



FRAGMENTATION AND COMMODITY MARKETS: RISKS AND VULNERABILITIES

CHAPTER 3, OCTOBER 2023 WEO

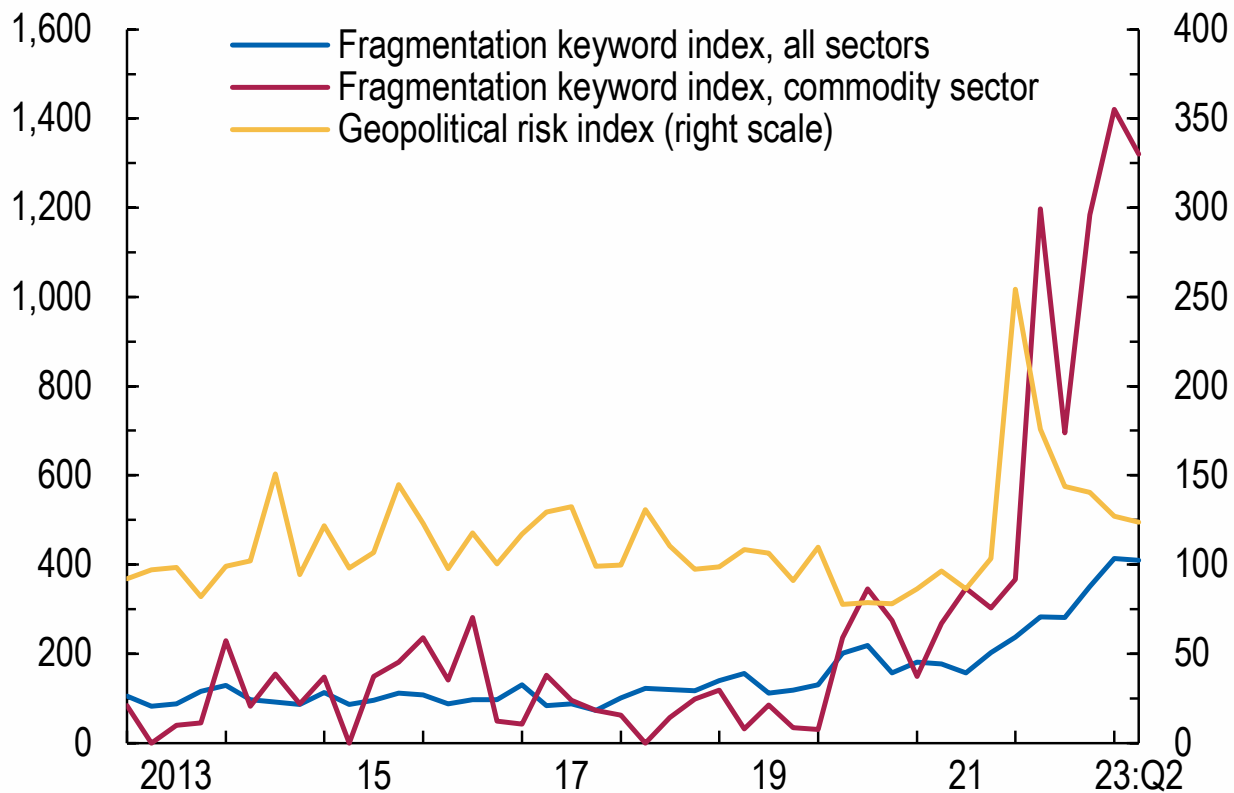
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CHIARA MAGGI, MARIKA SANTORO, ALEXANDRE SOLLACI, AND MARTIN STUERMER
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**WITH CONTRIBUTIONS FROM MARIJN BOLHIUS, JIAQIAN CHEN, BENJAMIN KETT,
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YAROU XU AND CANRAN ZHENG**

Fragmentation: a rising concern in commodity markets

Fragmentation Keywords in Earnings Calls

(Indices, 2013–15 = 100)



Sources: Caldara, Dario, and Matteo Iacoviello (2021); NL Analytics; and IMF staff calculations.

Notes: The y-axis on the left refers to the average number of sentences that mention at least one keyword per 1,000 earnings call. Fragmentation keywords include deglobalization, reshoring, onshoring, nearshoring, friend-shoring, localization, and regionalization.

Key Questions and Preview of Findings

1. Why should we be concerned about commodity markets?
→ Highly concentrated due to natural endowments.
2. Are there signs of rising fragmentation in primary commodity markets?
→ Yes.
3. Which commodities are most vulnerable to geoeconomic fragmentation?
→ Minerals and some agricultural goods most vulnerable.
4. What are the potential economic impacts from commodity market fragmentation?
→ Modest GDP impacts, but cross-country heterogeneity, price volatility.
5. What are the implications for the green transition?
→ Delay of green transition.

Scope and Research Design

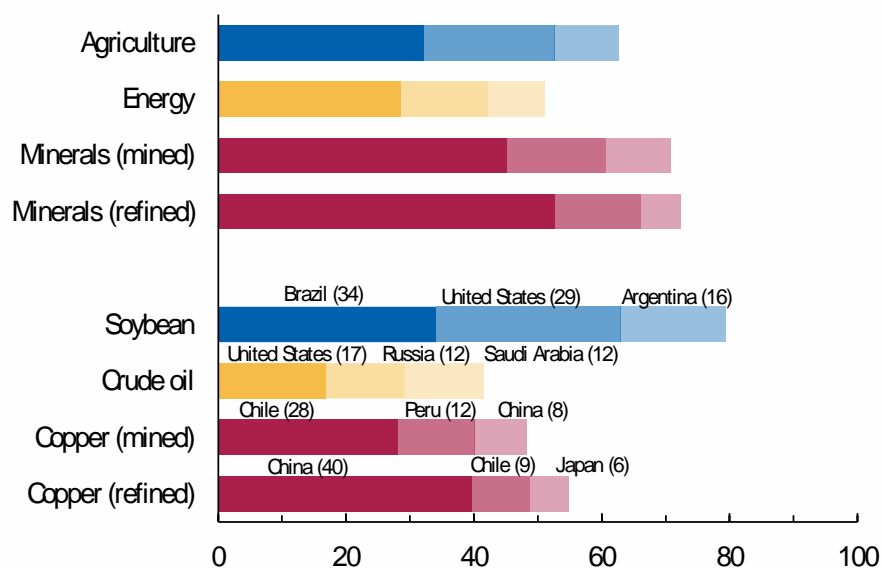
- **Focus:** 48 commodities : energy, agriculture and minerals.
- **Commodities selection** based on:
 - Among the most largely traded in their category
 - Identified as critical for the green transition or key technologies by the EU or US
- **Research Design:** Empirical analysis and combination of model simulations.
- **Fragmentation:** Any policy-driven reversal of integration.
- **Simulations:** Hypothetical fragmentation into two blocs along 2022 UN vote on Ukraine.

What makes commodities different?

Commodities are vulnerable to fragmentation due to concentrated production, high tradability and low substitutability

Share of Top 3 Countries in World Production

(Percent, averages across commodities)

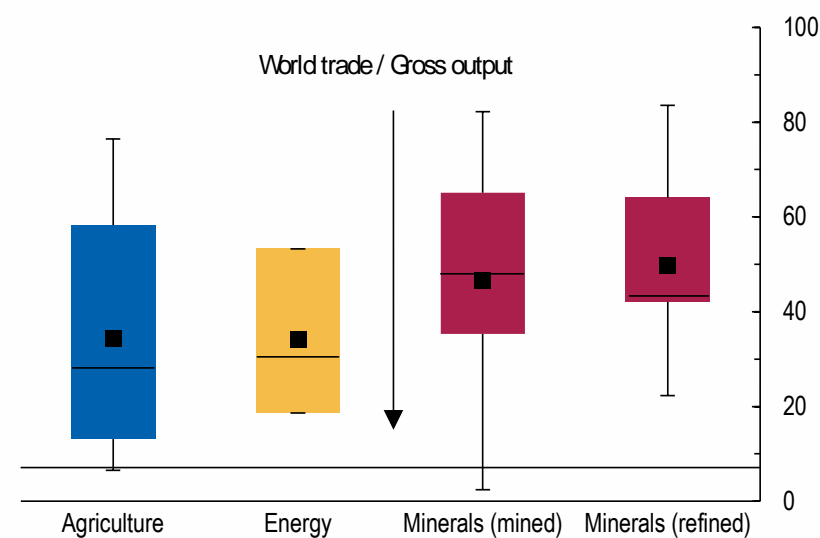


Sources: British Geological Survey; US Geological Survey; Food and Agriculture Organization of the United Nations; International Energy Agency, and IMF staff calculations.

Note: Energy refers to coal, natural gas and crude oil. The chart depicts the simple average across commodities in the group.

Share of World Production that is Traded

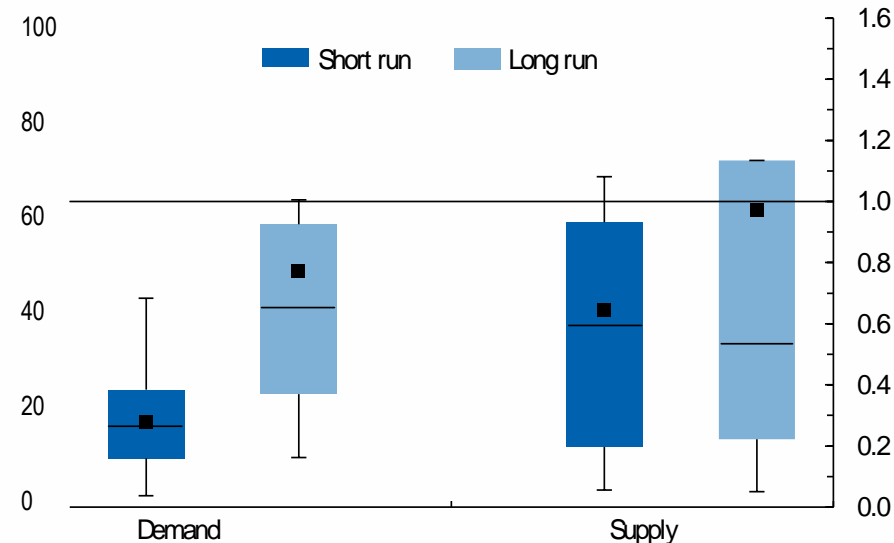
(Percent of production quantity, 2019)



Sources: BACI; British Geological Survey; US Geological Survey; Food and Agriculture Organization of the United Nations; International Energy Agency; and IMF staff calculations.

Note: Energy refers to coal, natural gas and crude oil. The horizontal lines in the bars represent the median, the cross the average, the bars the interquartile range, while the whiskers reflect the min and max value across commodities in the group.

Price Elasticities of Commodities' Supply and Demand

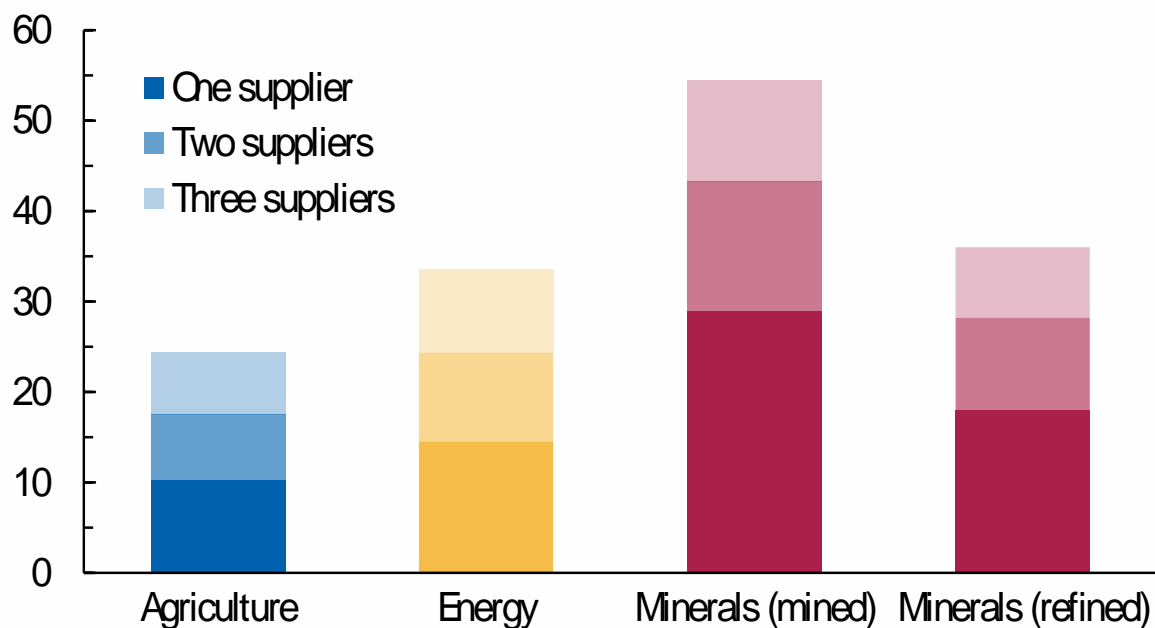


Sources: Fally and Sayre (2018), Dahl (2019); and IMF staff calculations.
 Note: The horizontal lines in the bars represent the median, the cross the average, the bars the interquartile range, while the whiskers reflect the min and max value across commodities in the group.

Most countries rely heavily on non-diversified commodity imports

Share of Countries that Import from only 1, 2 or 3 Suppliers

(Percent of countries, 2019)

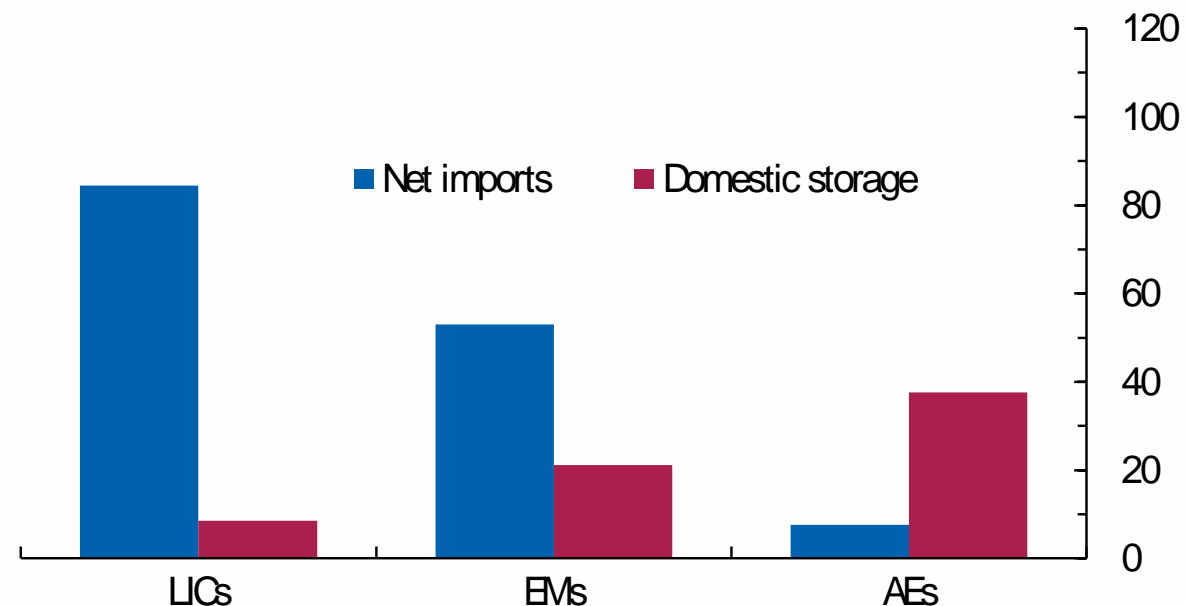


Sources: British Geological Survey; US Geological Survey; Food and Agriculture Organization of the United Nations; International Energy Agency, and IMF staff calculations.

Note: Energy refers to coal, natural gas and crude oil. The chart depicts the simple average across commodities in the group.

Vulnerability to Food Insecurity: The Case of Wheat

(Percent of annual wheat consumption, 2019)



Sources: US Department of Agriculture and IMF staff calculations.

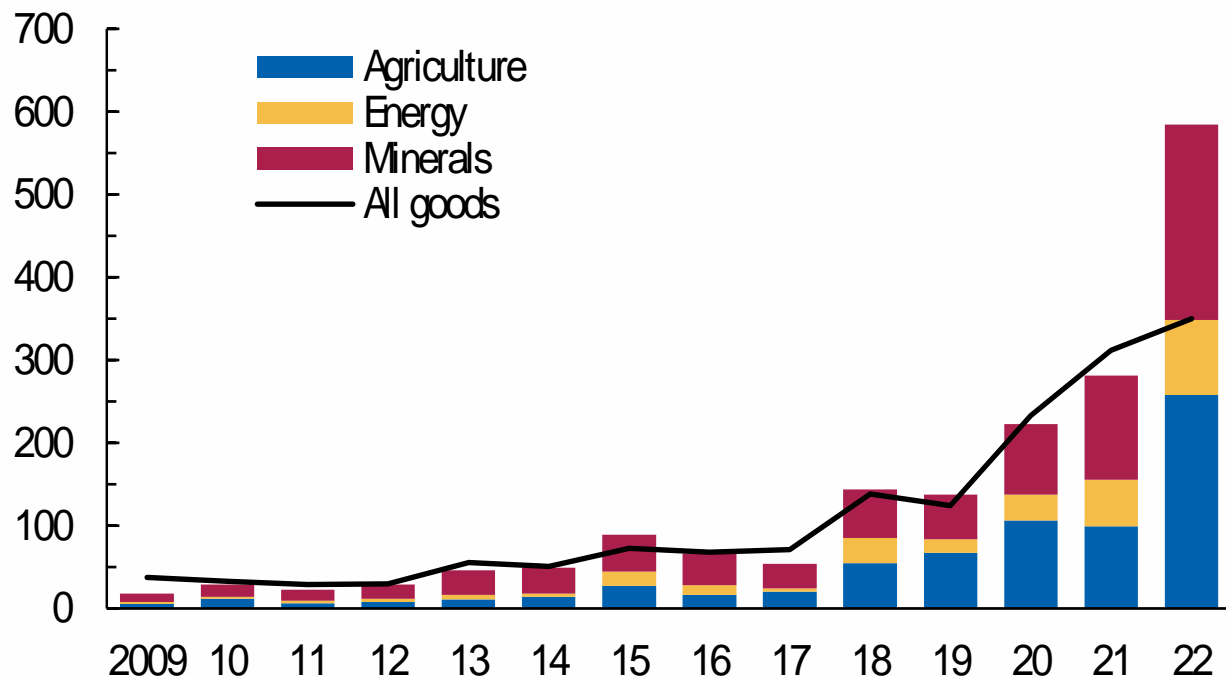
Note: The chart depicts the simple average across countries in each group, for 2019.

Are there signs of rising fragmentation?

