chi^n_{ij,t} = \underbrace{\log T_i - \theta\left(\log \tau_{ij} + \log w_i\right)}_{\log \bar{\xi}_i} \underbrace{-\theta\left(\log \bar{\gamma}_{ij,t} + \log \tilde{\gamma}^n_{ij,t}\right)}_{\log \epsilon^n_{it}} - \log \Theta^n_{j,t}(\gamma)$$

  if $i \in \mathcal{I}_j$, and re-write it in terms of a country FE and a firm-level error term
- Take log differences and set domestic sourcing potential to 1 so that:

$$\log \chi^n_{ij,t} - \log \chi^n_{jj,t} = \log \bar{\xi}_i + \log \epsilon^n_{i,t}$$

- Run OLS using data on firms' total imports from each country, wage bill, and total input usage to measure shares, to obtain $\bar{\xi}_i$

Results

Structural Estimation: Step 2, Estimating Shocks

- Let us define $\hat{\xi}_{i,t} = T_i \left(\tau_{ij} \bar{\gamma}_{ij,t} w_i\right)^{-\theta}$ and $\hat{\epsilon}^n_{i,t} = \left(\tilde{\gamma}^n_{ij,t}\right)^{-\theta}$, take first-differences over log sourcing share differences to identify shocks:

$$\Delta_{t,t-4} \left(\log \mathcal{X}^n_{ij,t} - \log \mathcal{X}^n_{jj,t}\right) = \Delta_{t,t-4} \left(\log \hat{\xi}_{i,t} + \log \hat{\epsilon}^n_{i,t}\right)$$

- Recover shocks as:
  - $\Delta_{t,t-4} \log \hat{\xi}_{i,t} = -\theta \log \bar{\gamma}_{i,t} / \bar{\gamma}_{i,t-4}$
  - $\Delta_{t,t-4} \log \hat{\epsilon}^n_{i,t} = -\theta \log \tilde{\gamma}^n_{i,t} / \tilde{\gamma}^n_{i,t-4}$
- To recover $\bar{\gamma}_{ij,t}$ and $\tilde{\gamma}^n_{ij,t}$, and $\bar{\sigma}^2$ and $\tilde{\sigma}^2$, we assume
  - Trend process follows random walk
  - Initial values are equal to 1, i.e., no shock,
  - Data follows a log-normal distribution.

Results, Chile-China/US

Structural Estimation: Step 3, Fixed Costs Estimation

- Use average 2012q1-2019q4 data.
- Firm-country fixed-costs depend on gravity related variables and control of corruption
  - $f_{ij}^n \sim$ log-normal$(\log \beta_c^f + \beta_d^f \log \text{ distance}_{ij} + \log \beta_l^f \text{ language}_{ij} + \beta_C^f \text{ control of corruption}_i, \beta_{disp,f}^n)$
  - We assume $f_{jj}^n = 0$.
- SMM to estimate

$$\delta = [E, \bar{f}_{\text{CHN}}, \bar{f}_{\text{USA}}, \bar{f}_{\text{ROW}}, \beta_{c,f}^n, \beta_{d,f}^n, \beta_{l,f}^n, \beta_{C,f}^n, \beta_{\text{disp},f}^n]$$

- Draw shocks:
  - Draw aggregate and idiosyncratic shocks γ from previous distrib.
  - Draw firm productivity φ from a Pareto distribution.
  - Draw firm-level fixed costs from Normal distribution.

SMM

- Moment selection: m_k data, $\hat{m}_k(\delta)$ simulated
  1. Share of importers for all firms.
  2. Share of importers with firm sales below the median.
  3. Share of firms that import from each country.
     - $(I-1) \times 1$ vector of moments.
  4. Share of firms whose input purchases from Chile are less than the median input purchases from Chile in the data.

- High dimensionality combinatorial problem:

  $\Rightarrow$ Use Jia's algorithm.

- Minimize $\hat{\delta} = \arg\min_{\delta} \ \hat{y}(\delta)^{\top} \ \mathbf{W} \ \hat{y}(\delta)$
  - We use $\hat{y}(\delta) = (\mathbf{m}/\hat{\mathbf{m}}(\delta) - 1)$ and assume $\mathbb{E}(\hat{y}(\delta_0)) = 0$ for the true parameter δ_0.

