Geoeconomic Fragmentation and Commodity Markets*

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Abstract

This paper studies the economic impact of fragmentation of commodity trade. We assemble a novel dataset of production and bilateral trade flows of the 48 most important energy, mineral and agricultural commodities. We develop a partial equilibrium framework to assess which commodity markets are most vulnerable in the event of trade disruptions and the economic risks that they pose. We find that commodity trade fragmentation – which has accelerated since Russia's invasion of Ukraine – could cause large price changes and price volatility for many commodities. Mineral markets critical for the clean energy transition and selected agricultural commodity markets appear among the most vulnerable in the hypothetical segmentation of the world into two geopolitical blocs examined in the paper. Trade disruptions result in heterogeneous impacts on economic surplus across countries. However, due to offsetting effects across commodity producing and consuming countries, surplus losses appear modest at the global level.

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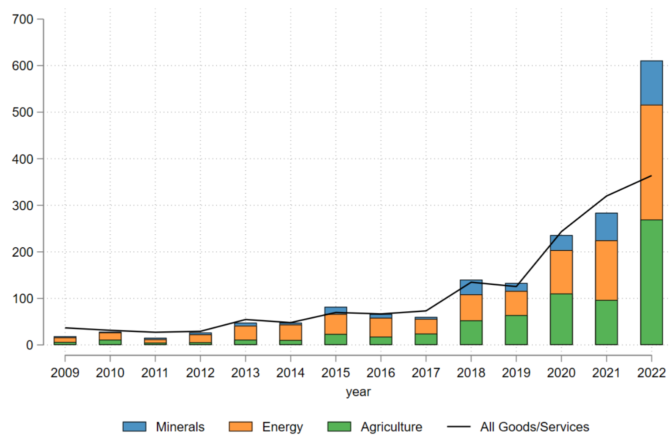
1 Introduction

With Russia's invasion of Ukraine, individual commodities such as crude oil, natural gas, and wheat were used to exert pressure in a major conflict for the first time since the end of the Cold War. New restrictions on commodities trade spiked in 2022 (Figure 1) contributing to inflationary pressures and affecting output in many countries.

Figure 1: New Trade Restrictions (Index, 2016-2019=100)



Note: Global Trade Alert (GTA) and authors' calculations. This chart shows the number of *new* trade interventions imposed on commodity sectors in each year. Data is sourced from the GTA database and adjusted for reporting lags (i.e., only interventions reported before Dec 31st each year are included in the database). Only interventions that the GTA deems "certain to discriminate against foreign commercial interests" are included.

While most commodity prices normalized in 2023, geopolitical tensions signal that more severe geoeconomic fragmentation[1] of commodity trade is still a major risk. But which commodities are most vulnerable in the event of further disruptions in international trade? And in which commodity markets would further fragmentation lead to sizable economic

[1] Building on Aiyar et al. (2023a), geoeconomic fragmentation (referred to as "fragmentation" for brevity in the rest of the paper) is defined as any policy-driven reversal of integration, including reversals guided by strategic considerations such as national security. It encompasses trade, fiscal and financial measures such as tariffs, export restrictions, subsidies, and restrictions on payments. The trade literature of the early 2000s used "fragmentation" to describe the geographic dispersion of production processes in globally integrated supply chains (see, e.g., Arndt and Kierzkowski, 2000; Deardorff, 2001).

losses? In this paper, we develop a comprehensive dataset and framework to assess the relative sensitivity of a broad set of commodity markets to fragmentation and gauge potential economic impacts.

Our analysis proceeds in two steps. First, we construct a new dataset linking production and bilateral trade flows for 48 of the most important energy, mineral and agricultural commodities. Second, we develop a single-commodity partial equilibrium trade model to examine the potential impacts of fragmentation on trade flows, prices, and production of each commodity. Applying this simple framework to individual commodities allows us to assess the relative price sensitivity and macro-importance of a large number of commodities with minimal data requirements.[2]

After calibrating the model using data from each commodity market in our dataset, we simulate a hypothetical fragmentation scenario in which the global market for each commodity splits into two theoretical blocs. As an illustrative example, we use the 2022 United Nations vote on Russia's war in Ukraine to classify countries in blocs.[3] For each commodity, we assess the implied price change in the two blocs, assuming in a highly stylized way that there is no trade in a particular commodity between blocs, while intra-bloc trade costs are unaffected. The change in commodity prices relative to the price in the fully integrated world is used as a measure of commodity-specific vulnerability in the event of fragmentation.[4]

[2] A general equilibrium exercise fragmenting multiple commodities would require further assumptions on how and which combination of markets are fragmented as well as a granular input-output matrix linking different commodity markets to other goods and services (see Fally and Sayre, 2018; Bolhuis et al., 2023).

[3] The two-bloc scenario presented here is meant to provide a clearly defined baseline and to make the exercise comparable to the recent literature. Countries' geopolitical alignment could be partly driven by trade linkages and risk management strategies to reduce the fallout from spikes in geopolitical tensions. However, the endogenous formation of blocs remains beyond the scope of the paper. The paper examines alternative scenarios, including the impact of countries' switching blocs and alternative bloc configurations, as discussed in Section 7.2.

[4] Our analysis uses commodity-specific elasticity estimates from the empirical literature on commodities, which capture complex substitution and cross-sectoral effects in a reduced form. The main advantages of

We then investigate the economic consequences of fragmenting individual commodity markets. We compute the change in total economic surplus (the sum of producer and consumer surplus) from the trade fragmentation of each commodity. Such measure simultaneously accounts for the price and quantity effects of fragmentation, allowing us to identify commodities whose fragmentation may pose the highest economic risk at the country level.

Building on the new dataset and the model, we derive four main results. First, we document key features of commodity markets that make commodities more sensitive in the event of trade disruptions. As essential inputs to production and consumption, commodities are widely used across countries and exhibit low demand elasticities. Yet, commodity production is geographically concentrated, given the high concentration of natural endowments. For example, on average, the three largest suppliers of minerals account for about 75 percent of global production. As a result, commodities are highly traded, with many importers relying on only a few suppliers.

Second, further geoeconomic fragmentation could cause wide price differentials across blocs and lead to large commodity price changes. The scale of the price effects depends on the supply and demand imbalances caused by fragmentation and the price elasticities of supply and demand of individual commodities. In our baseline simulations, the price effects are particularly strong for some minerals critical for the green transition, such as copper, nickel, cobalt and lithium, and some highly traded agricultural goods such as soybeans. This is due to the high concentration and uneven distribution of these commodities across the hypothetical trading blocs in our illustrative scenario.

this approach are its minimal data requirements and the use of empirically estimated elasticity estimates. We view this as complementary to the trade literature explicitly modelling cross-sectoral linkages in general equilibrium, which require a number of simplifying assumptions on parameters determining demand and supply elasticities (see Fally and Sayre, 2018; Bolhuis et al., 2023).

Third, geoeconomic fragmentation of commodity markets would also lead to higher price volatility. Smaller markets in a fragmented world would provide fewer buffers against commodity-specific supply and demand shocks, leading to larger price responses than under free trade. Moreover, given the high global reliance on individual producers of selected commodities, we find that individual country geopolitical realignments can yield very large global price effects. This would imply more supply shocks, volatility, and uncertainty in commodity markets.

Finally, the impact of fragmentation on economic surplus depends not only on the price vulnerability but also on the value of production and consumption of the individual commodity relative to aggregate output. For example, energy commodity prices are not particularly vulnerable in the event of fragmentation in our baseline simulation, but the associated declines in economic surplus are more significant compared to the changes in surplus associated with minerals and some agricultural commodities, because these commodities are widely consumed and produced. Overall, there is significant heterogeneity in the potential surplus effects across countries. Due to vastly different and often offsetting impacts across net commodity-producing and net commodity-consuming countries, however, surplus losses appear relatively modest at the global level.

There are two main caveats to our results. First, the assumption of complete commodity trade fragmentation across blocs and free trade within blocs is highly stylized. In this respect, our model does not account for more realistic intermediate scenarios, such as partial trade between blocs, neutral countries, and arbitrageurs that would mute effects. Second, due to its partial equilibrium nature, our approach does not allow for the simultaneous disruption of trade of many commodities, which could have opposing or reinforcing effects within the same country. Because of these limitations, our results should not be interpreted as projected impacts from realistically complex geopolitical fragmentation scenarios. Rather, estimates should be viewed as commodity-specific measures of relative price-sensitivity and macroeconomic fallout potential from trade fragmentation.

Our paper builds on several strands of literature. First, trade disruptions caused by the war in Ukraine and the COVID-19 pandemic have motivated numerous studies to gauge the macroeconomic effects of sectoral supply shocks, including those associated with commodity price movements (see Bonadio et al., 2021; Carvalho et al., 2021; Albrizio et al., 2023; Ilzetzki, 2022; Lafrogne-Joussier et al., 2022, among others). Our paper contributes by examining the economic impact of trade disruptions for a broad set of commodities.

Second, we contribute to a fast-developing literature that examines the consequences of geoeconomic fragmentation. Recent studies that quantify aggregate losses in this context include Attinasi et al. (2023), Felbermayr et al. (2023), Javorcik et al. (2022) and others.[5] Most related and complementary to our analysis are Fally and Sayre (2018) and Bolhuis et al. (2023), who show that the specific features of commodities amplify the aggregate effects of trade disruptions in multicountry, multisector trade models. Bachmann et al. (2022), Chepeliev et al. (2022), Di Bella et al. (2022), Albrizio et al. (2023) and others focus on the implications of supply disruptions to natural gas and oil markets mostly based on second order approximations derived from multicountry multisector trade models.

Third, the paper adds to the literature examining drivers of commodity price fluctuations and their economic effects.[6] We provide a simple model of trade disruptions as a source of

[5]These include IMF (2023a), IMF (2023b), Peiris et al. (2021) and Bekkers and Góes (2022).

[6]While most papers focus on oil prices (see Hamilton, 1983; Kilian, 2009; Baumeister and Hamilton, 2019; Herrera and Rangaraju, 2020; Känzig, 2021, and others), some study a broader set of commodities (see e.g., Stuermer, 2018; Jacks and Stuermer, 2020; Boer et al., 2023, among others).

shocks to supply and demand of commodities that affect prices and the economy for a large set of commodities.

Finally, our paper builds on previous studies by governments, international agencies and academics that document the concentration of production and trade as well as the widespread use of commodities with the goal of identifying those that are critical.[7] Our paper extends this work by providing a transparent framework to assess commodities' economic relevance and vulnerabilities in trade fragmentation scenarios.

The remainder of the paper is structured as follows. Section 2 describes the new dataset and provides key stylized facts on why commodity markets are vulnerable in the event of fragmentation. Section 3 lays out a simple model of trade fragmentation in each commodity market, while Section 4 describes its calibration. Section 5 presents our results on commodities' price changes and price volatility, respectively. Section 6 shows results on surplus changes. Section 7 discusses the sensitivity of the findings to alternative assumptions. Finally, Section 8 concludes and discusses avenues for future research.

2 What Makes Commodity Markets Vulnerable in the Event of Fragmentation?

We assemble a new dataset and present several features of commodity markets that potentially raise the economic costs of disrupting their trade, despite commodities' homogeneity and fungibility. These include the concentration of their production, the low elasticities of

[7] See, e.g., BGS (2020), DERA (2021, 2023), EU Commission (2022), IEA (2022, 2023), Fally and Sayre (2018).

supply and demand, the high share of production that is traded as well as the high trade dependencies of importing countries.[8]

2.1 A New Dataset

We collect a new annual dataset on bilateral trade flows and production data at the country and commodity level. We focus on 48 energy, mineral, and agricultural commodities, as listed in Appendix Table A.6. They were selected because they represent a large share of global trade, or are part of critical raw materials lists of the EU or US. Commodities with insufficient data were eliminated from consideration (e.g., uranium).

Starting from the methodology of Fally and Sayre (2018) and updated by Bolhuis et al. (2023), we create the new dataset with several key innovations. First, we develop a set of adjustment factors to correct for different unit measurements for mineral commodities in the production and trade data, which is often overlooked in the trade literature. For instance, some minerals are expressed in metric tons of metal content in the production database, while their counterparts are presented in gross metric tons in the trade database. The factors convert the quantities in the trade data into equivalent metric tons of metal content (see Appendix Table A.1). These adjustment factors can be commodity- and country-specific.

Second, our approach includes the markets for mined upstream commodities (e.g. copper ore) and refined commodities (e.g. refined copper). Distinguishing between the different products along the value chain can lead to distinctly different production concentrations and trading patterns. The production and trade data for refined commodities also include

[8] See Fally and Sayre (2018) for a discussion of commodities' characteristics from a recent perspective and Jacks et al. (2011) from a historical perspective.

recycled materials with the exception of aluminium.

Third, taking the concordances between minerals trade and production data from Fally and Sayre (2018) and Bolhuis et al. (2023) as a starting point, we develop concordances between the HS codes and commodity definitions used in production data. We do so based on consultations with the British Geological Survey (BGS) as well as the commodity-specific industry literature (see Tables A.2, A.3, and A.4 in the Appendix for the mapping between trade and production data for each commodity). For agricultural and energy commodities, we rely on concordances from the Food and Agriculture Organization (FAO) and the International Energy Agency (IEA), respectively.