Trade barriers are on the rise and prices have become more dispersed across markets

Number of Trade Interventions, by Sector

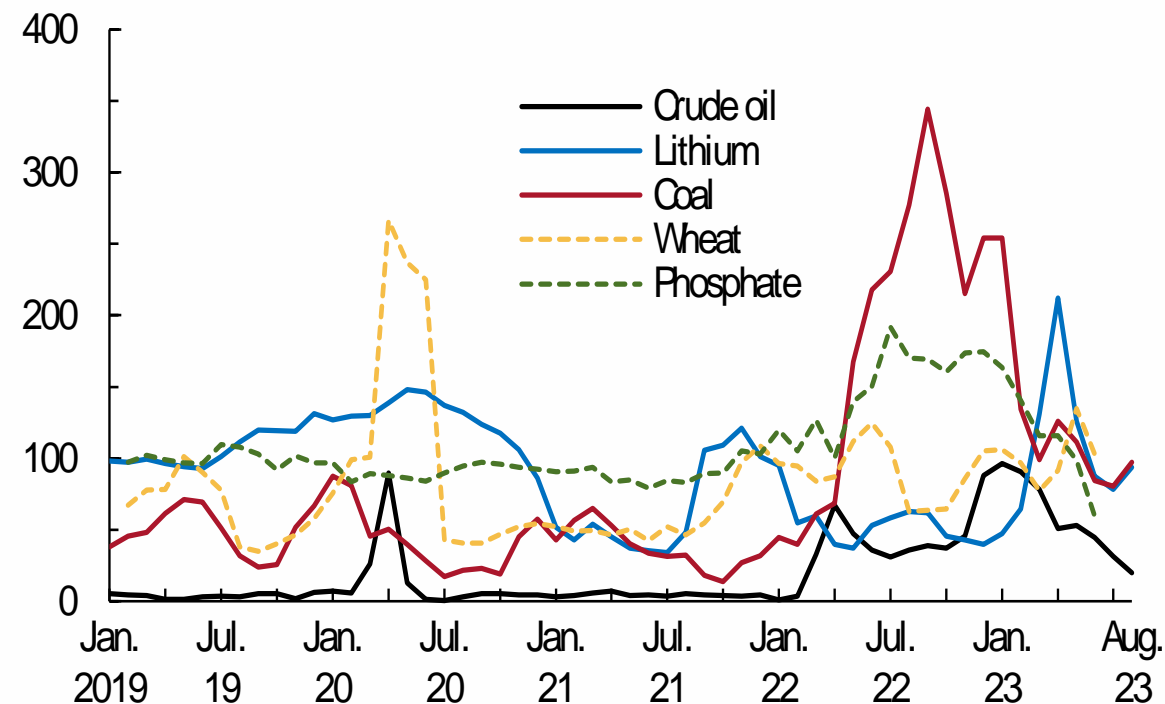
(Index, 2016-2019=100 for All Goods and All Commodities)



Sources: Global Trade Alert Database (adjusted for reporting lag); and IMF Staff calculations.
 Note: Trade-liberalizing interventions are excluded from the calculations. Energy refers to coal, natural gas and crude oil.

Price Dispersion

(Difference between max and min as percent of min price across regions)

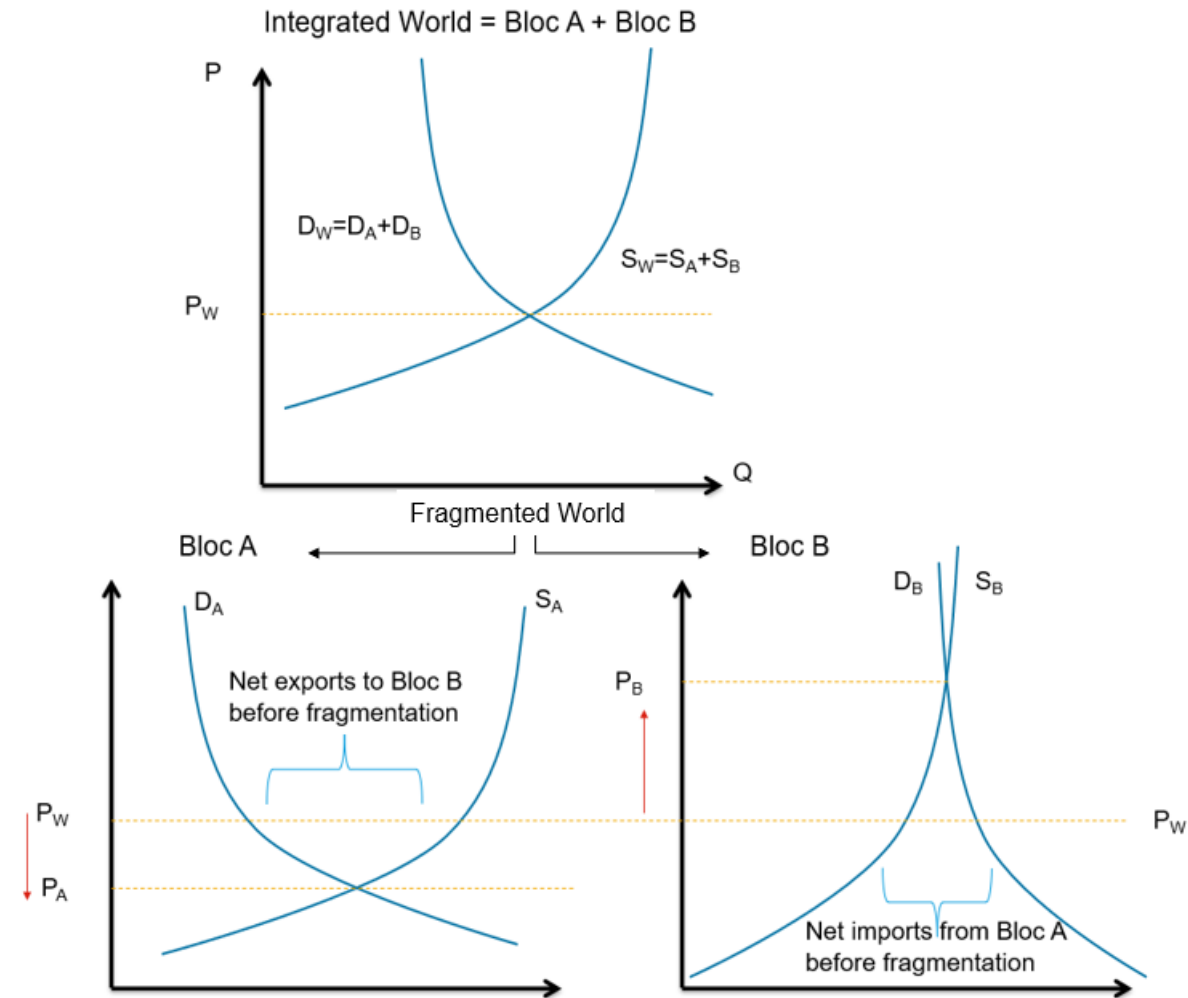


Sources: Bloomberg Finance L.P.; and IMF staff calculations.

Which commodities are most vulnerable to fragmentation?

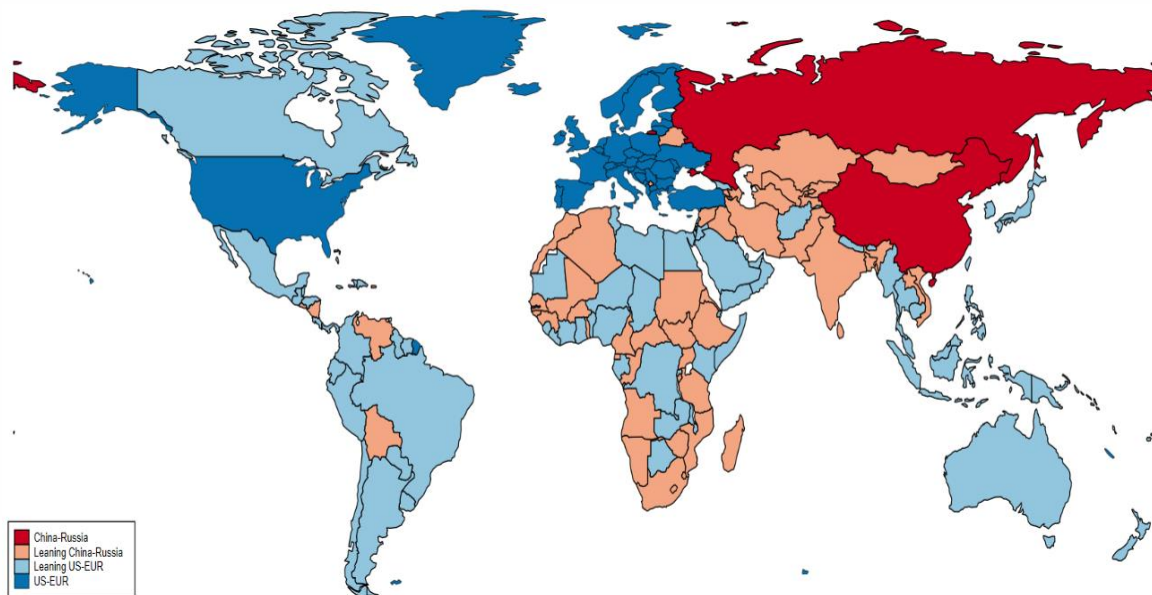
Vulnerability is assessed through a single-commodity model

- **Simple commodity market model:**
 - Full trade fragmentation between two blocs
 - Assume free trade within and no trade across blocs.
 - Calculate **counterfactual prices**
- **Vulnerability** to fragmentation:
 - Price difference fragmented vs integrated world (bloc-specific).
 - Depends on bloc-level supply-demand imbalances and elasticities.

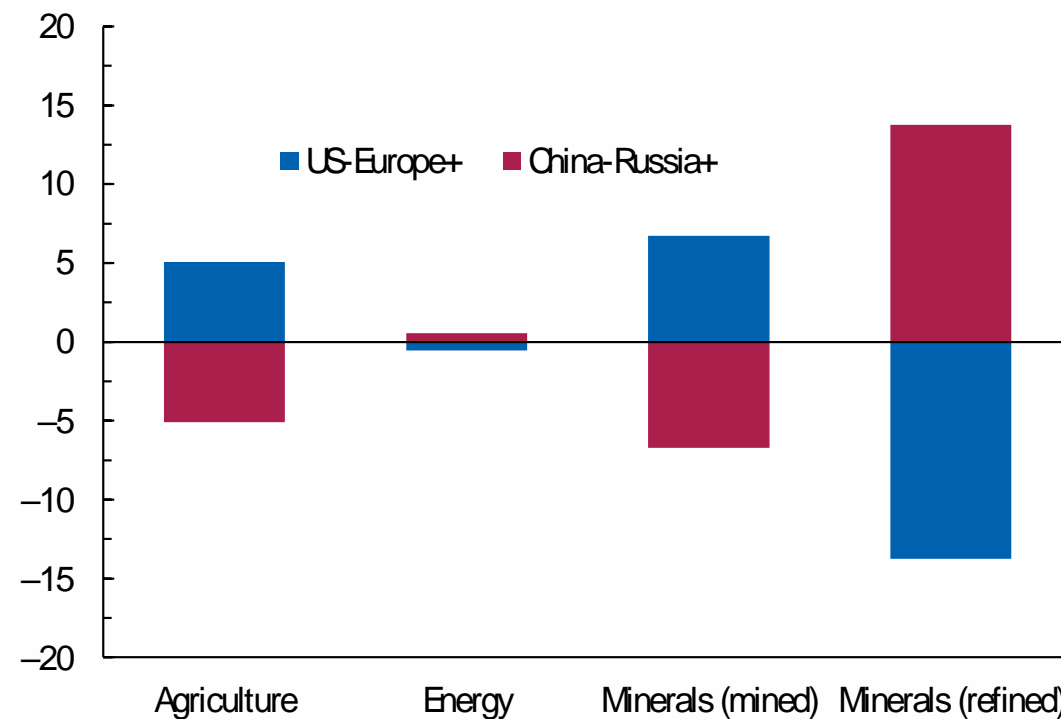


Blocs are defined along the 2022 UN vote on Ukraine

Hypothetical Blocs Based on the 2022 UN Vote on Ukraine



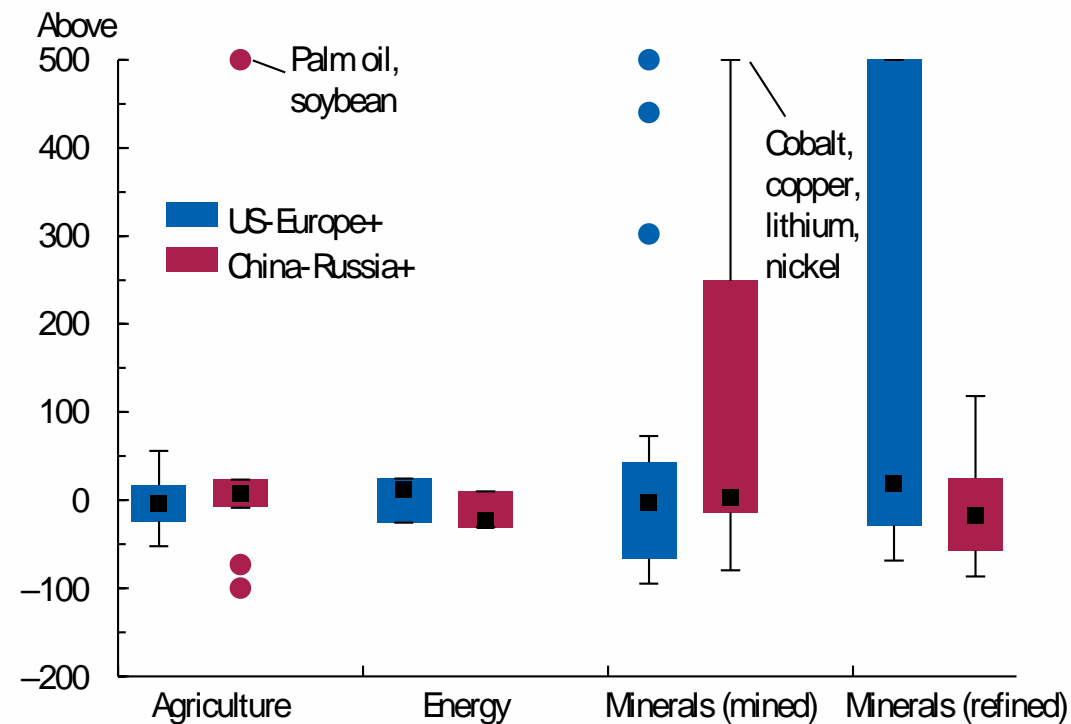
Trade Balance Across Blocs (Percent of World Production, 2019)



Sources: Food and Agricultural Organization of the United Nations; BACI; International Energy Agency; and IMF staff calculations.
Note: Energy refers to coal, natural gas and crude oil.

Minerals tend to be more vulnerable to fragmentation

Distribution of price changes by bloc and commodity group (Percent)

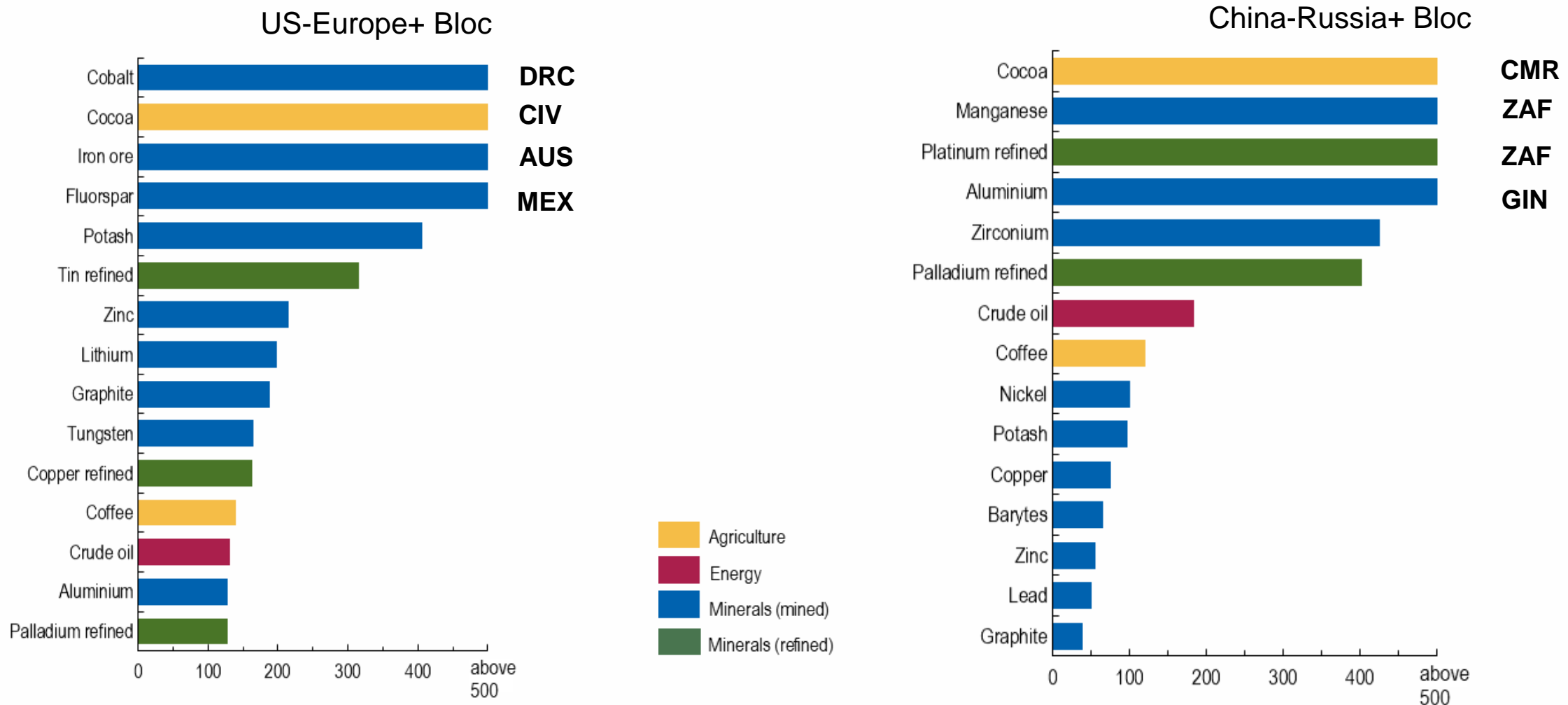


- CHN/RUS bloc vulnerable to fragmentation of minerals at the mining stage.
- US/EUR bloc vulnerable to fragmentation of refined minerals.
- Energy commodities less vulnerable to fragmentation.

Note: Price effects are capped at +500 percent for readability. Energy refers to coal, natural gas and crude oil. The horizontal lines in the bars represent the median, the bars the interquartile range, while the whiskers reflect the data points within 1.5 times the interquartile range from the 25th or 75th quartile across commodities in the group. The dots indicate outliers.

