

# Supply chain uncertainty and diversification

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# Supply chain disruption risk and firms' sentiments

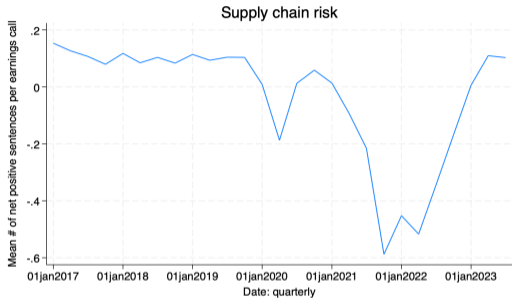


Figure 1: Average sentiment



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

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  - Are firms sourcing from foreign countries to diversify against risk? Or are they re-shoring?
  - Would firms import from cheaper or less risky countries?

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  - Multi-country sourcing model with supply chain idiosyncratic and aggregate *uncertainty*
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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 risk – four channels of expected profits:
    - ▷ *Option value* effect: risk raises the variance of sourcing capability, Oi-Hartman-Abel effect (+)
    - ▷ *Hedging* effect: covariance between sourcing capability & market demand (–)
  - Increase in uncertainty rises foreign sourcing: option value effect dominates the hedging effect, but aggregate ex-ante profits fall
  - Post-Covid-19: trade-cost *risk* (SD) rose – especially China and the world – driving entry into importing and a reallocation toward China

## Related Literature

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- ▶ 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

## Stylized facts: supplier diversification after Covid-19

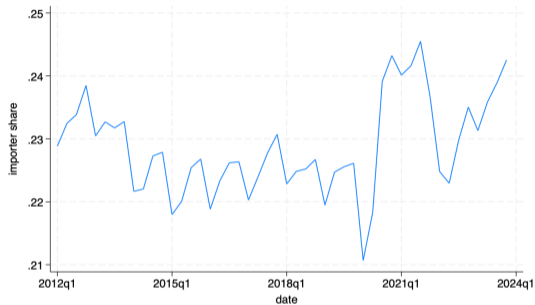


Figure 3: Share of importers among all firms

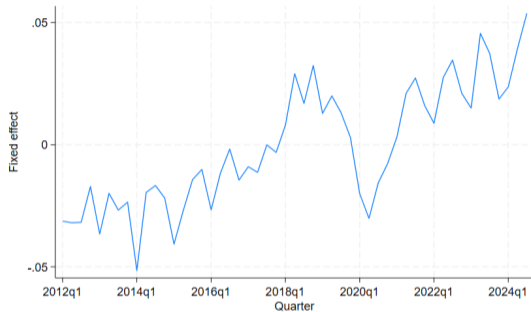


Figure 4: Number of sourcing origins per firm-product pair

- ▶ Chilean Customs  $\times$  tax data, 2012–2023 (quarterly):  $\approx 50$  origins,  $\approx 23\%$  of firms import
- ▶ Time fixed effects  $\delta_t$  from  $\log N_{fpt} = \alpha_{fp} + \delta_t + \epsilon_{fpt}$  ( $f$  firm,  $p$  HS6 product,  $t$  quarter)  
Stable until 2017, rises for 2018–19 trade war, falls during Covid-19, then recovers *above* past levels

## Stylized facts: entry into importing and substitution across origins



Figure 5: Share of importers from the US

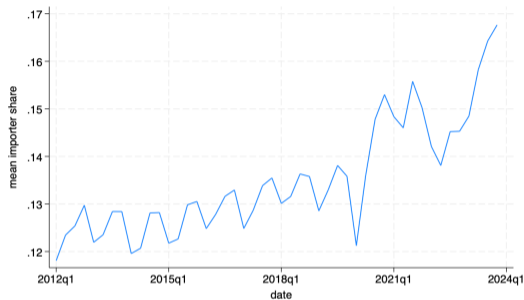


Figure 6: Share of importers from China

- ▶ Entry: share of importers trends down before 2020, then turns *up* – including among below-median-sales firms
- ▶ Substitution: the US share trends *down* while China's trends *up* – firms replace one origin for the other (avg. shares: US 0.098, China 0.128)

## Model: Set-up and timeline

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

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$$p_{ij}(\nu, \varphi) \equiv \tau_{ij} \underbrace{\tilde{\gamma}_j \hat{\gamma}_{ij} \tilde{\gamma}_{ij}(\varphi)}_{\equiv \gamma_{ij}} w_i$$

