# Digging Up the Value Chain

## Mineral Export Restrictions and Industrial Upgrading

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# Motivation

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In recent years, resource-rich developing countries are increasingly imposing export restrictions on raw minerals—

—as industrial policy tools to promote downstream processing, capture greater value-added, and reduce dependence on volatile commodity revenues.

# Motivation



fastFT Commodities + Add to myFT

## Nickel prices hit four-year high on Indonesia export ban

Fears of shortages as top producing country brings forward export restrictions

**Henry Sanderson** in London

Published AUG 30 2019

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Fears of sho

Henry Sande

Published AU

## India's iron ore exports ban hits shippers in Goa

China is one of India's largest trade partners but the relationship is an unequal one. India imports far more from China than it exports to it.

One of India's largest exports to China is iron ore. But mining bans in some parts of India have tipped the balance of trade even further.

Yogita Limaye in Goa takes a look at how this trade relationship has come under pressure.

Business · 17 September 2012

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Business · 17

Uganda Bans Raw Mineral Exports: What It Means For The Mining Sector

Source: Publicist East Africa

By The Voice Of Africa — Last updated Jul 13, 2025

ECONOMY & BUSINESS

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Business · 17

Uganda Bans Raw Mineral Exports: What It Means For The Mining Sector

Source: Public

By The Voice (

Congo extends ban on trade in minerals from sites in war-hit east

By Reuters

November 17, 2025 1:10 PM GMT · Updated November 17, 2025

# Motivation

Such policies often reflect a broader industrialization agenda:

> *"We really want to hit the brakes on exporting raw materials because there is no value addition and it does not create jobs. [...] We want these resources to be exported as semi-finished goods or as finished goods, because what we want is the added value"*
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However, the *effectiveness* of mineral export restrictions is still poorly understood.

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1. **Why?** Why do governments increasingly favor mineral export restrictions over alternative policy instruments?
2. **How?** Through what mechanisms can export restrictions promote downstream industrial development and enhance domestic welfare?
3. **Does it work?** Do such restrictions actually expand downstream processing and foster broader industrial upgrading?

# Literature

## Industrial Policies

- Liu (2019); Juhász et al. (2024); Lashkaripour and Lugovskyy (2023); Reed (2024)
- This paper: Highlight export restrictions as an industrial policy instrument

## Mineral Export Restrictions

- Korinek and Kim (2011); Alfaro et al. (2025); Bosker et al. (2025); Kee and Xie (2025)
- This paper: Examine the developmental consequences of export restrictions globally

## Resource Curse / The Dutch Disease

- van der Ploeg (2011); Venables (2016); Mien and Goujon (2021)
- This paper: Tests whether export restrictions help resource-rich countries industrialize

