# Derisking in the Time of Decoupling: U.S. Critical Supply Chains and Reliance on China

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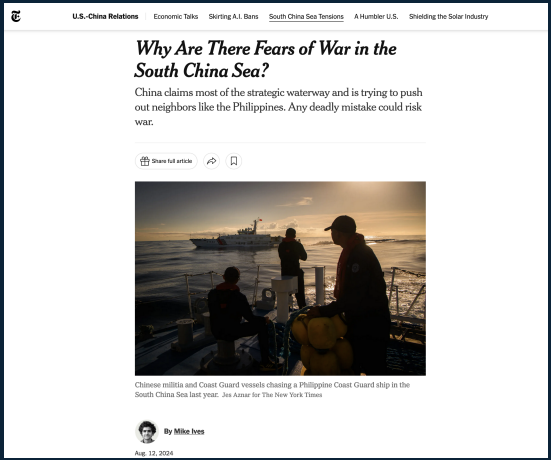
# Rising Tensions Surrounding China and the U.S.



U.S.-China Relations | Economic Talks | Skirting A.I. Bans | South China Sea Tensions | A Humbler U.S. | Shielding the Solar Industry

## *Why Are There Fears of War in the South China Sea?*

China claims most of the strategic waterway and is trying to push out neighbors like the Philippines. Any deadly mistake could risk war.

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Chinese militia and Coast Guard vessels chasing a Philippine Coast Guard ship in the South China Sea last year. Jes Aznar for The New York Times

By Mike Ives

Aug. 12, 2024

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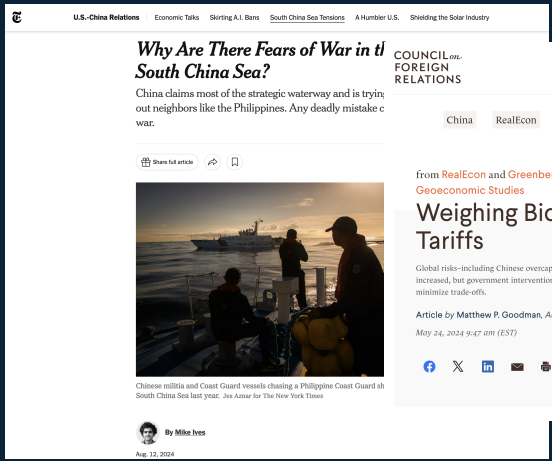


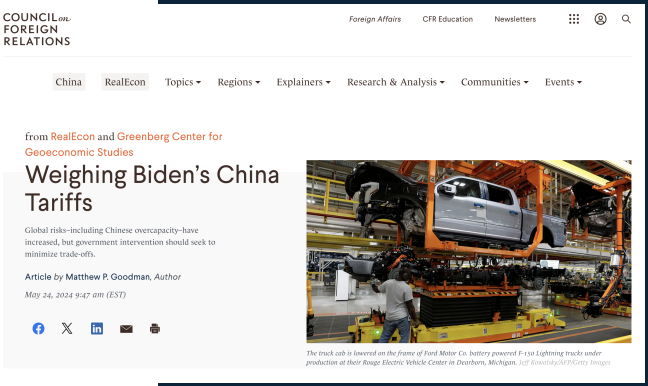


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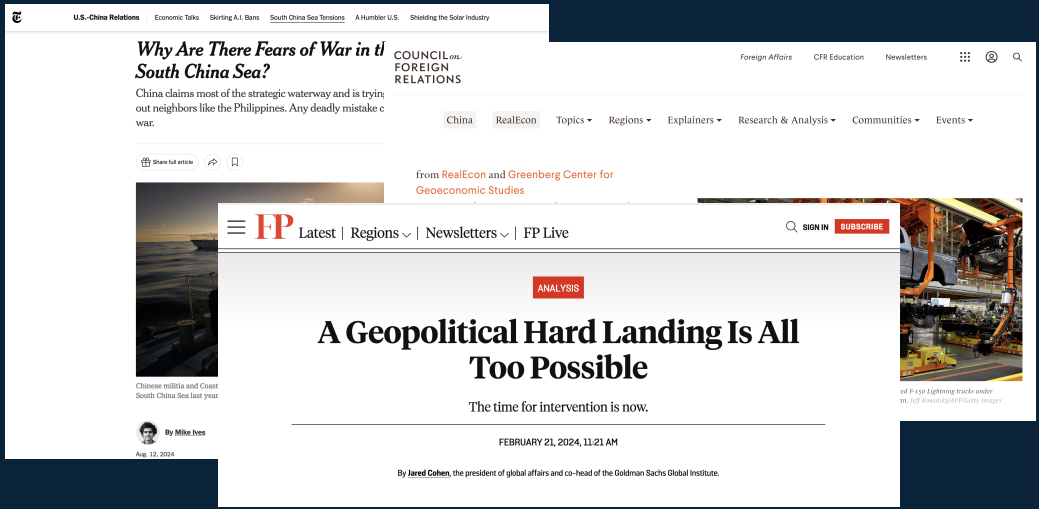