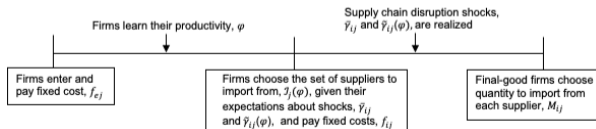
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- Household consumes final goods as a CES bundle with elasticity  $\sigma$

- ▶ Three-stages firm decision:



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

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- ▶ Share of intermediate input purchases for realized shocks:

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

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

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

⇒ *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  $\mathcal{I}_j(\varphi) = \{i : \mathbb{1}_{ij} = 1\}$ :

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

- ▶ With market demand in  $j$  defined as

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

⇒ Effect through price index Price index

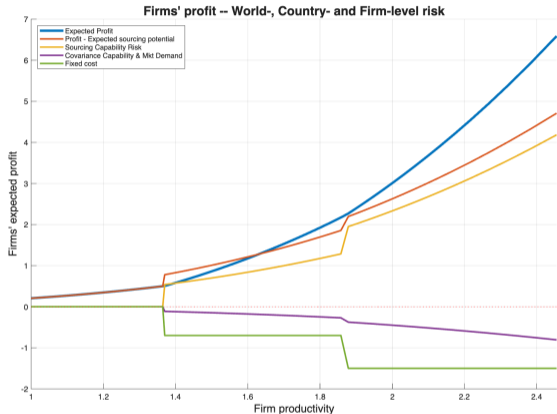
## Decomposition: What determines profits?

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- ▶ Expected profit decomposes into **four channels**:

$$\begin{aligned}
 \mathbb{E}[\pi_H(\varphi, \gamma)] = & \varphi^{\sigma-1} \left( \underbrace{\Theta_H(\varphi, \mathbb{E}[\gamma])^{\frac{\sigma-1}{\theta}}}_{\text{(i) Sourcing capability for expected cost}} \right. \\
 & + \underbrace{\mathbb{E}[\Theta_H(\varphi, \gamma)^{\frac{\sigma-1}{\theta}} - \Theta_H(\varphi, \mathbb{E}[\gamma])^{\frac{\sigma-1}{\theta}}]}_{\text{(ii) Option value (risk effect on capability)}} \left. \right) \times \underbrace{\mathbb{E}(B_H(\bar{\gamma}, \hat{\gamma}))}_{\text{(i-ii) Expected market demand}} \\
 & + \varphi^{\sigma-1} \underbrace{\text{Cov}(\Theta_H(\varphi, \gamma)^{\frac{\sigma-1}{\theta}}, B_H(\bar{\gamma}, \hat{\gamma}))}_{\text{(iii) Hedging effect (covariance)}} - \underbrace{w_H \sum_{i \in \mathcal{I}(\varphi)} f_{iH}}_{\text{(iv) Fixed cost of sourcing}}
 \end{aligned}$$

# Profit Decomposition – 3 Countries Example



- ▶ Three countries,  $\xi_0=1$ ,  $\xi_1=0.8$ ,  $\xi_2=0.3$ ,  $(\sigma-1)/\theta = 1.58$ .  
World, origin and firm shocks Bernoulli:  $\gamma=1$  w.p. 90%,  $\gamma=5$  w.p. 10%
- ▶ Total (blue) = expected cost + option value + hedging – fixed cost, staggered by the pecking order.  
Expected cost dominates: option value > hedging

# Firms' sourcing strategies and the extensive margin

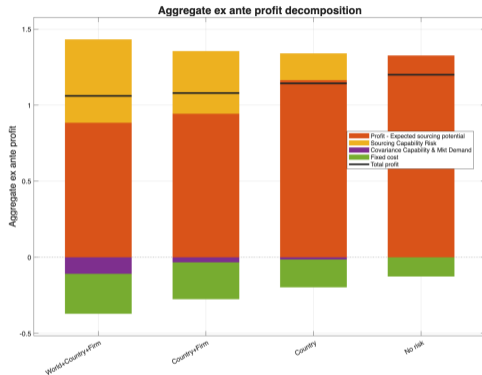


Figure 7: (a) Ex-ante profit decomposition

- ▶ Across risk scenarios (baseline = world + origin + firm risk  $\rightarrow$  no risk), more risk  $\Rightarrow$  more selection into importing: diversify to capture option values
- ▶ Aggregate ex-ante profit *falls* with risk: option-value gain  $<$  expected cost + hedging effect + fixed costs