Countries' switching blocs could lead to significant price changes in fragmented markets

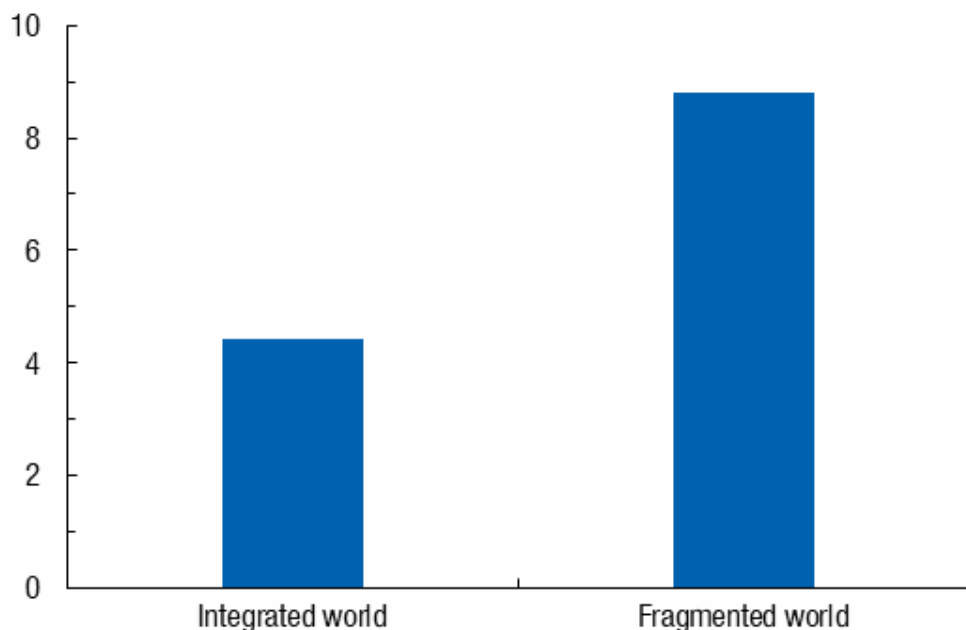
Distribution of price changes from largest exporter switching bloc



Note: Price effects capped at +500 percent for ease of exposition.

Smaller markets would increase commodity price volatility

Wheat Price Increase in the US-Europe+ Bloc
Due to a Harvest Shock
(Percent)



- In smaller markets bloc-level prices more responsive to country-level shocks.
- $$\frac{\Delta\% P_{Comm}^{Bloc}}{\Delta\% Supply_{Comm}^{Bloc}} = - \frac{\text{Size of Shock Relative to Market}}{\text{Supply Elasticity} - \text{Demand Elasticity}}$$
- A 3-standard deviation shock to US wheat harvest doubles the impact on wheat price in the US-Europe bloc in fragmented world.

Sources: Food and Agriculture Organization of the United Nations; and IMF staff calculations.

Note: The bars in the figure depict the change in the price of wheat in the US-Europe+ bloc from a three-standard-deviation negative shock to US wheat production. The figure compares the price increases in the bloc in a free-trade world to those in a fragmented world.

What are the economic impacts from commodity market fragmentation?

Three complementary approaches

Single-commodity
model

**Changes in total
surplus
(consumer surplus
+ producer surplus)**

Trade model

**Long-term GDP
effects**

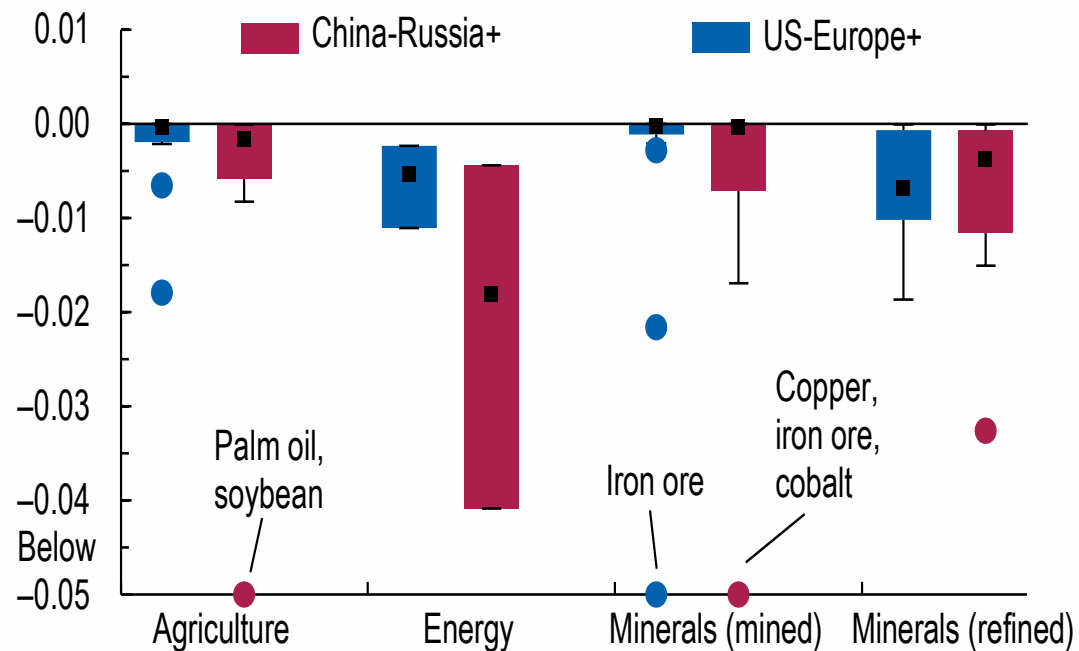
GMMET

Global Macroeconomic Model for
the Energy Transition

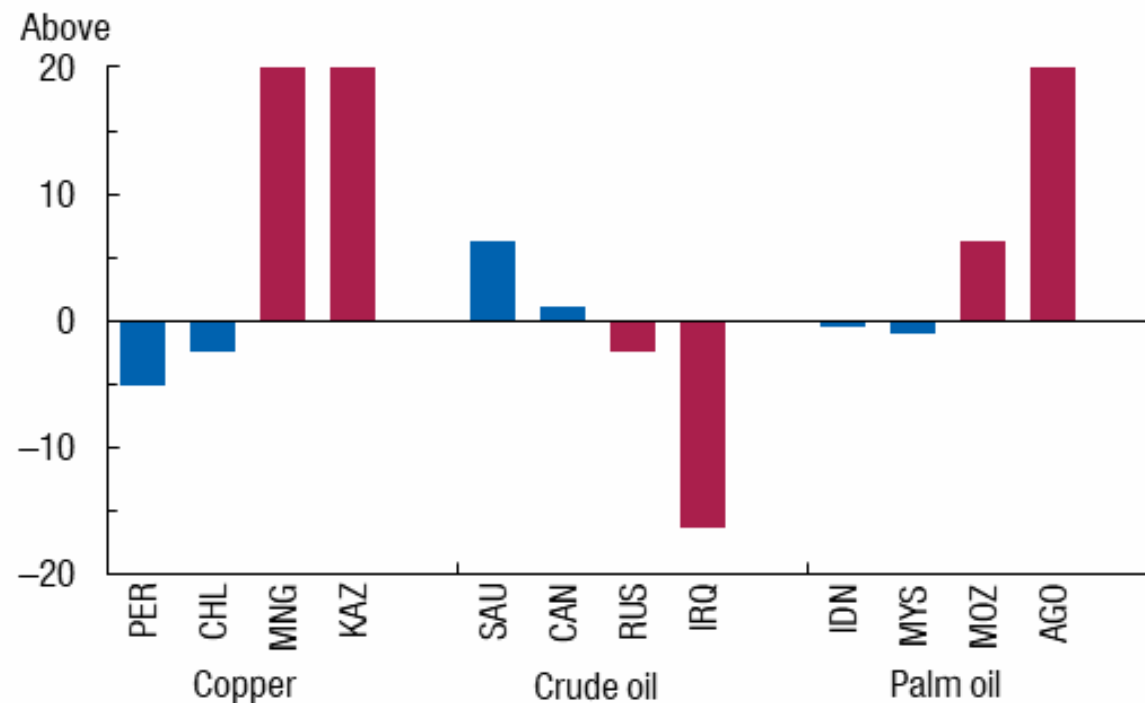
**Dynamic near- and
medium-term
effects on GDP and
inflation**

What commodities pose the greatest economic risk from fragmentation? A partial equilibrium approach

Distribution of Surplus Changes by Bloc and Commodity Group (Percent of GNE)



Surplus Changes for Top Two Net Exporters in Each Bloc for Selected Commodities (Percent of GNE)



Sources: Food and Agricultural Organization of the United Nations; BACI; British Geological Survey; US Geological Survey; and IMF staff calculations.

Note: Energy refers to coal, natural gas and crude oil. The horizontal lines in the bars represent the median, the bars the interquartile range, while the whiskers reflect the data points within 1.5 times the interquartile range from the 25th or 75th quartile across commodities in the group. The dots indicate outliers.

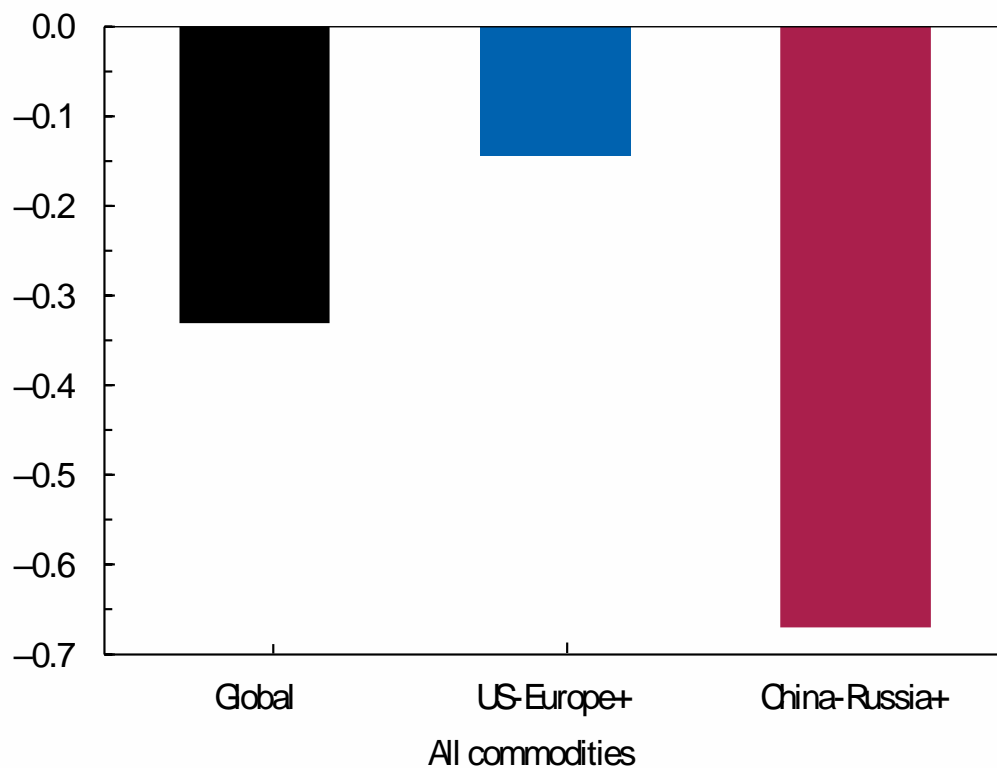
Sources: British Geological Survey; Food and Agriculture Organization of the United Nations; Gaulier and Zignago (2010); International Energy Agency; United States Geological Survey; and IMF staff calculations.

What are the long-term impacts of commodity market fragmentation? Trade model set-up

- Multi-country, multi-sector GE model with CES production (Bolhuis, Chen & Kett, 2023).
 - Final good is used as intermediate input → roundabout production (Caliendo and Parro, 2015).
- Key parameters are calibrated based on the recent literature.
 - Low demand elasticity for commodities (0.2 vs 1 for other sectors)
 - Low trade elasticities for commodities (~ 3 vs 6 on average for all sectors)
- Dataset: 133 commodities + 24 other sectors, 145 countries, 2019 (pre-pandemic)

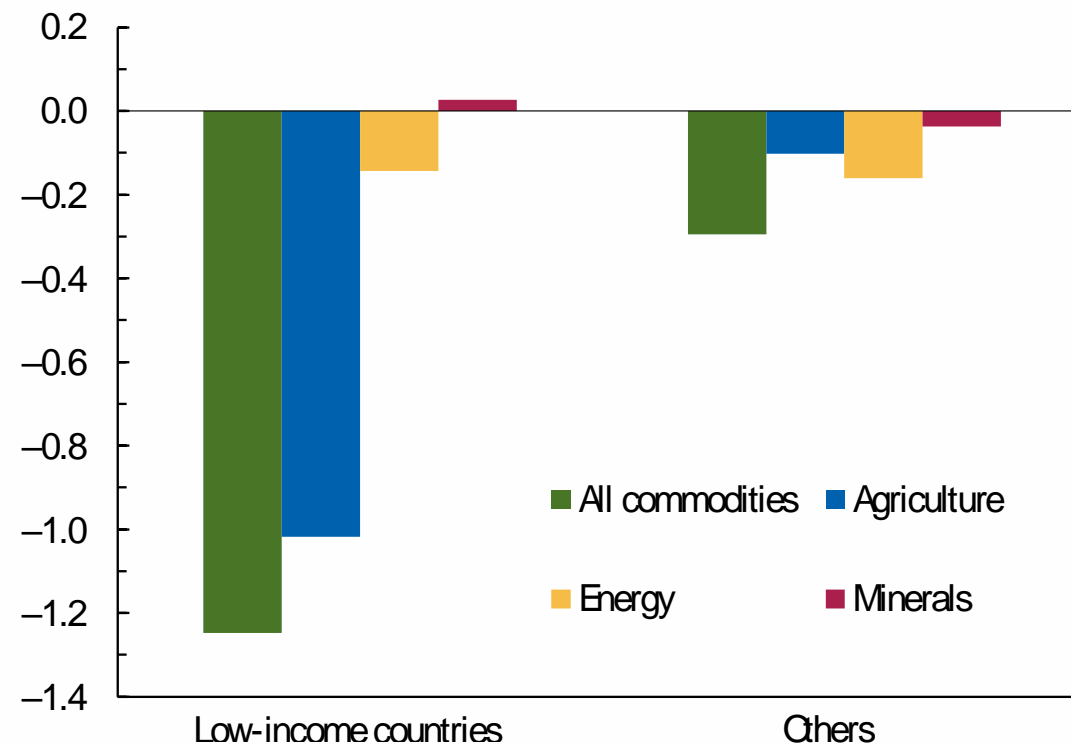
What are the long-term impacts of commodity market fragmentation? Trade model findings

Estimated Output Losses (Percent deviation from baseline)



Sources: EORA; Food and Agricultural Organization of the United Nations; BACI; British Geological Survey; US Geological Survey; and IMF staff calculations. For details, see Bolhuis, Chen and Kett (2023).
 Note: The bars represent the losses in GDP relative to baseline from eliminating trade in all commodities across hypothetical blocs. Country-level losses are aggregated to the bloc level using GDP PPP weights.

Estimated Output Losses in Low-income Countries and Others (Percent deviation from baseline)



Sources: EORA; Food and Agricultural Organization of the United Nations; BACI; British Geological Survey; US Geological Survey; and IMF staff calculations. For details, see Bolhuis, Chen and Kett (2023).
 Note: The bars represent the losses in GDP relative to baseline from eliminating trade in group of commodities across hypothetical blocs. Country-level losses are aggregated using GDP PPP weights.

What are the near-term impacts from commodity markets fragmentation? Augmented GMMET set-up

Key model ingredients:

- Multi-region, multi-sector DSGE with a large set of nominal and real rigidities
- Expanded to include **production/consumption/trade of fossil and renewable energy**
- Commodities included: **crude oil, coal, natural gas, copper, nickel, cobalt** and **lithium**
- 6 regions: USA, EUR, leaning toward USA/EUR, CHN, RUS, leaning toward CHN/RUS.

How are energy and minerals consumed/used in the model?

- Households: consume goods, energy, transportation, leisure
- Firms: produce tradables, nontradables, renewable energy structures and vehicles
 - Copper and nickel – for production of traditional and electric vehicles; tradables
 - Lithium and cobalt – for production of electric vehicles; tradables

IMF GMMET model: Fragmentation shock

We start from an equilibrium of total integrated markets

Then we ban trade between the US-Europe+ and the China-Russia+ blocs

Fragmentation main channels:

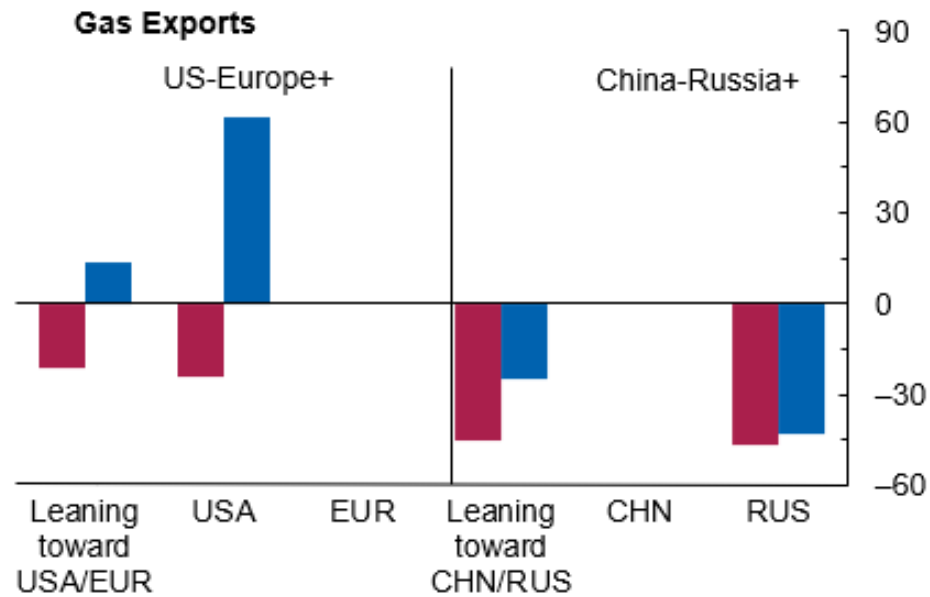
- Commodities' price response: demand relative to endowments in each bloc
- Expenditure switching and trade diversion — rigidities.
- Two key rigidities: **pipelines** and **mineral refining**

Pipelines and refining capacity affect the impact in the near-term

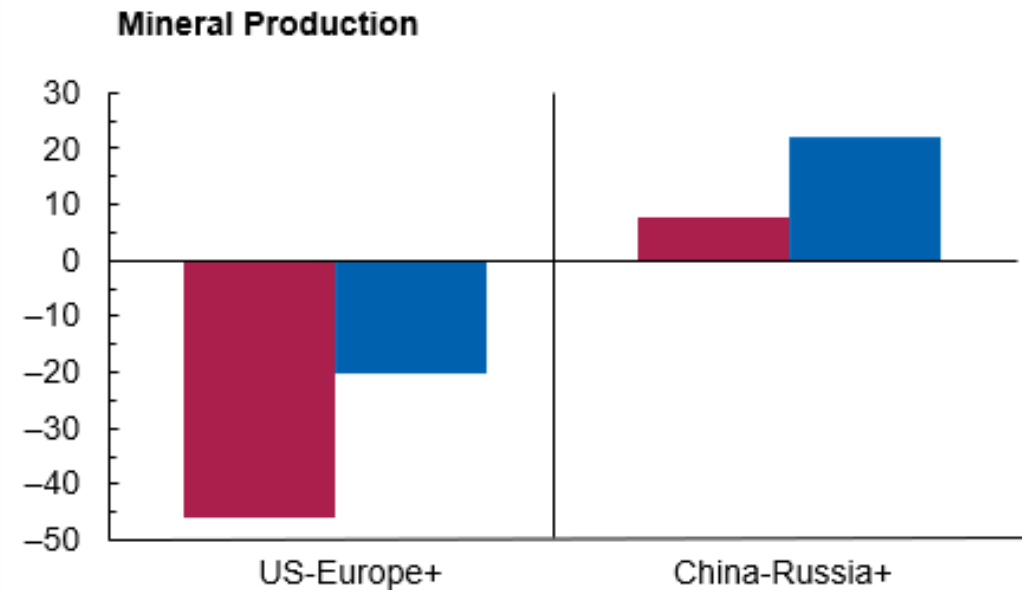
- Pipelines gas supply between Russia and Europe make it difficult for Russia to redirect gas flows
- Mineral refining capacity is currently concentrated in the China-Russia+ bloc
- It takes 5 to 10 years to scale up refining capacity