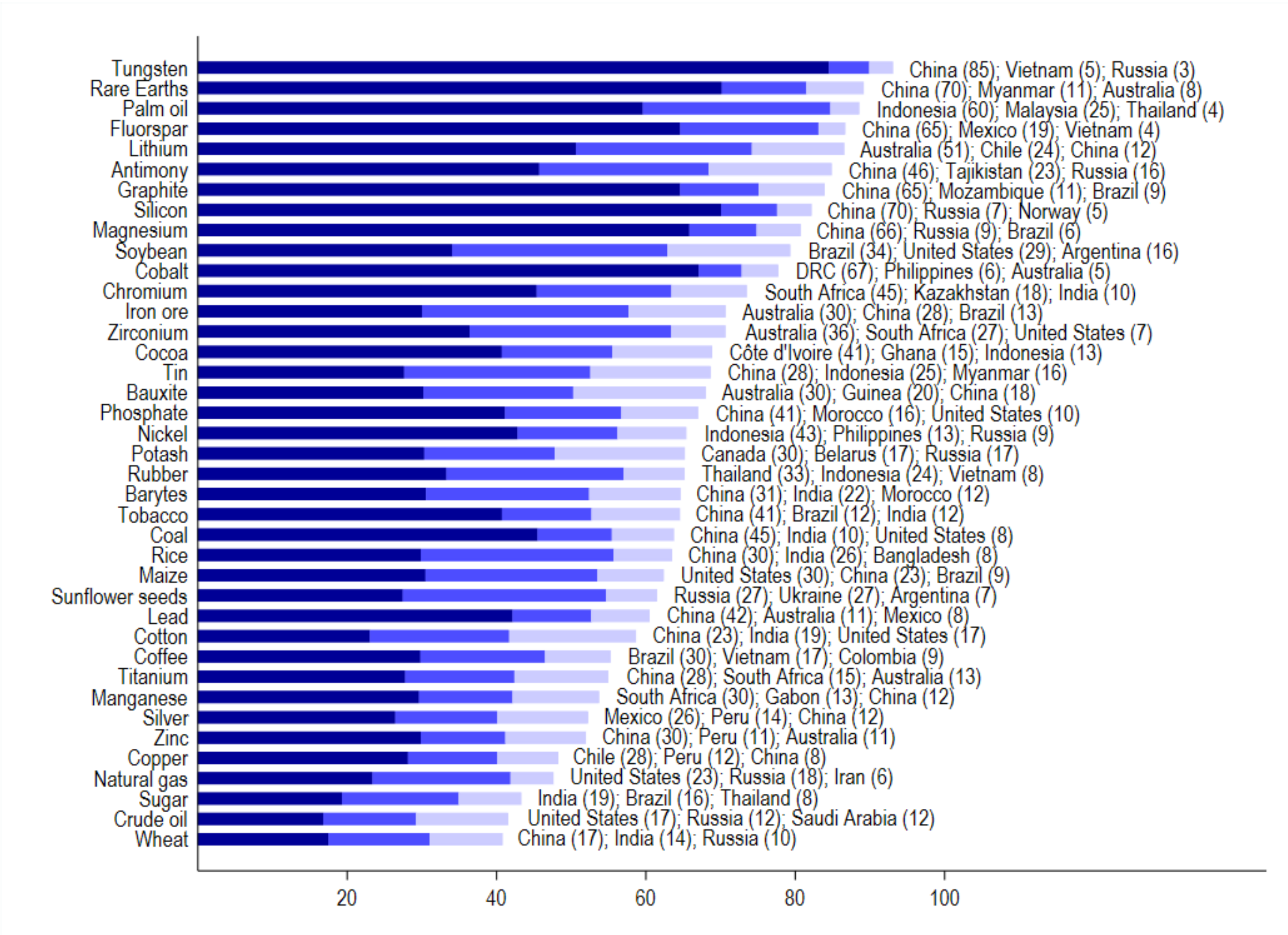
Data on agricultural commodities and energy production and trade are from the FAO and the IEA. For minerals, production data come from the BGS and US Geological Survey (USGS), while trade data are from the Bilateral Commodity Trade Database (BACI), based on UN Comtrade. The data are for 2019, prior to the COVID-2019 pandemic.

2.2 Concentration of Production

Unlike manufactured goods, the first stage of production of commodities depends on natural endowments that can be concentrated geographically. For instance, the extraction of energy and other mineral commodities requires cost effective geological deposits. The availability of fertile soil, water and adequate climate can constrain agricultural production and impact agricultural yields.

As a result of natural endowments' concentration, there is significant concentration of production at the country level, with the top three producers accounting on average for about 65 percent of the global output of agricultural, about 50 percent of energy and about 70 percent of mineral commodities (Figure 2).[9]

Figure 2: Share of Global Production of the Top 3 Producers



Note: For each commodity in the sample, the figure shows the share of global production that the top three producers account for in 2019.

For minerals, production is concentrated both at the mining stage due to the geographic concentration of deposits, but often also at the processing stage, with a few countries (most

[9]The paper focuses on countries and not firms. Commodity extraction is often done by multinationals or firms owned by foreign investors Leruth et al. (2022). Firm-level concentration could be different from country-level concentration (for a firm-level dataset on commodities' production see Jasansky et al. (2023)). However, governments are typically the ultimate owners of land or reserves and lease them to firms for a limited time. Renegotiations of lease terms, as well as expropriations, are common Jaakkola et al. (2019). The paper also focuses on production rather than reserves due to data availability. Reserves and production are highly correlated USGS (2023).

notably China), having developed a strong comparative advantage through the deployment of capital intensive facilities, efficient technological solutions, lighter environmental regulations, and relatively cheaper labor (see Figure B.1 in the Appendix).

2.3 Low Elasticities of Supply and Demand

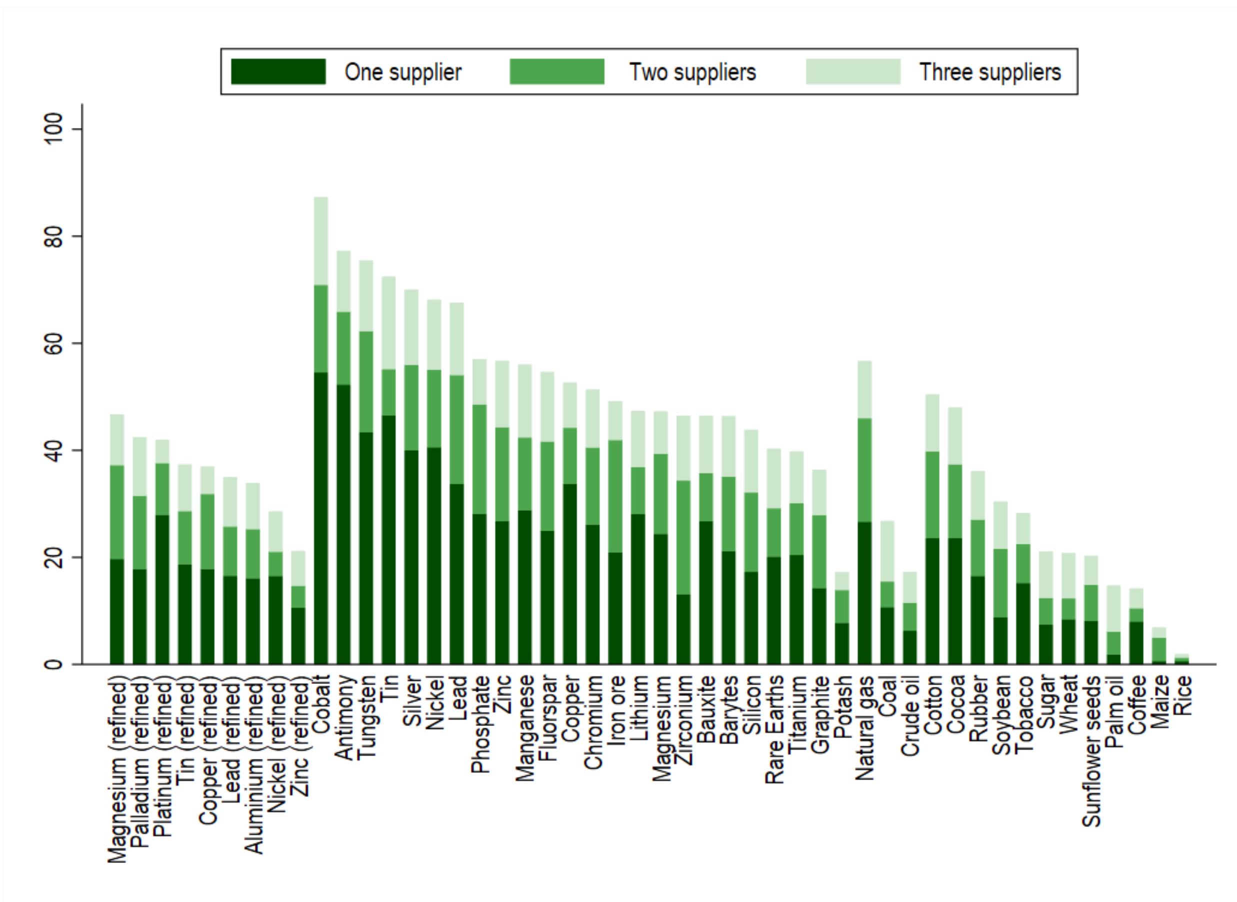
Commodities exhibit low elasticities of supply and demand, particularly in the short run (see Figure B.2 in the Appendix). On the supply side, scaling up production often requires large investments and long permitting processes that can delay a supply response to price changes. For example, it takes on average 16 years from exploration to the opening of copper mines (IEA, 2022). Discovering new deposits is also costly and takes time. Setting up processing capacity comes with its own challenges, such as regulations, access to know-how, technology, and skilled labor; infrastructure requirements; and labor costs (IEA, 2023).

On the demand side, many commodities are inputs for key technologies and products or are essential to household consumption, making them hard to substitute, and attenuating the demand response to price changes. This is reflected in their low price elasticity of demand, particularly in the short term.

2.4 Trade Dependence

With production highly concentrated and demand often spread across many countries, commodities are heavily traded. Their homogeneity and fungibility also contribute to market integration. As a consequence, the share of production that is traded internationally across commodity types is consistently higher than the ratio of world trade to gross output. Across agricultural commodities, around 40 percent of output is dedicated to trade, around 30 percent for energy and almost 50 percent for mineral commodities. For individual commodities, the share of traded output can be substantially higher: for example, more than 80 percent of lithium, or potash produced cross borders, with the share increasing over time for most raw commodities (see Figure B.3 in the Appendix).[10]

Figure 3: Import Dependency



Note: For each commodity, the figure shows the share of countries that import a commodity from only one, two or three countries.

A corollary to the high concentration of commodity production is that a handful of key producer countries typically dominate the export side (see Figure B.4, panel (a) in the

[10]Even though commodities are heavily traded, their share in global trade has declined as trade liberalization, lower transportation costs, and cross-border production chains have supported the rapid rise in intermediate goods trade. The share of primary goods in total goods trade has declined from roughly 45 percent in the first half of the 20th century to about 13 percent from 2019 to 2021.

Appendix). As a result, most countries have not diversified their commodity imports. For instance, more than 60 percent of countries rely on less than three suppliers to satisfy their imports of key minerals such as cobalt, silver or nickel (Figure 3).

3 A Multi-Country Partial Equilibrium Commodity Market Model

To assess the economic impact of fragmentation, we develop a single-commodity model with multiple countries that face country-specific supply and demand curves:

$$\ln(q_c^s) = \eta^s \ln(p_c) + \gamma_c^s, \tag{1}$$

$$\ln(q_c^d) = \eta^d \ln(p_c) + \gamma_c^d, \tag{2}$$

where c denotes the country, q_c^s and q_c^d are quantities supplied and demanded, p_c is the price, and $\eta^s > 0$ and $\eta^d < 0$ are the price elasticities of supply and demand. For simplicity and due to a lack of consistent country-specific estimates for a broader set of commodities, we assume that all countries face the same elasticities but have unique demand and supply shifters γ_c^d and γ_c^s.[11]

Countries can be classified into one of two hypothetical blocs $B \in \{H, ROW\}$. Aggregating all countries within each bloc B, we get the following bloc-level demand and supply

[11] The exercise does not explicitly model storage, which is an important feature of volatility smoothing (See among others, Williams (1936); Gustafson (1958); and Wright and Williams (1982). Carter et al. (2011), provide a literature review.

curves

$$\ln(Q_B^s) = \eta^s \ln(p_B) + \gamma_B^s \tag{3}$$

$$\ln(Q_B^d) = \eta^d \ln(p_B) + \gamma_B^d \tag{4}$$

where $Q_B^s = \sum_{c \in B} q_c^s,\ Q_B^d = \sum_{c \in B} q_c^d, \gamma_B^s = \ln\left(\sum_{c \in B} e^{\gamma_c^s}\right)$ and $\gamma_B^d = \ln\left(\sum_{c \in B} e^{\gamma_c^d}\right)$.

With this notation, we can define two market equilibria: one that allows trade between blocs and one that does not.

Integrated market equilibrium. The integrated market equilibrium must fulfill market clearing and non-arbitrage conditions such that $Q_H^s + Q_{ROW}^s = Q_H^d + Q_{ROW}^d$ and $p_H = p_{ROW} = p_w$, where p_w is the world price. The equilibrium world price can then be written as a function of supply and demand parameters. That is

$$\ln(p_w) = \frac{\Omega^d - \Omega^s}{\eta^s - \eta^d} \tag{5}$$

where $\Omega^d \equiv \ln(e^{\gamma_H^d} + e^{\gamma_{ROW}^d})$ and $\Omega^s \equiv \ln(e^{\gamma_H^s} + e^{\gamma_{ROW}^s})$. The equilibrium world price can be substituted into bloc- and country-specific demand and supply curves to obtain the corresponding quantities demanded, supplied, and net exports/imports.

Fragmented market equilibrium. The fragmented market equilibrium is defined as the one occurring from a full segmentation of the two blocs. Trade adjustments are assumed without cost across countries within a bloc. The equilibrium prices and quantities must then fulfill bloc-level market clearing conditions, inducing bloc-level prices. For bloc B, the fragmented market equilibrium price is given by

$$\ln(p_B) = \frac{\gamma_B^d - \gamma_B^s}{\eta^s - \eta^d} \tag{6}$$

As before, the bloc- and country-level quantities and net exports are given by substituting bloc level prices, p_B, into the corresponding supply and demand curves.