# LMICs specialize in upstream exports...

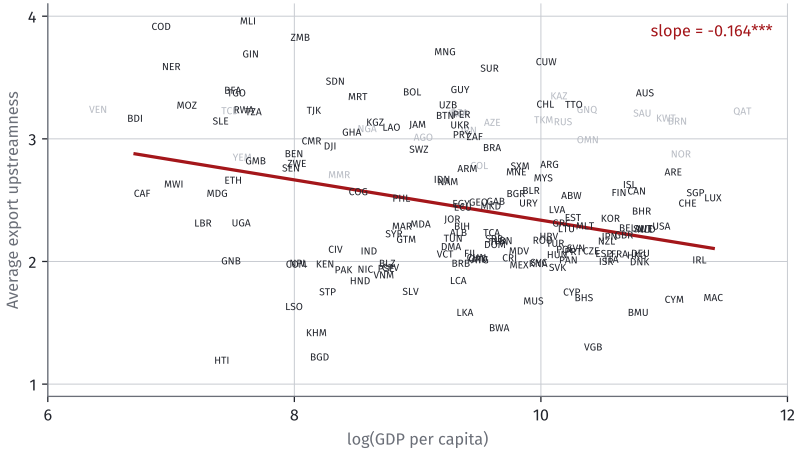



Figure: Export upstreamness by GDP per capita, 2015

# ...and export restrictions are their go-to industrial policy tool

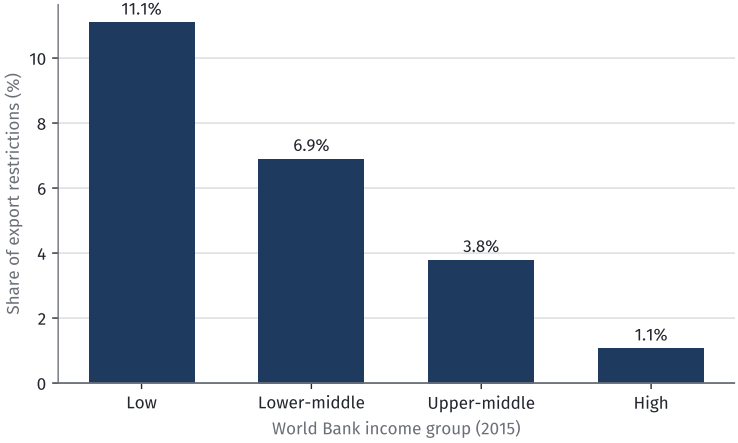



Figure: Share of export restrictions among all industrial policies, 2008–2023

# Raw minerals are natural targets: most upstream in value chains...

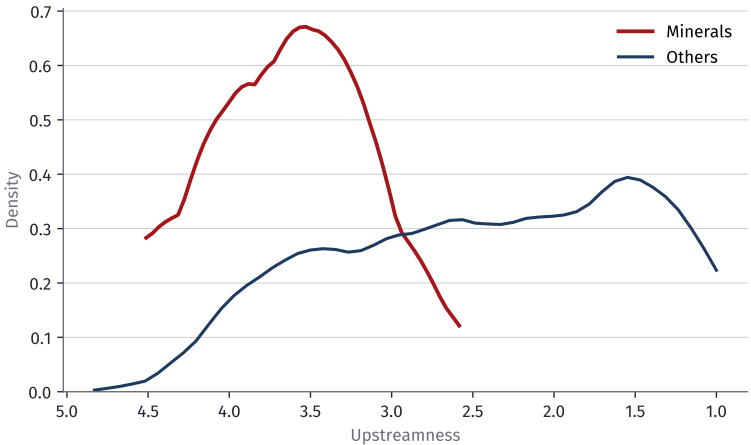



Figure: Upstreamness: minerals vs. other products

# ...with strong RCA that does not extend downstream

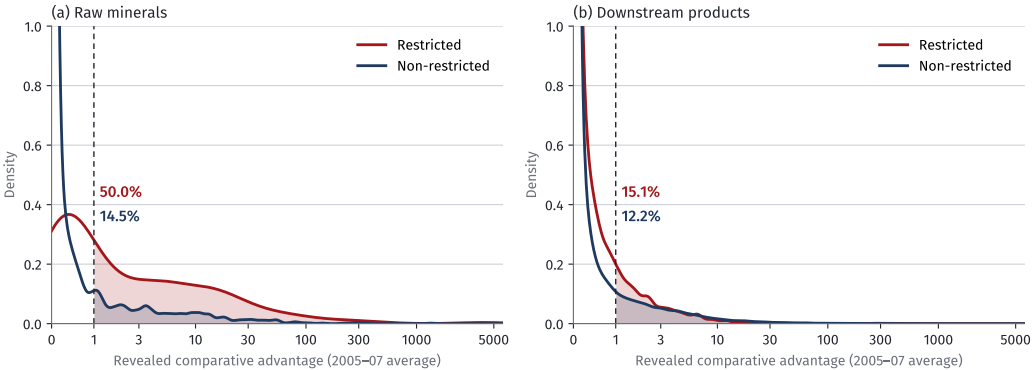



Figure: Revealed comparative advantage (2005–07): restricted vs. non-restricted products

## General Idea

Mineral export restrictions combine **trade** and **industrial** policies:

- Create price gaps between domestic and global mineral markets
- Provide implicit subsidies for downstream processing industries

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- Provide implicit subsidies for downstream processing industries

These dual-purpose policies raise welfare via two distinct channels:

- **TP channel**: Improve home country's terms of trade;
- **IP channel**: Correct domestic market failures
  - In this paper: External economies of scale in downstream industries

## Model Setup

**Environment:**

- Two countries – Home ($H$) and Foreign ($F$)
- Two sectors – Mining ($M$) and Manufacturing ($Y$)

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- Two sectors – Mining ($M$) and Manufacturing ($Y$)

**Factor Endowment:**

- Labor ($L, L^*$) – freely mobile across sectors within each country
- Mineral reserves ($R, R^*$) – fixed factors specific to the mining sector

## Production

**Mining sector** produces minerals $M$ using mineral reserves and labor:

$$M = R^{\beta} L_M^{1-\beta}, \quad \beta \in (0, 1).$$

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Individual firms in the **manufacturing sector** produces manufactures $Y$ using minerals and labor with **external economies of scale**:

$$y_j = A\, m_j^{\alpha}\, \ell_j^{1-\alpha}\, L_Y^{\gamma}, \quad \alpha \in (0,1),\ \gamma > 0,$$

where $m_j$ and $\ell_j$ are firm $j$'s demand for minerals and labor, $L_M$ is total manufacturing employment (taken as exogenous by each firm), and $A$ is country-specific total factor productivity.

## Mineral Export Restrictions

Both goods are tradable with iceberg trade cost $\tau > 1$: to deliver one unit to the foreign country, $\tau$ units must be shipped.

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**Home** imposes an ***ad valorem* export tax**, $t$, on mineral exports:

$$p_M = \frac{1-t}{\tau} p_M^* < \frac{1}{\tau} p_M^*,$$

which creates a wedge between the world and domestic mineral prices in Home, equivalent to an **implicit subsidy** to the manufacturing sector.

## Welfare Decomposition

A marginal increase in mineral export tax rate $t$ changes Home welfare by:

$$\frac{dW}{dt} = \frac{1}{1-t}\left[(1-s_Y)\,\Phi + s_Y\,\eta_{YY}\,(1-\Phi) - (1-s_Y)\,\eta_{IM}\,(1-\Phi)\right]$$

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## Towards a Multi-Stage Model

The manufacturing sector can be further divided into many **production stages**, each uses upstream intermediates and features external economies of scale.

