Exorbitant Privilege of the Periodic Table? Geoeconomics, Endogenous Centrality and Strategic Minerals for the Green Transition

Josh Kirk[1] Evgenia Passari[2] Hélène Rey[3]

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[1] *Imperial College*
[2] *Université Paris Dauphine-PSL, CEPR*
[3] *London Business School, CEPR, NBER*

Introduction

- "It will then be our aim to understand why and how relationships of dependence, of influence and even of domination can arise out of trade relations"
  Albert Hirschman in *National Power and The structure of Foreign Trade*
- Trade policy can be deployed deliberately to create dependencies that later become geopolitical tools.
- Hirschman developed the Hirschman Index (Herfindahl-Hirschman Index) to measure asymmetric relationships in international trade
- A natural extension of the HH index is to measure the shape of networks and their evolution to generalize those measures.
- Networks matter for power relations and for international transmission of policies [link with the literature on global financial cycles and international spillovers]

We argue that networks are a new and interesting way to think about Geoeconomics

This Paper: Centrality Is Pricing Power

Trade networks are endogenous: a country can choose how central to become, centrality maps into pricing power. Test on trade networks of critical minerals for green transition

- Outline:
  1. A stylised model: centrality is chosen and maps one-for-one into a Lerner index
  2. Network analysis of bilateral trade data (1995-2023) for electrification materials
  3. Graph-theoretic measures to capture asymmetric trading power
  4. LLM-based measures of supply and demand of specific commodities
  5. Local projections to estimate the effect of supply surprises on inflation
- Preview:
  - Centrality maps into pricing power: larger, more persistent price responses the more concentrated the network
  - Hub-and-spoke systems different from multilateral distributed systems of fossil fuels
  - China: central actor in electrification after 2005 – **built** through policy, not endowment
  - Chinese financial diplomacy targets the materials/countries where centrality pays off
  - Supply surprises in critical materials raise US/EU CPI more than those in fossil-fuels

Model

A Model of Endogenous Centrality and Pricing Power

- Market for a single processed electrification metal.
  Downstream demand $Q = D(p)$ (elasticity ε_D); competitive fringe $S_f(p)$ (elasticity ε_S)
- A dominant intermediary country (China) supplies the residual q: $D(p) = S_f(p) + q$
- Centrality $\equiv$ equilibrium market share:

$$\alpha \equiv \frac{q}{D(p)} = \frac{D(p) - S_f(p)}{D(p)} \in [0, 1] \tag{1}$$

  $\alpha \to 0$: price-taking fringe member. $\alpha \to 1$: monopoly.

Proposition 1 (Centrality is pricing power). The intermediary's Lerner index is

$$\mathcal{L} \equiv \frac{p - c}{p} = \frac{\alpha}{\varepsilon_D + (1 - \alpha)\varepsilon_S}, \tag{2}$$

strictly increasing in α, strictly decreasing in ε_D and ε_S.

A marginal, strategic supply cut $dq < 0$ by the central node:

$$\frac{d \ln p}{d \ln q} = -\frac{\alpha}{\varepsilon_D + (1-\alpha)\varepsilon_S} = -\mathcal{L} \tag{3}$$

Proposition 2 (Supply shocks reveal pricing power). The elasticity of the world price with respect to a supply cut by the central node equals (minus) its Lerner index.

- Larger α, smaller $\varepsilon_D, \varepsilon_S \Rightarrow$ larger **and more persistent** price response
- **Bridge to the data:** local-projection coefficients are reduced-form evidence on $\mathcal{L}$
- Centrality $\neq$ market power automatically: a pure transshipment hub can be central yet powerless if the fringe re-routes freely ($\varepsilon_S \to \infty \Rightarrow \mathcal{L} \to 0$). For electrification metals, high α coincides with an inelastic fringe – an empirical finding, not an assumption

The intermediary invests I in processing capacity, foreclosing the fringe: $\alpha = \alpha(I)$, $\alpha'(I) > 0$