IMF GMMET model: Fragmentation transition is different depending on rigidities

Rigidities: Gas Pipelines



Rigidities: Minerals refining capacity



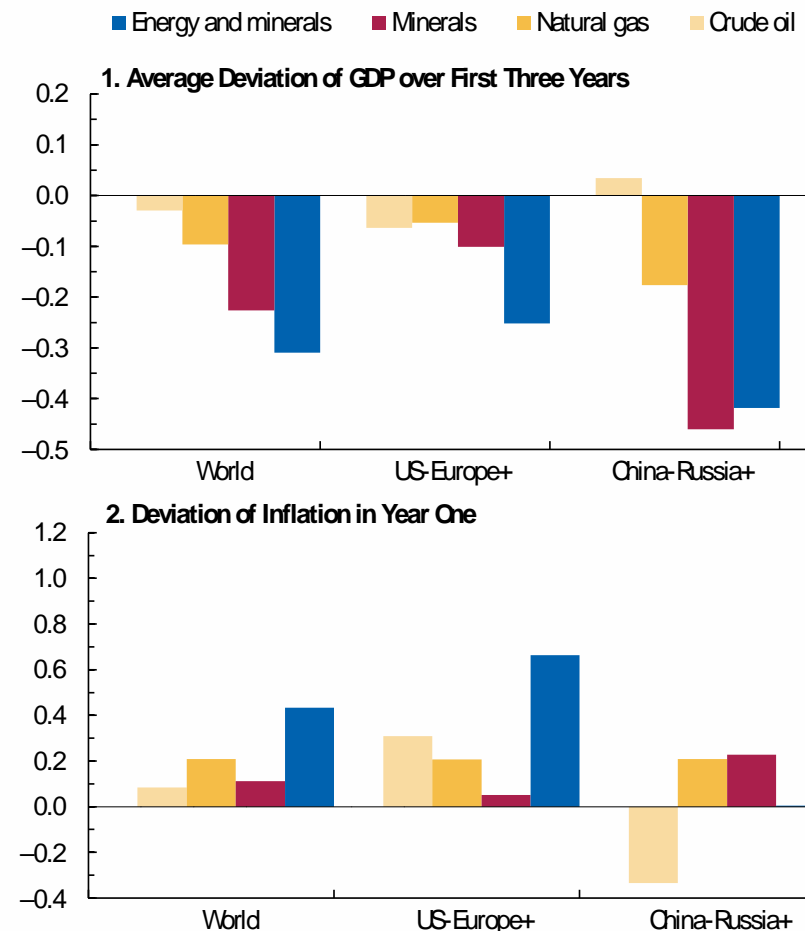
■ Year one ■ Year five

(Percent deviation from baseline)

What are the near-term impacts from commodity markets fragmentation? Augmented GMMET findings

- We simulate individual and joint commodity trade fragmentation
- What matters for the results?
 - Bloc configuration
 - Type of commodity
- Globally, moderate loss in terms of lower GDP, notable higher inflation

Impact of Fragmentation on real GDP and Inflation (Percent deviation from baseline)



Sources: OECD ICIO, Food and Agricultural Organization of the United Nations; BACI; British Geological Survey; US Geological Survey; and IMF staff calculations.

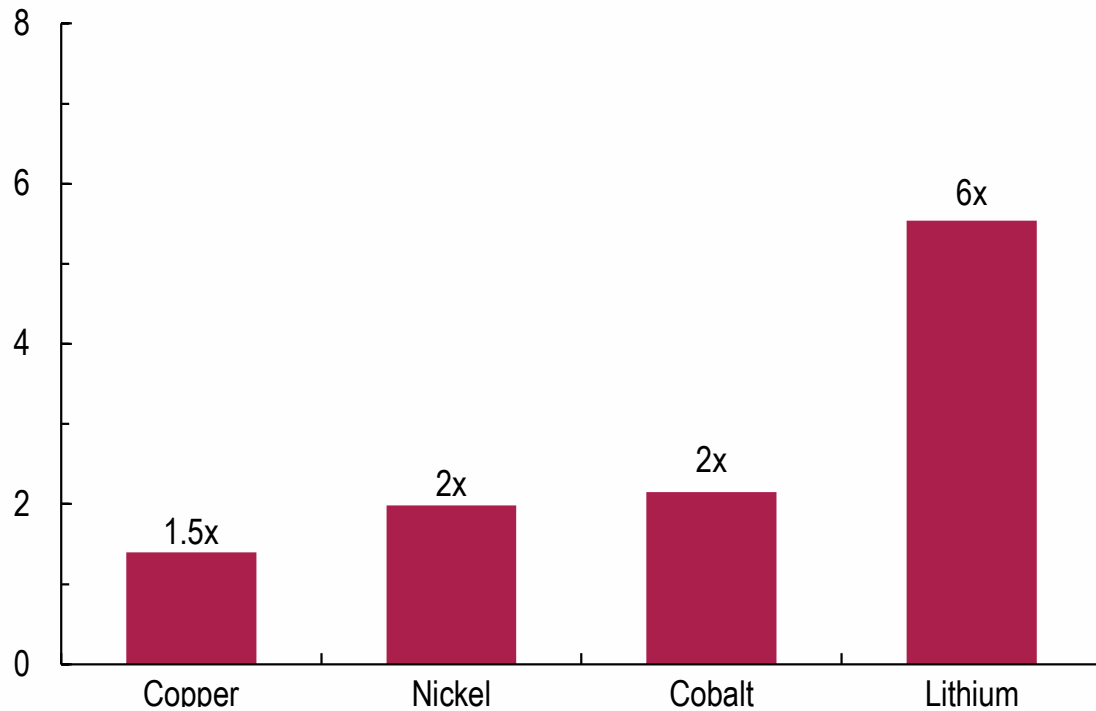
Note: Energy refers to coal, natural gas and crude oil. Region-level results are aggregated to the bloc (and world) level using GDP PPP weights.

What are the implications for the clean energy transition?

Steep demand increases could hit highly concentrated markets

Demand Increases for Critical Minerals until 2030

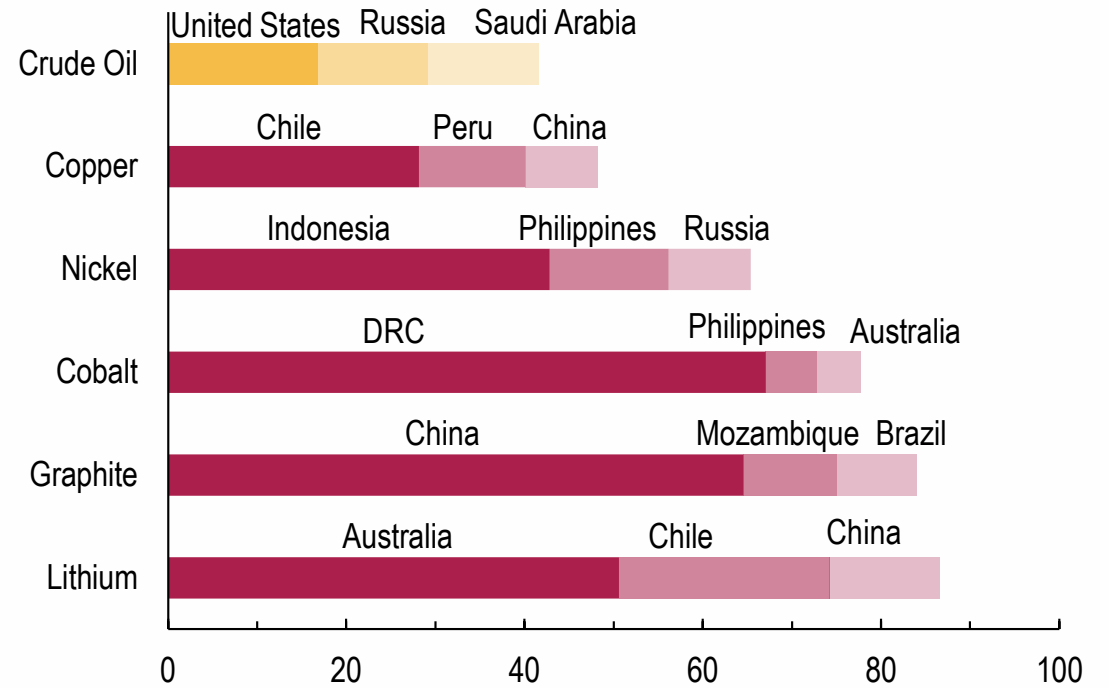
(Index, 2022 = 1, Net Zero Emissions Scenario)



Sources: International Energy Agency; and IMF staff calculations.

Share of Top 3 Producing Countries

(Percent of World Mine Production)



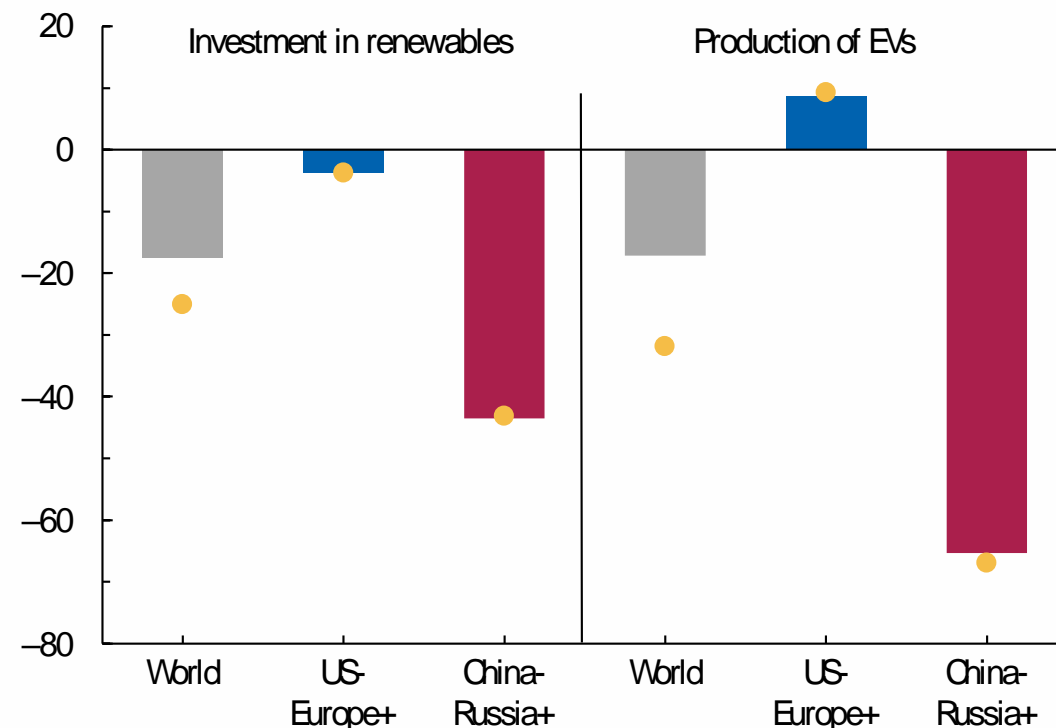
Sources: British Geological Survey; US Geological Survey; and IMF staff calculations.

What are the implications for the clean energy transition?

Augmented GMMET findings

- Prices of critical minerals could suffer upward pressures along the net-zero-emissions path
- Prices increase even more in China-Russia+ bloc when markets are fragmented
- In that bloc, fewer electric vehicles (EVs) from fragmentation and lower investment in renewables
- In US-EU+ bloc, oversupply of minerals. But time needed to scale up refining capacity. Small increase in EVs; no relevant change renewable investment

Impact of Fragmentation of Critical Mineral Markets on Investment in Renewables and Electric Vehicles, 2030 (Percent deviation from net zero emissions scenario without fragmentation)



Sources: British Geological Survey; Gaulier and Zignago (2010); IMF, Global Macroeconomic Model for the Energy Transition; International Energy Agency; United States Geological Survey; and IMF staff estimates.

Note: The bars and dots in the figure report the change in real investment in renewable energy and the production of EVs in a fragmented world relative to the net-zero-emissions path, with demand for cobalt, copper, lithium, and nickel increasing as projected by the International Energy Agency's net-zero-emissions scenario (in an integrated world). Country-level variables are aggregated to the bloc and world levels using weights based on GDP at purchasing power parity in the bars and on greenhouse gas emissions in the dots. The bloc including the countries that voted for Russia's withdrawal from Ukraine in the 2022 UN vote is labeled the "US-Europe+ bloc," and the remaining countries are included in the "China-Russia+ bloc." EVs = electric vehicles.

Summary and Policy Implications

Summary of Findings

1. Concentration in natural endowments makes commodities particularly vulnerable to fragmentation.
2. There are signs of rising fragmentation in commodity markets, both de-jure and de-facto.
3. Vulnerability to fragmentation is particularly high for some critical minerals and selected agricultural goods, especially in the hypothetical China-Russia+ bloc.
4. The long-term global macroeconomic impacts are likely modest but with large cross-country heterogeneity; more price volatility and food insecurity risks.
5. Commodity market fragmentation would delay the energy transition.

Policy Recommendations

- Establishing a “green corridor” for critical minerals for the energy transition, and potentially a “food corridor” to avoid food insecurity crises.
- International sharing and standardization of data on critical minerals.
- Countries can adapt to the risk of fragmentation:
 - Fostering production, trade integration and efficient use.
 - Diversification of supply sources.
 - Enhance preparedness against supply shocks.



World Economic Outlook October 2023

THANK YOU!

Background slides

Boxes

Box 1. “Historical Evidence on the Different Shades of Grey of Fragmentation”

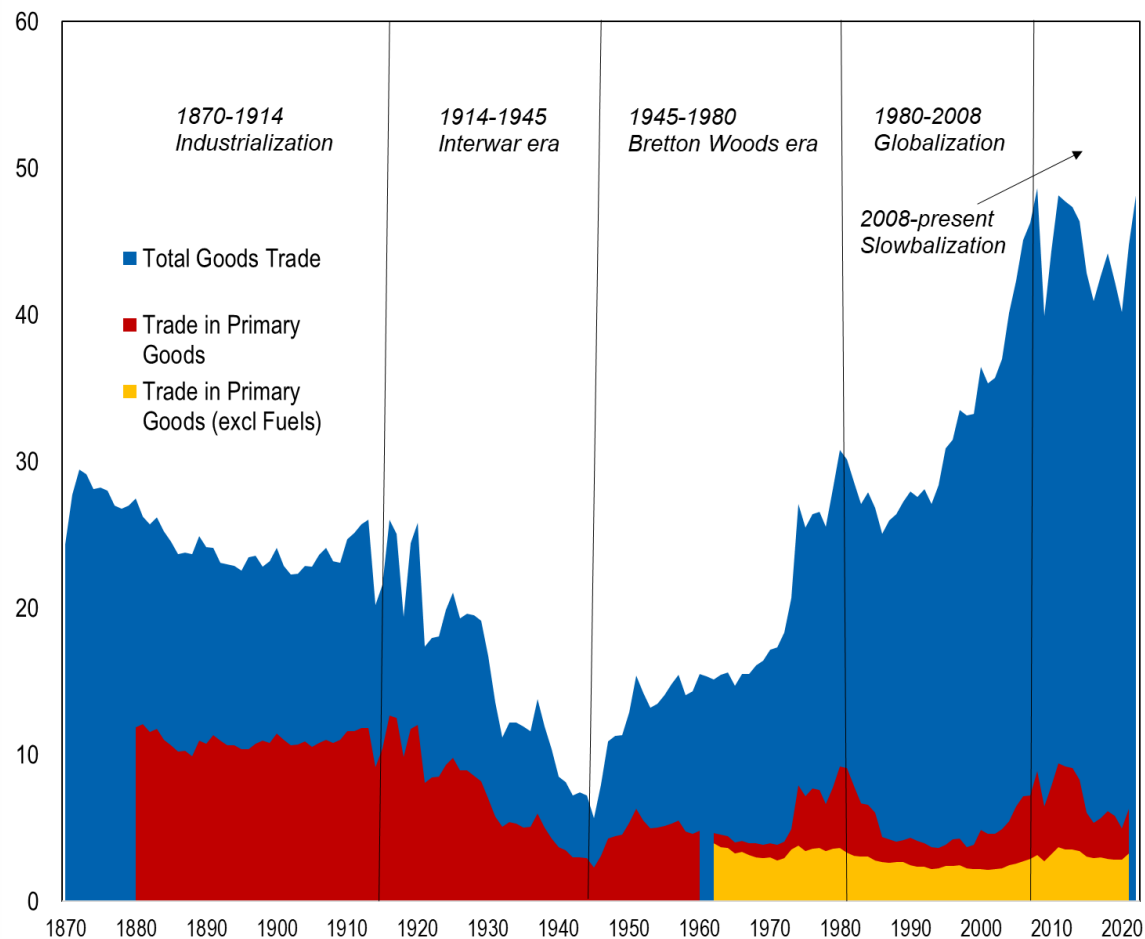
Box 2. “The Uneven Effects of Fragmentation” (by Marijn Bolhuis (SPR), Jiaqin Chen (RES), and Ben Kett (SPR))

Box 3. “Sanctions, Geopolitics and Commodities Trade: Evidence from Vessel Traffic Data” (by Seung Mo Choi (STA) and Alessandra Sozzi (STA))