Impact of fragmentation on commodity prices. In the model, the impact from market fragmentation is defined as the difference in country- and bloc-level quantities and prices between the integrated and fragmented market equilibria. The change in price is given by:

$$\ln(p_B) - \ln(p_w) = \frac{\left(\gamma_B^d - \gamma_B^s\right) - \left(\Omega^d - \Omega^s\right)}{\eta^s - \eta^d} \tag{7}$$

In our calibration, we standardize the initial world price to 1 in the model, so that

$$\gamma_c^d \quad = \ln(q_c^d) = \text{observed initial quantity demanded}$$

$$\gamma_c^s \quad = \ln(q_c^s) = \text{observed initial quantity supplied}$$

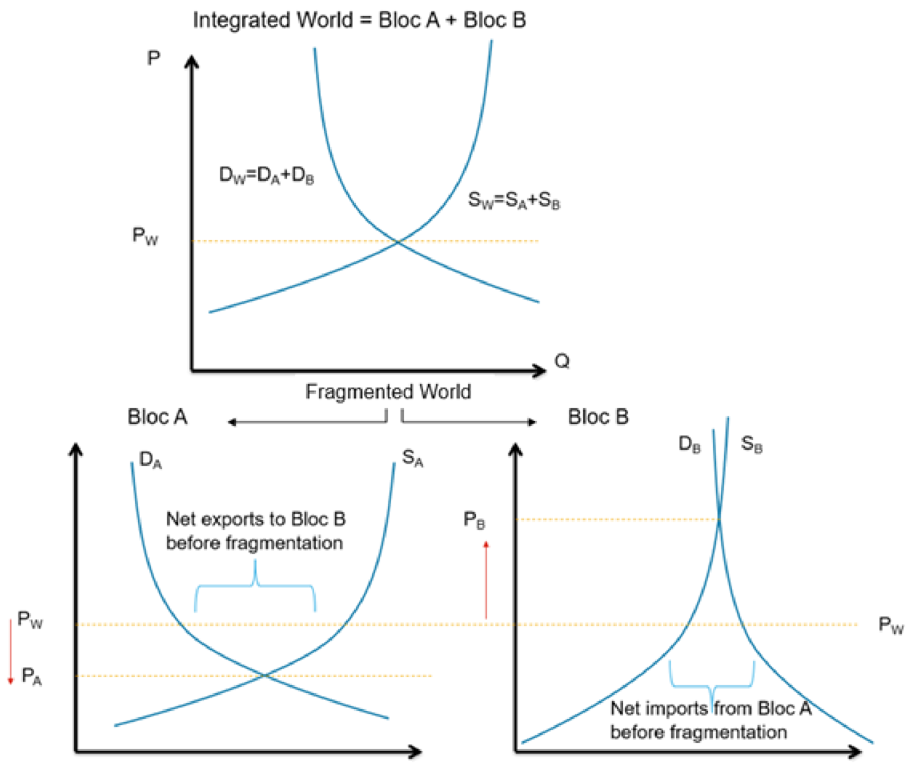
From initial equilibrium conditions, $\Omega^d = \ln\left(e^{\gamma_H^d} + e^{\gamma_{ROW}^d}\right) = \ln\left(q_H^d + q_{ROW}^d\right) = \Omega^s$, so $\Omega^d - \Omega^s = 0$. The change induced by fragmentation on bloc-level prices is therefore given by:

$$\ln(p_B) - \ln(p_w) = \frac{\gamma_B^d - \gamma_B^s}{\eta^s - \eta^d}, \tag{8}$$

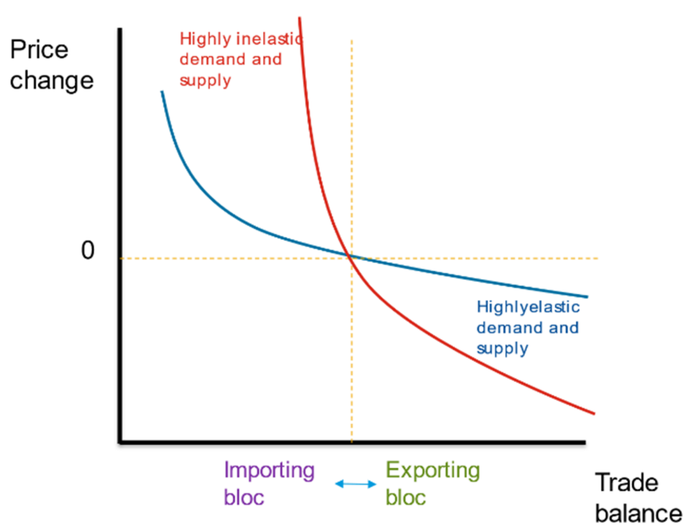
with changes in the quantities demanded and supplied obtainable by substituting (8) in the bloc-level demand and supply curves.

Figure 4: A Single-Commodity Model of Fragmentation

(a) Integrated and Fragmented Market Equilibria



(b) Determinants of Price Impact of Fragmentation



Equation (8) indicates that changes in prices (and quantities) depend on two factors. The first is the initial *bloc-level* trade imbalance $\left(\gamma_B^d - \gamma_B^s\right)$, with an initially exporting (importing) bloc experiencing a drop (rise) in the bloc-level price (see also Figure 4a). This induces a price gap between blocs ex-post. The second factor is the elasticities of demand and supply. The more inelastic supply and demand are, the greater the price response of the quantities supplied and demanded (see Figure 4b).

Consumer, producer and total economic surplus. The simple model can be used to analyze consumer, producer and total surplus. These are calculated as the areas under the demand curve (above equilibrium prices), for consumer surplus changes, and above the supply curve (under equilibrium prices), for producer surplus changes. Total surplus is defined as the sum of consumer and producer surplus. Specifically, changes in consumer and producer surplus for country c are given by:

$$\Delta CS_c \quad = -\int_{p_w}^{p_c} e^{\eta^d \ln(p)+\gamma_c^d} dp = -p_w q_{c,w}^d \frac{\left(\frac{p_c}{p_w}\right)^{1+\eta^d} - 1}{\eta^d + 1}, \tag{9}$$

$$\Delta PS_c \quad = \int_{p_w}^{p_c} e^{\eta^s \ln(p)+\gamma_c^s} dp = p_w q_{c,w}^s \frac{\left(\frac{p_c}{p_w}\right)^{1+\eta^s} - 1}{\eta^s + 1}, \tag{10}$$

where $p_c = p_B$ is the price in country c (which equals the bloc-level price in the fragmented equilibrium), and $p_w q_{c,w}^d$ and $p_w q_{c,w}^s$ are the quantities, in US-dollar terms, demanded and supplied in the integrated market equilibrium. The changes in both producer and consumer surplus depend on the price ratio between the integrated and fragmented equilibria $(\frac{p_c}{p_w})$, scaled by the supply and demand elasticity, and the total quantity demanded and supplied in dollar terms. Surplus changes are greater in economies that experience larger price changes in a more broadly consumed or produced commodity. This interaction is crucial to identify commodities with potentially larger macroeconomic impacts.

In the model, bloc-level total surplus necessarily falls with fragmentation, as shown in Appendix D. However, country-specific surplus need not decline. An exporter in an ex-ante importing bloc or an importer in an ex-ante exporting bloc will face more favorable prices that raise total surplus.

4 Calibration

We apply the model to a hypothetical baseline fragmentation scenario. We start by presenting the baseline allocation of countries across blocs. We then discuss the model calibration.

4.1 Baseline Bloc Configuration

Fragmentation in the baseline exercise is modelled along two hypothetical geopolitical blocs based on the March 2nd, 2022 United Nations (UN) vote on Russia's war in Ukraine (see Table A.5 in the Appendix). For simplicity of exposition, we call the hypothetical bloc containing the US, and most European economies the "US-Europe+ bloc" and the bloc containing China and Russia, the "China-Russia+ bloc".[12]

The two-bloc scenario is meant to provide a clearly defined baseline and to make the exercise comparable to the recent literature. Countries' geopolitical alignment could be partly driven by trade linkages and risk management strategies to reduce the fallout from spikes in geopolitical tensions. However, the endogenous formation of blocs remains beyond the scope of the paper. We examine alternative scenarios, including the impact of countries'

[12]Other bloc configurations have been analyzed in the literature (see Capital Economics (2022) for example).

switching blocs and alternative bloc configurations further below.

Figure B.5 in the Appendix provide an overview of the production concentration across the two blocs. Indeed, as the production of some commodities is heavily concentrated in one of the hypothetical blocs, cross-bloc trade is substantial with integrated markets. Figure B.4, panel b, shows that China accounts for the largest share of imports of many commodities, particularly minerals.

The exercise assumes that, under fragmentation, commodities cannot be traded between blocs, while intra-bloc trade costs remain unchanged. Thus, all countries in the bloc face the same commodity price. Less severe scenarios, for example allowing partial interaction between blocs, would result in more muted effects, but those remain beyond the scope of the paper.

4.2 Parameters

Demand and supply shifters. Standardizing the integrated market price to one ($p_w = 1$), we calibrate γ_c^d and γ_c^s to match the log of the initial quantity demanded and supplied of a particular commodity. Quantity produced is the volume in metric tons (content) of a commodity. Quantity demanded is calibrated as quantity produced minus net exports volumes for each commodity.[13] The model is calibrated so that the pre-fragmentation economy matches observed country and bloc-level trade flows for 2019, prior to the onset of the COVID-19 pandemic.[14]

[13] For consistency, whenever a country has positive values for the quantity produced of a given commodity and net exports are greater than production, we set production equal to net exports.

[14] Due to data quality considerations, the calibration of crude oil and zirconium uses data from 2018.

Elasticity parameters. The calibration of the elasticity parameters (η^d, η^s) is informed by empirical estimates from the literature. Given the broad range of estimates, the elasticities were selected as follows. For energy and agricultural commodities, we use the commodity-specific average of the minimum and maximum short-run price elasticities in the literature review in Fally and Sayre (2018). For minerals, we use the median of the short-run elasticities in the minerals-focused literature review by Dahl (2020). If no estimate of a particular commodity is available, we use the average elasticity for the type of commodity (e.g. agriculture and minerals). Table A.6 presents the resulting parameters and their sources. Section 7.1 discusses robustness simulations with different elasticities.

5 Fragmentation and Commodity Prices

Geoeconomic fragmentation can affect both the level and the volatility of commodities prices.

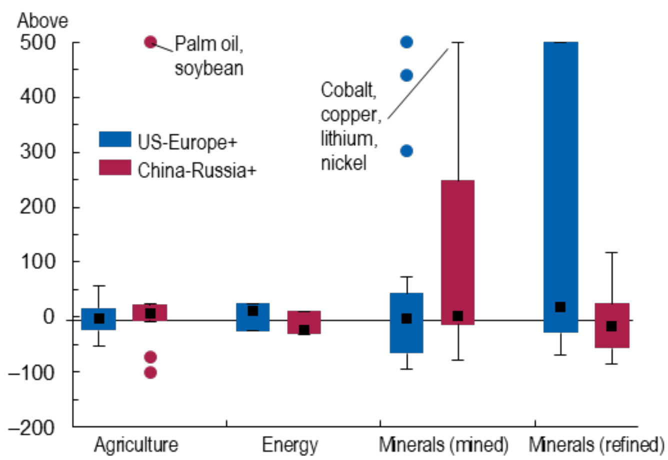
5.1 Effects on Price Levels

Using the model, we compute the fragmentation-induced price changes for each commodity in the two blocs and rank the commodities. The simulated price changes are directly proportional to the bloc-level commodity demand and supply imbalances triggered by the disruption of trade between blocs. Figure 5 presents the distribution of commodity price changes in the two blocs, while Figures 6a and 6b show the bloc-level simulated price changes for each commodity in the sample.

In our hypothetical baseline simulation, minerals tend to be the most vulnerable in the event of fragmentation, as their production is highly concentrated and unbalanced across blocs. The price of minerals at the mining stage would rise significantly in the China-Russia+ bloc, especially the prices of some of the key energy transition minerals (e.g. cobalt, lithium, copper and nickel as shown in Figure 6b). The production of these metals is concentrated in a handful of countries (Figure 2), while being largely consumed in the China-Russia+ bloc. At the same time, in the US-Europe+ bloc, prices of refined minerals would experience similar increases, driven by the prices of magnesium, platinum, palladium and aluminium. These commodities are mostly processed in China, South Africa and Russia (see Appendix Figure B.5).

In contrast, the price effects of fragmentation on energy (crude oil, natural gas, and coal) and most agricultural (e.g., wheat, cotton, rice, maize) commodities are more muted due to the relative self-sufficiency of each bloc. Important exceptions are palm oil and soybeans, which could experience large price increases in the China-Russia+ bloc. Around 80 percent of the production of these broadly consumed commodities is concentrated in up to three countries (Indonesia and Malaysia for palm oil, the United States, Brazil and Argentina for soybeans), which are all part of the hypothetical US-Europe+ bloc in our baseline.

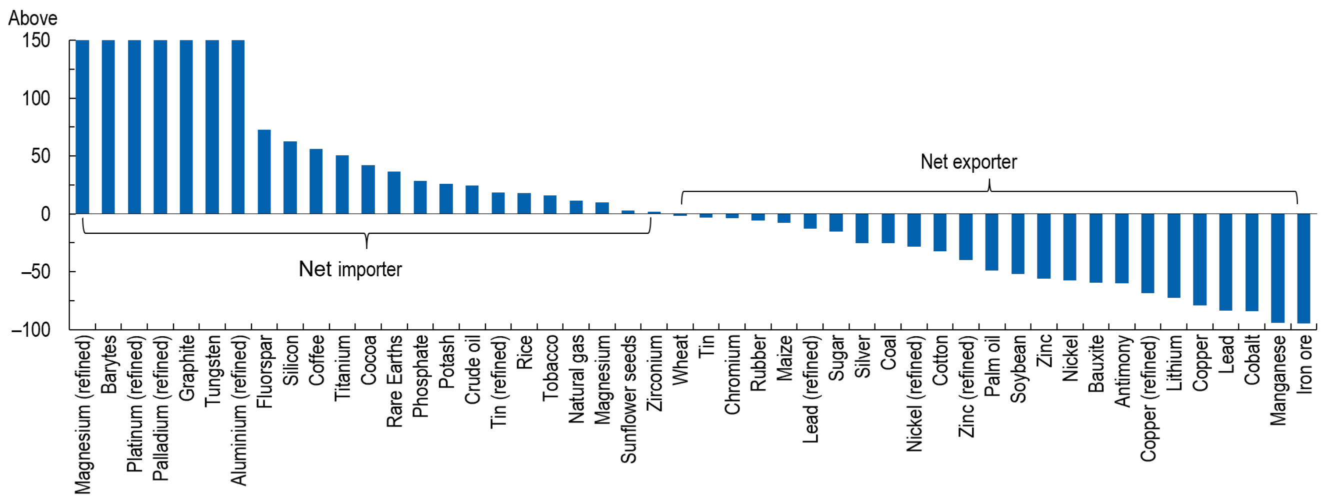
Figure 5: Commodity Price Changes Due to Fragmentation in Individual Commodity Markets: Distribution across Blocs and Commodities in the Baseline Scenario (Percent).