# U.S. Wants to Secure Supply Chains in Critical Sectors

- U.S. wants to ensure access to Critical Minerals and Information Communication Technologies (ICT), Green, and Public-Health Products.
- Led to an Executive Order directing the International Trade Administration to map out these products.


E.O. 14017

- U.S. firms must rely on imports to source many of these goods.
  - In many cases, they rely on imports from China.
- Firms face barriers to entry when importing from new countries.
  - These may be industry specific.

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# What are the Sunk Costs of Sourcing Critical Sector Products?

1. Do these vary by sector? Country?
2. How do sunk costs limit the ability of U.S. importers to respond to unexpected (decoupling) shocks?
3. Are policies meant to incentivize importers to diversify (derisking) more effective when implemented prior to the realization of an unexpected shock?

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# What are the Sunk Costs of Sourcing Critical Sector Products?

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Decoupling: Any increase in bilateral trade costs between the U.S. and China.

Derisking: Policy meant to incentivize U.S. firms to add new source countries.

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# This Paper

Use confidential U.S. Census data to document new stylized facts about the Executive Order 14017 products.

China exports these products to more U.S. firms compared to other countries.

Build and quantify a firm-level model of endogenous U.S. sourcing.

- Generalize Antràs, Fort, and Tintelnot, 2017 to multiple sectors, including a new estimation approach, and nest a model of shipping mode choice.
- Firms pay a sunk cost in first year of importing a critical sector from a new country as in Hoang, 2022.
- Use a revealed preference approach to bound sunk costs across critical sectors.

Estimate Counterfactuals of *Derisking* and *Decoupling*

Show that sunk costs can make *proactive* Derisking policies more effective than *reactive* ones.

# Critical Products Identified in Executive Order 14017

| Aggregate Sector | Subsector | Aggregate Sector | Subsector |
|---|---|---|---|
| Energy | Carbon Capture | ICT | Audiovisual Equipment |
| | Electric Grid | | Computer Equipment |
| | Fuel Cells | | Other Electronic Components |
| | Hydropower | | Semiconductors |
| | Large Capacity Batteries | | Telecom/Network Equipment |
| | Neodymium Magnets | Critical Minerals | Primary |
| | Nuclear Power | and Materials | Processed |
| | Platinum Group Metals | Public Health | PPE and Durable Medical Equipment |
| | Solar | | Pharmaceuticals & API |
| | Wind | | Testing and Diagnostics |

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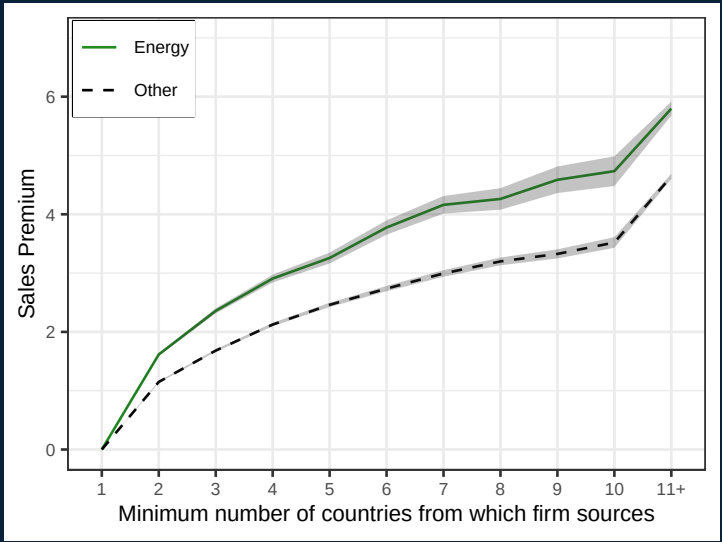
# Fact 1: Critical-Sector Inputs Carry a Larger Importer Premium

- Estimate sales revenue importer premium for critical sector imports and all other imports.
- Importer premium is higher for critical sectors.
- Similar pattern for employment.