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Once production is structured as a multi-stage chain, mineral export restrictions create a **policy dilemma:**

- Downstream stages carry larger welfare weights; correcting market failures here delivers larger efficiency gains.
- Mineral export restrictions drive the strongest labor reallocation in upstream stages, and their stimulus fades along the value chain.

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***Do we observe this pattern in reality?***

# Data

## Mineral Export Restrictions

- Export restrictions from the Global Trade Alert (GTA), 2008–2023 (Evenett, 2009)
- Targeting mineral products classified under HS Chapters 25 and 26
- 112 measures by 28 countries (200 country–mineral pairs), dated by announcement

→ Summary Stat.

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## Downstream Products

- AI-generated Production Network (Fetzer et al., 2024)
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## Downstream Products

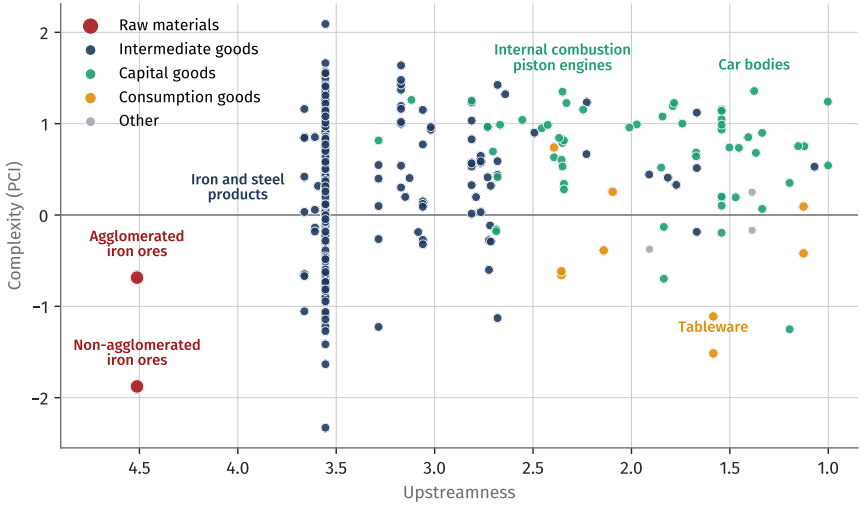
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## International Trade

- HS6-level exports from CEPII-BACI, 2002–2023 (Gaulier and Zignago, 2010)

→ Summary Stat.

# Example: The Iron-Steel Value Chain



## Stage Assignment

The AIPNET data do not provide information on the **stage structure** of each mineral-related downstream network, which is essential for the model.

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**Tarjan algorithm**: Find strongly connected components (SCCs) in a directed graph.

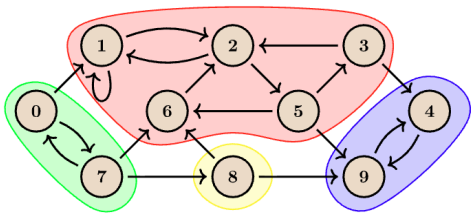
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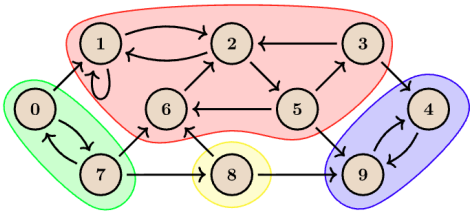


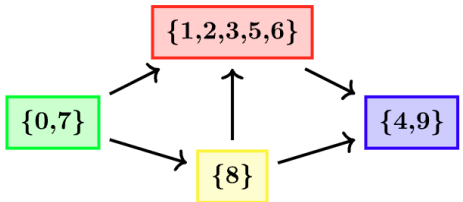
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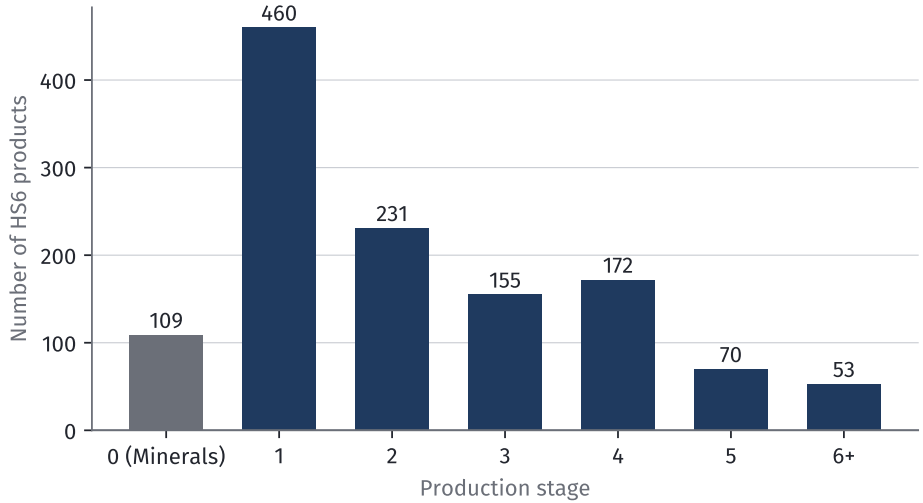
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# Stage Assignment: Summary