Commodity trade values: the long run perspective

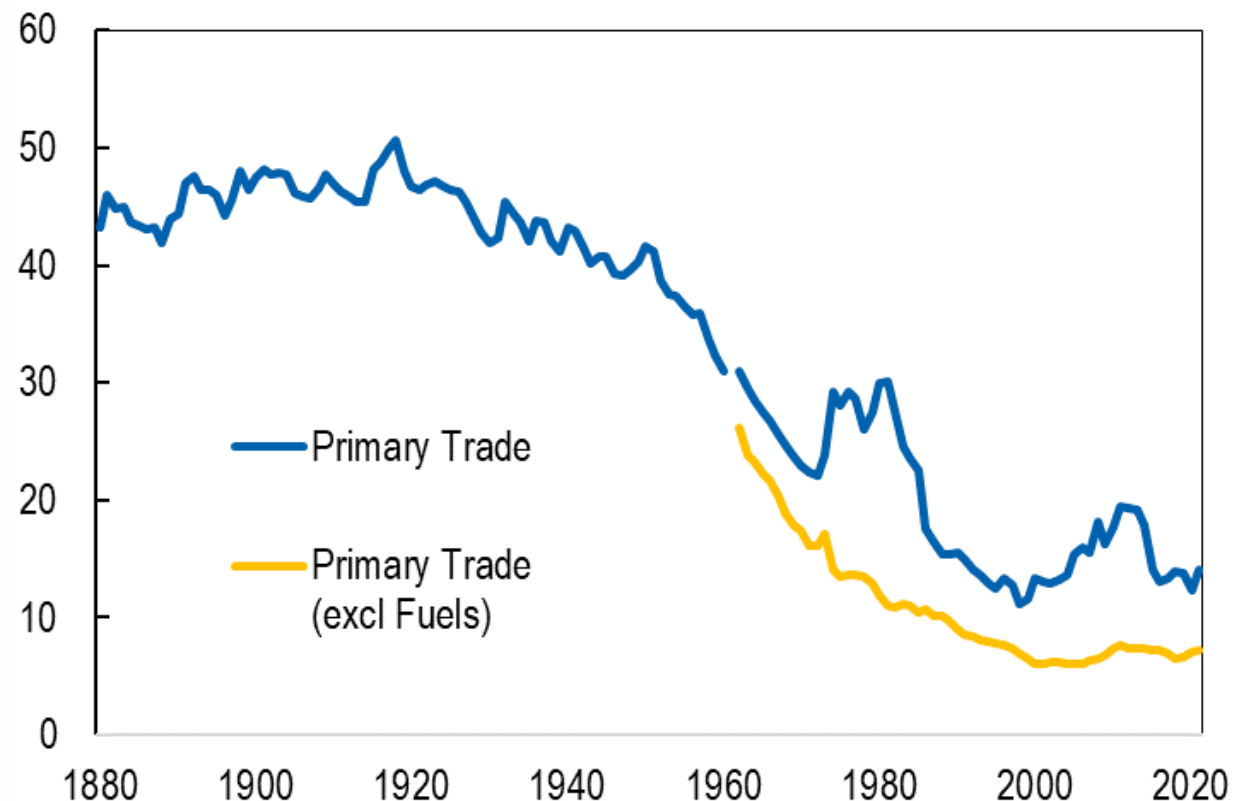
Total and Primary Trade Openness

(Sum of goods exports and imports, percent of GDP)



Primary Trade: Importance in Overall Trade

(Percent of total trade)



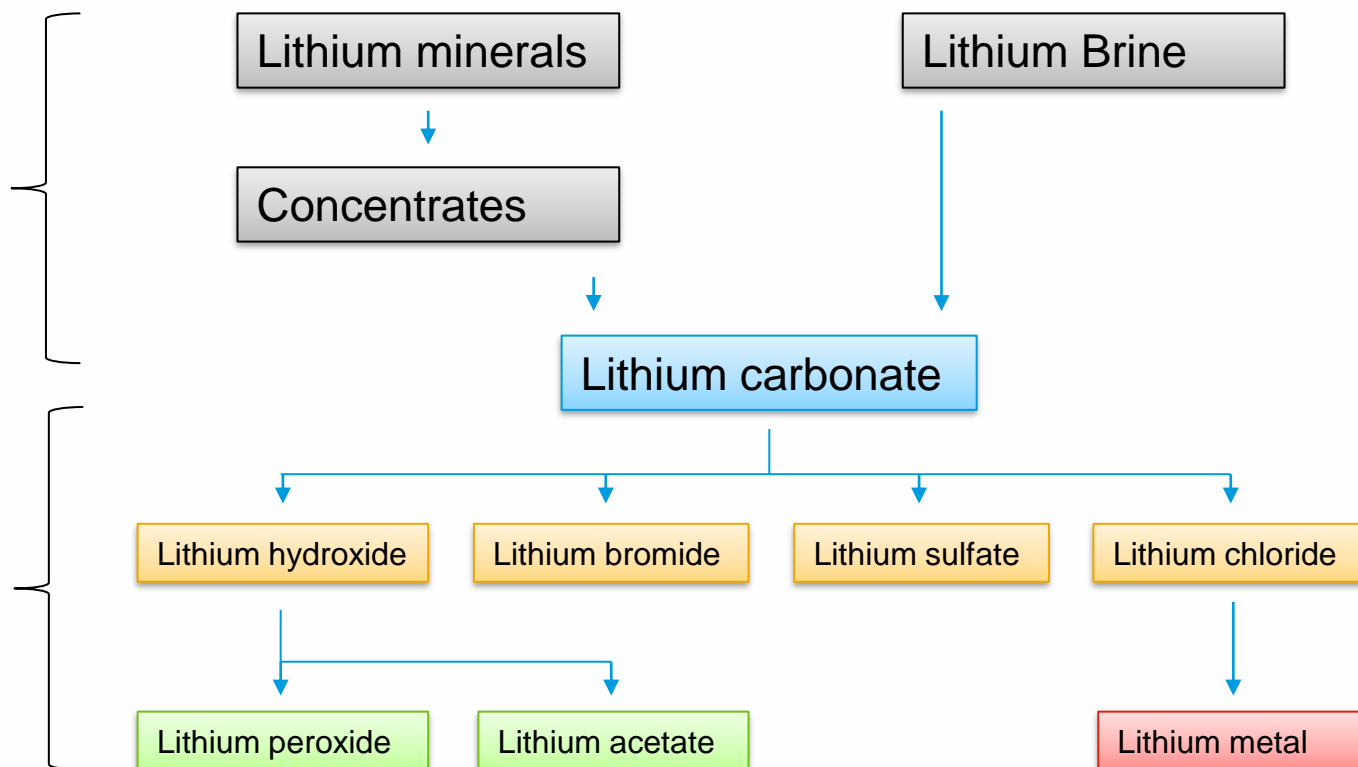
Source: IMF World Economic Outlook; Jacks and Tang (2018); Jordà-Schularick-Taylor (JST) Macrohistory Database; UN Comtrade; UN International Trade Statistics, 1900-1960; and IMF staff calculations. Note: Trade openness is measured as the ratio of exports and imports to GDP in nominal USD. Commodity trade is approximated by primary goods trade, using the Broad Economic Classification (BEC) Rev. 1. UN Comtrade data (1962-2022) is spliced with series from the UN International Trade Statistics, the JST Macrohistory Database, and Jacks and Tang (2018).

From Mining to Processing: the case of Lithium

Mining stage: Australia, Chile, Argentina
→ concentrated due to natural endowments

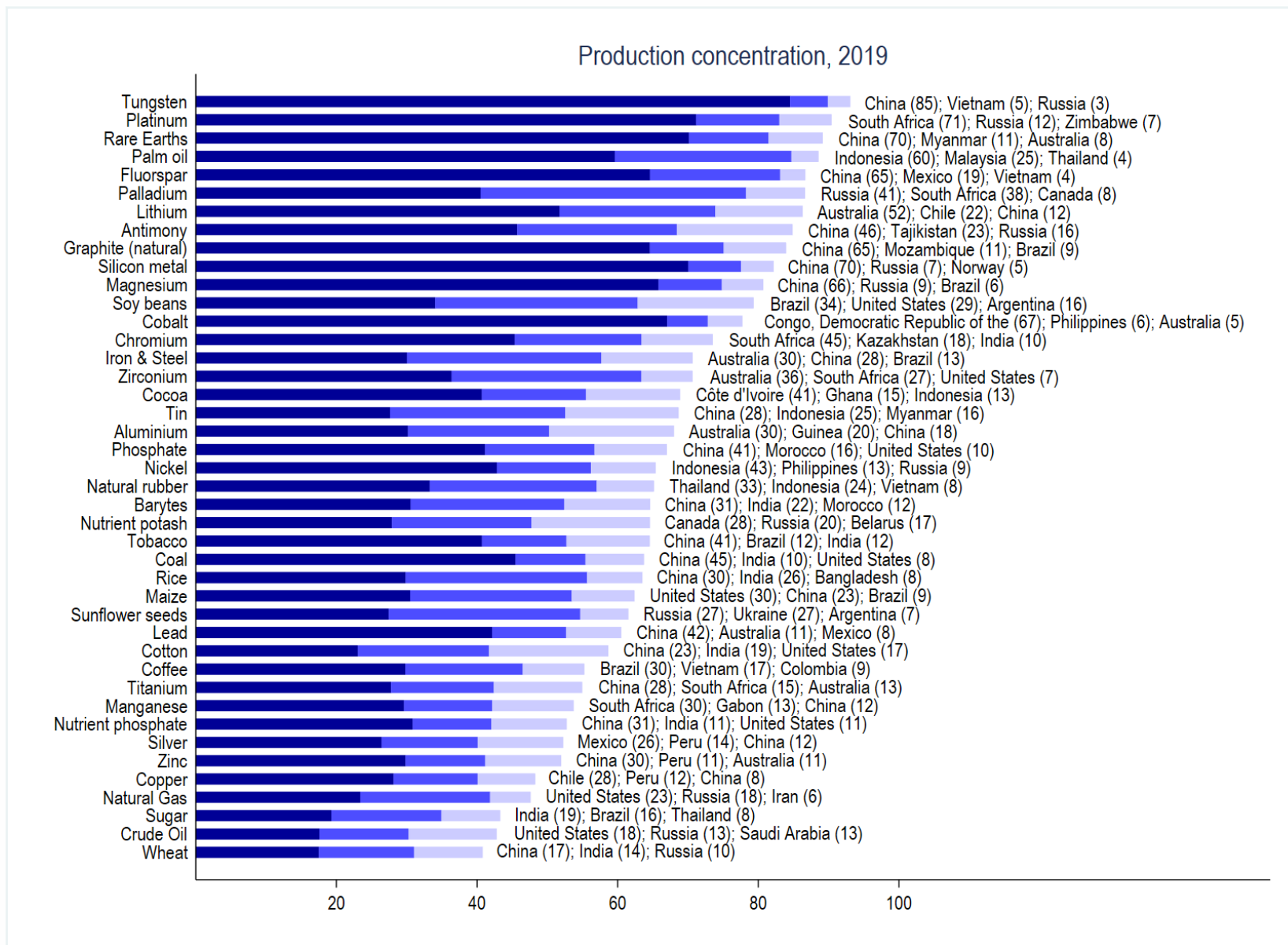
Processing stage: Mostly China
→ concentrated due to regulations, energy and labor costs, among others.

Simplified Value Chain for Lithium



Source: Adapted from German Federal Resource Agency (DERA), 2023.

List of commodities and production concentration

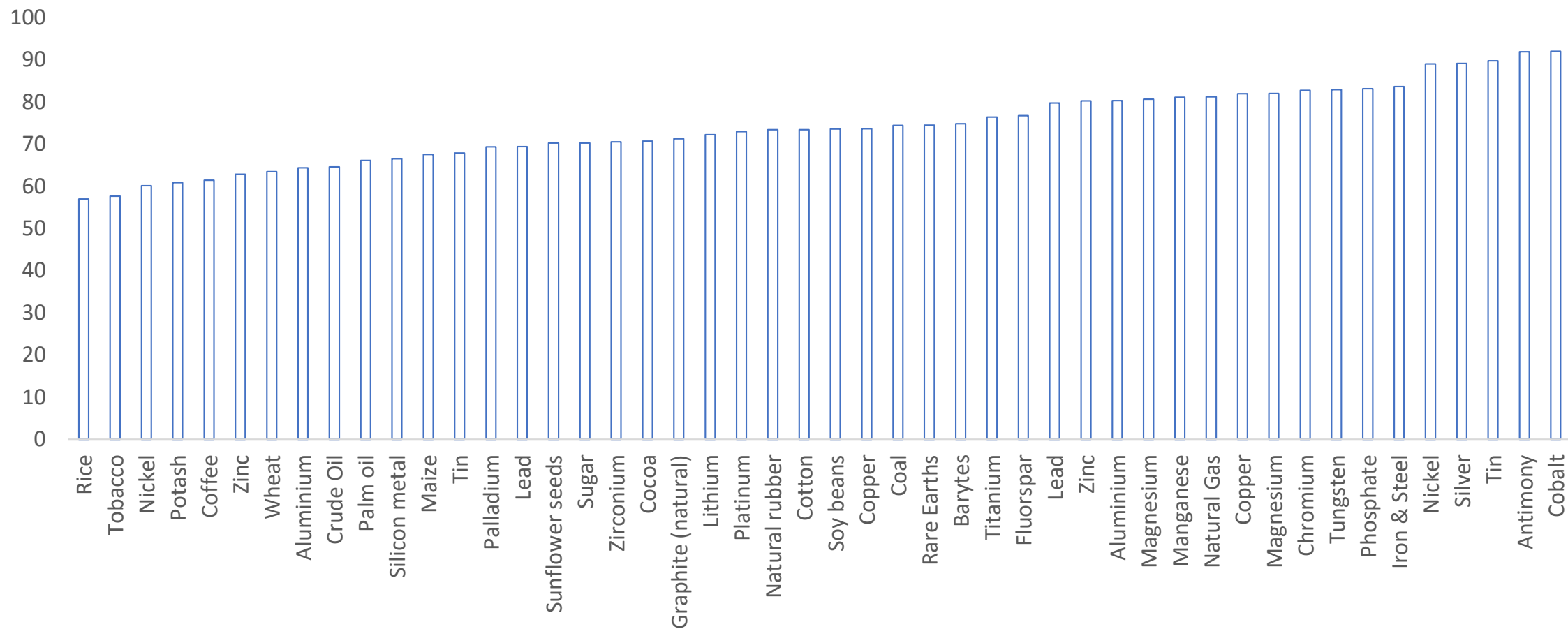


agg_name	commo_type
Cocoa	Ag
Coffee	Ag
Cotton	Ag
Maize	Ag
Natural rubber	Ag
Palm oil	Ag
Rice	Ag
Soy beans	Ag
Sugar	Ag
Sunflower seeds	Ag
Tobacco	Ag
Wheat	Ag
Coal	Fuel
Crude Oil	Fuel
Natural Gas	Fuel
Aluminium	Min
Antimony	Min
Barytes	Min
Chromium	Min
Cobalt	Min
Copper	Min
Fluorspar	Min
Graphite (natural)	Min
Iron & Steel	Min
Lead	Min
Lithium	Min
Magnesium	Min
Manganese	Min
Nickel	Min
Nutrient phosphate	Min
Nutrient potash	Min
Palladium	Min
Phosphate	Min
Platinum	Min
Rare Earths	Min
Silicon metal	Min
Silver	Min
Tin	Min
Titanium	Min
Tungsten	Min
Zinc	Min
Zirconium	Min

A large share of commodity imports are provided by the top three suppliers

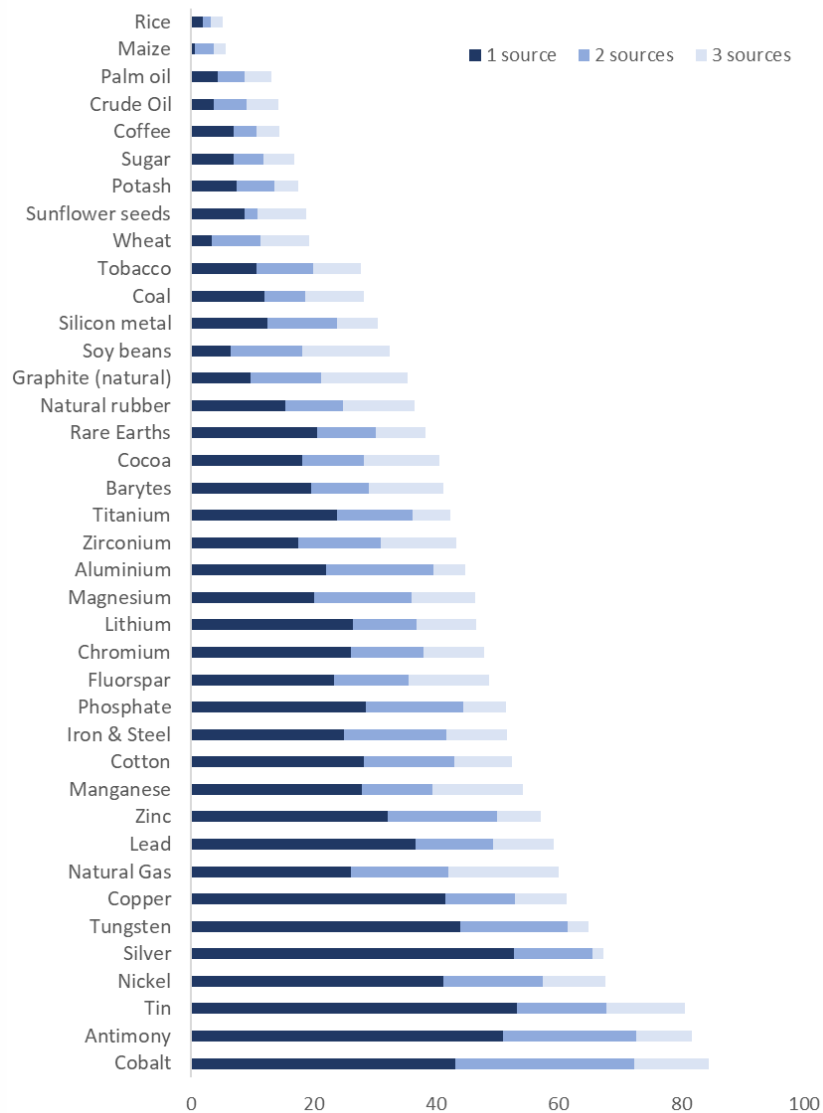
Share of country's imports that comes from top 3 suppliers

(Percentage of country's imports, 2019)