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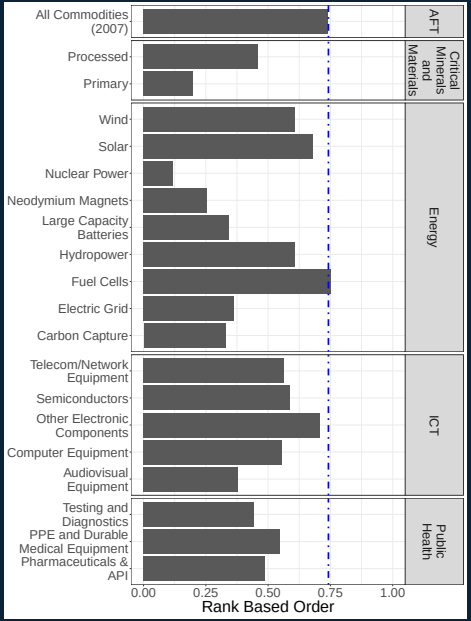
# Fact 2: High Divergence in Number of Importers and U.S. Import Values

- Compare country rankings of import values and the number of U.S. firms.
- *Divergence in the order of rankings suggests fixed-cost barriers to importing.*
- Use rank-based order (RBO) to compare the two ranking.s
  - Score equal to 1 indicates rankings are identical.
- Most critical sectors are less-similar relative to aggregate similarity.




RBO

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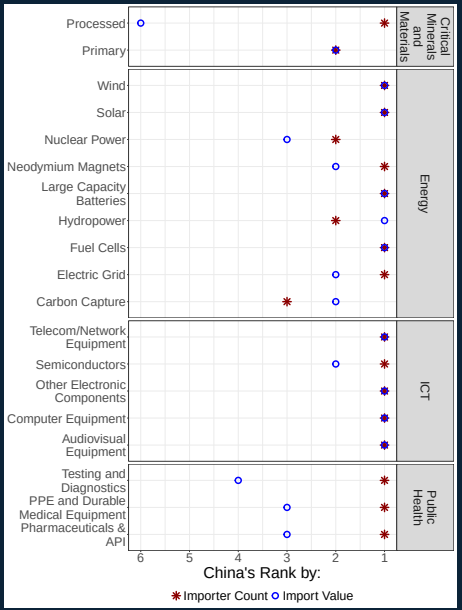


# Fact 3: China is a More Important Supplier of Critical Products when Ranking Countries by the Number of U.S. Importers

- Exposure to China is worse in critical sectors when considering the number of U.S. firms that import over import values.
- Suggests that U.S. firms face lower fixed-costs when sourcing from China.

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# Model Setup

- Final goods firm $\varphi$ produces a unique variety in a monopolistically competitive market using domestic inputs and imports of critical sector goods $s$.
  - Love of variety with demand elasticity of substitution denoted by $\sigma$
- Intermediates are the only traded goods; perfectly competitive market.
- For each variety of a critical subsector $s$, firms search prices in a limited set of countries ($\mathcal{J}^s(\varphi)$) and purchases from the lowest priced country.
- Firms must pay a fixed cost ($f_{s,j}$) in every country $j$ they source from.
- Additional sunk cost must be paid ($\psi_{s,j}$) if the firm did not source from the country in the previous year, $j \in \mathcal{J}_t^s(\varphi) \setminus \mathcal{J}_{t-1}^s(\varphi)$.

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# Trade in Intermediate Goods

- Trade in intermediates is perfectly competitive ($p_j^s = w_j^s$) across countries $j$
- Importer's price includes costs of transport, tariffs, and efficiency of product. $p^s(\varphi, \nu) = \min_{j \in \mathcal{J}^s(\varphi)}\{\tau_{\varphi,j}^s a_j^s(\varphi, \nu) w_j^s\}$
  - $w$: marginal cost of production;
  - $\tau$: firm- and country-specific transportation costs; tariffs
- With $\Pr(a_j^s(\nu, \varphi) \geq a) = e^{-T_j^s a^{\theta_s}}$, where $T_j^s > 0$
  - $T$: technology shifter;
  - $\theta_s$ governs shape of the distribution
- Leads to (Eaton and Kortum, 2002)-style firm-level import share eq'n, where the import elasticity is $\theta_s$...