## Stage Assignment: Examples

| HS Code | HS Description | Stage |
|---|---|---|
| 720110 | Non-alloy pig iron | 1 |
| 740311 | Refined copper and copper alloys, unwrought | 2 |
| 860711 | Driving bogies and bissel-bogies (locomotive parts) | 3 |
| 846011 | Flat-surface grinding machines | 4 |
| 854121 | Transistors with a dissipation rate of less than 1 W | 5 |
| 910310 | Clocks with watch movements, electrically operated | 6 |
| 870600 | Chassis fitted with engines | 7 |
| 880230 | Aeroplanes and other aircraft | 8 |

# Empirical Strategy

**For targeted minerals:**

$$Y_{ikt} = \exp\left[\alpha + \beta \cdot ER_{ikt} + \gamma_{ik} + \delta_{it} + \eta_{kt}\right] + \varepsilon_{ikt}$$

- $Y_{ikt}$: exports of product $k$ by country $i$ in year $t$
- $ER_{ikt} = 1$ if product $k$ is restricted by country $i$ in year $t$
  - Assumption: $ER_{ikt}$ is *absorptive* at the country-product level
- All regressions are estimated using PPML

## Empirical Strategy

**For targeted minerals:**

$$Y_{ikt} = \exp\left[\alpha + \beta \cdot ER_{ikt} + \gamma_{ik} + \delta_{it} + \eta_{kt}\right] + \varepsilon_{ikt}$$

**For downstream products:**

$$Y_{ikt} = \exp\left[\alpha + \beta_1 \cdot ER(\text{Upstream})_{ikt} + \beta_2 \cdot ER_{ikt} + \gamma_{ik} + \delta_{it} + \eta_{kt}\right] + \varepsilon_{ikt}$$

- $ER(\text{Upstream})_{ikt} = 1$ if any of the upstream minerals of $k$ is restricted
- $ER_{ikt} = 1$ if product $k$ itself is restricted
- All regressions are estimated using PPML

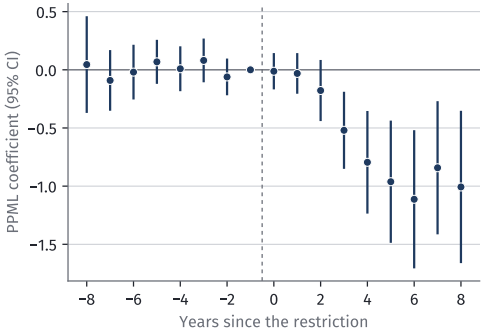
# Exports of Targeted Minerals

Mineral exports **decrease** by 42 percent in value and 56 percent in quantity

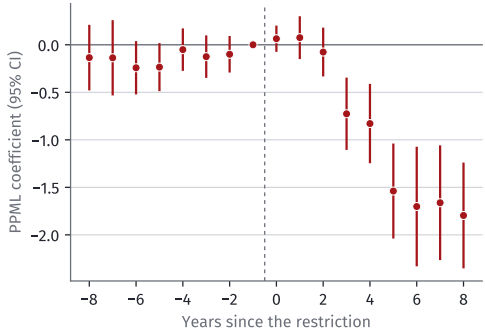
| | Export Value | Export Quantity | Unit Value |
|---|---|---|---|
| Export Restriction | -0.547*** | -0.831*** | 0.107** |
| | (0.172) | (0.173) | (0.0486) |
| Country-Product FE | ✓ | ✓ | ✓ |
| Country-Year FE | ✓ | ✓ | ✓ |
| Product-Year FE | ✓ | ✓ | ✓ |
| Estimator | PPML | PPML | OLS |
| # of Clusters | 16,512 | 16,377 | 14,139 |
| # of Obs. | 357,198 | 351,749 | 188,004 |

*Notes:* This table presents the effects of export restrictions on the exports of affected goods. Unit value in logs. Standard errors are clustered at the country-product level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

# Exports of Targeted Minerals




(a) Export Value




(b) Export Quantity

→ Hetero. DID → ETWFE → Export Diversification

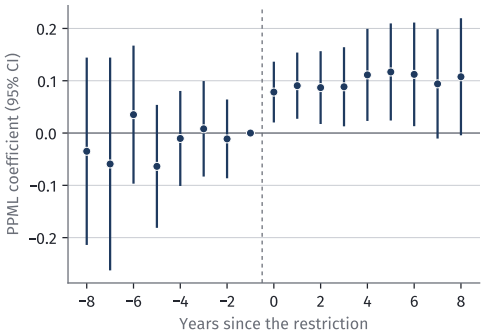
# Exports of Downstream Products

Downstream exports **increase** by 12 percent in value and 24 percent in quantity