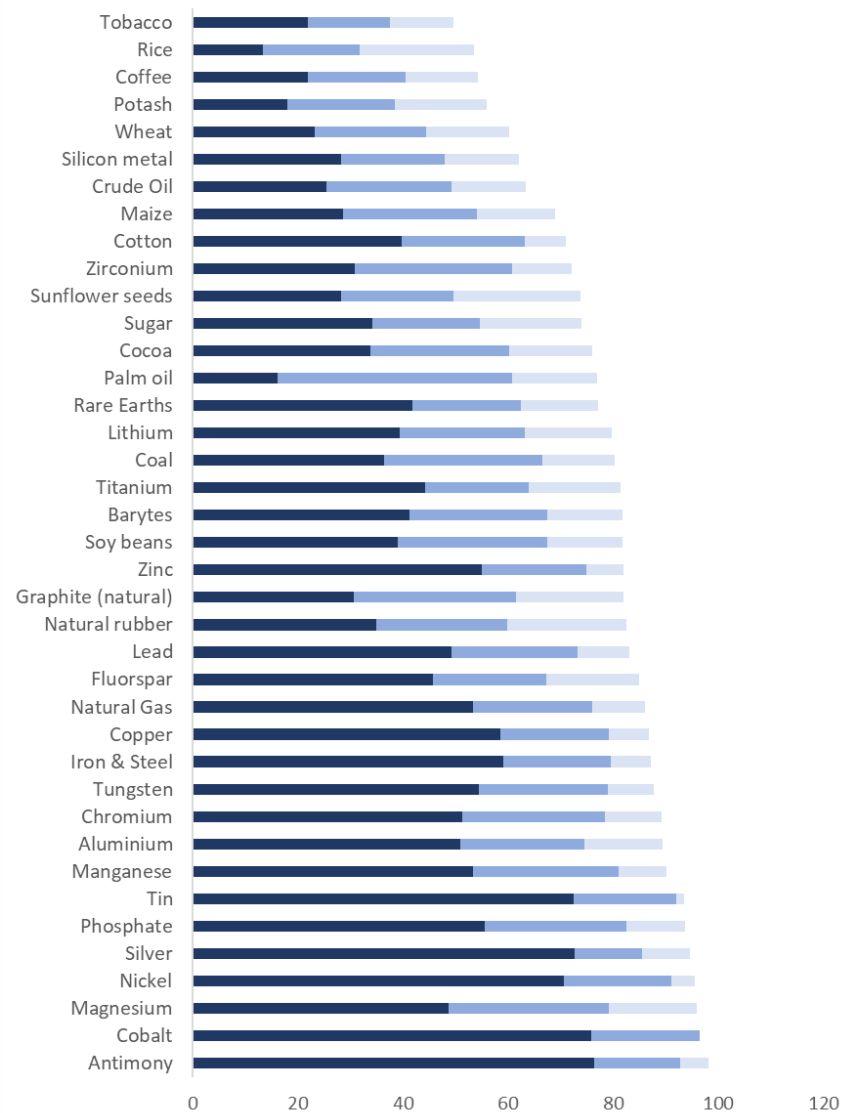


Many commodity importers rely on 3 or fewer suppliers

Proportion of importers with 1, 2 or 3 sources for imports

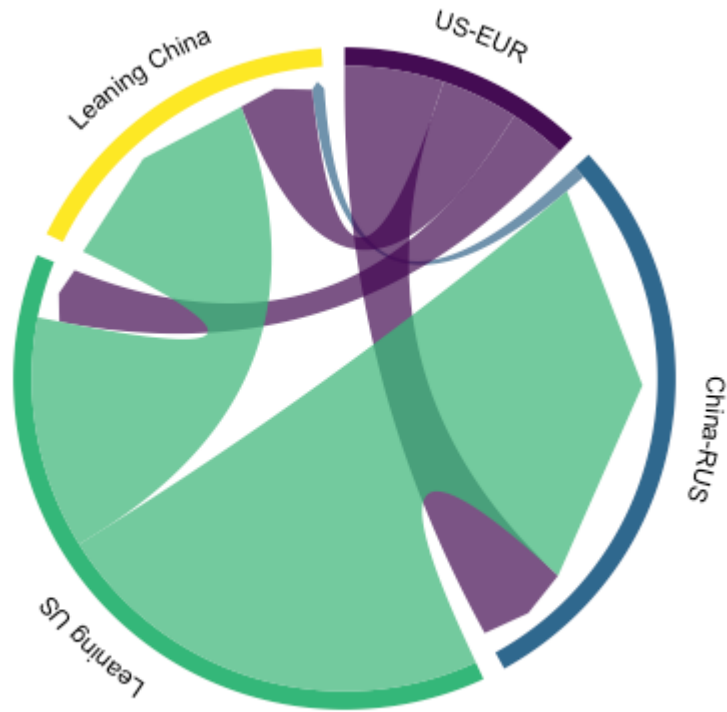


Proportion of importers with 1, 2 or 3 sources for 90% of imports



Trade dependence across blocs

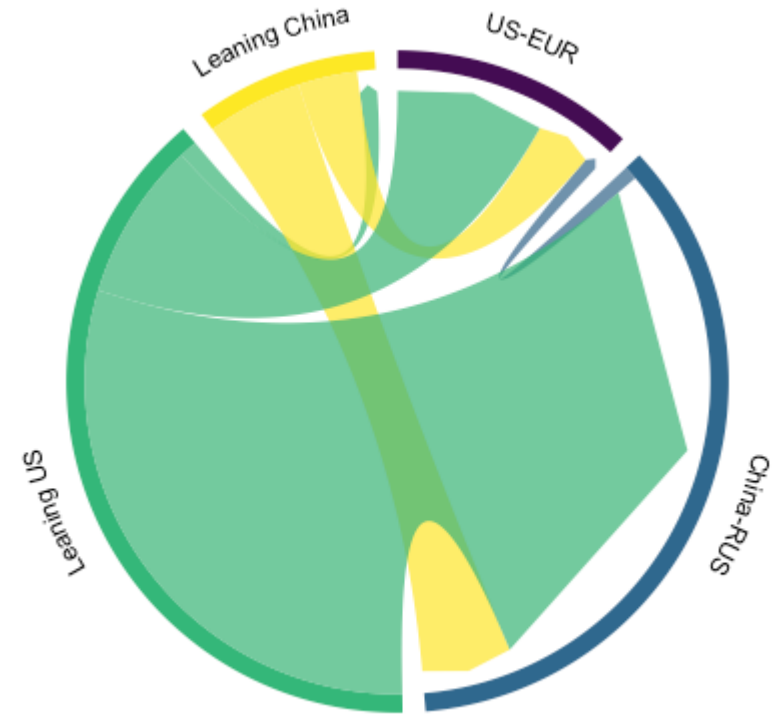
Agricultural Commodities



Energy



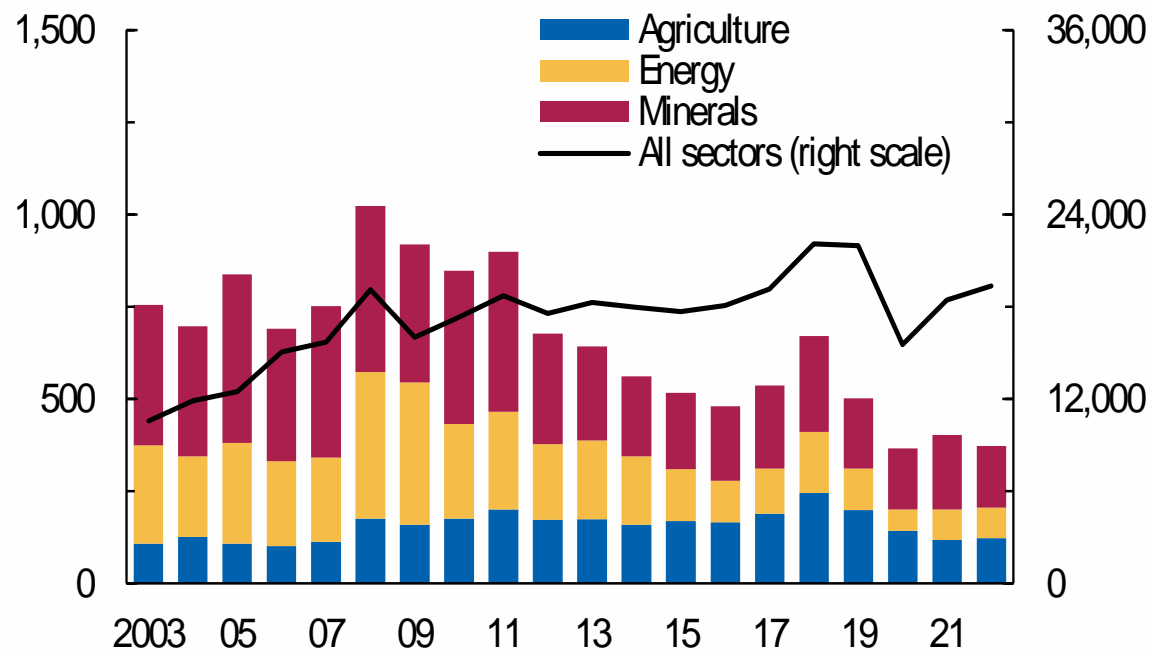
Minerals



FDI flows in commodity sectors are also declining

Greenfield FDI and M&As

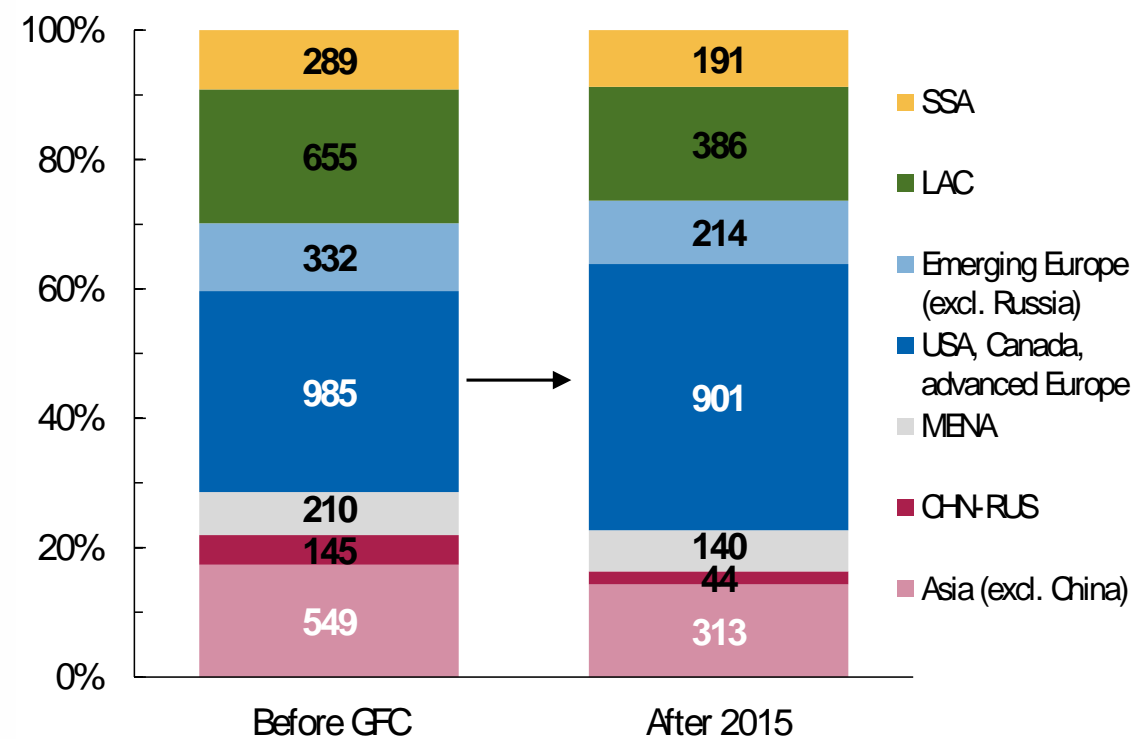
(Number of projects per year)



Sources: fDI Markets; and IMF staff calculations.

Commodities Greenfield FDI and M&As from USA, Canada and Advanced Europe

(Percent of projects)



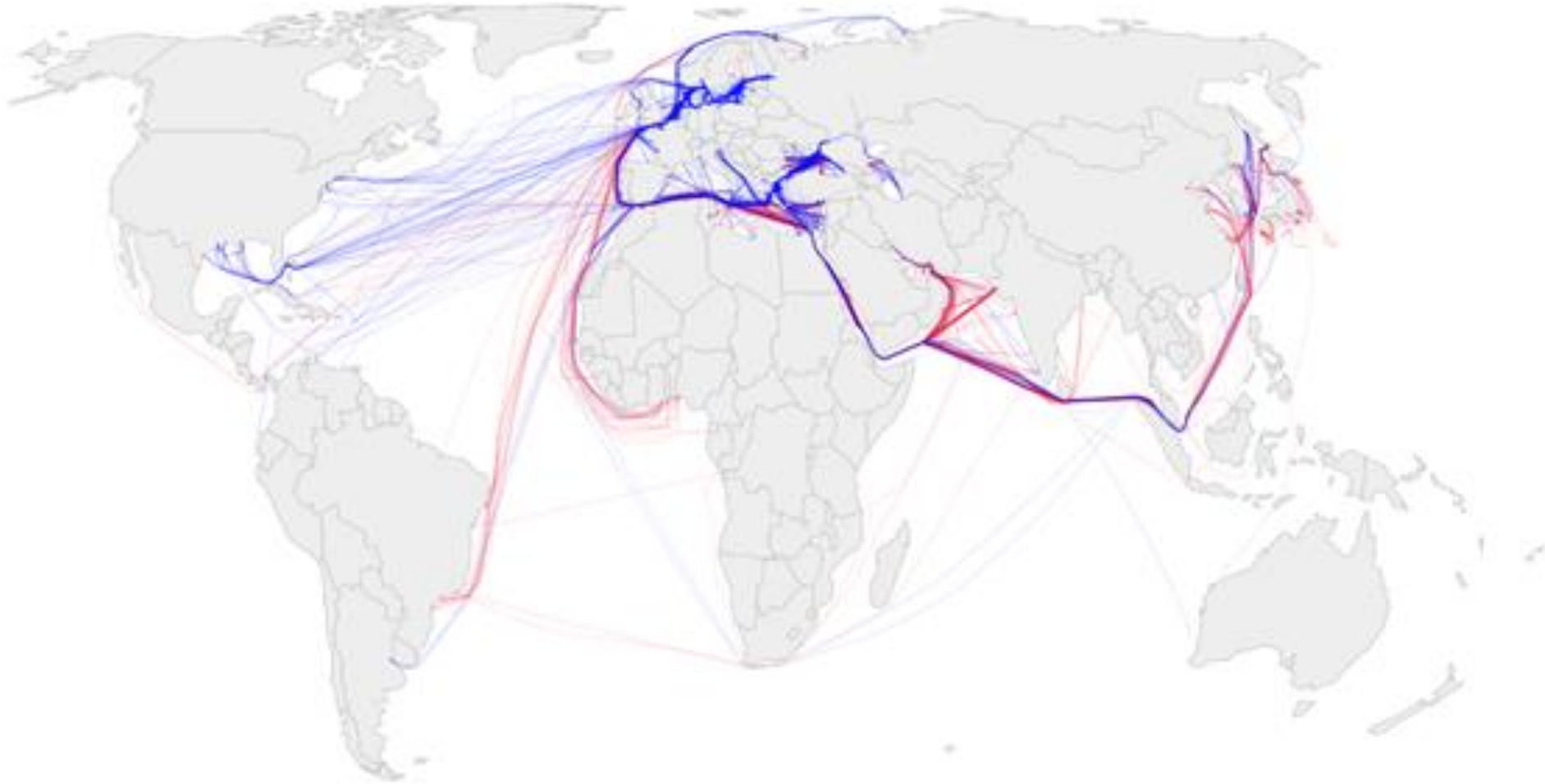
Sources: fDI Markets; and IMF staff calculations.

Note: The numbers reported inside the bars reflect the total number of greenfield FDI projects and M&As in the commodities sector from USA, Canada and Advanced Europe to the respective destination over the 2003-2008 and 2016-2022 periods.

Oil traffic patterns have changed significantly

Traffic of Tankers Departing Russian Ports, Changes 2019-2023

(Blue = decreased traffic; Red = increased traffic)

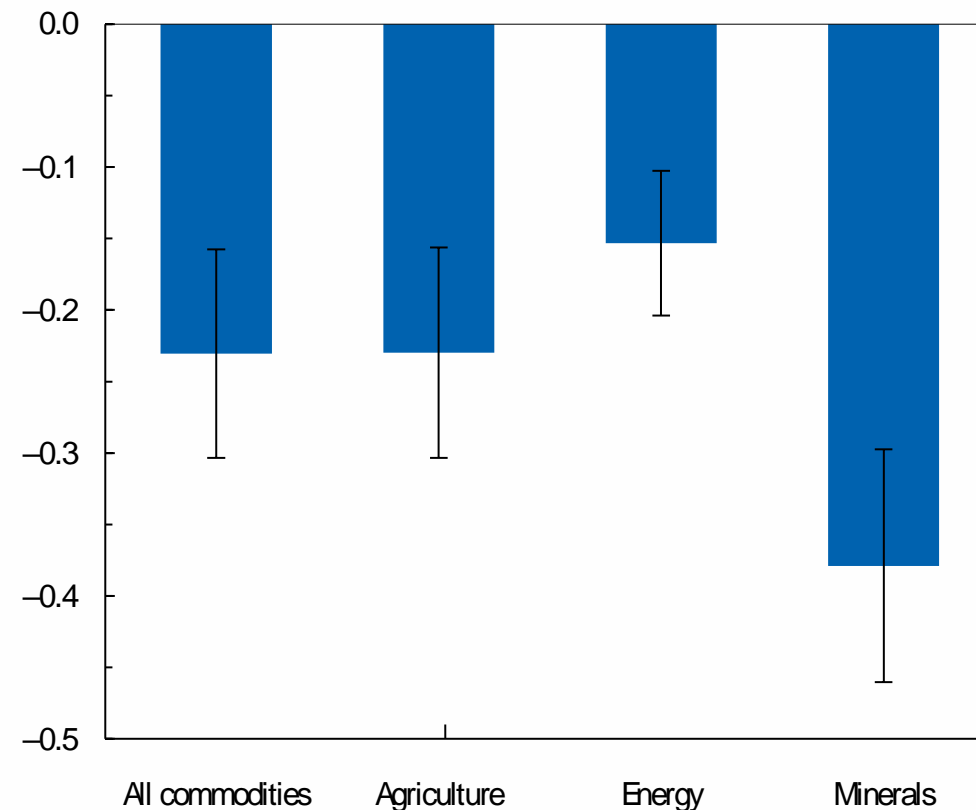


Sources: Marine traffic AIS data; and IMF Staff calculations.

Escalation of geopolitical tensions could reduce commodity trade

- Gravity model for 48 commodities.
 - Political distance: Military alliances.
 - Controls: geographical distance, other standard gravity controls, fixed effects.
- Negative correlation between bilateral commodity trade and political distance, though direct of causality difficult to establish.
- Negative correlation strongest for minerals.

Estimation Coefficients for the Relation between Commodity Trade and Political Distance



Sources: Signorino and Ritter (1999); BACI, CEPII; FAO; WEO; and IMF Staff calculations.
Note: Energy refers to coal, natural gas and crude oil. The bars denote the point estimates, while the vertical lines represent the 95th percentile confidence interval. Estimates are based on an inverse hyperbolic sine specification to account for zeros. Standard errors are clustered at the importer country level.

Does geopolitical distance matter for commodity trade flows?