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# Firm Import Share Equation

Share of firm-$\varphi$'s imports of subsector-$s$ goods from $j$:

$$x_j^s(\varphi) = \frac{T_j^s (w_j^s \tau_{j\varphi}^s)^{-\theta_s}}{\Phi^s(\varphi)} E^s(\varphi)$$

Define a country's *Sourcing Potential* as $T_j^s (w_j^s \tau_{j\varphi}^s)^{-\theta_s}$

- Informs how efficiently country-$j$ supplies subsector-$s$ on **per-unit basis**.
- Increasing in country's technology $T_j^s$
- Decreasing in import costs, $\tau_j^s$, and production costs, $w_j^s$.

A firm's *Sourcing-Capacity* ($\Phi^s(\varphi)$) is the sum of the Sourcing Potential for the countries it sources from.

- $\Phi^s(\varphi) \equiv \sum_{j \in \mathcal{J}^s(\varphi)} T_j^s (w_j^s \tau_{j\varphi}^s)^{-\theta_s}$

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# Profits, Fixed and Sunk Costs

$$\Pi_t(\varphi) = \sigma^{-1} r_t(\varphi) - w_{US,t} \sum_S \sum_{j \in \mathcal{J}_t^S(\varphi)} f_j^s + \psi_j^s \cdot \mathbb{I}(j \in \mathcal{J}_t^s(\varphi) \setminus \mathcal{J}_{t-1}^s(\varphi))$$

- $\sigma^{-1} r_t(\varphi)$: variable profit (monopolistic competition)
- $f$: fixed costs
- $\psi$: sunk costs
- $w_{US,t}$: U.S. Wages (fixed costs paid using domestic labor)
- $\mathbb{I}(j \in \mathcal{J}_t^s(\varphi) \setminus \mathcal{J}_{t-1}^s(\varphi))$: indicates if firms pay sunk costs in year t

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# Change in Profits from Adding/Dropping a Supplier

- Sourcing from a new country increases variable profits if $(\sigma - 1) > \theta_s$.
- Sourcing Potential, relative to firm's current Sourcing Capacity determines how impactful the country is as a supplier.

$$r_{jt}(\varphi, \mathcal{J}_t^s(\varphi)) = \begin{cases} r_t(\varphi)\left(\left[\frac{\Phi_t^s(\varphi) + T_{tj}^s(\tau_{t,\varphi j} w_{t,j}^s)^{-\theta_s}}{\Phi_t^s(\varphi)}\right]^{(\sigma-1)/\theta_s} - 1\right) & \text{if } j \notin \mathcal{J}_t^s(\varphi) \\ r_t(\varphi)\left(1 - \left[\frac{\Phi_t^s(\varphi) - T_{tj}^s(\tau_{t,\varphi j} w_{t,j}^s)^{-\theta_s}}{\Phi_t^s(\varphi)}\right]^{(\sigma-1)/\theta_s}\right) & \text{if } j \in \mathcal{J}_t^s(\varphi) \end{cases}$$

To decide if it should or drop a supplier country for a critical subsector, the firm weighs the above expression against the fixed and sunk-costs of importing ($f_j^s$ and $\psi_j^s$, respectively).

Free Entry | Moments

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# Data

## Census Data

- *Economic Censuses*: Revenues, Employment, Total Expenditures, Industry
- *Longitudinal Business Database*: Revenues, Employment
- *Longitudinal Firm Trade Transactions Database*: Import values and cost of shipment

## External Data

Use to create a cost shifter that varies by firm, country, subsector and year.

- Distance Data: Shortest maritime distance and great circle distance between U.S. and foreign ports.
- Quarterly prices of diesel and jet fuel.