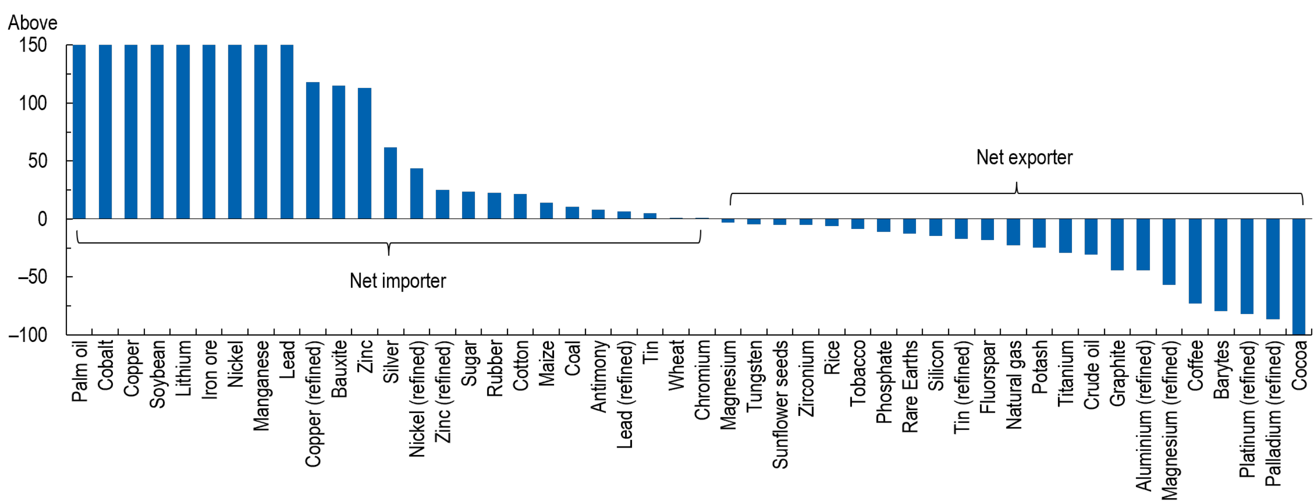
Note: Price effects are capped at 500 percent for readability. "Energy" refers to coal, natural gas, and crude oil. The black squares in the bars represent the median, the bars the interquartile range, and the whiskers the data points within 1.5 times the interquartile range from the 25th or 75th percentile across commodities in the group. The dots indicate outliers. Selected commodities which experience price increases higher than 500 percent are labeled.

Figure 6: Commodity Price Changes Due to Fragmentation in Individual Commodity Markets in the Baseline Scenario (Percent).

(a) US-Europe+ Bloc



(b) China-Russia+ Bloc



Note: Each bar represents the bloc-level commodity price change from fragmenting commodity trade. Changes in prices are capped at 150 percent for ease of exposition.

5.2 Effects on Price Volatility

Geoeconomic fragmentation could also lead to higher price volatility. Jacks et al. (2011) show empirically that commodity price volatility is typically higher when markets are disintegrated. Based on our model, there are two channels that could be consistent with this empirical finding. First, smaller market sizes due to fragmentation result in a larger impact of any demand and supply shocks on prices. Second, due to large global dependence on individual commodity suppliers, the geopolitical realignment of certain countries can induce large bloc-level shocks.

5.2.1 Smaller Market Sizes

In a fragmented world, markets become smaller and bloc-level prices would be more responsive to country-level shocks (see also Albrizio et al., 2023). In the partial equilibrium single-commodity model, the price response is proportional to the supply shock's size relative to the overall market. Thus, by restricting the set of countries they trade with, countries would face larger price increases in response to the same negative supply shock.

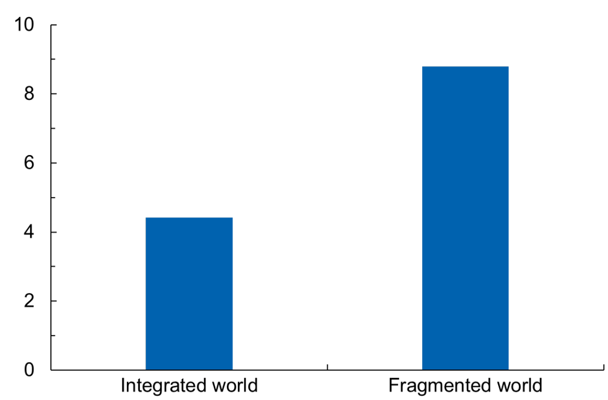
Given the expression for $\ln(p_B)$ in equation (7), it is straightforward to show that the elasticity of the price of a commodity to country-level supply shocks is

$$\frac{\partial \ln p}{\partial \gamma_c^s} = -\frac{1}{\eta^s - \eta^d} \frac{e^{\gamma_c^s}}{\sum_c e^{\gamma_c^s}}, \tag{11}$$

with the second term representing the production share of country c in a given commodity. For a given numerator, the denominator of the second ratio would be smaller in a fragmented world, leading to higher price responsiveness to a given country-level supply shock.

In an illustrative example, Figure 7 compares the impact on wheat prices of a three-standard deviation shock to the US wheat production in an integrated market with that of a fragmented market. The same supply shock has double the impact on wheat prices when the market is fragmented into two smaller blocs.[15] This is important, as climate change is expected to raise the variability of agricultural output. Overall, in fragmented markets, the price response to supply and demand shocks is amplified.

Figure 7: Wheat Price Increases in the US-Europe+ bloc from a US Wheat Harvesting Shock in an Integrated versus Fragmented World (Percent).



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

5.2.2 Countries Switching Blocs

In a fragmented world, major commodity producers would face powerful incentives to switch geopolitical allegiances, representing a new source of supply and demand shocks. For highly

[15] The US accounts for about 7 percent of global and 15 percent of US-Europe+ bloc wheat production. A three-standard deviation harvest shock corresponds to about 60 percent of US wheat production, or 4 percent of global output, holding wheat prices constant. The exercise uses a price elasticity of supply of 0.2 and a relatively high price elasticity of demand of -0.85. Lower elasticities would lead to higher prices impacts, while fragmentation would still double the price impact.

concentrated commodity markets, a single exporting country switching to the other bloc can lead to a large supply gap and trigger substantial price changes. Uncertainty about a country's geopolitical alignment could lead to price volatility itself, as traders update their priors regarding potentially large fragmentation-induced price swings.

5.2.3 Maximum Commodity Price Increases from a Single Exporting Country Switching Blocs

Starting from the fragmented equilibrium, the change in prices from one country leaving (joining) the bloc is given by:

$$\ln(p_{B'}) - \ln(p_B) = \frac{\gamma^d_{B'} - \gamma^s_{B'}}{\eta^s - \eta^d} - \frac{\gamma^d_B - \gamma^s_B}{\eta^s - \eta^d}, \tag{12}$$

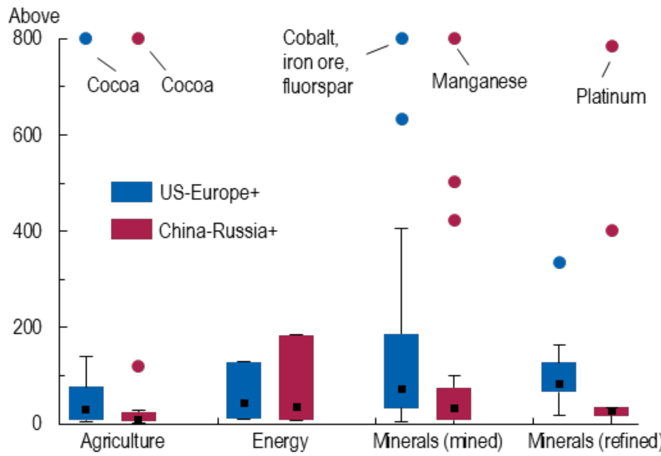
where B' is the new bloc without (with) the leaving (joining) country. For a country c leaving, using the aggregating equation and calibration above, we get

$$\gamma^d_{B'} = \ln(Q^d_{B,w} - q^d_{c,w}) \tag{13}$$

$$\gamma^s_{B'} = \ln(Q^s_{B,w} - q^s_{c,w}) \tag{14}$$

Figure 8 shows the distribution of the greatest price increase in a bloc that can be induced by a single exporter switching alliances in each commodity market. The underlying top 15 most vulnerable commodities are presented in Figures 9a and 9b.

Figure 8: Largest Price Increases Induced by a Single Exporter Switching Blocs (Percent)

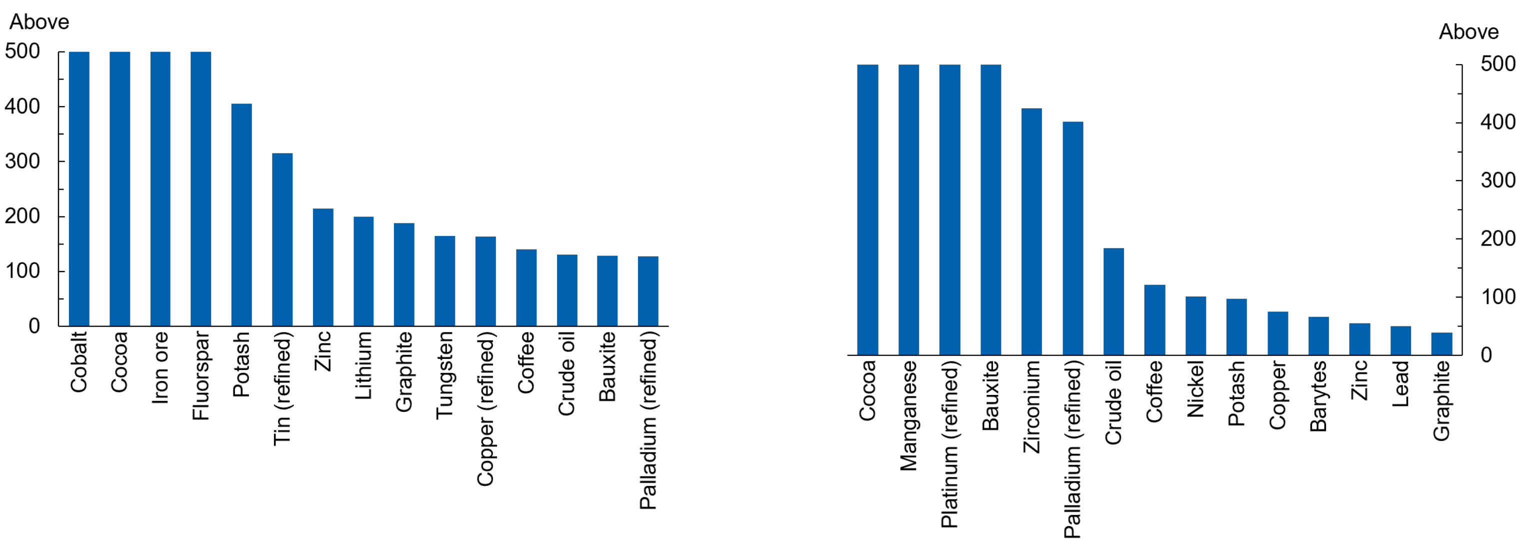


Note: Price changes are capped at 800 percent for readability. Each observation in the box plots represents the largest price increase that a commodity can experience in each bloc from a single exporting country's switching to the other bloc. Note that the US (China) are not allowed to switch away from the US-Europe+ (China-Russia+) bloc. The black squares in the bars represent the median, the bars the interquartile range, and the whiskers the data points within 1.5 times the interquartile range from the 25th or 75th percentile across commodities in the group. The dots indicate outliers; commodities representing the largest outliers are labeled.

Figure 9: Top 15 Largest Price Increases from a Single Exporter Switching Blocs (Percent)

(a) US-Europe+ Bloc

(b) China-Russia+ Bloc



Note: Each bar represents the largest bloc-level price increase that the corresponding commodity experiences from a single exporting country switching to the other bloc.

Given their highly concentrated production, minerals at the mining stage tend to be most sensitive to exporters' switching blocs. For example, South Africa produces one-third of the world's manganese, a metal used in steel-making and batteries. If South Africa switched to the hypothetical US-Europe+ bloc, the price of manganese in the China-Russia+ bloc could rise more than 800 percent.

5.2.4 Accounting for Countries' Probability to Switch Blocs

Not all countries are equally likely to switch allegiances in a fragmented world. A commodity market may experience higher volatility if the pivotal country behind the maximum price effect discussed in the previous section is also more likely to switch. Conversely, the price changes shown above might be less relevant if the countries behind those effects are core members of a hypothetical geopolitical bloc. This section constructs a measure that accounts for the likelihood that countries change their allegiances.

We first test how well each country's assigned bloc can be predicted by its economic and military proximity to the "core" countries in our hypothetical blocs.[16] Specifically, consider the model

$$b_c = \text{logit}\left(\beta_0 + \sum_{j\in\{US,EU,RUS,CHN\}} \left[\beta_E^j E_c^j + \beta_M^j M_c^j\right] + \varepsilon_c\right)$$

where b_c is a dummy that equals 1 when country c is in the US-Europe+ bloc, and 0 when it is in the China-Russia+ bloc. Economic distance is measured by the trade flows between country c and each of the core members of each bloc; specifically, $E_c^j = 1 - \frac{s_{x,c}^j + s_{i,c}^j}{2}$, where $s_{x,c}^j$ is the share of exports from country c that are destined to country j, and $s_{i,c}^j$ is the

[16]See Aiyar et al. (2023b) for a related gravity model exercise on flows of foreign direct investment and geoeconomic fragmentation.

share of imports by country c that come from country j. Military distance is measured as $M_c^j = 1 - \sigma_c^j$, where σ_c^j is a similarity score between the portfolio of military alliances of countries c and j (Signorino and Ritter, 1999), measured using data from the Alliance Treaty Obligations and Provisions (ATOP) project (see Leeds et al., 2002).[17] For better interpretation, the military distance measure is normalized so the standard deviation of its cross-country distribution is 1. We also include a constant term β_0 and the residual is ε_c.