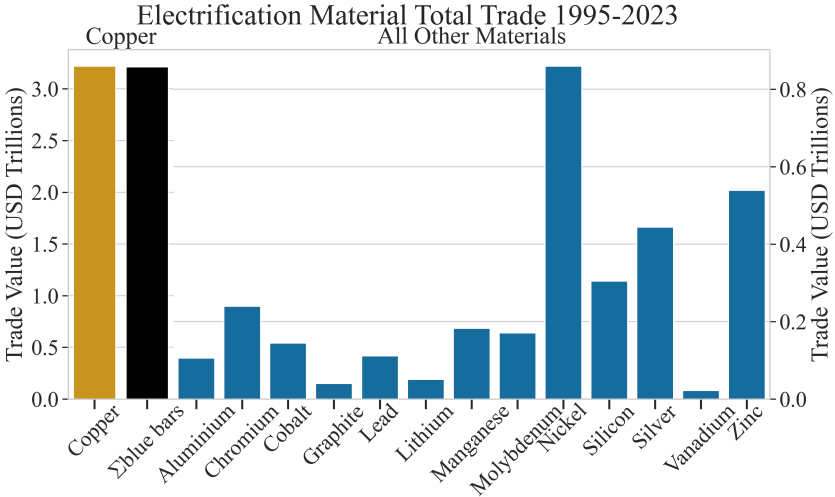
$$\Pi(I) = \underbrace{[p(\alpha(I)) - c]\, q(\alpha(I))}_{\text{market rents } R(\alpha)} + \underbrace{V(\alpha(I))}_{\text{strategic value of leverage}} - \kappa(I) + \sigma I \tag{4}$$

Proposition 3 (Centrality is endogenous). Equilibrium centrality α^* is increasing in the strategic value of leverage, in the industrial-policy subsidy σ, and in downstream inelasticity – **and does not depend on the country's own resource endowment.**

- $V(\alpha)$: coercion value [Clayton, Maggiori & Schreger (2025, 2026)] + security/option value of guaranteed access, both increasing in α
- China holds few reserves of nickel, cobalt or lithium – centrality was **built** (processing investment, industrial policy, development finance), not inherited

Data & Methodology

- Metals and minerals essential for the energy transition (IMF WEO 2021):
  - Aluminium, chromium, cobalt, copper, graphite, lead, lithium, manganese, molybdenum, nickel silicon, silver, vanadium and zinc.
- Sort through Harmonized System Codes from the World Customs Organization (6 digits):
  - Relevant for energy transition: *Silicon carbide (HS 284920)* used both for cutting tools and for electric vehicles.
  - Processed or raw: *Zinc, not alloyed, unwrought and less than 99% pure (HS 790112)*


Electrification Material Total Trade 1995-2023
Copper
All Other Materials
Trade Value (USD Trillions)
Trade Value (USD Trillions)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
0.0
0.2
0.4
0.6
0.8
Copper
Σblue bars
Aluminium
Chromium
Cobalt
Graphite
Lead
Lithium
Manganese
Molybdenum
Nickel
Silicon
Silver
Vanadium
Zinc

Network Analysis

▷ Measures of network centrality:

- Weighted degree centrality captures countries' direct trade links. For node i, it is given by:

$$s_i = \sum_{j \in V} (w_{ij} + w_{ji}) \tag{5}$$

where w_{ij} denotes the value of exports from country i to country j, and w_{ji} trade in the opposite direction.

- Katz centrality assigns scores based on both direct and indirect connections, reducing the influence of distant nodes through an attenuation factor α. Katz centrality for node i is computed as:

$$k_i = \beta + \alpha \sum_{j \in V} A_{ij} k_j \tag{6}$$

where A is the adjacency matrix representing edge weights ($A_{ij} = w_{ij}$). Katz centrality measures a node's influence by considering all paths in a network, but discounts longer ones so that closer connections matter more.