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# Estimation

## Transport Costs

- Estimated using firm specific shipping costs by shipping mode
- Result: Predicted shipping costs $\tau_{j\varphi}^{s}$ and mode-choice elasticity $\rho_s$

## Sourcing Potential

- Estimated using firm-country trade costs, country-sector fixed effects, and firm-sector fixed effects.
- Result: Firm-country-sector sourcing potential and sector specific import elasticities $\theta_s$

## Fixed and Sunk Costs

- Estimated using sourcing potential, $\theta_s$, and firm revenues
- Result: Sector fixed and sunk costs ranges

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# Transportation Mode Choice

- Need variation in firm import costs that vary by supplier country and critical sector, use shipment cost from LFTTD.
- Nest a discrete-choice model of mode shipping similar to Allen and Arkolakis, 2014 and Jaworski, Kitchens, and Nigai, 2023.
- Functional form of trade costs: $\tau^s_{\varphi jt} = B^s_{\varphi t}\left(\sum_{m\in\mathbb{M}_j}\left(\tau^s_{mjt}\right)^{-\rho_s}\right)^{-1/\rho_s}$
- Estimate using:
  - Share of $\varphi$'s imports, imported using mode-$m$ ($\varsigma^s_{mj\varphi t}$) is LHS variable
  - $\tau^s_{mjt}$ is instrumented by quarterly fuel costs interacted with distance shipped.

$$log(\varsigma^s_{mj\varphi t}) = \beta^s log(\tau^s_{mjt}) + \beta^s X_{mj\varphi st} + \mu_{\varphi st} + \delta_{jst} + \epsilon^s_{mj\varphi t}$$

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# Estimates: Transportation Mode Choice Elasticities

- Zero shares matter, use two-stage PPML.
- Mode-choice elasticities used to simulate mode-specific transportation shocks in counterfactuals.
- Use fixed effects with mode-choice elasticities to recover $\widehat{\tau^{s}_{\varphi jt}}$

| | Mode-Choice Elasticity |
|---|---|
| Critical Minerals and Materials | -0.7914** |
| | (0.3447) |
| Energy | -2.618*** |
| | (0.8547) |
| ICT | -3.077** |
| | (1.251) |
| Public Health | -2.841* |
| | (1.502) |
| Fixed Effects: | Firm-sector-year |
| | Country-sector-year |
| Bootstrap S.E. Clustered | Sector |

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# Sourcing Potential and Import Elasticities

- Use estimated firm-country-subsector specific transport cost estimates as cost shifters.
- Take logs of import share equation and use as estimating equation.
- Normalize by domestic expenditures to control for any correlated domestic sourcing.

$$\widehat{\xi^s_{j\varphi t}} = -\theta_s log(\widehat{\tau^s_{\varphi jt}}) + \gamma^s_{jt} + \iota^s_{\varphi t} + \epsilon^s_{j\varphi t}$$

- $\widehat{\xi^s_{j\varphi t}}$: Import share normalized by domestic expenditures.
- $\gamma^s_{jt}$: country-sector fixed effects
- $\iota^s_{\varphi t}$: firm-sector fixed effects

Normalization Sourcing Potential

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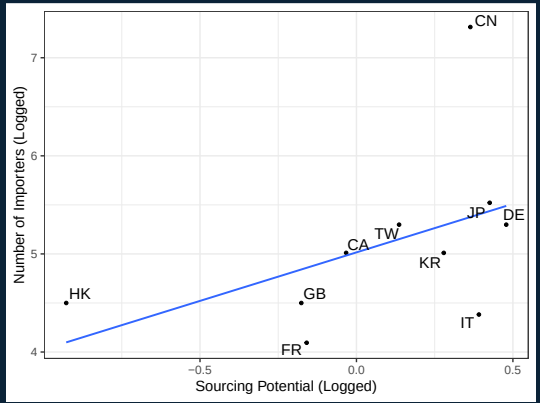
# Elasticity Estimates

| | Import Elasticity ($\theta_s$) |
|---|---|
| Critical Minerals | -1.839*** |
| ...and Materials | (0.0634) |
| Energy | -3.514** |
| | (1.446) |
| ICT | -6.048** |
| | (2.403) |
| Public Health | -2.569*** |
| | (0.8028) |
| Fixed-Effects: | Country-Sector-Year Triplet |
| S.E.: Clustered | by: Country & Sector |
| R2 | 0.1129 |