Estimated coefficients using data from 2018 are shown in Table 1. Based on those coefficients, military distance appears to be a better predictor of bloc positioning than economic distance, with countries that are more distant from the US and Europe being less likely to be in the US-Europe+ bloc (similarly, countries more distant from Russia are more likely to be in the US-Europe+ bloc).[18]

We use the logit model above to calculate the predicted probabilities that each country belongs to the US-Europe+ bloc, $\hat{p}_c$. Since b_c is simply a dummy variable, we set the probability that any given country will permanently switch from their current bloc as

$$\mathbb{P}(\text{switch}_c) = |b_c - \hat{p}_c|.$$

Thus, if a country is in the US-Europe+ bloc, its probability of switching is $1 - \hat{p}_c$; if the same country is instead placed in the China-Russia+ bloc, then its probability of switching is simply $\hat{p}_c$. In either case, the probability of switching is equal to the model-implied likelihood

[17] Since Europe is not a country, we calculate σ_c^{EU} as the average of all similarity scores between country c and European countries.

[18] For robustness, we also run a linear probability model, and a constrained logit model in which the coefficients for US and EU are constrained to be negative, while the coefficients for China and Russia are constrained to be positive. The correlation between the estimated probabilities in each model are all above 90%.

that the country is placed in the wrong bloc. Intuitively, a country is less likely to switch from their current bloc when assigned to the bloc that contains countries to which they are historically closer to, in both economic and military terms.

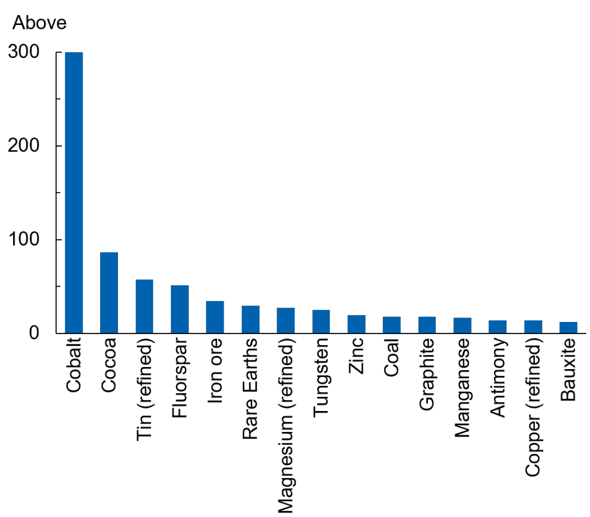
Table 1: Probability of Being in the US-Europe+ Bloc

Model	Coefficients									
	β_E^{US}	β_E^{EU}	β_E^{CN}	β_E^{RU}	β_M^{US}	β_M^{EU}	β_M^{CN}	β_M^{RU}	N	R^2
Logit	1.07	-1.50	3.43	13.59	-1.03***	-2.47**	-1.59	3.82**	156	0.22
	(3.20)	(1.51)	(2.16)	(9.39)	(0.40)	(1.04)	(1.10)	(1.69)		
Linear	0.23	-0.21	0.75**	1.08*	-0.15***	-0.26***	-0.37***	0.57***	156	0.24
	(0.33)	(0.22)	(0.36)	(0.58)	(0.04)	(0.09)	(0.13)	(0.17)		

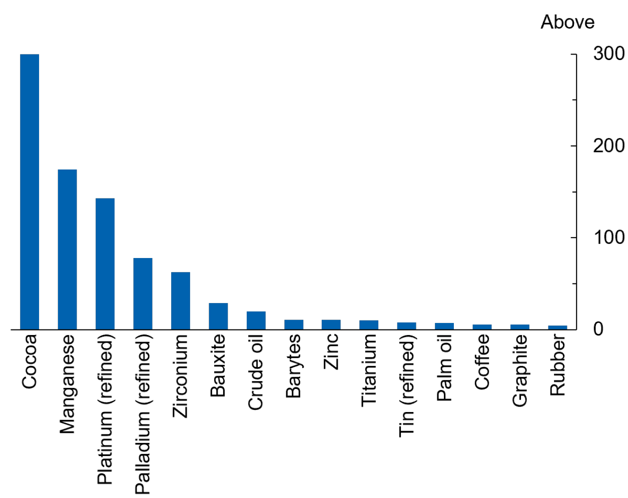
Robust standard errors in parenthesis; ***, **, and * indicate coefficients are statistically different from zero at the 1%, 5%, and 10% levels, respectively.

Figure 10: Top 15 Expected Price Increases from Exporting Countries Switching Blocs Weighted by the Probabilities of Switching (Percent).

(a) US-Europe+ Bloc



(b) China-Russia+ Bloc



Note: Each bar represents the expected average bloc-level price increase that the corresponding commodity experiences from individual exporting countries switching to the other bloc weighted by the probability of each exporting country switching.

This exercise allows us to weigh the price change induced by a single exporter switching by the probability of each country switching, as illustrated in Figure 10. Comparing this figure, to Figures 9a and 9b we find that the top most vulnerable commodities remain broadly unchanged in both groups once we account for differences in switching probabilities. This implies that major exporters switching blocs and the associated supply shocks would be a real concern in a fragmented world.

6 Fragmentation and Economic Surplus

We use changes in consumer, producer and total surplus due to the disruption of trade in commodities to measure individual commodities' macro-relevance. This measure accounts for both changes in price and the importance of each commodity in overall consumption and production.

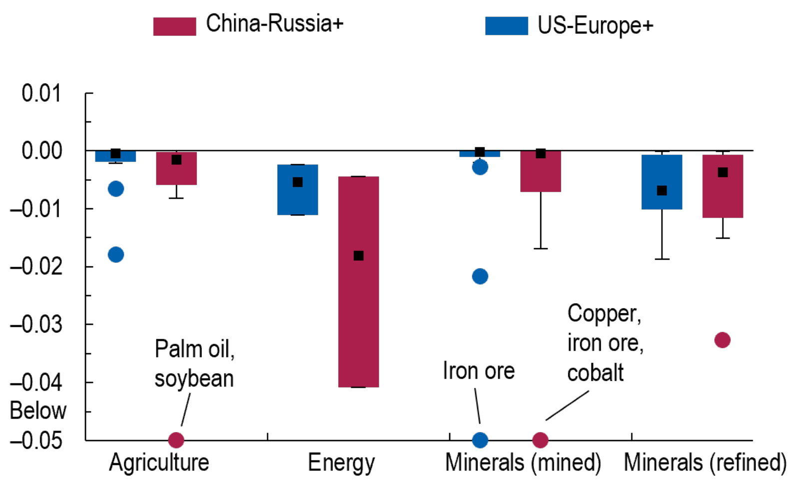
Several findings are revealed by the analysis, as shown in Figure 11a. First, inefficiencies associated with restricting free trade result in losses in bloc-level surplus, and consequently, the global economy is worse off from fragmentation of trade in individual commodities. This finding is independent of the precise definition of blocs as demonstrated in Appendix 7.2 and in Appendix D . Global economic losses, as captured in surplus changes, are, however, small in magnitude.

Second, bloc- and country-level changes in total surplus are generally small as a share of Gross National Expenditure (GNE) with notable exceptions. Figure B.6b in the Appendix show that fragmentation in palm oil and copper markets could cause declines in surplus of over 1 percent of GNE in the China-Russia+ bloc.

Figure 11: Changes in Surplus due to Fragmentation in Individual Commodity Markets

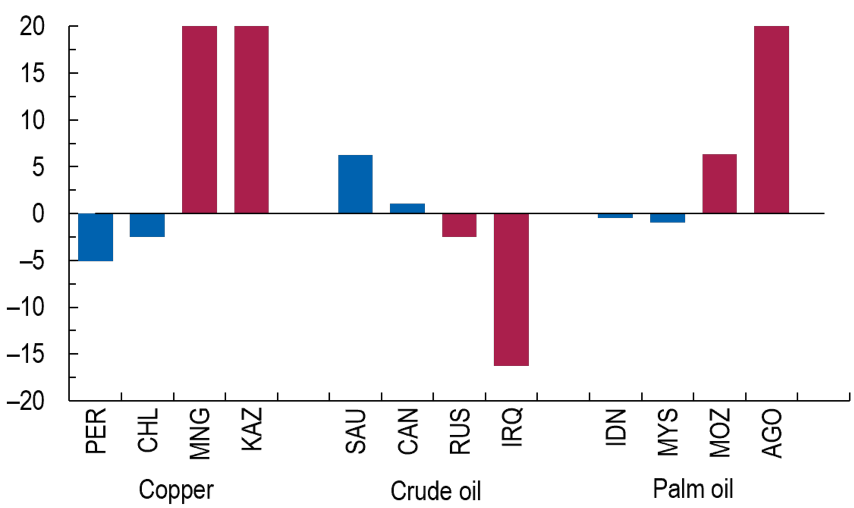
(a) Bloc-Level Surplus Changes by Commodity Groups

(Percent of Bloc-Level GNE)



(b) Surplus Changes for Top 2 Net Exporters (Selected Commodities)

(Percent of Country GNE)



Note: In panel 1, each data point in the box plots represents the total bloc-level surplus change from fragmenting trade in a single commodity. The black squares in the bars represent the median, the bars are the interquartile range, and the whiskers reflect the data points within 1.5 times the interquartile range from the 25th or 75th percentile across commodities in the group. Dots indicate outliers; the commodities associated with the largest surplus declines are labeled. Data labels use International Organization for Standardization (ISO) country codes. GNE = gross national expenditure.

Two reasons underpin the mostly moderate effects: (i) changes in total surplus reflect changes in consumer and producer surplus, which move in opposite directions within a country or a bloc, for a given price change. When the price of a commodity increases, part of the decline in consumer surplus is offset by an increase in producer surplus; and (ii) many of the most price-sensitive commodities do not represent large shares in consumption or production.

Restricting trade in commodities that are less price-vulnerable in the event of fragmentation could still lead to sizable surplus declines. For example, energy commodities are not particularly price vulnerable under the baseline bloc configuration, but the associated declines in surplus are more significant. This is because energy commodities are widely consumed and produced, and even small price changes matter. In contrast, the changes in surplus associated with disruptions in the more-price-sensitive minerals' trade are more subdued due to their limited relevance in countries' production and consumption.[19]

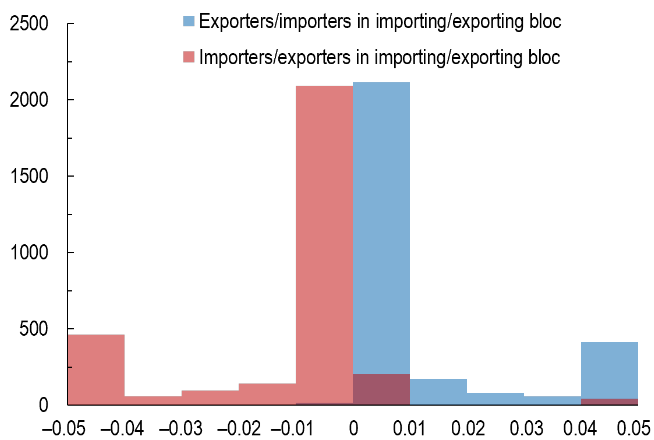
Importantly, bloc-level aggregation masks important heterogeneities across countries (see Figure B.7 in the Appendix). Within each bloc, some countries experience an increase in surplus (net-exporting countries in a net-importing bloc, and net-importing countries in a net-exporting bloc) and some experience a decline, as shown in Figure 12 and in the theoretical proof in Appendix D. Such changes can be quite sizable for a few commodity importers and exporters.[20] For instance, Figure 11b plots the surplus changes in the top two net exporters of copper, oil and palm oil across the two blocs. Fragmentation of trade in copper ores and concentrates would reduce surplus by 2.5-5 percent of GNE in Peru and

[19]The relevance of some key minerals for innovation and the clean energy transition is bound to increase in the next few years (IEA, 2022).

[20]It is possible in the model for an importer in an importing bloc or an exporter in an exporting bloc to experience a positive surplus change if their importing/exporting status changes, though this is rarely the case as shown in Figure 12.

Chile, the largest copper exporters in the US-Europe+ bloc, where copper prices would fall. At the same time, fragmentation would lead to large surplus gains in Mongolia and Kazakhstan, who would substantially scale up production and export at higher prices in the copper-scarce China-Russia+ bloc.

Figure 12: Distribution of Surplus Changes Across Exporting and Importing Countries in the Two Blocs.



Note: The figure plots the distribution of changes in total surplus due to fragmentation in individual commodity markets as a share of gross national expenditure. Each observation in the distribution is a commodity-country combination. Separate histograms are plotted for two groups of countries: (i) net-commodity-exporting countries in a commodity-importing bloc and net-commodity-importing countries in a commodity-exporting bloc [blue], and (ii) net-commodity-exporting countries in commodity-exporting blocs, and net-commodity-importing countries in commodity-importing blocs [red]. Countries' importing/exporting status is based on the pre-fragmentation baseline.

7 Robustness Analysis

The results from our baseline simulation are robust to alternative price elasticities of supply and demand. In line with the sensitivity of the simulated price changes to major producing countries switching blocs, the precise bloc configuration is an important factor underpinning the results for individual commodities. In highly concentrated markets, the assignment of major producers across blocs often makes a difference.

7.1 Alternative Elasticities

Given the uncertainty surrounding estimates of commodity-specific elasticities, we examine the robustness of the model simulations to different elasticities. In the first alternative specification, the demand and supply elasticities are set to the median values among the estimates listed in the literature review in Fally and Sayre (2018) as shown in Table C.7 in the Appendix. As shown in Figure C.8, the ranking of commodity price vulnerabilities to fragmentation is quite similar to the one in the baseline.[21] The results on the five largest surplus changes across blocs in Figure C.9 in the Appendix are also qualitatively similar to the baseline results.