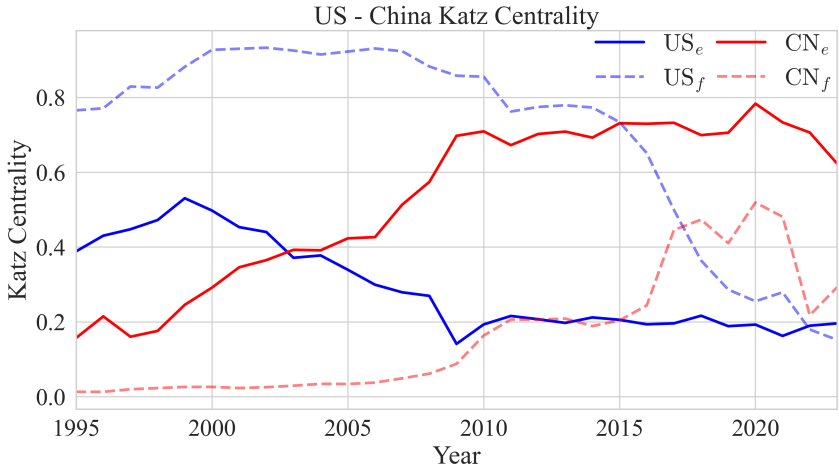
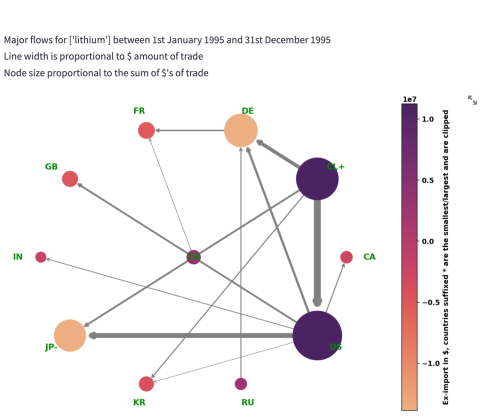
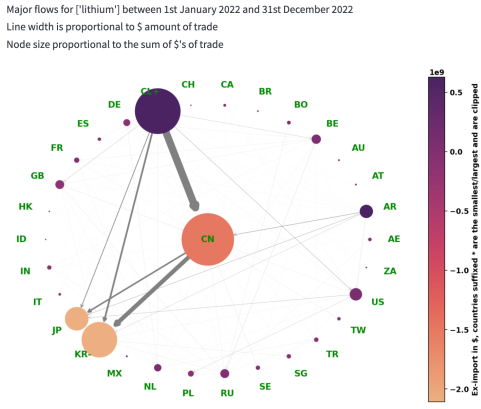


Figure 1: Katz Centrality of the United States and China across electrification materials (e) and fossil fuels (f) (1995-2023)

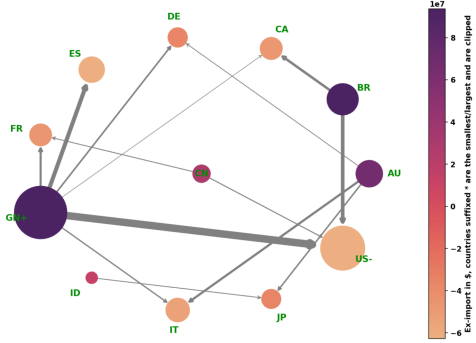
Lithium Trade Network 1995 vs 2022



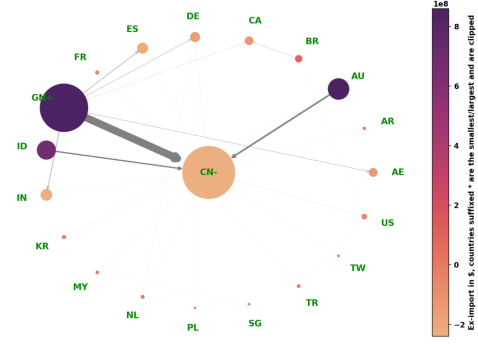


Aluminium Trade Network 1995 vs 2022

Major flows for ['aluminium'] between 1st January 1995 and 31st December 1995
Line width is proportional to $ amount of trade
Node size proportional to the sum of $'s of trade

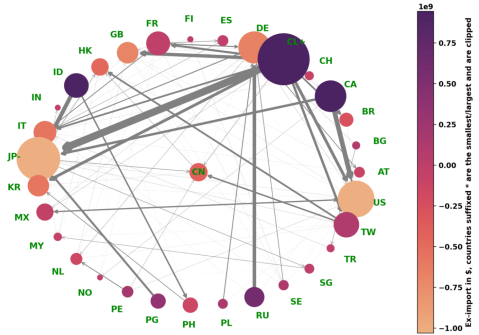


Major flows for ['aluminium'] between 1st January 2022 and 31st December 2022
Line width is proportional to $ amount of trade
Node size proportional to the sum of $'s of trade