Large Capacity Batteries

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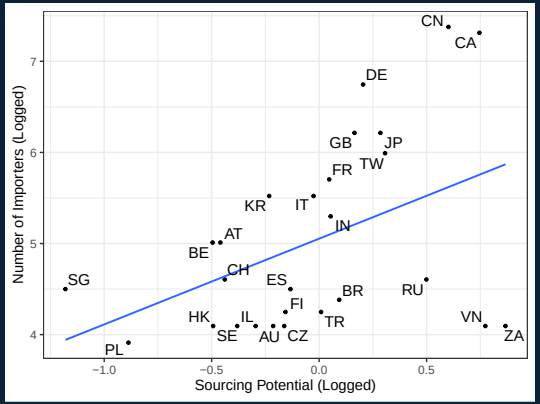
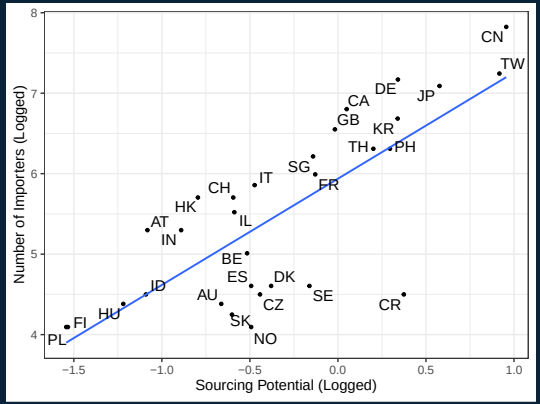
# Relationship between Sourcing Potential and Extensive Margin Varies Across Subsectors




Critical Minerals: Processed




Semiconductors

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# Moments to Bound Fixed and Sunk Costs

- **Deviation 1:** Imports in both t and t-1 (Fixed cost upper bound)

$$\Pi_{\varphi jt} = \sigma^{-1} r_{\varphi jt}(\mathcal{J}^s_{\varphi t}) - \gamma^f_{sj} - \epsilon^f_{\varphi jt}$$

$\sigma$ Estimates | Revenue Change

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- **Deviation 2:** Imports in t but not t-1 (Fixed and sunk cost upper bound)

$$\Pi_{\varphi jt} = \sigma^{-1} r_{\varphi jt}(\mathcal{J}^s_{\varphi t}) - \gamma^f_{sj} - \gamma^S_{sj} - \epsilon^f_{\varphi jt}$$

$\sigma$ Estimates | Revenue Change

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- **Deviation 2:** Imports in t but not t-1 (Fixed and sunk cost upper bound)
$$\Pi_{\varphi jt} = \sigma^{-1} r_{\varphi jt}(\mathcal{J}^s_{\varphi t}) - \gamma^f_{sj} - \gamma^S_{sj} - \epsilon^f_{\varphi jt}$$

- **Deviation 3:** Imports in t-1 but not t (Fixed cost lower bound)
$$\Pi_{\varphi jt} = \sigma^{-1} r_{\varphi jt}(\mathcal{J}^s_{\varphi t}) + \gamma^f_{sj} + \epsilon^f_{\varphi jt}$$

- **Deviation 4**: Does not import in t or t-1 (Fixed and sunk cost lower bound)
$$\Pi_{\varphi jt} = \sigma^{-1} r_{\varphi jt}(\mathcal{J}^s_{\varphi t}) + \gamma^f_{sj} + \gamma^S_{sj} + \epsilon^s_{\varphi jt}$$

$\sigma$ Estimates Revenue Change

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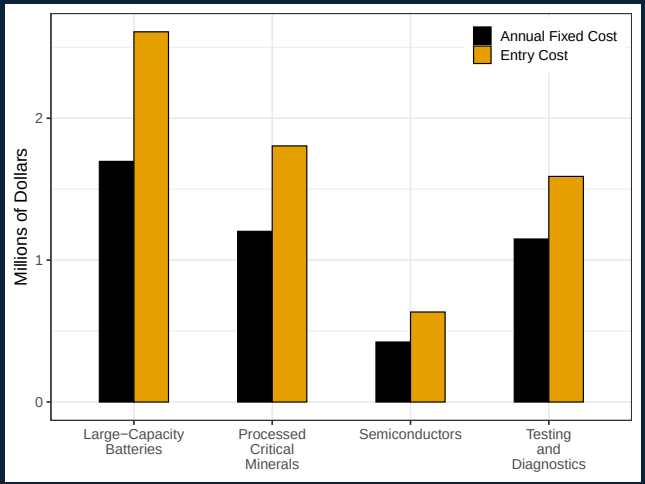
# Estimates: Fixed and Sunk Cost

- Plots estimates of upper bounds.
- Different relationships between sunk and fixed costs across sectors.
- Next disclosure will include country-specific estimates.