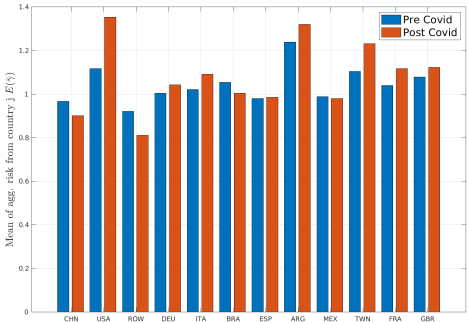
Model Fit Jia's

Counterfactual exercise

- Estimate model using average values from 2012-2019
- Re-estimate model using average standard deviation for aggregate shocks in period 2020-2023
- Evaluate effects on shares of importing firms by country (extensive margin) and decompose effects on shares of intermediate purchases by country
- Evaluate correlation btw change in agg. uncertainty and these effects
- Evaluate effect on HHI

Change in aggregate uncertainty

Figure 3: Change in the mean and standard deviation of aggregate shock



(a) Change in $\mathbb{E}(\tilde{\gamma}_{ij})$

Change in aggregate uncertainty

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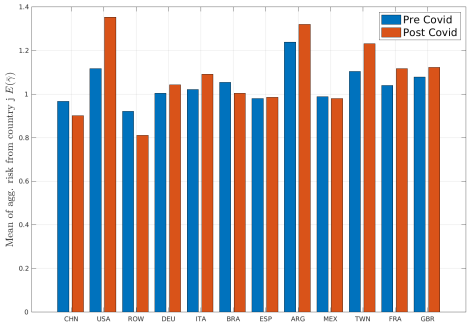

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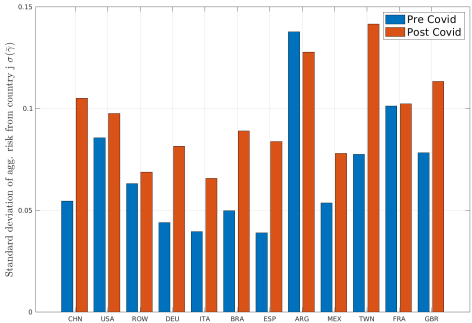


(b) Change in $\sigma(\tilde{\gamma}_{ij})$

Variation in aggregate and idiosyncratic uncertainty

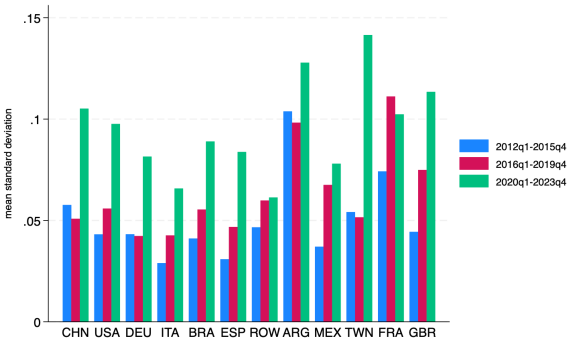


Figure 5: Change in std dev of aggregate shock

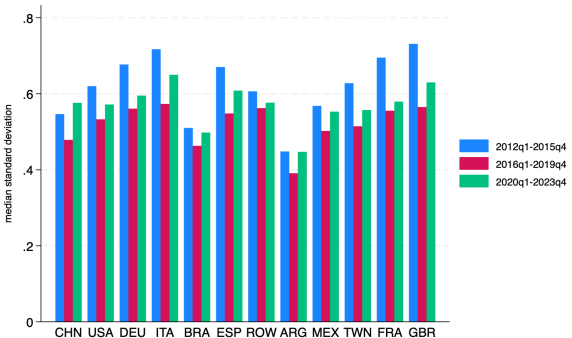
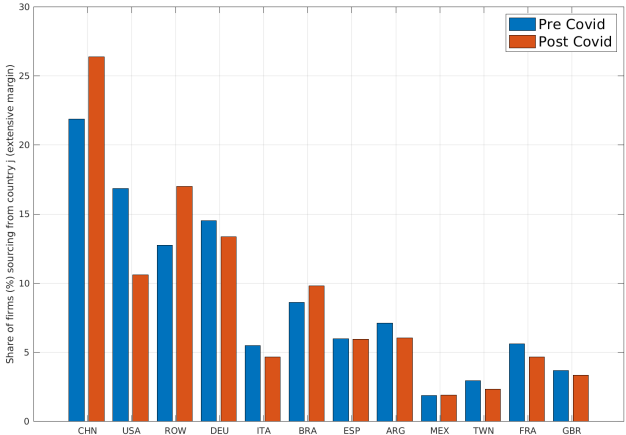