In the second alternative specification, we assume that all agricultural, mineral and energy commodities have the same elasticity within their category as shown in Table C.8. The results, plotted in Figure C.10 and C.11 in the Appendix, are in line with our baseline.

7.2 Alternative Blocs Configurations

We examine the sensitivity of our results to two alternative bloc configurations.

7.2.1 Bloc Configuration I

In bloc configuration I, all emerging market and developing economies, excluding India, Indonesia and Latin American countries, are assigned to the China-Russia+ bloc, as listed

[21] Our results on the price changes implied by fragmentation in the baseline and alternative blocs configurations are also summarized in Figures C.16a and C.16b in the Appendix, which allow for a better comparison across the different specifications.

in Table C.9 in the Appendix.

This configuration leads to price increases for a larger number of commodities in the hypothetical US-Europe+ bloc than under the baseline (see Figure C.12 in the Appendix). Key differences are as follows: (1) The price of crude oil would increase by more in the US-Europe+ bloc than in the baseline due major oil producers being in the China-Russia+ bloc (United Arab Emirates, Libya, Nigeria, Qatar, Saudi Arabia, Kuwait); (2) the price of cocoa would increase in the US-Europe+ bloc, as Ivory Coast, the largest world producer of cocoa, would become part of the China-Russia+ bloc; (3) because the Democratic Republic of Congo, the world largest producer of cobalt, would be in the China-Russia bloc, the price of cobalt would rise in the US-Europe+ bloc; (4) the China-Russia bloc would experience milder price increases for palm oil and manganese. The former is because important palm oil producers such as Malaysia and Thailand are now assigned to the China-Russia+ bloc. Manganese would become less vulnerable in the China-Russia+ bloc because India, a major importer of this commodity, is now assigned to the US-Europe+ bloc.

Turning to the implications of fragmentation for changes in total surplus across blocs, crude oil and cocoa are now the commodities causing the largest surplus declines in the US-Europe+ blocs (see Figure C.13 in the Appendix). They imply surplus losses in the US-Europe+ bloc between 2.5 and 4.5 percent of GNE. This is because both commodities experience large price increases, while also being widely used as inputs into the economy. Crude oil would cause substantial surplus declines in the China-Russia bloc as well (over 1 percent of GNE). In this case, it would be due to producers surplus declining, as exporting countries in this bloc would experience large reduction in prices.

7.2.2 Bloc Configuration II

In bloc configuration II, a country is assigned to the US-Europe+ bloc if it trades more with the US and the EU combined than with China and Russia combined. Otherwise it is assigned to the China-Russia+ bloc.

Under this bloc configuration, the US-Europe+ bloc would experience large price increases in palm oil due to the shift of Indonesia and Malaysia, which account for 80 percent of global production, and due to the shift of the DRC to the China-Russia+ bloc. The bloc would be less vulnerable to trade fragmentation of graphite, platinum, and palladium, because Mozambique and South Africa would be in the US-Europe+ bloc. Like in the baseline, the China-Russia+ bloc would still experience large price increases of soybean, copper, manganese, zinc, and lead, but not of iron ore and lithium, as Australia would be assigned to to the China-Russia+ bloc (see Figure C.14 in the Appendix). Changes in total economic surplus remain larger in the China-Russia+ bloc, but lower in magnitude relative to the baseline, as shown in Figure C.15 in the Appendix.

8 Conclusion

This paper examined the economic implications of trade fragmentation in individual commodities, using a novel dataset of production and bilateral trade flows of the 48 most important energy, mineral and agricultural commodities. Commodities appear highly vulnerable in the event of fragmentation due to their highly concentrated and difficult-to-relocate production, hard-to-substitute consumption, and their critical role as inputs for manufacturing and key technologies.

Our simple partial equilibrium framework suggests that fragmentation could cause wide price differentials across blocs and lead to large changes in commodity prices, depending on the resulting supply and demand imbalances and commodities' elasticities of supply and demand. In our illustrative simulation, minerals critical to the clean energy transition and some highly traded agricultural goods are among the most vulnerable in the event of fragmentation, implying risks to global climate change goals and food security. Moreover, potential economic impacts from fragmentation differ vastly across countries, with offsetting effects across consumer and producer countries resulting in modest surplus losses at the global level. Our results also suggest that a fragmented world would be more volatile due to smaller markets and potentially large price movements induced by country-specific geopolitical realignments.

Comprehensively mapping vulnerable commodity markets and fragmentation implications across multiple global markets required several simplifying assumptions, which merit refinement – especially in those markets identified as most vulnerable and macroeconomically impactful. A consistently estimated set of price elasticities of demand and supply, ideally at the country- and commodity-level, could provide important foundations for a more rigorous calibration of models with disaggregated commodity markets. The role of recycling in increasing supply elasticities and dampening the effects of fragmentation on minerals markets could be explored further. Across the commodity space, our results suggest that the impact of fragmentation of critical minerals on the clean energy transition merits special attention. A deeper understanding of the intra-country effects of fragmentation on food security given the high vulnerability of specific agricultural commodities could be another area of focus.

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Appendices

A Data

Table A.1: Adjustment Factors Used to Convert Gross Quantities Trade Data for Minerals into Metal Content

Commodities	Type	Adjustment Factor	Note
Aluminium (refined)	Minerals		
Antimony	Minerals	0.325	There are country specific adjustment factors.[22]
Barytes	Minerals		
Bauxite	Minerals		
Chromium	Minerals		
Cobalt	Minerals	0.07	There are country specific adjustment factors.
Copper	Minerals	0.3	There are country specific adjustment factors.
Copper (refined)	Minerals		
Fluorspar	Minerals		
Graphite	Minerals	0.913	
Iron ore	Minerals		
Lead	Minerals	0.6	There are country specific adjustment factors.
Lead (refined)	Minerals		
Lithium	Minerals		
Magnesium	Minerals		
Magnesium (refined)	Minerals		
Manganese	Minerals		
Nickel	Minerals	0.015	There are country specific adjustment factors.
Nickel (refined)	Minerals		There are both sub-commodity and country specific adjustment factors.
Palladium (refined)	Minerals		
Phosphate	Minerals		
Platinum (refined)	Minerals		
Potash	Minerals		There are both sub-commodity and country specific adjustment factors.
Rare Earths	Minerals	0.6	
Silicon	Minerals		

[22] Country- and commodity-specific adjustment factors are available from the authors upon request.

Commodities	**Type**	**Adjustment Factor**	**Note**
Silver	Minerals	0.017	
Tin	Minerals	0.73	There are country specific adjustment factors.
Tin (refined)	Minerals		
Titanium	Minerals	0.5266	There are country specific adjustment factors.
Tungsten	Minerals	0.561	
Zinc	Minerals	0.65	There are country specific adjustment factors.
Zinc (refined)	Minerals		
Zirconium	Minerals		

Table A.2: Mapping Table for the Trade and Production of Agricultural Commodities

Commodity	**Name in FAO Classification**	**FAO Item Code**
Cocoa	Cocoa beans	661
Coffee	Coffee; green	656
Cotton	Cotton lint	767
Maize	Maize (corn)	56
Palm oil	Palm oil	257
Rice	Rice; milled	31
Rubber	Natural rubber in primary forms	836
Soy beans	Soy beans	236
Sugar	Raw cane or beet sugar (centrifugal only)	162
Sunflower seeds	Sunflower seeds	267
Tobacco	Tobacco, unmanufactured	826
Wheat	Wheat	15

Source: Data is obtained from the FAO crops and livestock products dataset, except for rice and sugar, which is obtained from the FAO supply utilization accounts dataset.

Table A.3: Mapping Table for Mineral Commodities

	Trade		**Production**
Commodity	**Name**	**HS Code**	**Name**
Aluminium (refined)	Aluminium unwrought, not alloyed Aluminium unwrought, alloyed	760110 760120	Primary aluminium
Antimony	Antimony ores and concentrates	261710	Antimony
Barytes	Natural barium sulphate (barytes)	251110	Barytes

Bauxite	Aluminium ores and concentrates	260600	Bauxite
Chromium	Chromium ores and concentrates	261000	Chromium ores and concentrates
Cobalt	Cobalt ores and concentrates	260500	Cobalt
Copper	Copper ores and concentrates	260300	Copper
Copper (refined)	Copper: refined, unwrought, cathodes and sections of cathodes	740311	Refined copper
	Copper: refined, unwrought, wire-bars	740312	
	Copper: refined, unwrought, billets	740313	
	Copper: refined, unwrought, n.e.s. in item no. 7403.1	740319	
	Master alloys of copper	740500	
Fluorspar	Fluorspar containing by weight <=97% of calcium	252921	Fluorspar
	Fluorspar containing by weight >97% of calcium	252922	
Graphite	Graphite: natural, in powder or in flakes	250410	Graphite
	Graphite: natural, in other forms, excluding powder or flakes	250490	
Iron ore	Non-agglomerated iron ores and concentrates	260111	Iron ore
	Agglomerated iron ores and concentrates	260112	
Lead	Lead ores and concentrates	260700	Lead
Lead (refined)	Lead refined unwrought	780110	Refined lead
	Lead unwrought nes	780199	
	Lead monoxide	282410	
	Lead oxide	282490	
Lithium	Carbonates: lithium carbonate	283691	Lithium minerals
Magnesium	Natural magnesium carbonate (magnesite)	251910	Magnesite
Magnesium (refined)	Magnesium: unwrought, containing at least 99.8% by weight of magnesium	810411	Primary magnesium metal
	Magnesium: unwrought, containing less than 99.8% by weight of magnesium	810419	
	Magnesium raspings,turnings or granules graded	810430	

Manganese	Manganese ores and concentrates, with a mangane	260200	Manganese ore
Nickel	Nickel ores and concentrates	260400	Nickel
Nickel (refined)	Nickel unwrought, not alloyed Nickel unwrought, alloyed Nickel chloride Sulphates of nickel Ferro-nickel	750210 750220 282735 283324 720260	Nickel (smelter/refinery)
Palladium (refined)	Palladium unwrought or in powder form Palladium in other semi-manufactured forms	711021 711029	Palladium
Phosphate	Natural calcium phosphates, natural aluminium calcium phosphates and phosphatic chalk: unground Natural calcium phosphates, natural aluminium calcium phosphates and phosphatic chalk: ground	251010 251020	Phosphate rock
Platinum (refined)	Platinum unwrought or in powder form Platinum in other semi-manufactured forms	711011 711019	Platinum
Potash	Potassium chloride Potassium sulphate potassium nitrate Potassic, n.e.s. in heading no. 3104	310420 310430 283421 310490	Potash
Rare Earths	Cerium compounds Compounds, inorganic or organic, of rare-earth	284610 284690	Rare earth oxides
Silicon	Silicon: containing by weight not less than 99.99% of silicon Silicon: containing by weight less than 99.99% of silicon	280461 280469	Silicon
Silver	Silver ores and concentrates	261610	Silver
Tin	Tin ores and concentrates	260900	Tin
Tin (refined)	Tin not alloyed unwrought Tin alloys unwrought	800110 800120	Tin (smelter)
Titanium	Titanium ores and concentrates	261400	Titanium mineral concentrates

Tungsten	Tungsten ores and concentrates	261100	Tungsten
Zinc	Zinc ores and concentrates	260800	Zinc
Zinc (refined)	Zinc not alloyed unwrought containing by weight	790111	Slab zinc
	Zinc not alloyed unwrought containing by weight	790112	
	Zinc alloys unwrought	790120	
	Hard zinc spelter	262011	
	Zinc oxide, zinc peroxide	281700	
Zirconium	Zirconium ores and concentrates	261510	Zirconium minerals

Sources: Production data are obtained from the British General Survey. For Titanium, Silicon, and Potash, we rely on production data from the U.S. Geological Survey. Trade data are from Bilateral Commodity Trade Database (BACI), which draws on UN Comtrade.

Table A.4: Mapping Table for the Data on Trade and Production of Energy Commodities from the International Energy Agency

Commodity	**HS Name**	**HS Code**	**IEA Name**
Coal	Anthracite, not agglomerated	270111	Anthracite (ANTCOAL)
	Bituminous coal, not agglomerated	270112	Other bituminous coal (BITCOAL)
	Other coal, not agglomerated, nes	270119	Sub-bituminous coal (SUBCOAL)
	Lignite, not agglomerated	270210	Lignite (LIGNITE)
	Agglomerated lignite	270220	Coking coal (COKCOAL)
Crude oil	Petroleum oils and oils obtained from bituminous minerals, crude	270900	Crude/NGL/feedstocks (CRNGFEED)
	Petroleum gases and other gaseous hydrocarbons: liquefied, propane	271112	
	Petroleum gases and other gaseous hydrocarbons: liquefied, butanes	271113	
	Petroleum gases and other gaseous hydrocarbons: liquefied, ethylene, propylene, butylene and butadiene	271114	
	Petroleum gases and other gaseous hydrocarbons: liquefied, n.e.s. in heading no. 2711	271119	
Natural gas	Natural gas, liquefied	271111	Natural gas (NATGAS)
	Natural gas in gaseous state	271121	

Sources: Production data are from the International Energy Agency (IEA) world energy balances database, except for coal, which is obtained from the IEA world energy statistics database. Bilateral trade data for energy are from the Bilateral Commodity Trade Database (BACI), which draws on UN Comtrade.