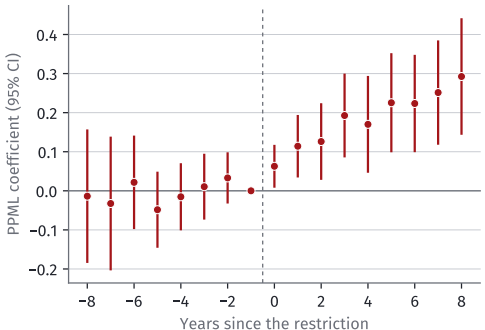
| | Export Value | | Export Quantity | | Unit Value | |
|---|---|---|---|---|---|---|
| Export Restriction (Up) | 0.116** | 0.116** | 0.211*** | 0.221*** | -0.00799 | -0.00817 |
| | (0.0511) | (0.0510) | (0.0580) | (0.0579) | (0.00832) | (0.00832) |
| Export Restriction (Own) | | -0.0227 | | -0.115** | | 0.00994 |
| | | (0.0227) | | (0.0470) | | (0.00810) |
| Country-Product FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Country-Year FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Product-Year FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Estimator | PPML | PPML | PPML | PPML | OLS | OLS |
| # of Clusters | 724,742 | 724,742 | 718,339 | 718,339 | 646,489 | 646,489 |
| # of Obs. | 15,714,045 | 15,714,045 | 15,433,472 | 15,433,472 | 9,401,797 | 9,401,797 |

*Notes:* This table presents the effects of export restrictions on the exports of downstream products. Standard errors are clustered at the country-product level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

# Exports of Downstream Products




(a) Export Value

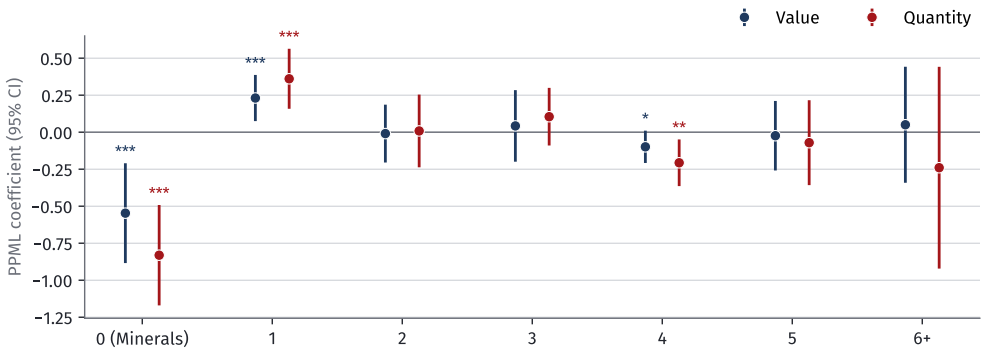



(b) Export Quantity

→ Hetero. DID → ETWFE → Export Diversification

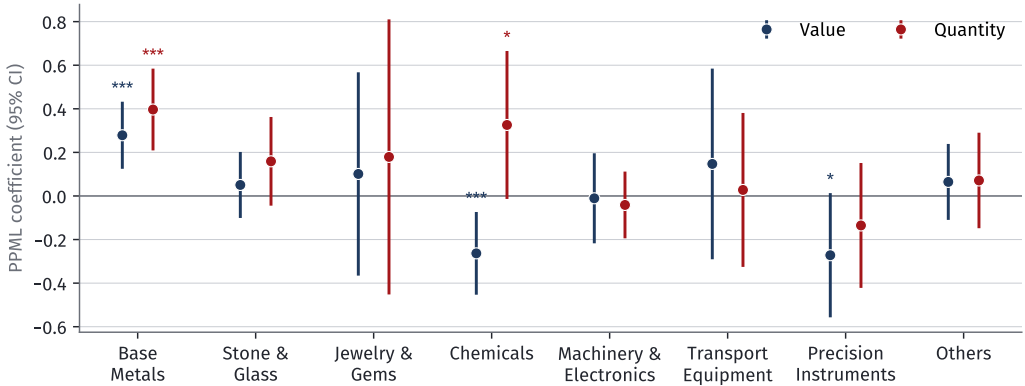
# Heterogeneous Treatment Effects by Stage

Export gains are concentrated in the **immediate downstream stage**



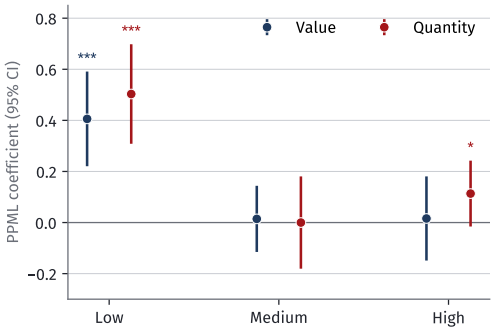
# Elusive Industrial Upgrading

**Base metal products** see large export gains, while effects on other downstream sectors are insignificant or turn negative