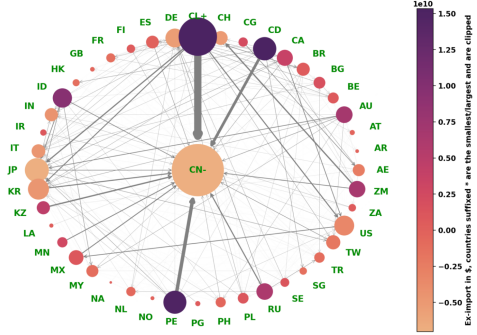


Copper Trade Network 1995 vs 2022

Major flows for ['copper'] between 1st January 1995 and 31st December 1995
Line width is proportional to $ amount of trade
Node size proportional to the sum of $'s of trade



Major flows for ['copper'] between 1st January 2022 and 31st December 2022
Line width is proportional to $ amount of trade
Node size proportional to the sum of $'s of trade



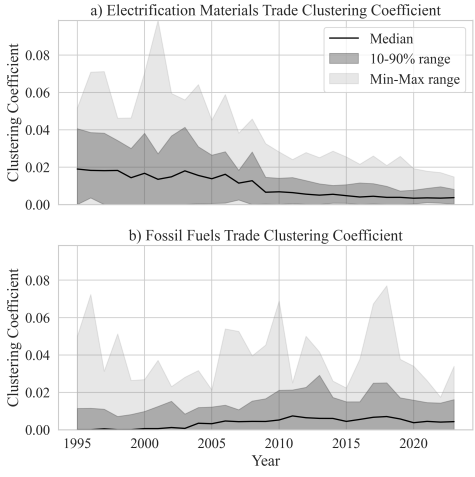
- Measure of Trade clustering:
  - Quantifies structural differences between hub-centric and multilateral trade systems. For node i, this is computed as:

$$c_i = \frac{\sum_{j,k \in V} \left(w_{ij} w_{jk} w_{ki}\right)^{1/3}}{s_i(s_i - 1) - 2\sum_{j \in V} w_{ij} w_{ji}} \tag{7}$$

    where w_{ij} represents the trade value (USD) from country i to j, and s_i is the weighted degree of node i. The numerator captures "closed triplets"—instances where countries A, B, and C form triangular trading relationships—while the denominator normalises by all possible such relationships.
  - High clustering coefficients indicate regional trading blocs where partners trade with each other's partners; low values reveal hub-and-spoke systems where countries trade through central intermediaries but not with each other.

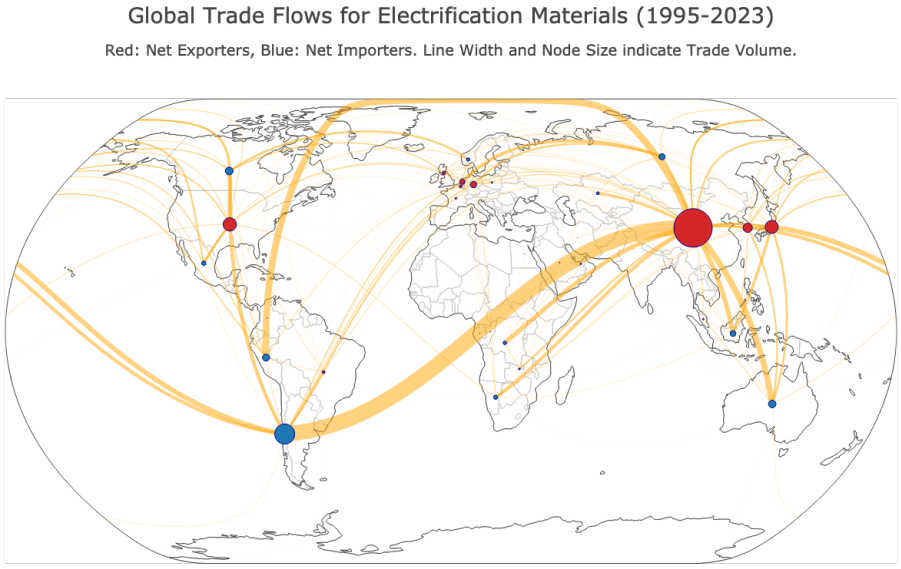
Network Analysis: Trade Clustering over Time

Towards Hub-and-Spoke for electrification materials. Stable for Fossil Fuels.