Figure 6: Change in std dev of idiosyncratic shock

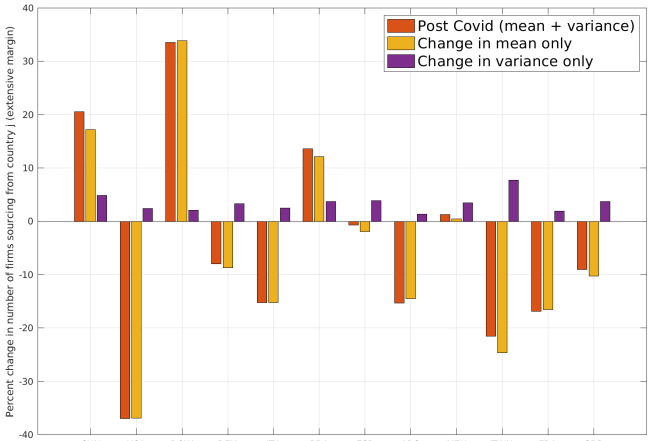
Change in proportion of importing firms

Figure 7: Share of importing firms by country



Change in mean and variance

Figure 8: Extensive v/s intensive margin (% change)



Decomposition of average shares into margins

- Extensive margin:

$$\lambda_{ij} = \int_{\varphi} \mathbb{1}\{i \in \mathcal{I}_j(\varphi)\}\, dG(\varphi)$$

- Decomposition:

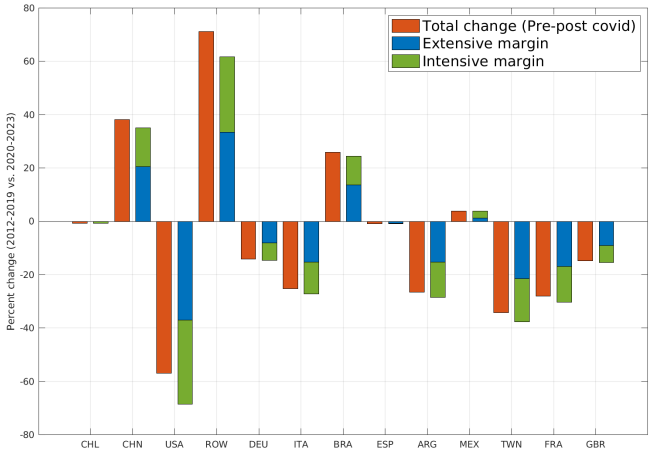
$$\bar{\chi}_{ij} \equiv \mathbb{E}_{\gamma}\left[\int_{\varphi} \chi_{ij}(\varphi,\gamma) dG_j(\varphi)\right] = \underbrace{\lambda_{ij}}_{\substack{\text{extensive}\\ \text{margin}}} \times \underbrace{\frac{\bar{\chi}_{ij}}{\lambda_{ij}}}_{\substack{\text{intensive}\\ \text{margin}}}$$

- We hence plot, for each country i, the decomposition:

$$\Delta\%\bar{\chi}_{ij} \approx \Delta\%\lambda_{ij} + \Delta\%\frac{\bar{\chi}_{ij}}{\lambda_{ij}}$$

Change in margins

Figure 9: Extensive v/s intensive margin (% change)



Conclusion

- Conclusion:
  a. Theoretically, main effect from decrease in overall cost through increased competition. However, uncertainty affects firms' sourcing decisions non trivially.
  b. Counterfactual:
     – Increase in uncertainty increases foreign sourcing via both the extensive margin and the intensive margin.
  c. Even though aggregate uncertainty has two opposing forces, the option value effect dominates over the hedging effect.
- Next steps:
  - Introduce aggregate shocks correlation (Covid-19)
  - Any feedback for the future of the project is very welcome

References I

Antràs, P., T. C. Fort, and F. Tintelnot (2017). The margins of global sourcing: Theory and evidence from us firms. *American Economic Review 107*(9), 2514–64.