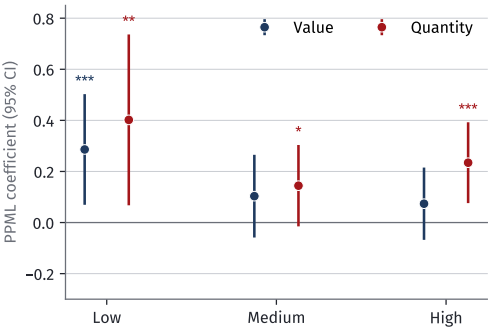


# Elusive Industrial Upgrading

No value gains for **technologically complex** or **input-intensive** downstream products




(a) Complexity




(b) Input requirements

# Robustness Checks

## Alternative estimators

- ETWFE PPML (Wooldridge, 2023)
- Callaway–Sant'Anna, Borusyak et al., de Chaisemartin–D'Haultfœuille (appendix)

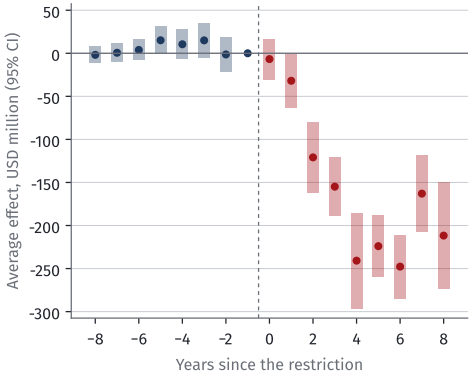
## Alternative samples

- Countries/products ever subject to export restrictions
- Excluding China
- Excluding broad-based policies (10+ minerals)

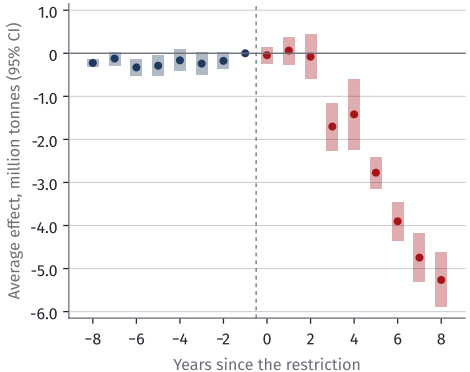
## Mineral definitions

- Metallic vs. non-metallic
- Excluding slag, ash & residues
- Critical raw materials (ADB–WTO)