Table A.5: Economies Included and the Composition of Blocs in the Baseline Scenario

US-Europe+ Bloc	Afghanistan; Albania; Andorra; Antigua and Barbuda; Argentina; Aruba; Australia; Austria; Bahamas, The; Bahrain; Barbados; Belgium; Belize; Benin; Bhutan; Bosnia and Herzegovina; Botswana; Brazil; Brunei Darussalam; Bulgaria; Cabo Verde; Cambodia; Canada; Chad; Chile; Colombia; Comoros; Congo, Democratic Republic of the; Costa Rica; Côte d'Ivoire; Croatia; Cyprus; Czech Republic; Denmark; Djibouti; Dominica; Dominican Republic; Ecuador; Egypt; Estonia; Fiji; Finland; France; Gabon; Gambia, The; Georgia; Germany; Ghana; Greece; Grenada; Guatemala; Guyana; Haiti; Honduras; Hungary; Iceland; Indonesia; Ireland; Israel; Italy; Jamaica; Japan; Jordan; Kenya; Kiribati; Korea; Kuwait; Latvia; Lebanon; Lesotho; Liberia; Libya; Lithuania; Luxembourg; Malawi; Malaysia; Maldives; Malta; Marshall Islands; Mauritania; Mauritius; Mexico; Micronesia; Moldova; Montenegro, Rep. of; Myanmar; Nauru; Nepal; Netherlands; New Zealand; Niger; Nigeria; North Macedonia; Norway; Oman; Palau; Panama; Papua New Guinea; Paraguay; Peru; Philippines; Poland; Portugal; Qatar; Romania; Rwanda; Samoa; San Marino; São Tomé and Príncipe; Saudi Arabia; Serbia; Seychelles; Sierra Leone; Singapore; Slovak Republic; Slovenia; Solomon Islands; Somalia; Spain; St. Kitts and Nevis; St. Lucia; St. Vincent and the Grenadines; Suriname; Sweden; Switzerland; Thailand; Timor-Leste; Tonga; Trinidad and Tobago; Tunisia; Turkey; Tuvalu; Ukraine; United Arab Emirates; United Kingdom; United States; Uruguay; Vanuatu; Yemen; Zambia
China-Russia+ Bloc	Algeria; Angola; Armenia; Azerbaijan; Bangladesh; Belarus; Bolivia; Burkina Faso; Burundi; Cameroon; Central African Republic; China; Congo, Republic of; El Salvador; Equatorial Guinea; Eritrea; Eswatini; Ethiopia; Guinea; Guinea-Bissau; India; Iran; Iraq; Kazakhstan; Kyrgyz Republic; Lao P.D.R.; Macao SAR; Madagascar; Mali; Mongolia; Morocco; Mozambique; Namibia; Nicaragua; Pakistan; Russia; Senegal; South Africa; South Sudan; Sri Lanka; Sudan; Syria; Tajikistan; Tanzania; Togo; Turkmenistan; Uganda; Uzbekistan; Venezuela; Vietnam; Zimbabwe

Table A.6: Price Elasticities and Sources

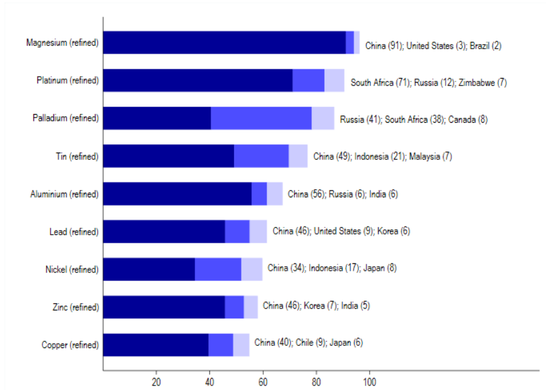
Commodity	Short-Run Demand Elasticity	Short-Run Supply Elasticity	Source
Agriculture			
Cocoa	-0.075	0.075	Fally and Sayre (2019)
Coffee	-0.305	0.285	Fally and Sayre (2019)
Cotton	-0.684	0.497	Fally and Sayre (2019)
Maize	-0.34	0.327	Fally and Sayre (2019)
Rice	-0.24	0.167	Fally and Sayre (2019)
Soy beans	-0.1895	0.383	Fally and Sayre (2019)
Sugar	-0.3265	0.1308	Fally and Sayre (2019)
Sunflower seeds	-0.3759375	0.258975	Average agriculture elasticities
Tobacco	-0.3759375	0.258975	Average agriculture elasticities
Wheat	-0.8475	0.207	Fally and Sayre (2019)
Palm oil	-0.3759375	0.258975	Average agriculture elasticities
Minerals			
Aluminium (refined)	-0.047	0.235	Dahl (2020)
Antimony	-0.2715304	0.265625	Average mineral elasticities
Barytes	-0.2715304	0.265625	Average mineral elasticities
Bauxite	-0.047	0.235	Dahl (2020)
Chromium	-2.622	0.265625	Dahl (2020)
Cobalt	-0.07	0.23	Dahl (2020)
Copper	-0.014	0.188	Dahl (2020)
Copper (refined)	-0.014	0.188	Dahl (2020)
Fluorspar	-0.2715304	0.265625	Average mineral elasticities
Graphite	-0.2715304	0.265625	Average mineral elasticities
Iron ore	-0.145	0.16	Dahl (2020)
Lead	-0.054	0.169	Dahl (2020)
Lead (refined)	-0.054	0.169	Dahl (2020)
Lithium	-0.54	0.265625	Dahl (2020)
Magnesium	-0.2715304	0.265625	Average mineral elasticities
Magnesium (refined)	-0.2715304	0.265625	Average mineral elasticities

Commodity	Short-Run Demand Elasticity	Short-Run Supply Elasticity	Source
Manganese	-0.212	0.104	Dahl (2020)
Nickel	-0.03	0.75	Dahl (2020)
Nickel (refined)	-0.03	0.75	Dahl (2020)
Palladium (refined)	-0.2	0.265625	Dahl (2020) and average mineral supply elasticity
Nutrient phosphate	-0.2715304	0.265625	Average mineral elasticities
Phosphate	-0.2715304	0.265625	Average mineral elasticities
Platinum (refined)	-0.344	0.265625	Dahl (2020) and average mineral supply elasticity
Potash	-0.2715304	0.265625	Average mineral elasticities
Rare Earths	-0.4	0.265625	Dahl (2020) and average mineral supply elasticity
Rubber	-0.3759375	0.258975	Fally and Sayre (2019)
Silicon	-0.2715304	0.265625	Average mineral elasticities
Silver	-0.856	0.265625	Dahl (2020) and average mineral supply elasticity
Tin	-0.121	0.3	Dahl (2020)
Tin (refined)	-0.121	0.3	Dahl (2020)
Titanium	-0.1602	0.265625	Dahl (2020) and average mineral supply elasticity
Tungsten	-0.15	0.11	Dahl (2020)
Zinc	-0.007	0.181	Dahl (2020)
Zinc (refined)	-0.007	0.181	Dahl (2020)
Zirconium	-0.2715304	0.265625	Average mineral elasticities
Energy			
Natural gas	-0.5015	0.075	Fally and Sayre (2019)
Crude oil	-0.0415	0.1445	Fally and Sayre (2019)
Coal	-0.5	0.0565	Fally and Sayre (2019)

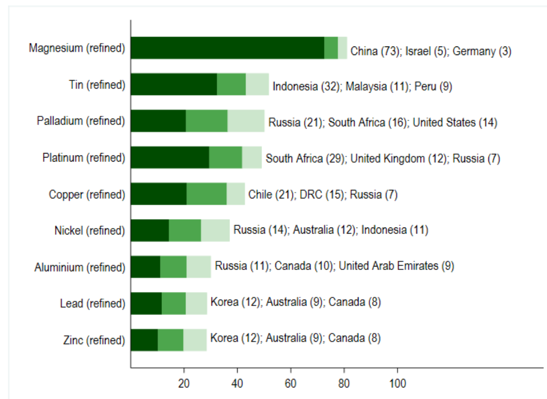
B Additional Figures

Figure B.1: Refined Metals: Production, Export and Import Concentrations

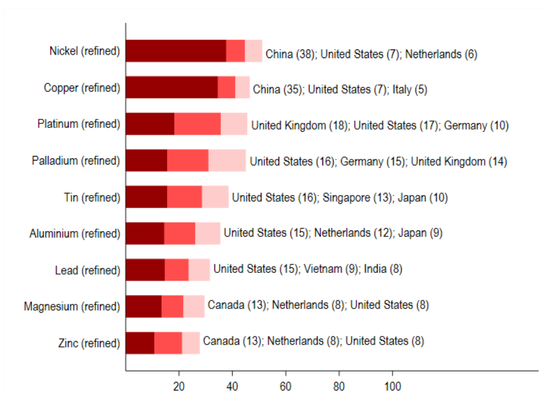
(a) Production



(b) Exports



(c) Imports



Note: For each refined metal in our sample, the figure shows the share of global production that the top three producers (blue), the share of exports of the top three exporters (green) and the share of imports of the top three importers (red) in 2019.

Figure B.2: Distribution of the Price Elasticities of Demand and Supply

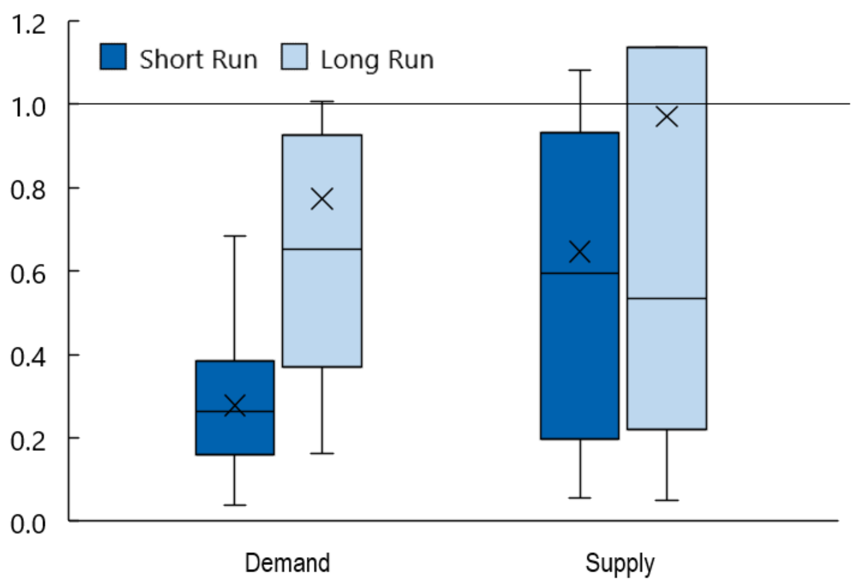
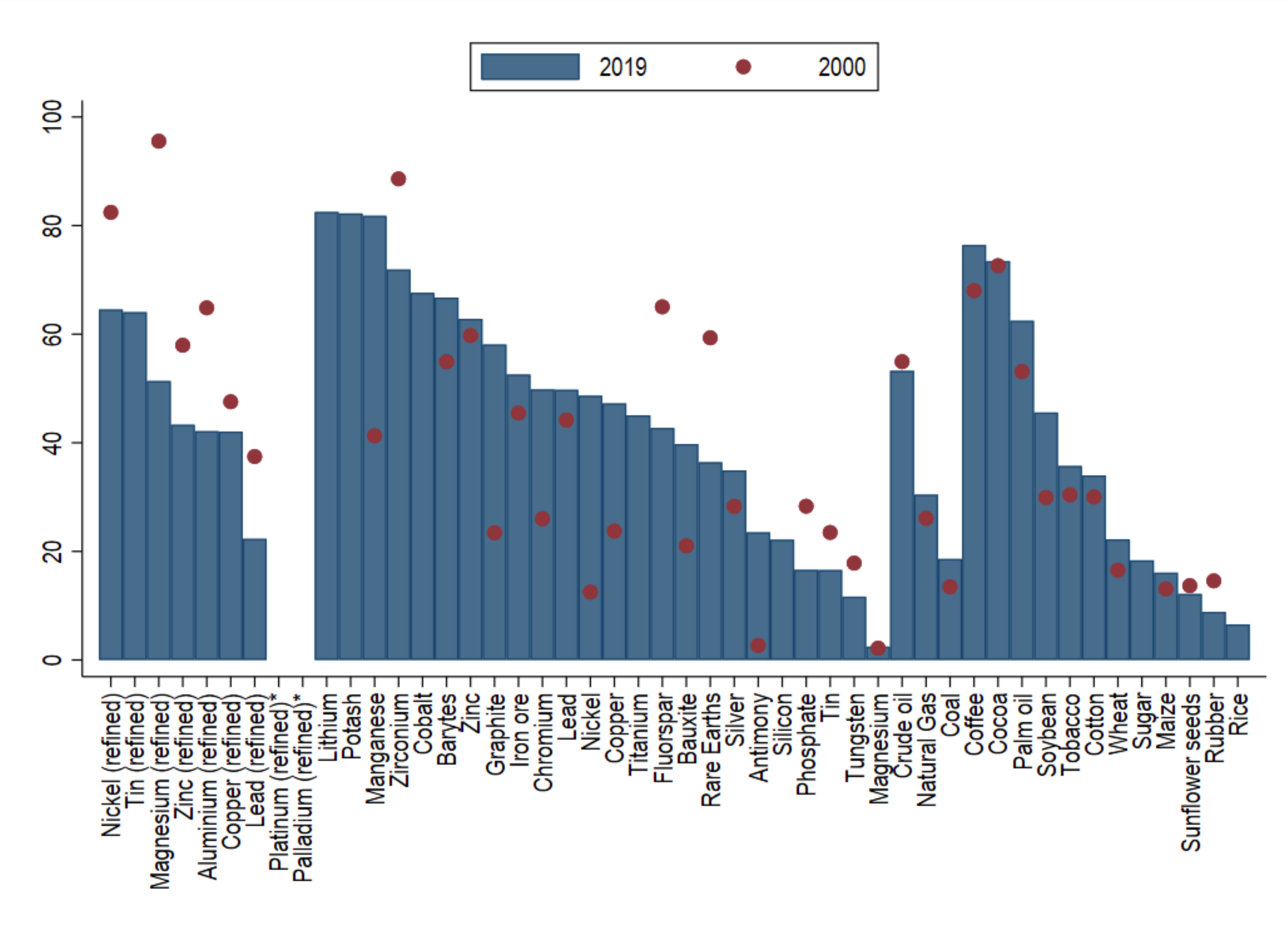