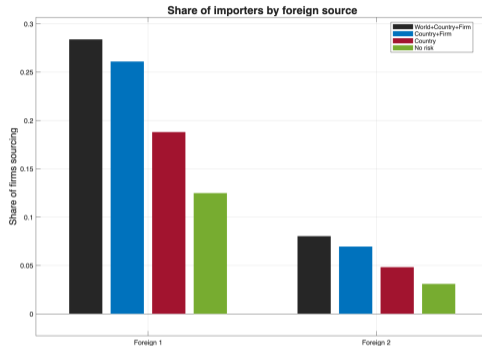
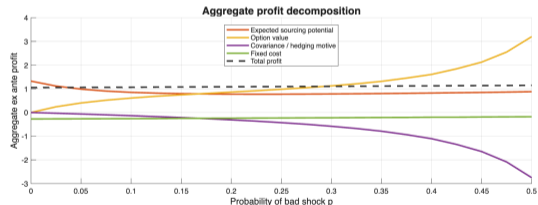
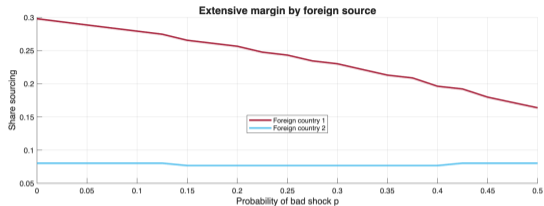


Figure 8: (b) Share of importers by source

# Extensive margin and profit vs. risk



- ▶ Increase probability  $p$  of high-cost shock (raises both mean and variance of  $\gamma$ )
- ▶ Share importing from Foreign 1 falls in  $p$  (mean effect)  
aggregate profit roughly flat: **expected cost**  $\downarrow$  and **option value**  $\uparrow$  offset by **hedging**  $\downarrow$  and **fixed cost**

- ▶ 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

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We estimate the parameters and shocks  $\bar{\gamma}_{j,t}, \hat{\gamma}_{ij,t}, \tilde{\gamma}_{ij,t}^n, f_{ij}^n$ .

- ▶ Take  $\theta$  and  $\sigma$  from [Antràs et al. \(2017\)](#):  $\theta = 1.789, \sigma = 3.85 \Rightarrow (\sigma - 1)/\theta = 1.583 > 1$
- ▶ Recall sourcing potential:  $\xi_j^n \equiv T_j(\tau_{ij}\gamma_{ijt}^n w_i)^{-\theta}$   
& import share:  $\mathcal{X}_{ijt}^n = T_j(\tau_{ij}\gamma_{ijt}^n w_i)^{-\theta} / \Theta_{jt}^n$  if  $i \in \mathcal{I}_j^n$
- ▶ Average component of sourcing potential:  $\bar{\xi}_j \equiv T_j(\tau_{ij} w_i)^{-\theta}$
- ▶ Compare each firm's import share to its domestic share and estimate an origin fixed effect:

$$\log \mathcal{X}_{ijt}^n - \log \mathcal{X}_{jtt}^n = \alpha_i + u_{int}, \quad \alpha_i \mapsto \log \bar{\xi}_j$$

- ▶ Normalize  $\xi_j = 1$  (no domestic disruptions). OLS on  $\approx 50$  origins using imports, wage bill, and input usage

Results

## Structural Estimation: Step 2, Estimating Shocks

- ▶ Treat changes in relative import shares as changes in effective sourcing costs. The 4-quarter difference of log relative shares decomposes into three components:

$$\Delta_4 [\log \mathcal{X}_{ij,t}^n - \log \mathcal{X}_{jj,t}^n] = \underbrace{\bar{\lambda}_t}_{-\theta \Delta_4 \log \bar{\gamma}_{j,t}} + \underbrace{\hat{\lambda}_{it}}_{-\theta \Delta_4 \log \hat{\gamma}_{ij,t}} + \underbrace{e_{it}^n}_{-\theta \Delta_4 \log \tilde{\gamma}_{ij,t}^n}$$