- Explore role of political distance through the lens of a gravity model of trade

$$\log(y_{ijct}) = E_{ict} + I_{jct} + \delta_{ijct} + \varepsilon_{ijct}$$

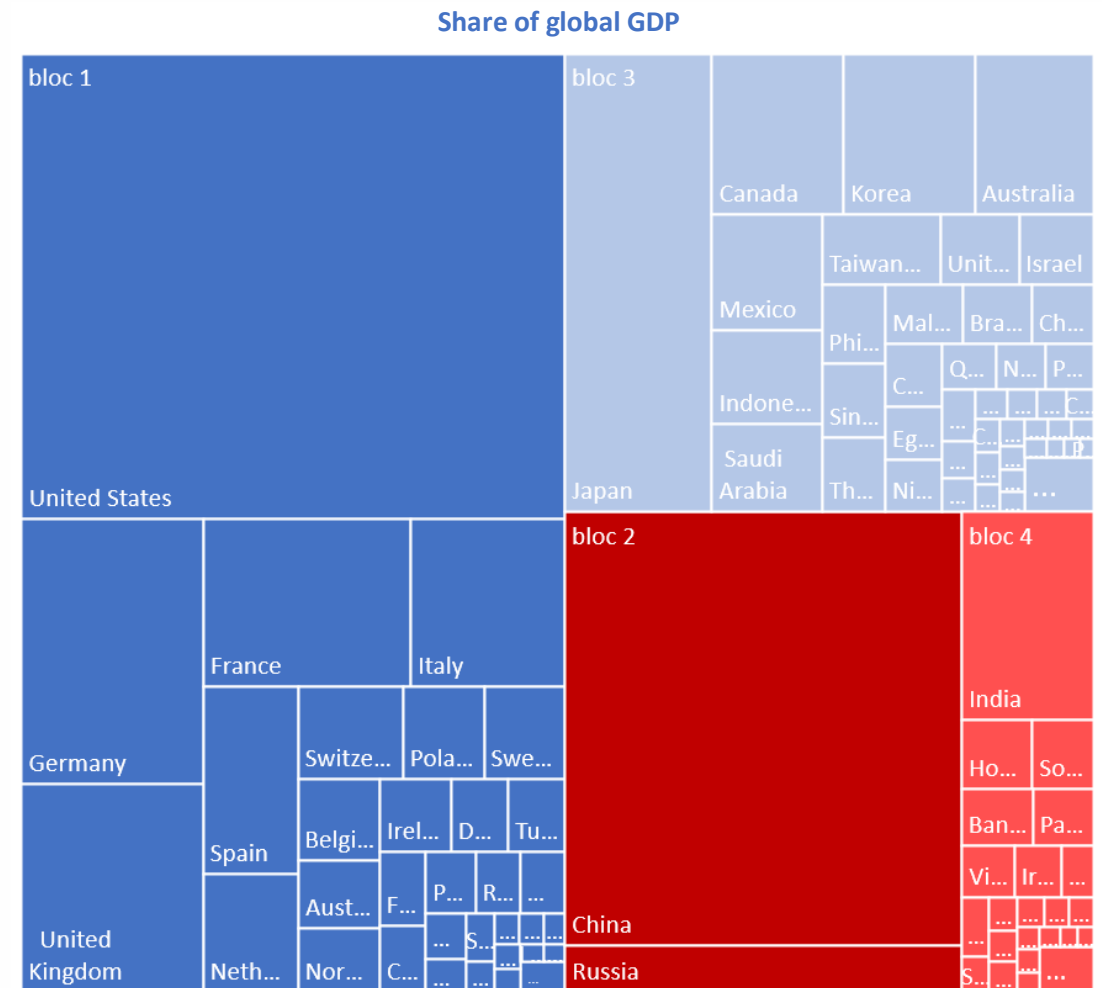
- y_{ijct} are exports from country i to country j of commodity c in year t ; E_{ict} and I_{jct} are importer/exporter-commodity-year fixed effects
- δ_{ijct} captures the propensity that a country pair ij trades commodity c in year t (undirected)
 - δ_{ijct} - function of political distance PD_{ijt} and traditional gravity controls X_{ij}
 - PD_{ijt} - measured using military alliances (Signorino and Ritter, 1999)
 - α_c - impact of political distance and other gravity controls allowed to vary by commodity c

$$\delta_{ijct} = \alpha_c PD_{ijt} + \beta_c \log(GD_{ij}) + \Gamma_c X_{ij} + u_{ijct}$$

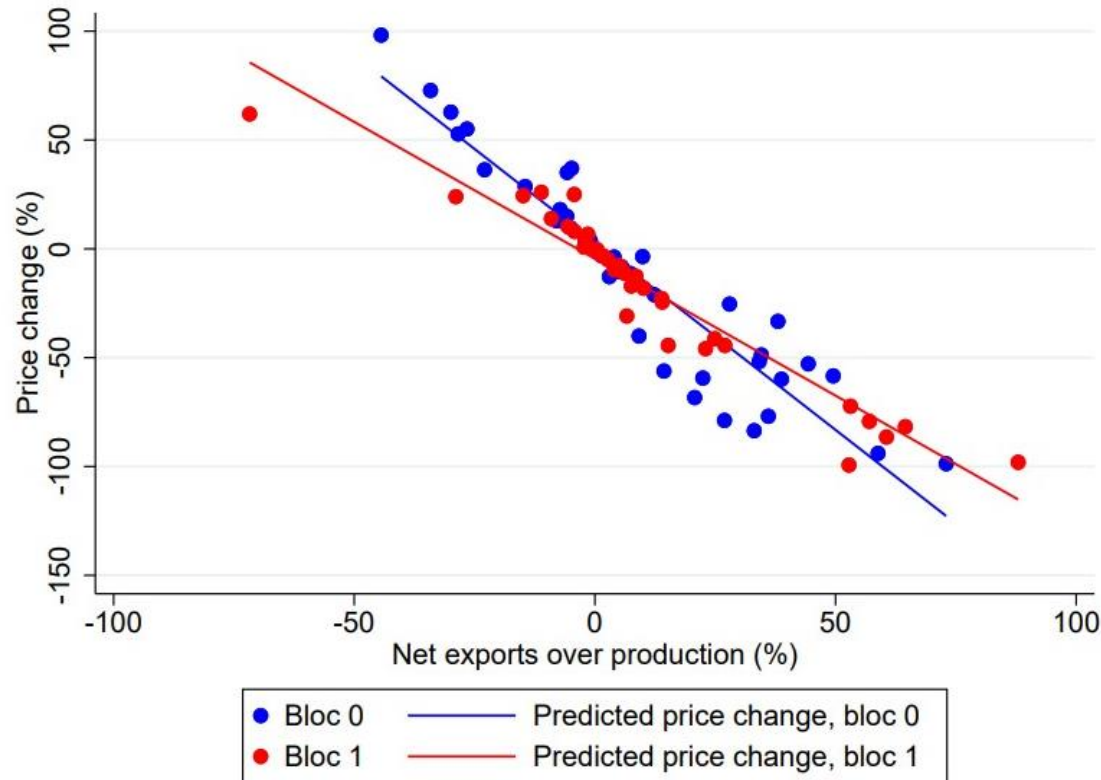
- Test if link between trade and political distance is weaker or stronger for different type of commodities

Why choose blocs based on the 2022 UN vote on Ukraine?

- Transparency.
- High uncertainty → Hard to assess plausibility of different bloc scenarios.
- More in line with the data used for the GMMET exercise.
- In line with the 2022 October APD REO chapter on fragmentation.



Commodity vulnerability is tightly related to demand-supply imbalances across blocs



Most vulnerable commodities

US bloc: magnesium refined, barytes, platinum and palladium refined, graphite, tungsten, aluminum

China bloc: palm oil, copper (mined), soy beans, cobalt (mined), manganese, iron ore, lithium

Definitions

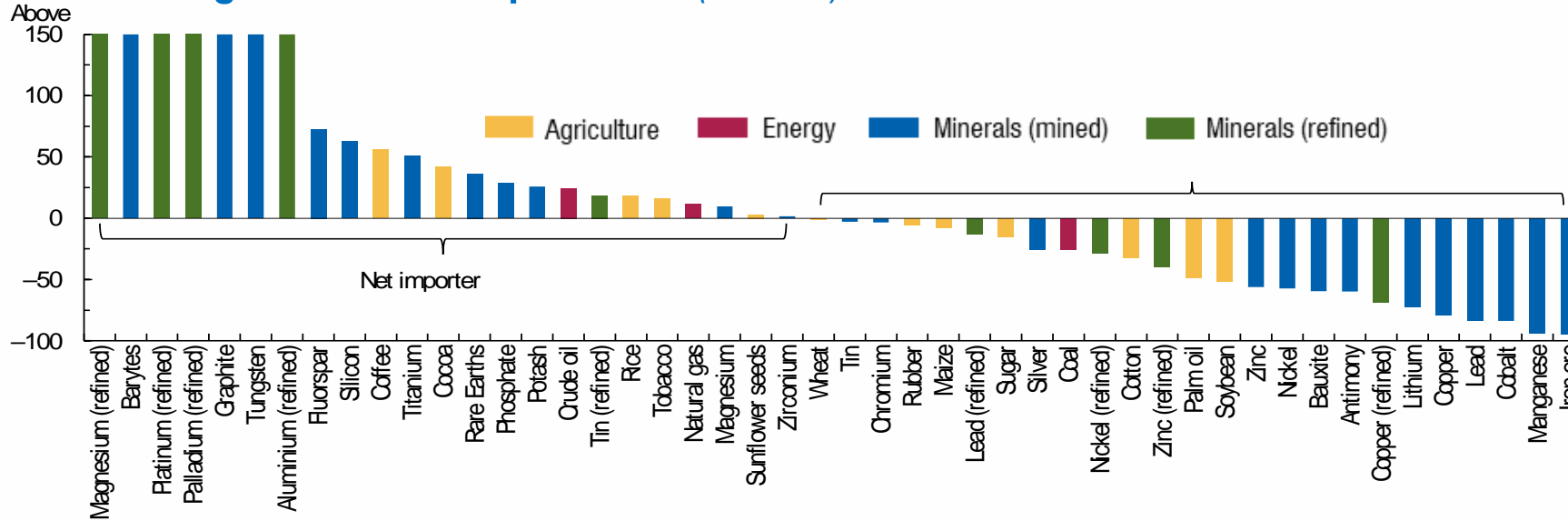
Supply-Demand Imbalance: Pre-fragmentation bloc exports minus imports as a share of pre-fragmentation production

Price Change: Percent change in commodity price (post-fragmentation price in bloc relative to pre-fragmentation world price)

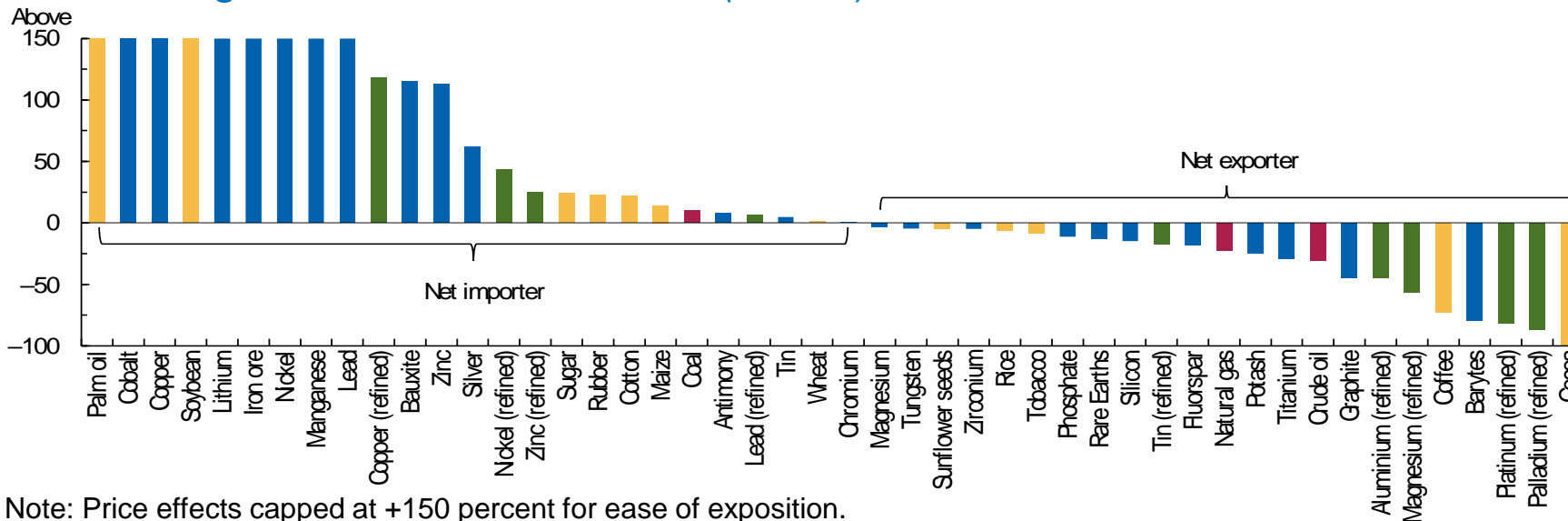
Note: Price effects shown in graph capped at +500 percent for ease of exposition.

Minerals tend to be more vulnerable to fragmentation

Price Changes in US-Europe+ Bloc (Percent)



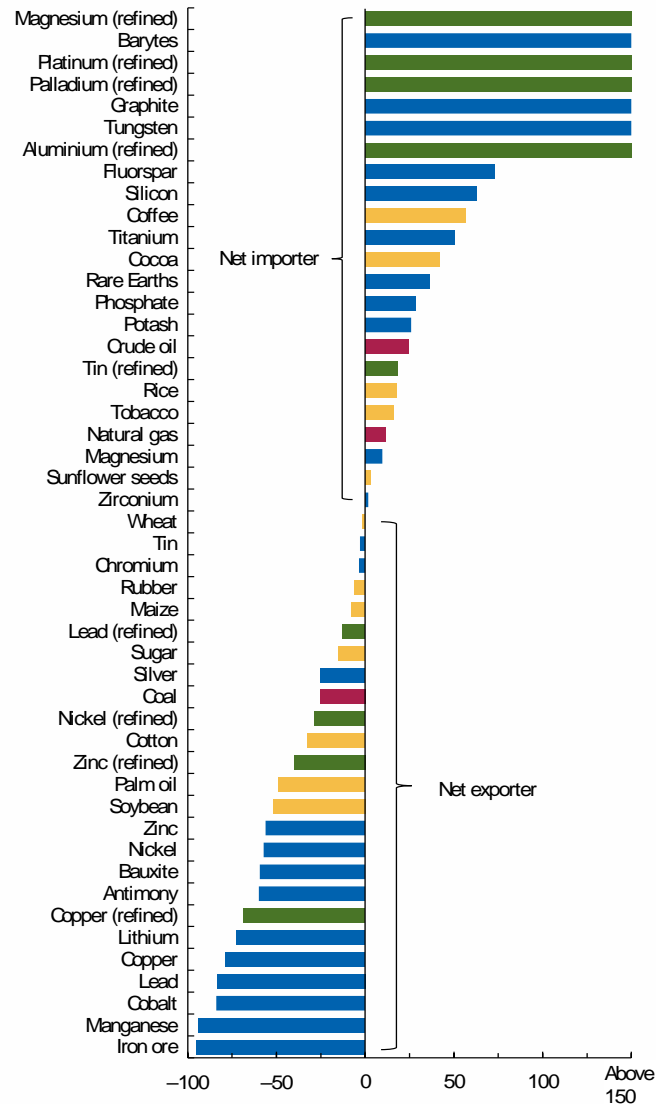
Price Changes in China-Russia+ Bloc (Percent)



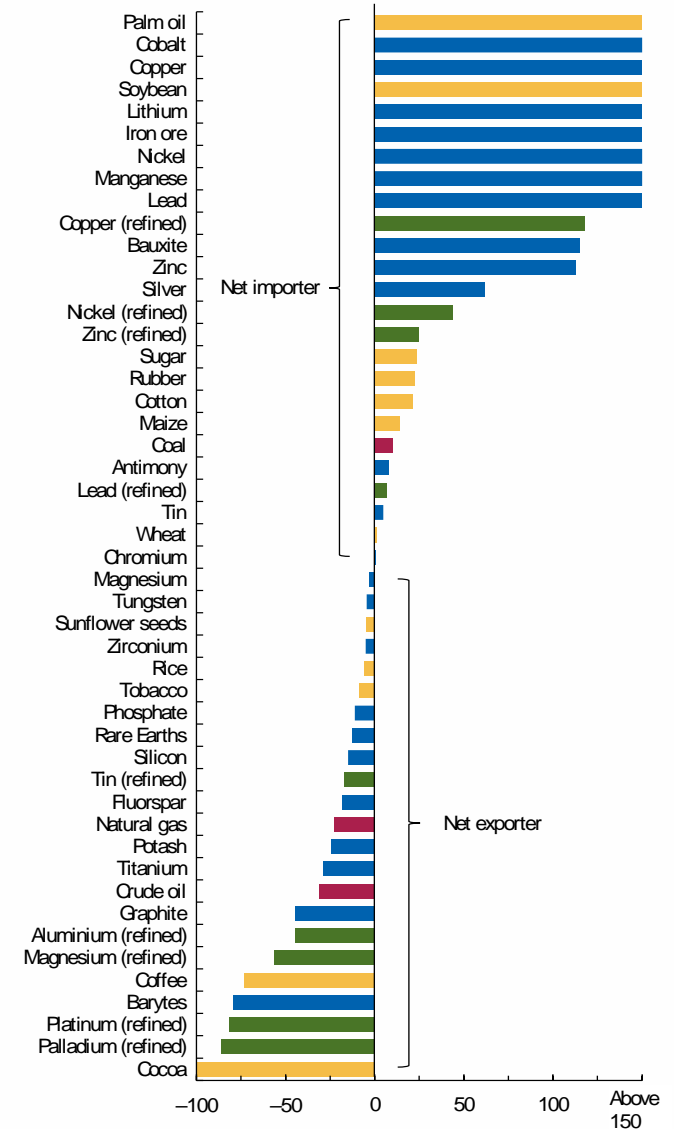
Note: Price effects capped at +150 percent for ease of exposition.