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# Two Counterfactual Scenarios of Supply Chain Disruption

## Decoupling from China

1. Reduce China's sourcing potential by half
2. Enact preemptive Indo-Pacific Economic Framework (IPEF) with market-access provisions
   - Reduce China's sourcing potential with preemptive IPEF agreement in place

   Difference in impact is IPEF's effectiveness at reducing U.S. exposure to decoupling shocks.

## South China Sea Disruption

- Disrupt trade in the South China Sea
- Increase the cost of importing for China, Vietnam, Japan, and the Philippines

*Currently incomplete, don't allow for changes in firm sourcing strategies!*

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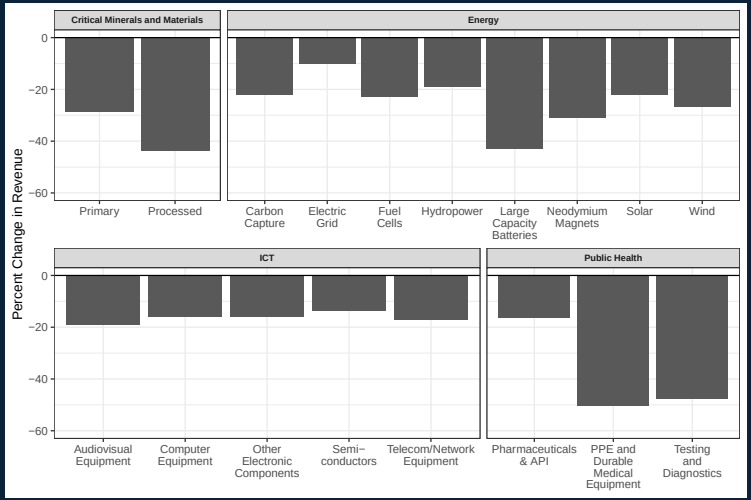
# China Decoupling Counterfactual: Importer Revenues (No IPEF)

*Preliminary*: Different subsectors have varying levels of exposure to decoupling shocks.

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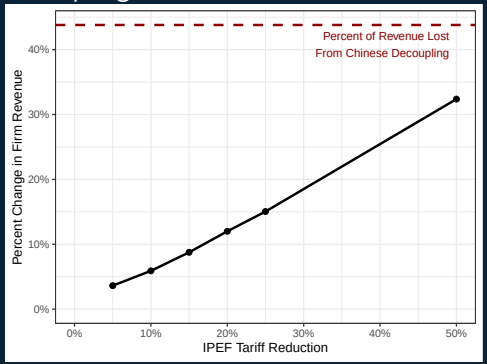
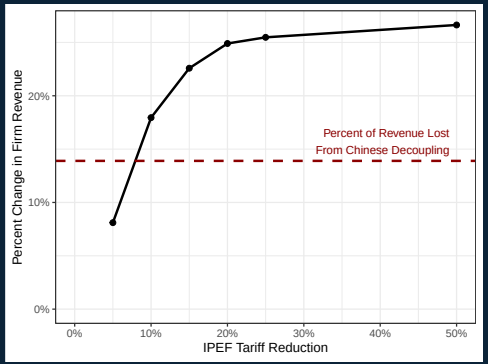
# China Decoupling Counterfactual: Importer Revenues (With IPEF)

Size of market access in IPEF determines effectiveness of Derisking in insulating U.S. firms from Decoupling shock. In some industries IPEF could not offset losses from Decoupling.




Critical Minerals and Materials: Processed

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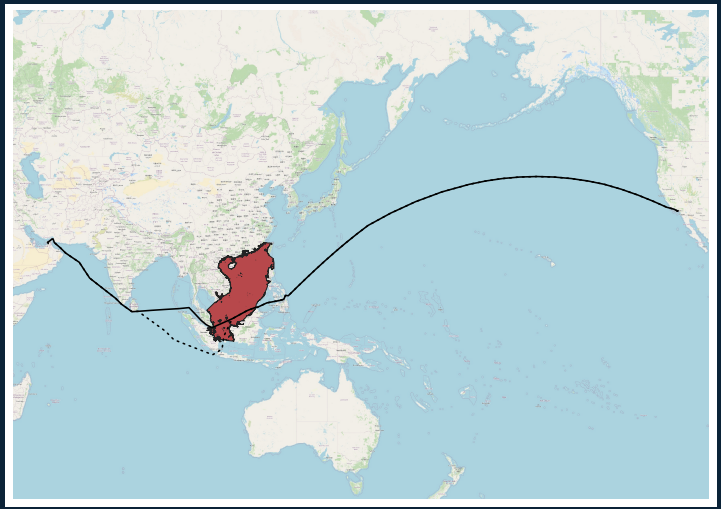
# South China Sea Scenario