- ▶ OLS with **time FE** (world  $\bar{\gamma}_j$ ), **origin  $\times$  time FE** (origin  $\hat{\gamma}_{ij}$ ), and a **firm–origin residual** (idiosyncratic  $\tilde{\gamma}_{ij}^n$ )
- ▶ Recover levels assuming: log shocks follow a random walk. Initial value = 1 (no shock), log-normal  $\Rightarrow$  mean and variance per component

Results, Chile–China/US

## Structural Estimation: Step 3, Fixed Costs Estimation

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- ▶ Use average 2012q1-2019q4 data: SMM for 13 countries (incl. Chile)
- ▶ Firm–origin fixed cost depends on gravity variables and control of corruption
  - $\log f_{ij}^n = \beta_c^f + \beta_d^f \log \text{dist}_{ij} + \beta_l^f \log \text{lang}_{ij} + \beta_C^f \text{corruption}_i + \nu_{ij}^n$ ,  $\nu_{ij}^n \sim \mathcal{N}(0, (\beta_{\text{disp}}^f)^2)$
  - We set  $f_{jj}^n = 0$ .
- ▶ SMM to estimate

$$\delta = [E, \beta_c^f, \beta_d^f, \beta_l^f, \beta_C^f, \beta_{\text{disp}}^f]$$

- ▶ Drawing shocks: Monte Carlo
  - Draw world, origin and firm shocks  $\gamma$  from log-Normal distributions (Quasi–Monte Carlo / Sobol sequences)
  - Draw firm productivity  $\varphi$  from a Pareto distribution.
  - Draw firm-level fixed costs  $f_{ij}^n$  from Normal distribution.

- ▶ 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.
  
- ▶ Model solution:
  - ▶ Equilibrium Price *Fixed point*,  
 $\Rightarrow$  for each aggreg. shock (Monte Carlo) world  $\bar{\gamma}_j$  + country  $\hat{\gamma}_{ij}$ , solve for  $P(\bar{\gamma}, \hat{\gamma})$
  - ▶ Firm sourcing: high dimensionality *combinatorial* discrete choice problem  
 $\Rightarrow$  For each firm  $\varphi$ , use Jia (2008)'s algorithm, in expectations (MC draws) to find  $\mathcal{I}_j^{\varphi}(\varphi)$
  
- ▶ 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  $\delta_0$ .

# Estimated supply-chain disruption shocks

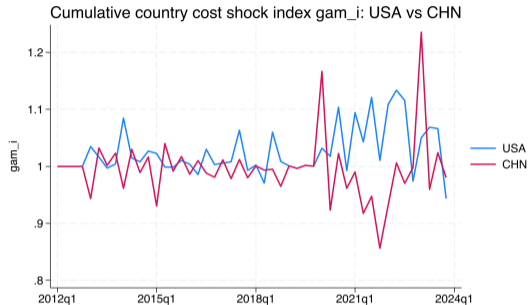


Figure 9: Source-specific shock  $\hat{\gamma}_{ij,t}$ : USA vs. China

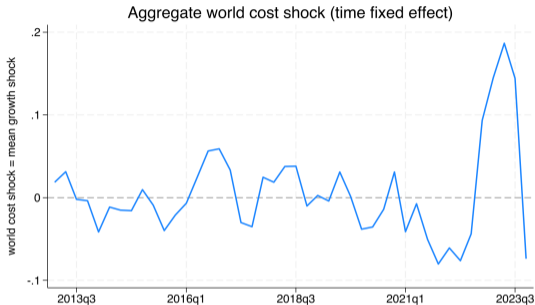


Figure 10: Global (world) shock  $\bar{\gamma}_t$

- ▶ Higher  $\hat{\gamma} \Rightarrow$  harder to source: post Covid, costlier to source from US and less from China
- ▶ World shock: trade became *easier* post pandemic (2021), then 2022 bottlenecks + Russia–Ukraine war raised costs