Minerals tend to be more vulnerable to fragmentation

Price Changes in US-Europe+ Bloc (Percent)



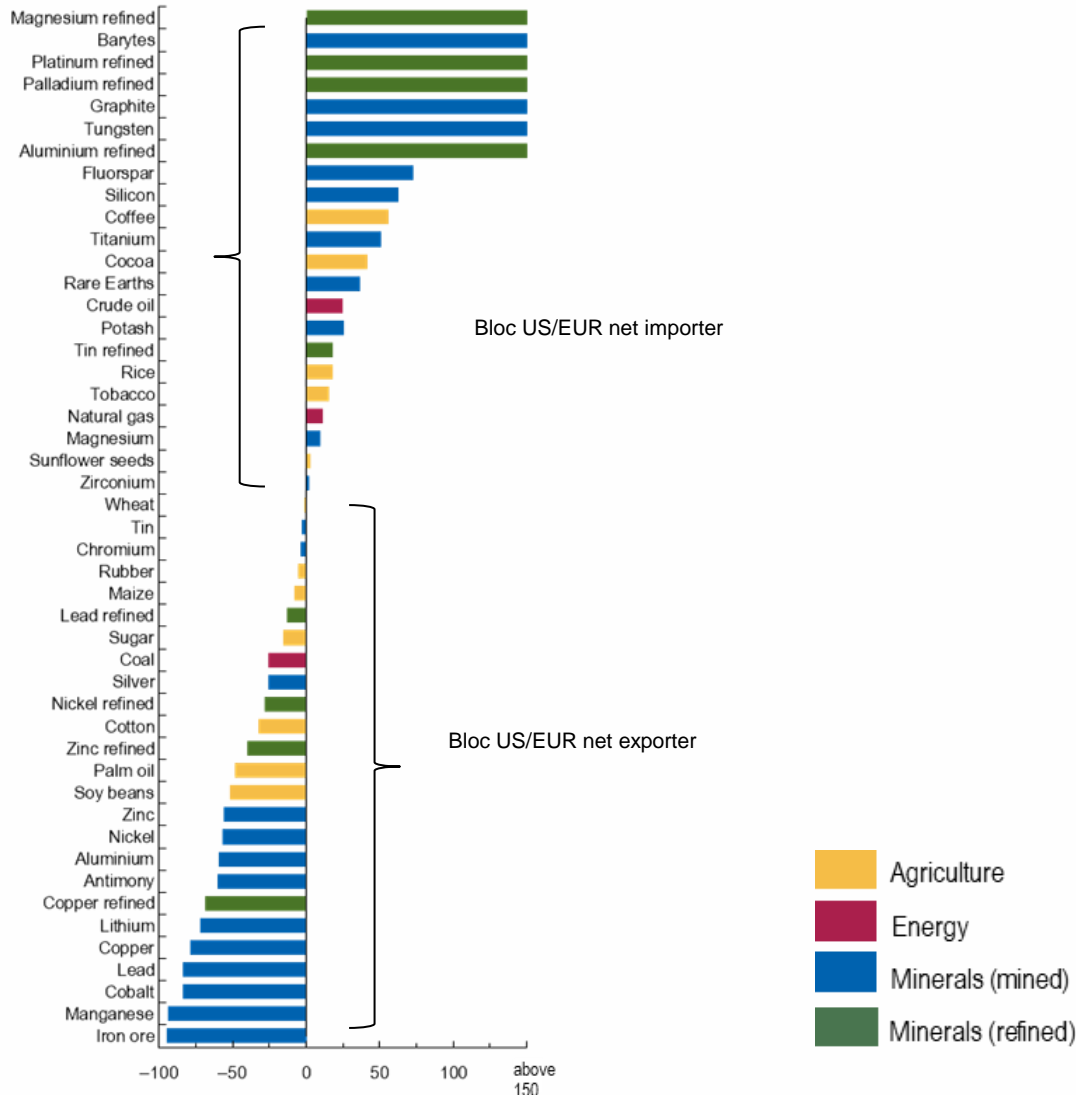
Price Changes in China-Russia+ Bloc (Percent)



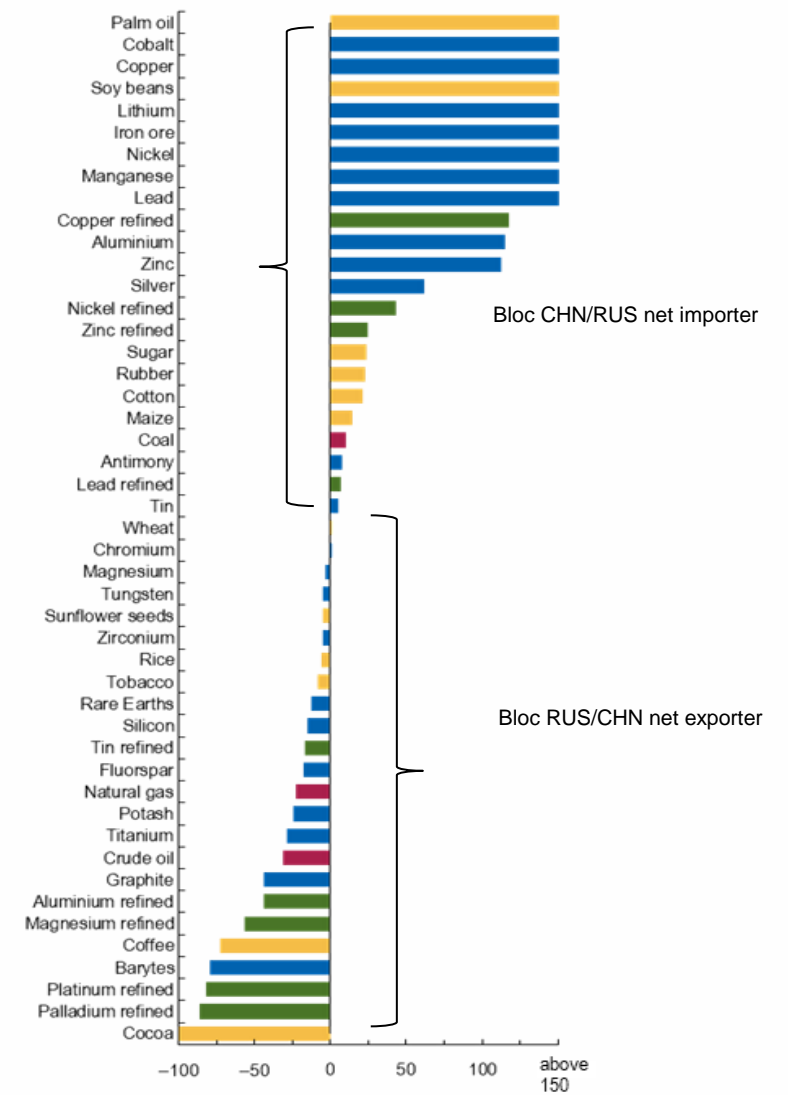
Note: Price effects capped at +150 percent for ease of exposition.

Minerals at mining and refining stage more vulnerable to fragmentation

Price changes (%) in US-EUR bloc



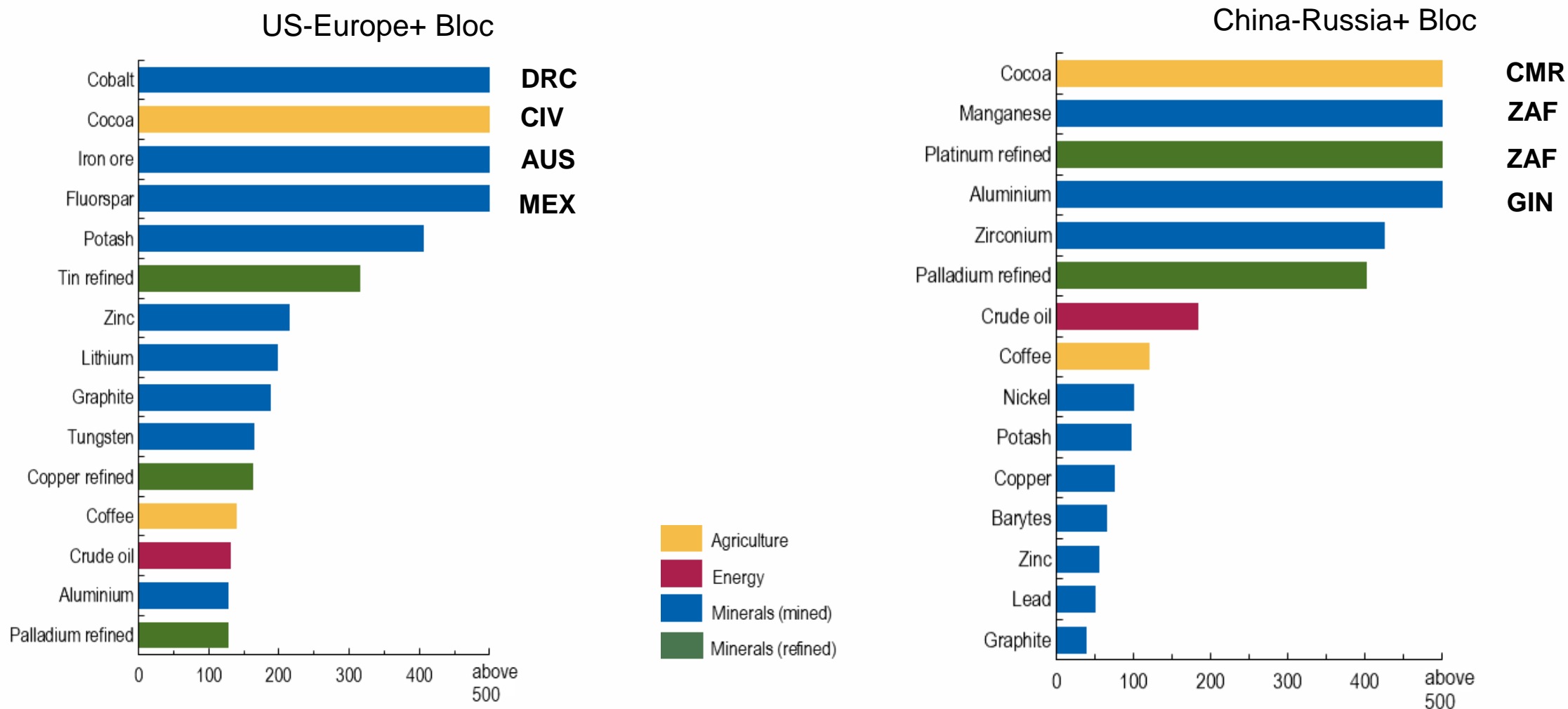
Price changes (%) in CHN-RUS bloc



Note: Price effects capped at +150 percent for ease of exposition.

Countries' switching blocs could lead to significant price changes in fragmented markets

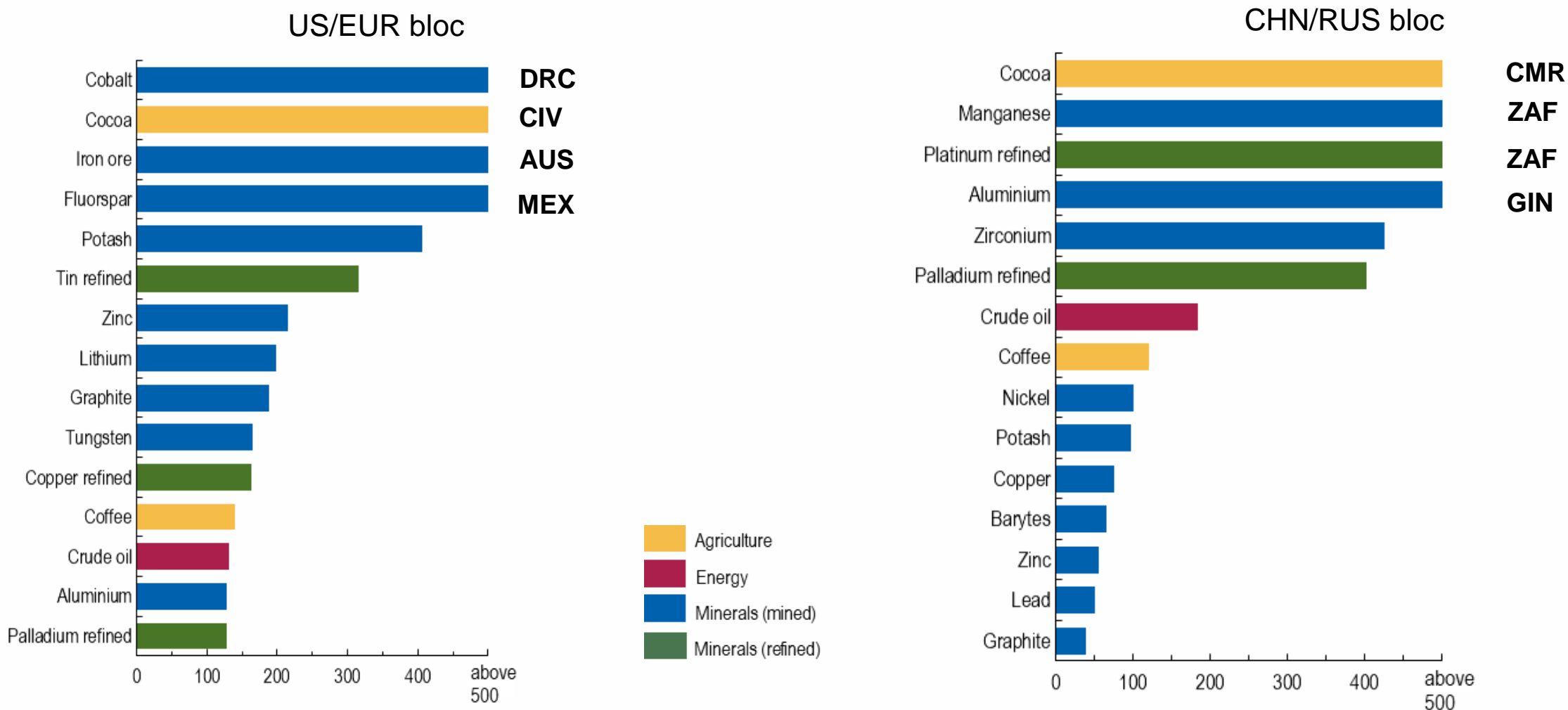
Distribution of price changes from largest exporter switching bloc



Note: Price effects capped at +500 percent for ease of exposition.

Countries' switching blocs could lead to significant price changes in fragmented markets

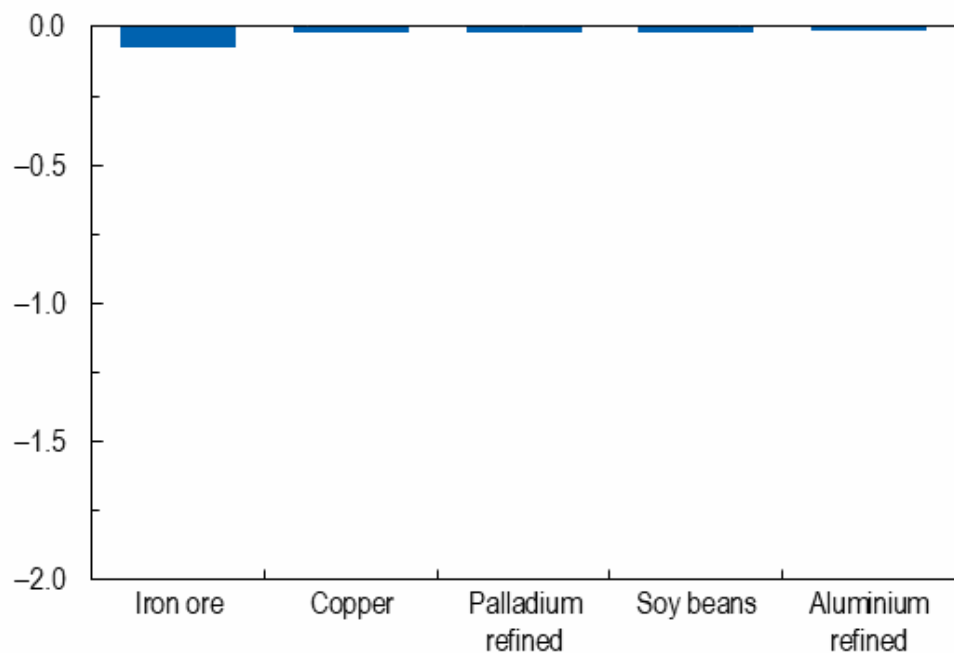
Distribution of price changes from largest exporter switching bloc



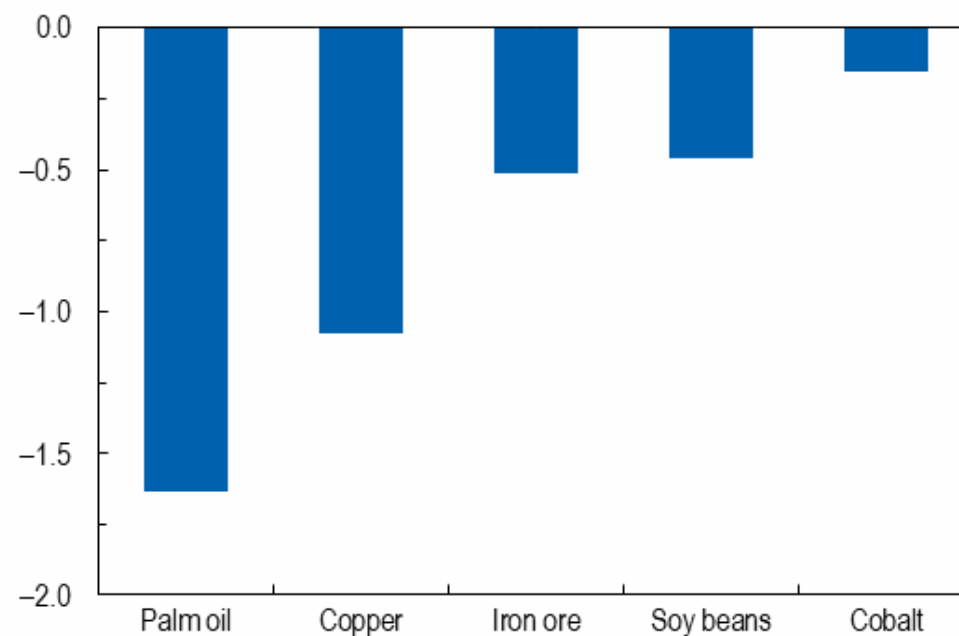
Note: Price effects capped at +500 percent for ease of exposition.

What commodities pose the greatest economic risk from fragmentation? A partial equilibrium approach

Total Surplus Change for the US/EUR bloc (% GNE)

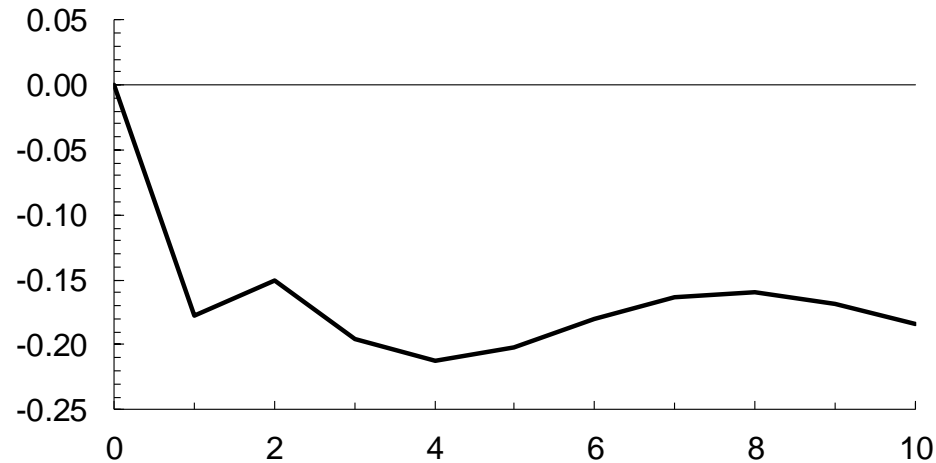


Total Surplus Change for the CHN/RUS bloc (% GNE)

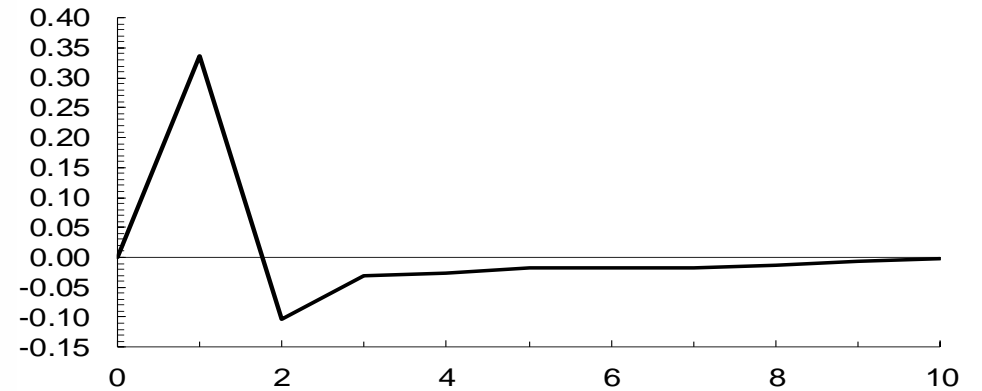


What are the dynamic impacts of commodity market fragmentation? Augmented GMMET

World GDP
(Percent deviation)



World inflation
(Percentage point deviation)



Price of Oil
(Percent deviation)