# ETWFE (Wooldridge, 2023): Targeted Minerals

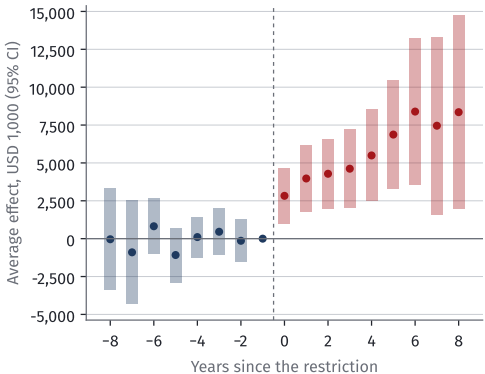



(a) Export Value

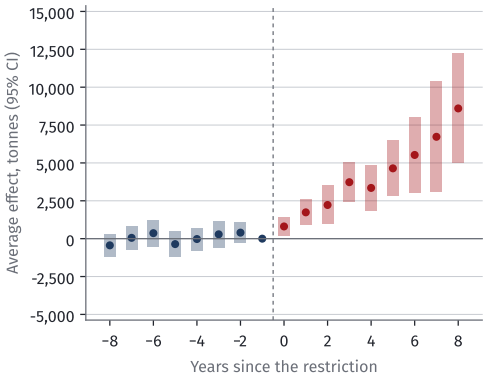



(b) Export Quantity

# ETWFE (Wooldridge, 2023): Downstream Products

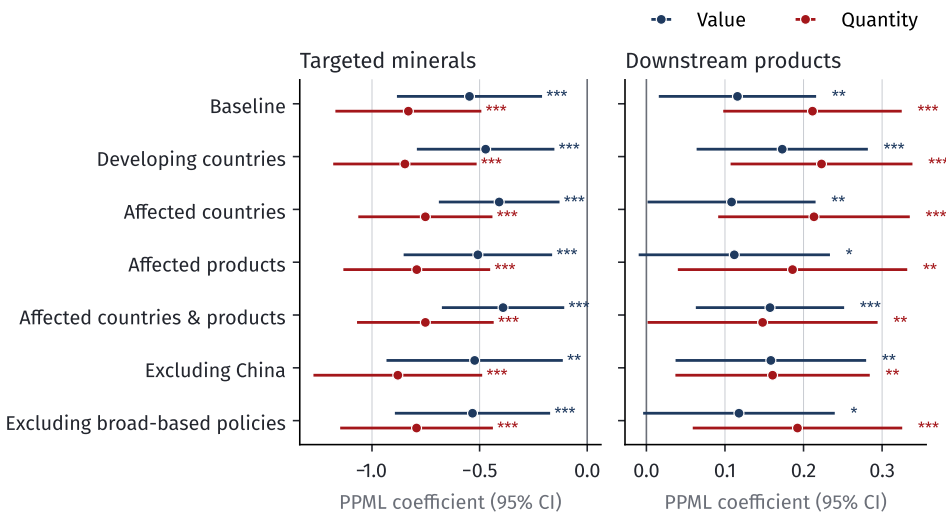



(a) Export Value

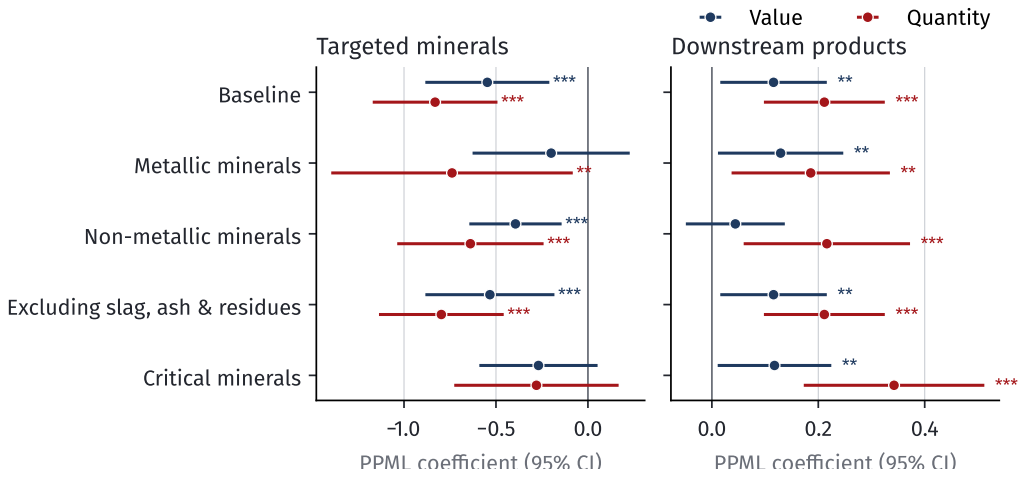



(b) Export Quantity

# Alternative Samples



# Alternative Mineral Definitions



# Conclusion

Mineral export restrictions implicitly subsidize downstream manufacturing

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Developing countries should exercise extra caution in pursuing such policies

- They face the dilemma of correcting **downstream market failures** with **upstream intervention**

# Thank You!

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## Summary Statistics ← back

| | All Export Restrictions (N = 1380) | Mineral Export Restrictions (N = 112) |
|---|---|---|
| Intervention Type | | |
| Export ban | 411 / 29.78% | 24 / 21.43% |
| Export tax | 575 / 41.67% | 55 / 49.11% |
| Export quota | 114 / 8.26% | 10 / 8.93% |
| Export licensing | 227 / 16.45% | 17 / 15.18% |
| Other measures | 53 / 3.84% | 6 / 5.36% |
| Median HS codes affected | 2 | 3 |
| Median duration (months) | 5 | 9.5 |
| Without removal date | 506 / 36.67% | 60 / 53.57% |

## Compare AIPNET with BEA Input-Output Tables ← back

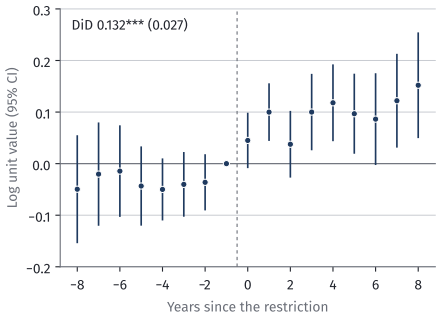
Predicted linkages from AIPNET are significantly positively correlated with direct requirement coefficients from the BEA I-O Table.

| | $Link_{ij}$ | $Link_{ij}$ | $Link_{ij}$ | $Link_{ij}$ | $Link_{ij}$ |
|---|---|---|---|---|---|
| $DR_{ij}$ | 14.902*** | 0.753*** | 0.740*** | 0.723*** | 0.738*** |
| | (1.541) | (0.154) | (0.141) | (0.180) | (0.158) |
| Input FE | | | ✓ | | ✓ |
| Output FE | | | | ✓ | ✓ |
| Estimator | Logit | OLS | OLS | OLS | OLS |
| (Pseudo-)$R^2$ | 0.0375 | 0.0152 | 0.0969 | 0.194 | 0.256 |
| # of Obs. | 123,089 | 123,089 | 123,089 | 123,082 | 123,082 |

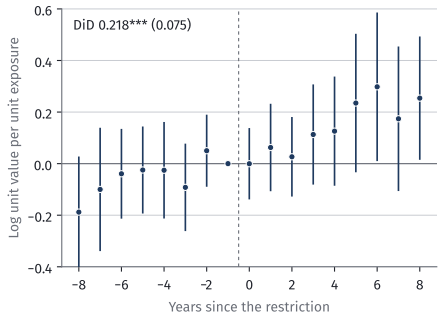
*Notes:* This table presents the results of predicting AIPNET linkages using BEA direct requirement coefficients. Standard errors are clustered at the input level. * p $<$ 0.1; ** p $<$ 0.05; *** p $<$ 0.01.