# Aggregate shocks: mean and risk by period

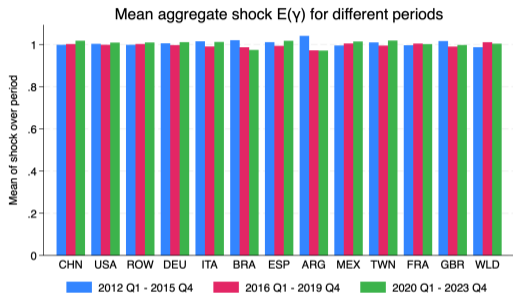


Figure 11: Mean  $E[\bar{\gamma}_t]$ ,  $E[\hat{\gamma}_{jt}]$

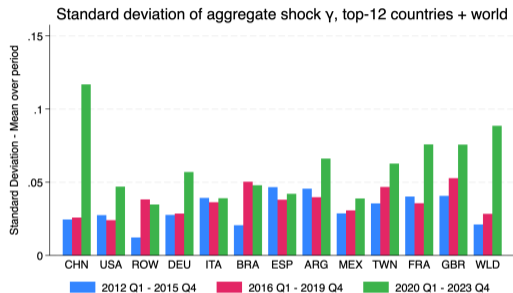


Figure 12: Std. dev.  $\sigma(\bar{\gamma}_t)$ ,  $\sigma(\hat{\gamma}_{jt})$

- ▶ Periods: 2012q1–15q4, 2016q1–19q4, 2020q1–23q4. Means rise modestly (China, US, world, trade-war peak in 2016–19)
- ▶ Post-Covid **risk (SD) rises markedly**, especially for China and the world – the key input to the counterfactual

## Counterfactual exercise

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- ▶ Estimate the model on 2012q1–2019q4 data: baseline sourcing and entry (**State 1**)
  
- ▶ Apply 2020q1–2023q4 trade-cost moments in three cumulative steps:
  - **State 2:** change the *means*  $\mathbb{E}[\gamma_{ij}]$
  - **State 3:** add the change in *idiosyncratic* risk  $\sigma(\tilde{\gamma}_{ij})$
  - **State 4:** add the change in *aggregate* risk  $\sigma(\hat{\gamma}), \sigma(\bar{\gamma})$
  
- ▶ Evaluate effects on entry into importing and sourcing by country, and decompose aggregate ex-ante profits into the four channels

## Post-Covid-19 uncertainty: firms' reactions

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Table 1: Counterfactual states (2020–23 moments applied cumulatively)

State	Importer share	Origins/firm	China share	U.S. share
1: Baseline	0.1968	2.956	0.1430	0.0999
2: + Mean shock	0.1956	2.968	0.1404	0.0990
3: + Idiosyncratic risk	0.2095	2.832	0.1665	0.0958
4: + Aggregate risk	0.2135	2.815	0.1717	0.0963

- ▶ Risk (States 3–4) raises the **importer share**: more firms enter into importing
- ▶ Origins per firm falls: new importers source from a *single* foreign origin
- ▶ **China share rises**, U.S. share falls then partly recovers – reallocation toward China

# Profit decomposition of post-Covid-19 uncertainty

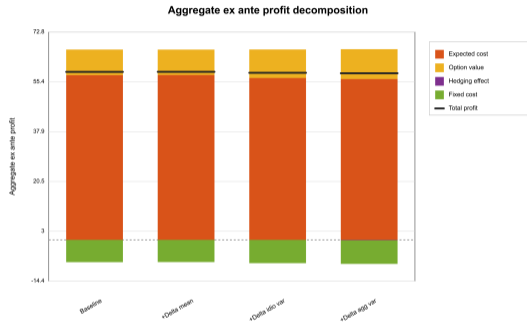


Figure 13: (a) Profit decomposition, 2020–23 uncertainty

- ▶ Expected-cost contribution *falls* (GE competition as more firms import). *Option value rises* and dominates
- ▶ Hedging effect & fixed costs become more negative  $\Rightarrow$  aggregate ex-ante profit falls, as more firms diversify

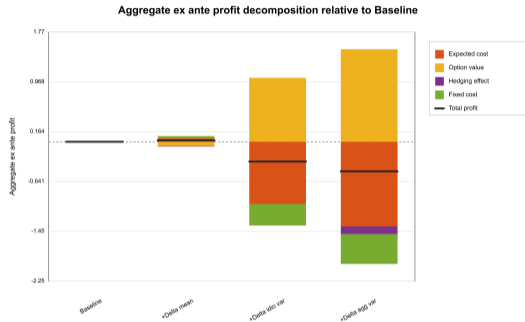


Figure 14: (b) Difference relative to baseline 2012–19

## Conclusion

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▶ Conclusion:

- a. Uncertainty shapes sourcing through **four channels**:
  - ▷ profits level is driven mainly by sourcing capability at expected costs
  - ▷ risk channels (option value, hedging effect) are an order of magnitude smaller
- b. Post-Covid-19, trade-cost *risk* rose sharply (esp. China and the world) while means moved less: firms responded by entering into importing and reallocating toward China
- c. The option value effect dominates the hedging effect, so firms diversify – yet aggregate ex-ante profits still *fall* (GE competition, hedging effect, and fixed costs)