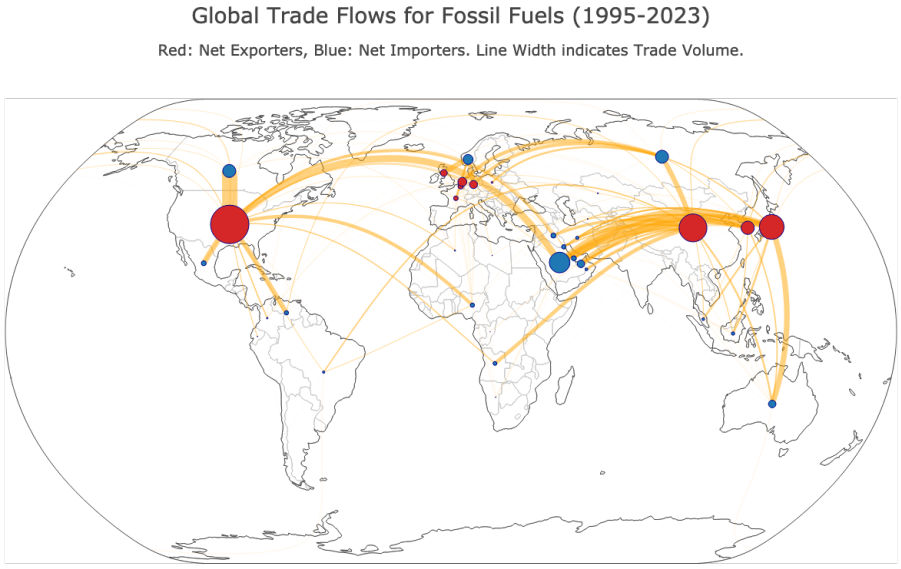


Network Structure: Green Materials & Fossils

Green materials: Hub-and-Spoke Structure. China at the Centre

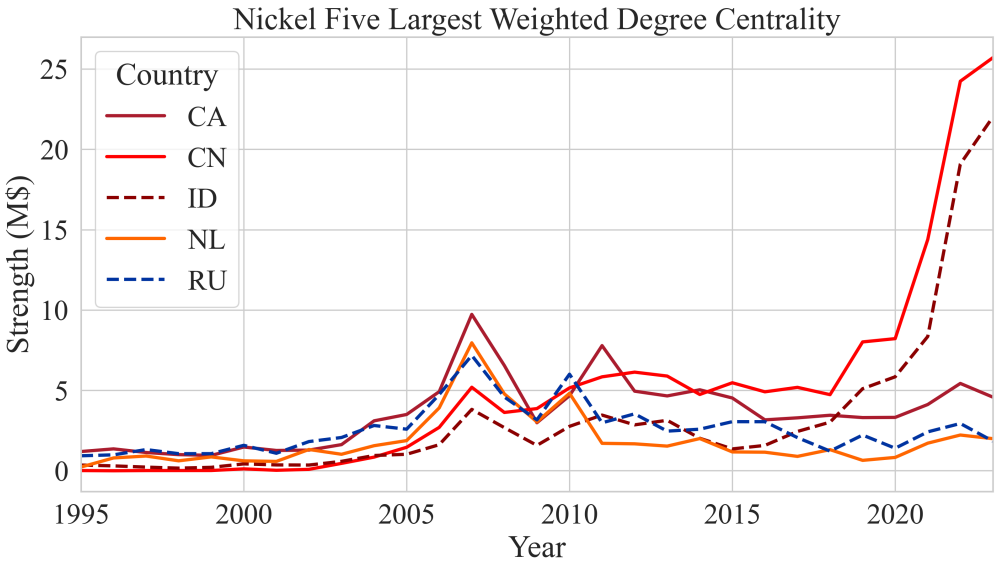


Fossil Fuels: Distributed Structure

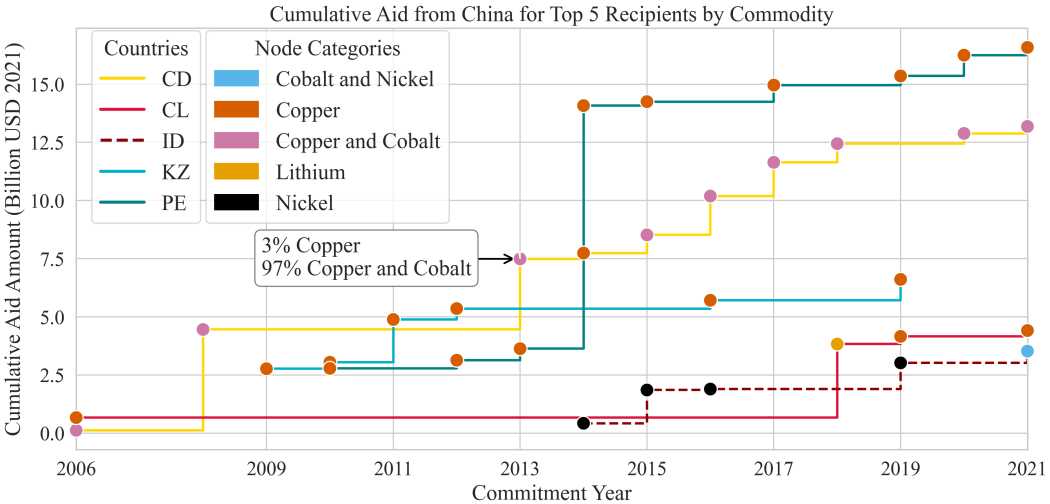


- Green Materials: Chinese Centre of the Hub-and Spoke:
  - China has a dominant position as both processor and consumer of critical materials. Spans all continents.
  - Transformation from a system of separate trading communities to a globally integrated network with a single dominant hub.
  - Technological change is affecting the structure of global energy trade.
  - Strategic positioning of China.

The Other Side: Rise of China and Indonesia in Nickel Trade



Chinese Development Finance for Transition Minerals Exporters (Walsh et al. (2025)).



Why does the shape of the network matter?

- Historical precedent (Alfaro et al. (2024))
  - Following a territorial dispute with Japan in 2010, China increased restrictions on its exports of Rare Earths to the rest of the world.
  - China was monopolist in the extraction and sales of most REE minerals at that time.
  - Negative Rare earth supply shock. Global Rare eath unit prices spiked and remained high for about five years.
- Depends on technological innovation and patterns of substitution.
- Investigate effect of surprises in net supply on prices.