# Who Pays? Prices of Restricted Minerals

Restricting countries **charge more**; importers **pay more** on average



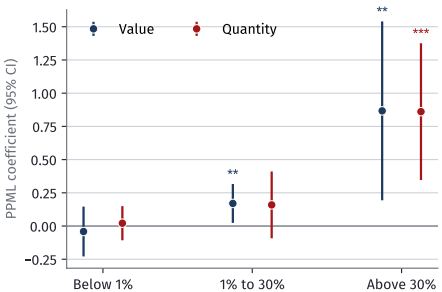

(a) Restricting country's export price



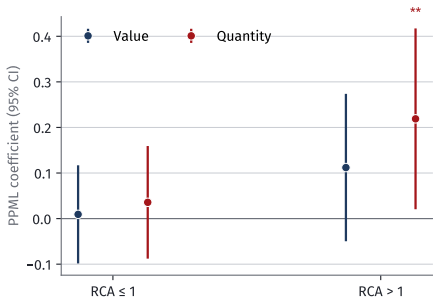

(b) Importers' average price paid

# Where Do Downstream Gains Arise?

Gains need **upstream market power** and **existing comparative advantage**

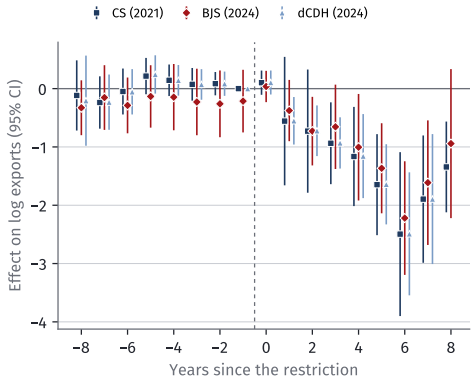



(a) Upstream market share, 2008

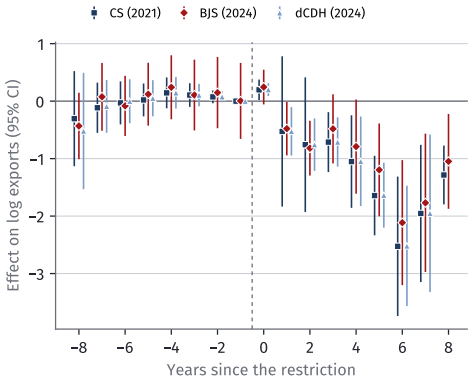



(b) Downstream RCA, 2005–07 average

# Heterogeneous DID: Targeted Minerals ← back

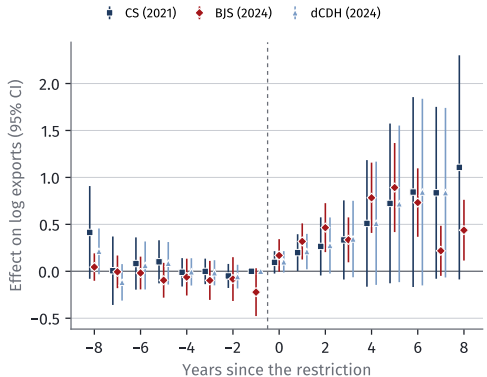



(a) Export Value

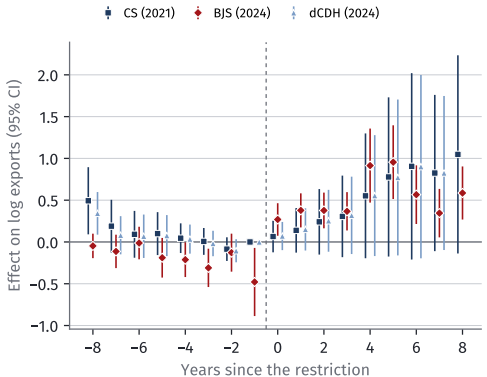



(b) Export Quantity

# Heterogeneous DID: Downstream Products ← back

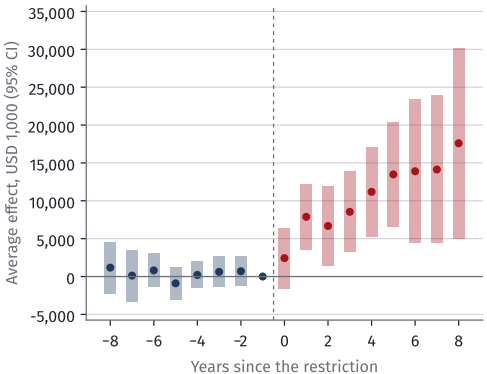



(a) Export Value

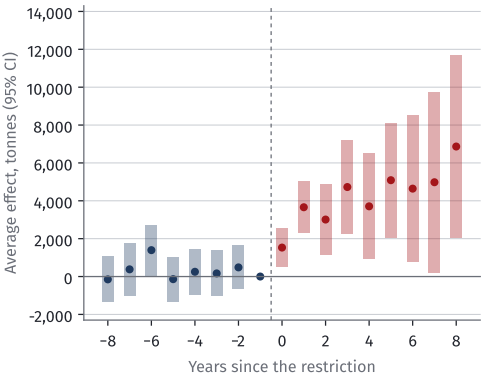



(b) Export Quantity

# ETWFE: Downstream Products, Ever-Exposed Sample ← back




(a) Export Value




(b) Export Quantity