▶ Next steps:

- ▶ Multi-sector model a la Caliendo Parro, with  $\frac{\sigma-1}{\theta} < 1$  within sector
- ▶ Model with adjustment cost / export quantity frictions  $\Rightarrow$  rationing
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- ▶ Thank you! ***tb3219@columbia.edu***

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- ▶ 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:

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

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

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## Proposition 1

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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

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## 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:

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

# Parameterization

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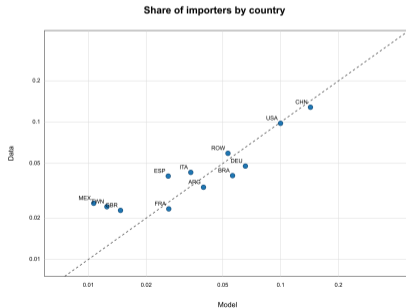
Variable	Definition	Value
$\gamma$ shock	Bernoulli: $\gamma=1$ ( $p=0.9$ ), $\gamma=5$ ( $p=0.1$ )	$\mathbb{E}[\gamma]=1.3$
$\rho$	Substitutability across intermediate varieties	2.00
$l$	Number of countries	3.00
$\xi_D$	Domestic sourcing potential	1.00
$\xi_{F1}$	Sourcing potential Foreign 1 (China)	0.80
$\xi_{F2}$	Sourcing potential Foreign 2 (US)	0.30
$f_D$	Fixed cost of sourcing Domestic	0.00
$f_{F1}$	Fixed cost of sourcing Foreign 1 (China)	0.70
$f_{F2}$	Fixed cost of sourcing Foreign 2 (US)	0.80
<i>Calibration for high complementarity <math>(\sigma - 1)/\theta = 1.58</math> following <a href="#">Antràs et al. (2017)</a></i>		
$\sigma$	Elasticity of final demand	3.85
$\theta$	Productivity Fréchet distribution shape	1.79

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Table 2: 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 15: Model fit: share of importers by country



## Jia's Algorithm

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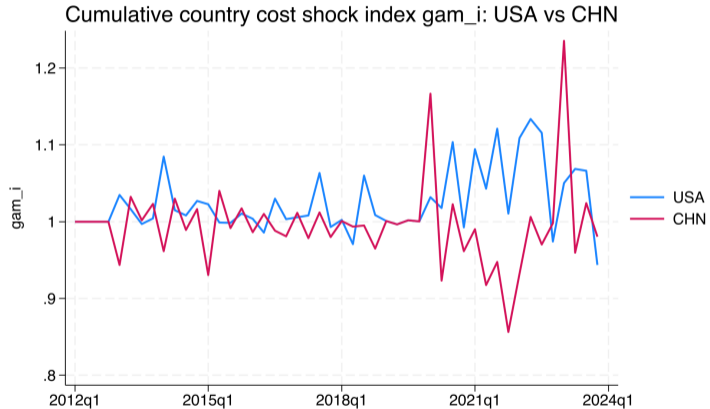
- ▶ Proposition:  $\forall i$ , define mapping  $V_{ij}(\varphi, \mathcal{I})$  to be one whenever including country  $i$  in sourcing strategy  $\mathcal{I}$  raises firm-level expected profits  $\mathbb{E}(\pi_j(\varphi, \mathcal{I}))$ , and a value of zero o/w. Then, when  $(\sigma - 1)/\theta \geq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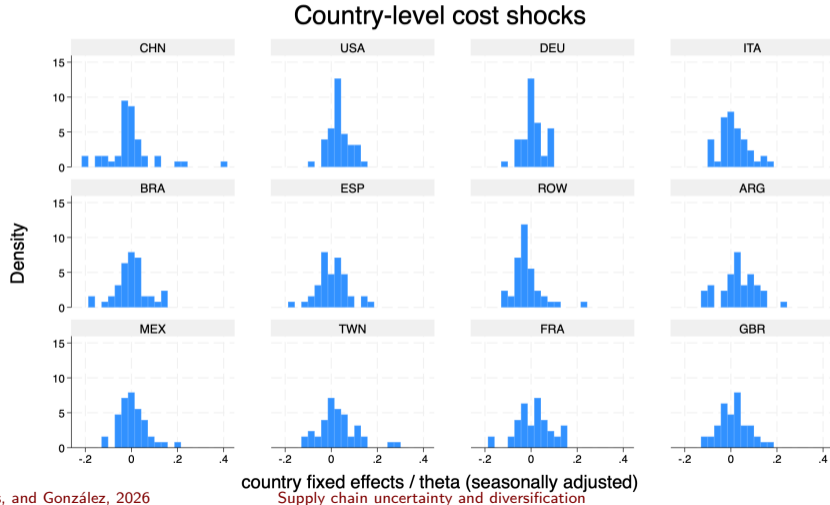
# Estimated Source-Specific Supply Chain Disruption Shocks