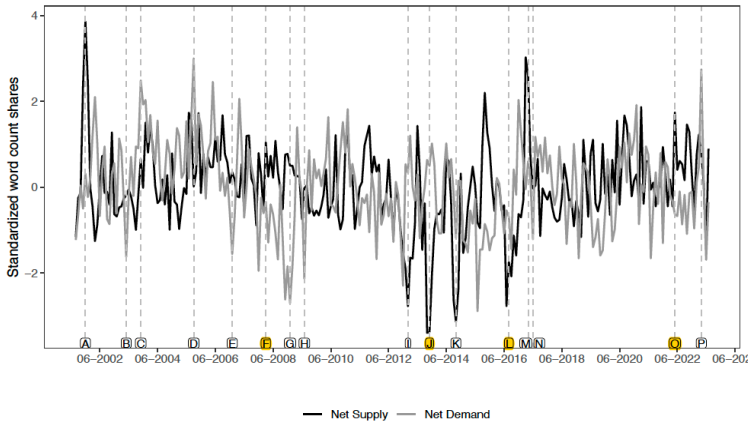
LLM Measures of Supply & Demand

- We build on automated, narrative approach of Lumbanraja, Mouabbi, Passari, Rousset Planat and Lumbanraja (2025) to construct net supply & demand indices.
- We refine the methodology to be able to deal with sparse data for some commodities. (Kirk (2025))
- We use a comprehensive data base from Dow Jones Factiva covering 20 commodities eligible for S&P GSCI Composite Index inclusion from 2000–2024, yielding over eight million articles.

LLMs Based Measures of Green Commodities' Supply and Demand

- **Data collection**: eight million articles
- **Teacher labelling** AI model (DeepSeek R1) was asked to read and label 5,750 articles per commodity according to whether they contained positive or negative supply signals or positive or negative demand signals. The labels correspond to categories: supply increasing (SI), supply decreasing (SD), demand increasing (DI), or demand decreasing (DD)
- **Validation**: Human review of a subset of the AI's labels to ensure quality before proceeding to model training
- **Student model training**: A lighter, more efficient model (ModernBERT-Large) was trained on the labelled examples. Fine-tuned to make sure the student learned to mimic the teacher's judgements as accurately as possible
- **Corpus labelling**: The optimised student model labelled the full eight-million-article corpus.