Antràs, P. and E. Helpman (2004). Global sourcing. *Journal of Political Economy 112*(3), 552–580.

Antràs, P. and E. Helpman (2006). Contractual frictions and global sourcing. *NBER Working Paper* (12747).

Bernard, A. B. and A. Moxnes (2018). Networks and trade. *Annual Review of Economics* (10), 65–85.

Boehm, C. E., A. Flaaen, and N. Pandalai-Nayar (2019). Input linkages and the transmission of shocks: Firm-level evidence from the 2011 tōhoku earthquake. *Review of Economics and Statistics 101*(1), 60–75.

Carreras-Valle, M. J. (2021). Increasing inventories: The role of delivery times.

Carvalho, V. M., M. Nirei, Y. U. Saito, and A. Tahbaz-Salehi (2021). Supply chain disruptions: Evidence from the great east japan earthquake. *The Quarterly Journal of Economics 136*(2), 1255–1321.

Caselli, F., M. Koren, M. Lisicky, and S. Tenreyro (2020). Diversification through trade. *The Quarterly Journal of Economics 135*(1), 449–502.

Castro-Vincenzi, J. (2022). Climate hazards and resilience in the global car industry.

References II

Charoenwong, B., M. Han, and J. Wu (2023). Trade and foreign economic policy uncertainty in supply chain networks: Who comes home? *Manufacturing & Service Operations Management 25*(1), 126–147.

D'Aguanno, L., O. Davies, A. Dogan, R. Freeman, S. Lloyd, D. Reinhardt, R. Sajedi, and R. Zymek (2021). Global value chains, volatility and safe openness: Is trade a double-edged sword?. *Bank of england financial stability paper 46*.

Gervais, A. (2018). Uncertainty, risk aversion and international trade. *Journal of International Economics 115*, 145–158.

Gervais, A. (2021). Global sourcing under uncertainty. *Canadian Journal of Economics/Revue Canadienne d'Économique 54*(3), 1103–1135.

Grossman, G. M., E. Helpman, and H. L'Huillier (2023). Supply chain resilience: Should policy promote international diversification or reshoring? *Journal of Political Economy 131*(12), 3462–96.

Grossman, G. M., E. Helpman, and A. Sabal (2023). Resilience in vertical supply chains. *National Bureau of Economic Research*. (No. w31739).

Handley, K. and N. Limão (2017). Policy uncertainty, trade, and welfare: Theory and evidence for china and the united states. *American Economic Review 107*(9), 2731–2783.

Handley, K., N. Limão, R. D. Ludema, and Z. Yu (2020). Firm input choice under trade policy uncertainty. *National Bureau of Economic Research*. (w27910).

References III

Hassan, T. A., S. Hollander, L. Van Lent, M. Schwedeler, and A. Tahoun (2023). Firm-level exposure to epidemic diseases: Covid-19, sars, and h1n1. *The Review of Financial Studies 36*(12), 4919–4964.

LaBelle, J., F. Leibovici, and A. M. Santacreu (2021). Global value chains and us economic activity during covid-19. *Available at SSRN 3885399.*.

Lafrogne-Joussier, R., J. Martin, and I. Mejean (2022). Supply shocks in supply chains: Evidence from the early lockdown in china. *IMF Economic Review*, 1–46.

Price Index

- The price index is:

$$P_j(\tilde{\gamma}) = \left(\int_{\tilde{\varphi}} \int_{\tilde{\gamma}(\varphi)} p_j(\varphi, \gamma)^{1-\sigma} d\tilde{\Psi}_j^{\varphi}(\tilde{\gamma}) dG_j(\varphi) \right)^{\frac{1}{1-\sigma}}$$

with:

$$p_j(\varphi, \gamma) = \frac{\sigma}{\sigma - 1} \underbrace{\frac{1}{\varphi} \left(\eta \Theta_j(\varphi, \gamma) \right)^{-\frac{1}{\theta}}}_{mc_j(\varphi)}$$

and $\eta = \left[\Gamma \left(\frac{\theta + 1 - \rho}{\theta} \right) \right]^{\frac{\theta}{1-\rho}}$