Figure 17: Source-specific supply chain disruption shock  $\hat{\gamma}_{ij,t}$ : USA vs. China



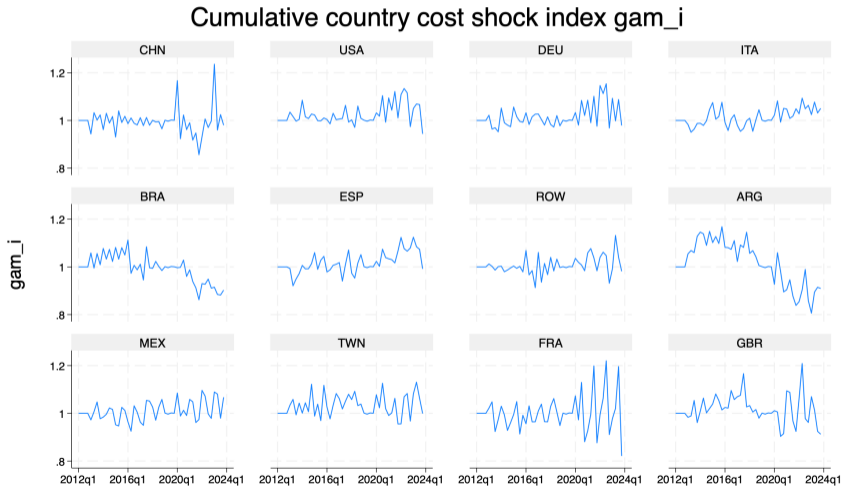
# Estimated Source-Specific Supply Chain Disruption Shocks

Figure 18: Source-specific supply chain disruption shock  $\Delta_4 \log \hat{\gamma}_{ij,t}$



# Estimated Source-Specific Supply Chain Disruption Shocks

Figure 19: Source-specific supply chain disruption shock  $\hat{\gamma}_{ij,t}$ : all countries



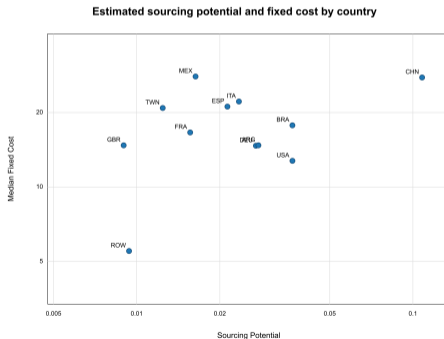
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## Results: Fixed cost estimation

Table 3: Estimated Parameters (fixed costs in thousands USD)

E	$f_{CHN}$	$f_{USA}$	$f_{ROW}$	$\beta_c^f$	$\beta_d^f$	$\beta_l^f$	$\beta_C^f$	$\beta_{disp}^f$
256.6	27.72	12.76	5.51	1.73	0.277	1.122	-0.259	0.625

Figure 20: Estimated Sourcing Potential and Median Fixed Cost



## Pecking order (data vs. random entry)

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Table 4: Strings of countries followed by importers (top-10 origins)

String of countries	Data		Random Entry	
	Firms	% Imp.	Firms	% Imp.
CHN	7,970	23.68	1,865	5.54
CHN-USA	2,201	6.54	2,034	6.04
CHN-USA-RoW	348	1.03	664	1.97
⋮				
Total following pecking order	12,005	35.67	4,855	14.42

- ▶ 35.67% of top-10 importers follow a strict pecking order, vs. 14.42% under random entry  
⇒ strong (but not perfect) ordering

## Decomposition of average shares into margins

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- ▶ Extensive margin:

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

- ▶ Decomposition:

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

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

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