Net supply and demand for electrification commodities: Copper example



Source: Lumbanraja, Mouabbi, Passari, Rousset Planat (2025). F: political crisis Zambia J: China produces more L: Chile, Peru strikes, Indonesia dispute over rights O: protests in top mines in Peru

Local Projections

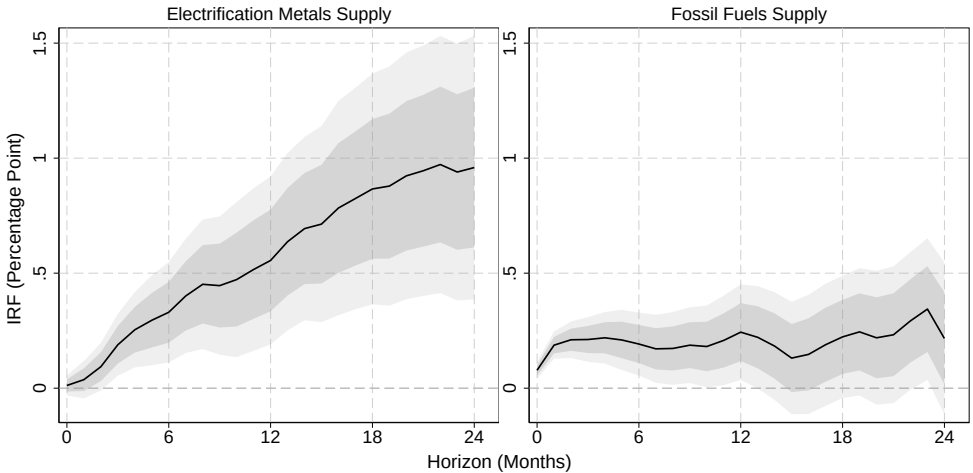
From Centrality to Pricing Power: Local Projections

- Aggregate series across commodities using dynamic GSCI production weights: electrification-metals basket (aluminium, copper, lead, nickel, silver, zinc) vs. fossil-fuel basket (crude oil, natural gas)
- Supply/demand innovations: AR(1) residuals of the text-based net supply/demand indices
- Report responses to a one-s.d. supply **contraction**

$$\Delta_h x_{t+h} = \alpha^h + \beta^h S_{k,t} + \sum_{j=1}^{p} \gamma_j^h \Delta x_{t-j} + \delta^h D_{k,t-1} + \theta^h S_{-k,t-1} + \lambda^h D_{-k,t-1} + \varepsilon_{t+h}^h$$

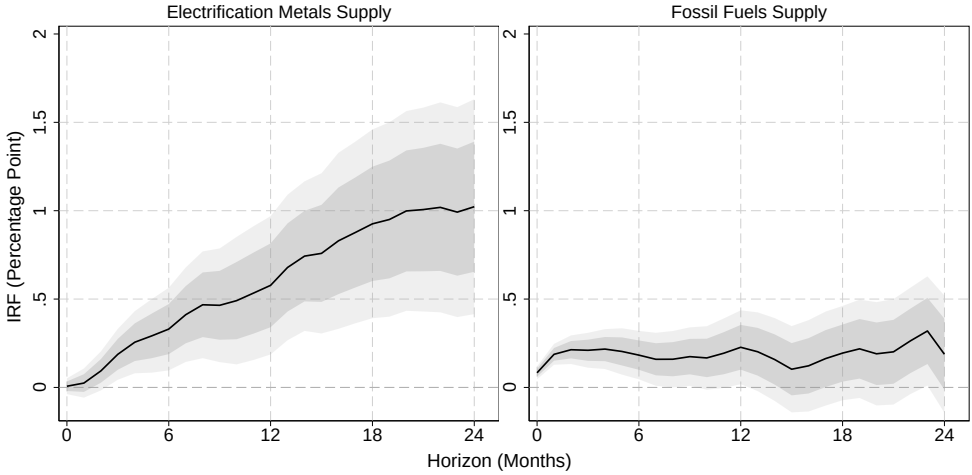
$100 \times \beta^h$: cumulative % impulse response – reduced-form counterpart to $\mathcal{L}$ (Prop. 2)
Demand and cross-basket controls enter with a one-period lag (avoid mechanical same-month correlation with the text classifier)
US: Newey–West SEs. EU: panel over member economies, country FE, Driscoll–Kraay SEs.