Back

Proposition 1

1. Higher productivity firms will increase their expected profits by sourcing more from more or "better" countries:

$$\mathbb{E}\left(\Theta_j(\mathcal{I}_j(\varphi_H, \gamma(\varphi_H))^{\frac{\sigma-1}{\theta}} B_j(\bar{\gamma})\right) > \mathbb{E}\left(\Theta_j(\mathcal{I}_j(\varphi_L, \gamma(\varphi_L))^{\frac{\sigma-1}{\theta}} B_j(\bar{\gamma})\right)$$

2. If $\sigma - 1 > \theta$, import countries are **complements** in the sourcing decisions
   - More productive firms source from more countries
   - Pecking order: Same ordering of countries if fixed costs are the same across firms

Back

Closing the model: gravity and HHI

- Outside sector, freely tradable and big enough to pin down wages
- Using free entry condition and Fubini's theorem:

$$N_j = \frac{\alpha L_j}{\sigma \left(\int_{\tilde{\varphi}_j}^{\infty} \int_{\tilde{\gamma}(\varphi)} \sum_{i \in \mathcal{I}_j(\varphi)} f_{ij} \, d\Psi_{ij}^{\varphi}(\tilde{\gamma}) dG_i(\varphi) + f_{ej} \right)}$$

- Gravity:

$$M_{ij}(\bar{\gamma}) = \frac{E_j}{P_j(\bar{\gamma})^{1-\sigma}/N_j} \frac{Q_i}{\sum_k \frac{E_k}{P_k(\bar{\gamma})^{1-\sigma}/N_k} (\tau_{ik}\bar{\gamma}_{ik})^{-\theta} \Lambda_{ik}(\bar{\gamma})} (\tau_{ij}\bar{\gamma}_{ij})^{-\theta} \Lambda_{ij}(\bar{\gamma})$$

  with $Q_i = \sum_k M_{ik}$ total production of intermediate inputs in i

- Model-implied HHI:

$$HHI_j = \sum_{i=1}^{I} \left(\frac{T_i (\tau_{ij}\bar{\gamma}_{ij} w_i)^{-\theta} \Lambda_{ij}(\bar{\gamma})}{\sum_{k=1}^{I} T_k (\tau_{kj}\bar{\gamma}_{kj} w_k)^{-\theta} \Lambda_{kj}(\bar{\gamma})} \right)^2$$

Back

Parameterization

Variable	Definition	Value
SD(γ)	Standard deviation of shock	0.25
ρ	Substitutability across intermediate varieties	2.00
I	Number of countries	3.00
$T_D(\tau_D w_D)^{-\theta}$	Domestic sourcing potential	1.00
$T_{F1}(\tau_{F1} w_{F1})^{-\theta}$	Sourcing potential Foreign 1	0.10
$T_{F2}(\tau_{F2} w_{F2})^{-\theta}$	Sourcing potential Foreign 2	0.03
N	Number of domestic firms	150
f_D	Fixed cost of sourcing Domestic	0.00
f_{F1}	Fixed cost of sourcing Foreign 1	0.22
f_{F1}	Fixed cost of sourcing Foreign 2	0.12
Calibration for high complementarity $(\sigma-1)/\theta = 1.58$ *following* Antràs et al. (2017)		
σ	Elasticity of final demand	3.85
θ	Productivity Fréchet distribution shape	1.79
Calibration for medium complementarity $(\sigma-1)/\theta = 1.00$		
σ	Elasticity of final demand	3.1
θ	Productivity Fréchet distribution shape	2.1
Calibration for low complementarity $(\sigma-1)/\theta = 0.482$		
σ	Elasticity of final demand	2.30
θ	Productivity Fréchet distribution shape	2.70

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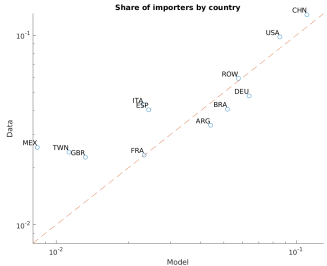
Model Fit