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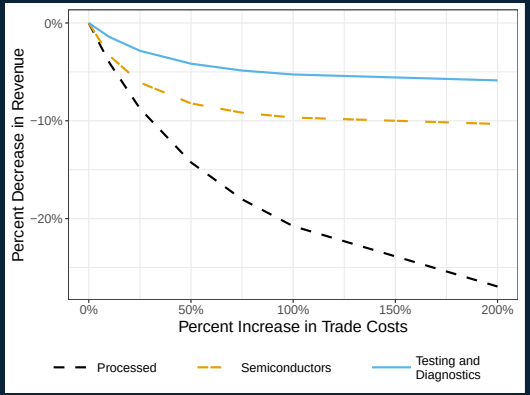
# South China Sea Counterfactual: Importer Revenues




- Simulate an increase in maritime shipping costs for countries highly exposed to the South China Sea.
  - Utilize our mode-choice model.
- Future versions will utilize maritime network data and Dijkstra algorithm, and not restrict shock to select countries.

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# Thank you! Questions/Comments

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# Rank Based Order (RBO)

- Compare the similarities of two ranked lists.
- Higher weight on top ranks.
- RBO = 0 implies no similiarities, RBO = 1 implies perfect match
- We rank countries by:
  - The number of U.S. firms that import from the country ($N_j$).
  - The total value of those imports ($V_j$).
- Apply rank based order to these two lists

Definitions:

- The element at rank i in set S as $S_i$
- $S_{:d}$ as $\{S_i : 1 \leq i \leq d\}$

$$A_d = |N_{:d} \cap V_{:d}| \Big/ d$$

- Choose a weighting factor $p$ (we chose $p = 0.95$)
- Rank based order is:

$$RBO(p) = (1-p) \cdot \sum_{d=1}^{|V_j|} p^{(d-1)} \cdot A_d$$

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# Demand Elasticity Estimation

- Follow Antràs, Fort, and Tintelnot, 2017
- Establishment reported markups used to estimate demand elasticities $\sigma$ under monopolistic competition assumption.
- Estimate 28.5% average markup with a bootstrapped standard error of 0.0015.
- Implies $\sigma = 4.5$.

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# Normalization Method

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Take logs of each firm i's ratio of sector-s intermediate inputs from j to the total intermediates from h (the U.S.).

$$\log X^s_{\varphi jt} - \log X_{\varphi ht} = \log S^s_{\varphi jt} - \log S_{\varphi ht} + \epsilon^x_{\varphi jst}$$

Assume that domestic sourcing potential of sector s inputs is constant across firms ($S^s_{\varphi ht} = S^s_{ht}, \forall \varphi$). Then regress the left hand side on a year dummy:

$$\log X^s_{ijt} - \log X_{iht} = \nu^s_t + \xi^s_{ijt}$$

The structural error and the sourcing potential from firm j are both embedded in $\xi^s_{\varphi jt}$. That is:

$$\xi^s_{\varphi jt} \equiv \log S^s_{\varphi jt} + \epsilon^x_{\varphi jst}$$

Where $S^s_{\varphi jt} \equiv T^s_{jt}(w^s_{jt}\tau^s_{jt\varphi})^{-\theta_s}$

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# Closing the Model

Free entry for final-goods producers:

$$\int_{\tilde{\varphi}}^{\infty} \sum_{s} \left[ \varphi^{\sigma-1} (\gamma_s \Phi_t^s(\varphi))^{(\sigma-1)/\theta_s} B_t - w_t \sum_{j \in \mathcal{J}_t^s(\varphi)} \left( f_j^s + \psi_j^s \cdot \mathbb{I}(j \in \mathcal{J}_t^s(\varphi) \backslash \mathcal{J}_{t-1}^s(\varphi)) \right) \right] dG(\varphi) = w_t f_e$$

- $B$ is a final-demand shifter
- $\gamma_s$ is a scalar dependent on Pareto parameters
- Firms only realize their productivity draw after the firm entry cost, $f_e$, is drawn.
- Freely tradeable and homogeneous outside good. Serves as the numeraire and pins down wages

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