LP: US CPI Response to Supply Disturbances



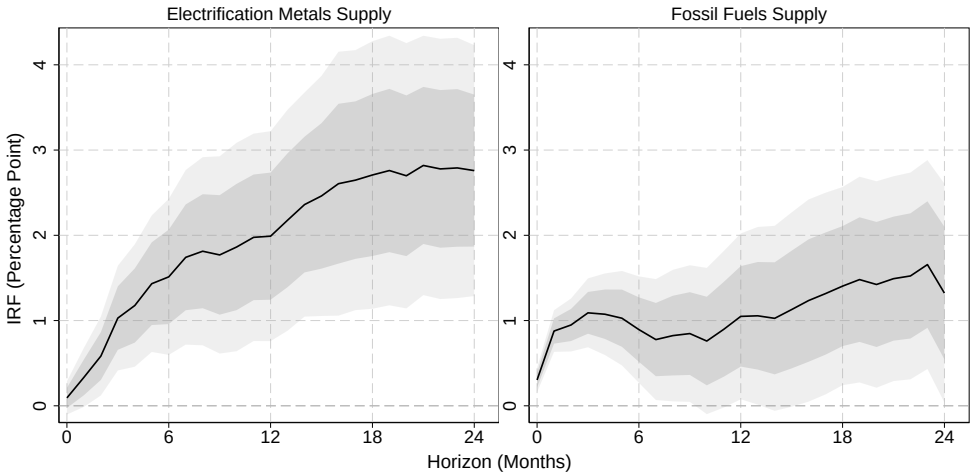
A one-s.d. metals contraction raises US CPI by ∼1pp – about twice the comparable fossil-fuel shock, and more persistently.

LP: EU CPI Response to Supply Disturbances



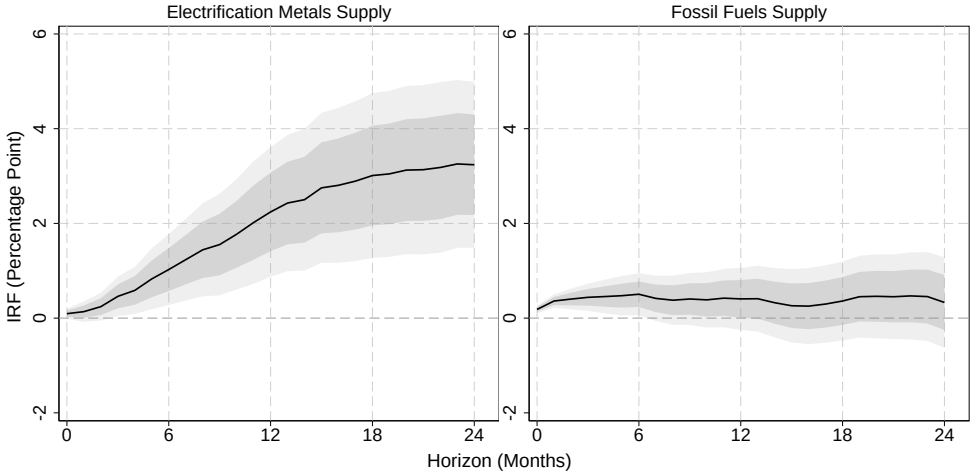
Panel over EU member economies, country fixed effects, Driscoll–Kraay SEs. Same asymmetry as the US.

LP: US PPI Response to Supply Disturbances



Same shape as CPI, but ∼2.5–3× the magnitude – consistent with wholesale-to-retail attenuation (mark-ups, taxes, smoothed retail pricing).

LP: EU PPI Response to Supply Disturbances



CPI estimates are a conservative lower bound on the pricing leverage the network confers at the producer level.

Concluding remarks

Conclusion

- Networks are an interesting tool to think about geoeconomics
  - Network statistics can be thought about as a generalisation of Hirschmans's concentration Index approach
- Hub-and-Spokes in Green Commodities
  - China has positioned itself strategically as a hub
  - Unlike a lot of the geoeconomics literature we focus on the strategic choice of the shape of the network
- Possible consequences
  - Use cutting-edge LLMs to construct net supply surprises for green critical metals
  - Estimate effect of negative net supply surprises on PPI, CPI and IP for US and Euro area.
- Ongoing work
  - Pushing more on identification: instruments for surprises (structural shocks)