Table 1: Targeted Moments

Moments	Data	Model
Share of importers	0.226	0.1959
Share imp. w/sales below median	0.082	0.0848
Median input purchases	124.430	112.56

Figure 10: Model fit: share of importers by country



Jia's Algorithm

- Proposition: $\forall i$, define mapping $V_{ij}(\varphi, \mathcal{I})$ to be one whenever including country i in sourcing strategy $\mathcal{I}$ raises firm-level expected profits $\mathbb{E}(\pi_j(\varphi, \mathcal{I}))$, and a value of zero o/w. Then, when $(\sigma - 1)/\theta \geq 1$, $V_{ij}(\varphi, \mathcal{I}') \geq V_{ij}(\varphi, \mathcal{I})$ for $\mathcal{I} \subseteq \mathcal{I}'$

- Algorithm:
  1. Let $V_i^n(\mathcal{I}) = 1$ if mg. ben. of adding country i is positive and 0 o/w
  2. When starting from set $\underline{\mathcal{I}}$ (no countries), iteratively add each country to the set (lower bound set)
     - Optimal sourcing strategy: minimum # of countries s.t. $V_i^n(\mathcal{I}) = 1$
  3. Then, starting from set $\bar{\mathcal{I}}$, remove 1-by-1 and find optimal sourcing str. (upper bound set)
  4. If sets do not overlap, only consider profits of upper bound set

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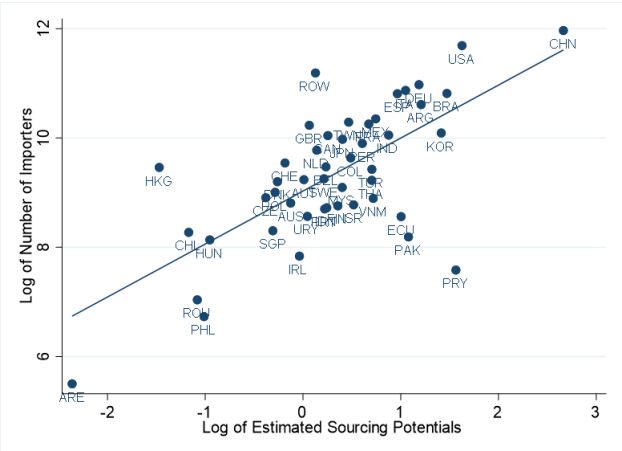
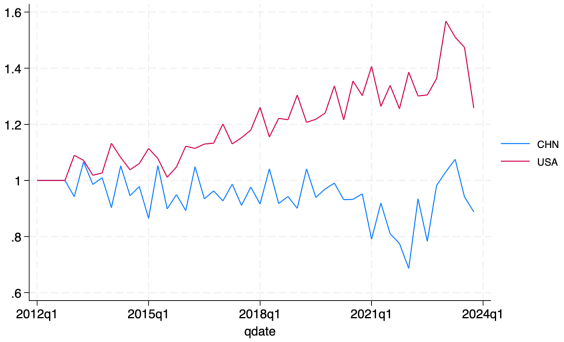
Estimated Sourcing Potential

Figure 11: Sourcing potential and extensive margin



Estimated Aggregate Supply Chain Disruption Shocks

Figure 12: Aggregate supply chain disruption shock $\bar{\gamma}_{ij,t}$



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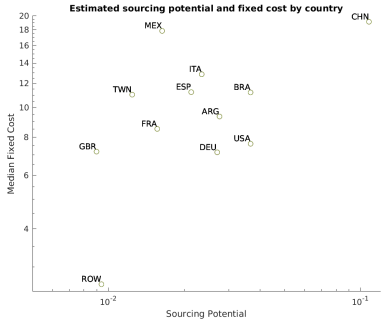
Results: Fixed cost estimation

Table 2: Estimated Parameters Without Uncertainty

E	fc_{CHN}	fc_{USA}	fc_{ROW}	β_c^f	β_d^f	β_l^f	β_C^f	β_{disp}^f
222.42	19.258	7.635	2.624	1.272	0.255	1.093	-0.368	0.691

Figure 13: Estimated Sourcing Potential and Median Fixed Cost



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