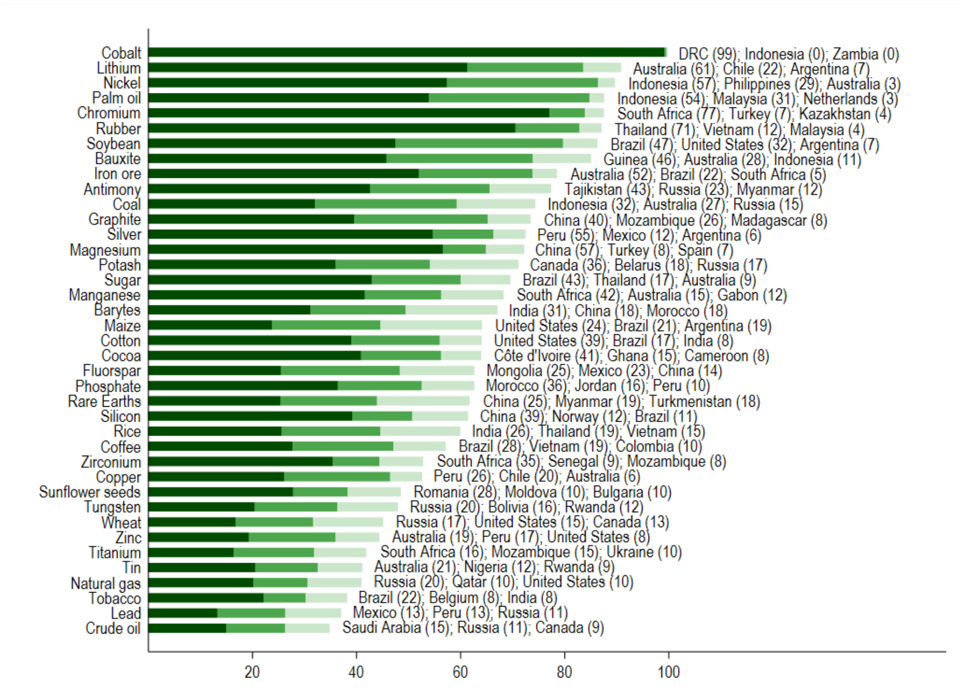
Figure B.3: Share of Production That Is Traded



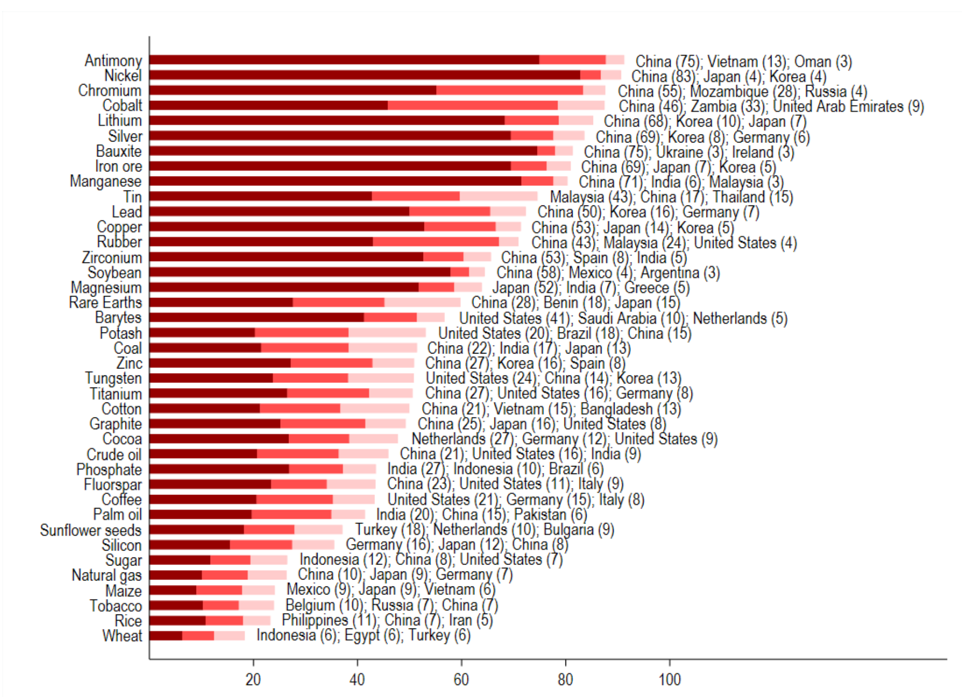
Note: The figure displays the share of production that is traded, for each commodity in our sample in 2019 (blue bars) and 2000 (red dots). Commodities are grouped by commodity type.

Figure B.4: Share of Global Exports/Imports Accounted for by the Top 3 Exporters/Importers

(a) Exports



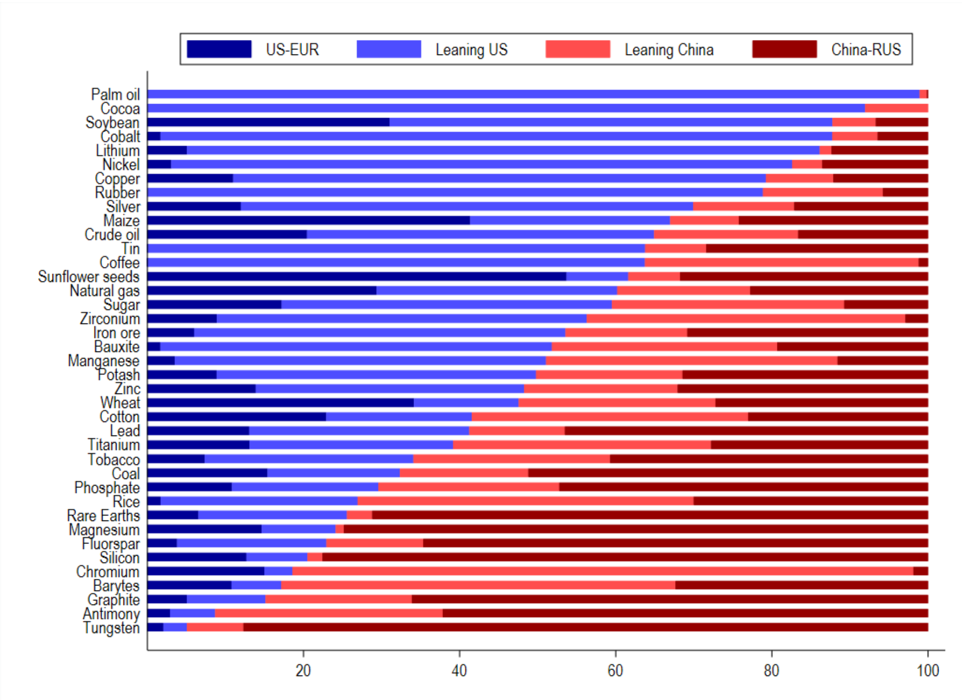
(b) Imports



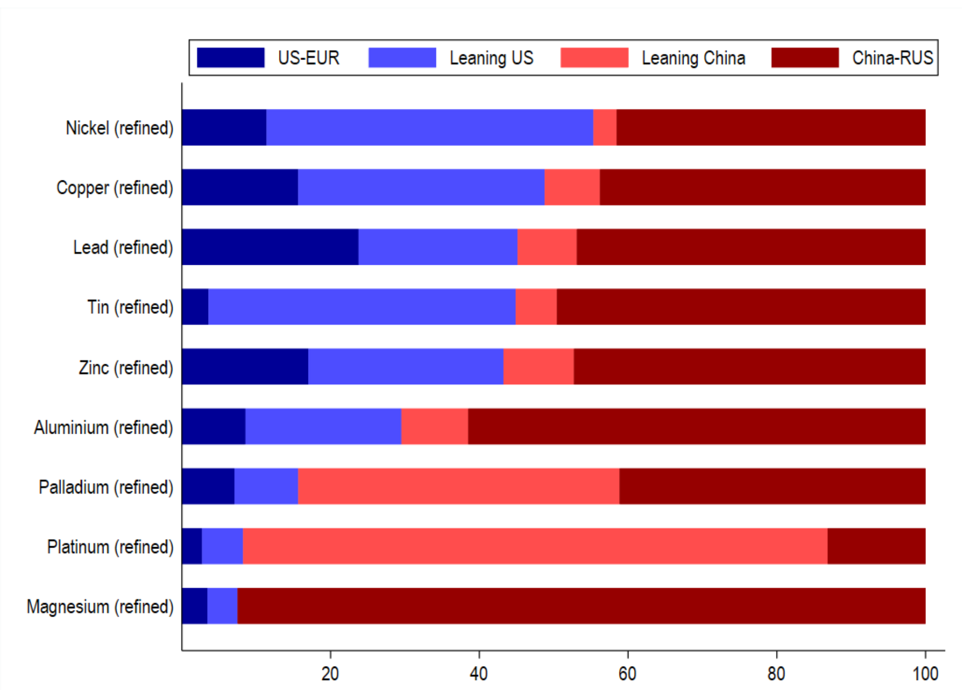
Note: The figure displays the share of global exports (resp. imports) that the top 3 exporters (resp. importers) account for, for each of the commodities in our sample, in 2019.

Figure B.5: Production Across Blocs

(a) Commodities

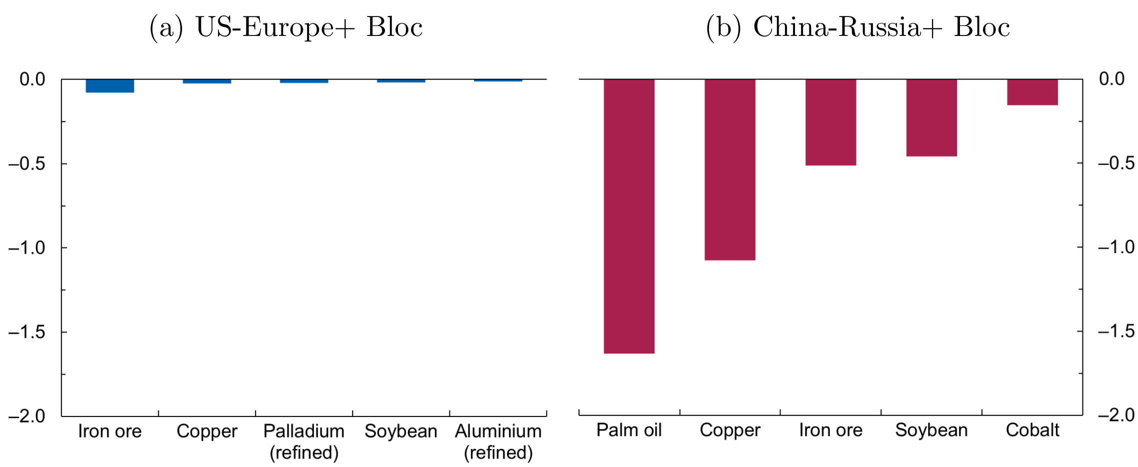


(b) Refined Metals



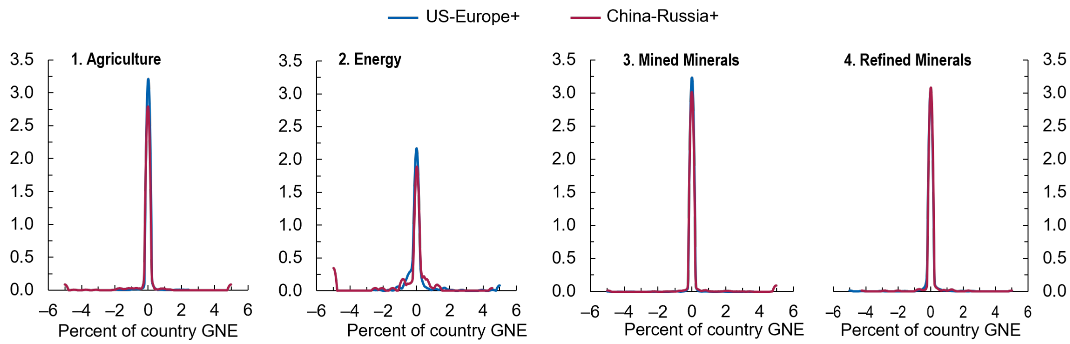
Note: For each commodity in our sample, the figure shows the share of global production that each bloc in our hypothetical baseline scenario account for in 2019.

Figure B.6: Top 5 Largest Changes in Bloc-Level Total Economic Surplus (Percent of Bloc-Level GNE)



Note: Each bar represents the decline in bloc-level total economic surplus from fragmenting trade of the corresponding commodity in the axis. GNE = gross national expenditure.

Figure B.7: Distribution of Country-Level Changes in Total Surplus from Fragmentation of Each Commodity Market (Percent of Country GNE- horizontal axis)



Note: Changes in total economic surplus at the country level are capped at +/− 5 percent of GNE for readability. Each observation represents the total economic change in the surplus of a country due to the fragmentation of a single commodity market. The y-axis is the probability density function for the kernel density estimation. GNE = gross national expenditure.

C Tables and Figures for the Robustness Exercises

Table C.7: Alternative Calibration with Median Elasticities from Fally and Sayre (2018)

Commodity	Short-Run Demand Elasticity	Short-Run Supply Elasticity	Source
Cocoa	-0.08	0.08	Fally and Sayre (2018)
Coffee	-0.20	0.19	Fally and Sayre (2018)
Cotton	-0.68	0.50	Fally and Sayre (2018)
Maize	-0.25	0.24	Average elasticity across agricultural commodities
Palm oil	-0.25	0.24	Average elasticity across agricultural commodities
Rice	-0.15	0.18	Fally and Sayre (2018)
Rubber	-0.25	0.24	Average elasticity across agricultural commodities
Soy beans	-0.21	0.53	Fally and Sayre (2018)
Sugar	-0.13	0.13	Fally and Sayre (2018)
Sunflower seeds	-0.25	0.24	Average elasticity across agricultural commodities
Tobacco	-0.25	0.24	Average elasticity across agricultural commodities
Wheat	-0.28	0.11	Fally and Sayre (2018)
Minerals			
Bauxite	-0.27	0.14	Fally and Sayre (2018)
Aluminium (refined)	-0.27	0.14	Fally and Sayre (2018)
Antimony	-0.17	0.52	Average elasticity across mineral commodities
Barytes	-0.17	0.52	Average elasticity across mineral commodities
Chromium	-0.19	0.52	Fally and Sayre (2018); Average elasticity across mineral commodities
Cobalt	-0.17	0.23	Fally and Sayre (2018)
Copper	-0.31	0.34	Fally and Sayre (2018)
Copper (refined)	-0.31	0.34	Fally and Sayre (2018)

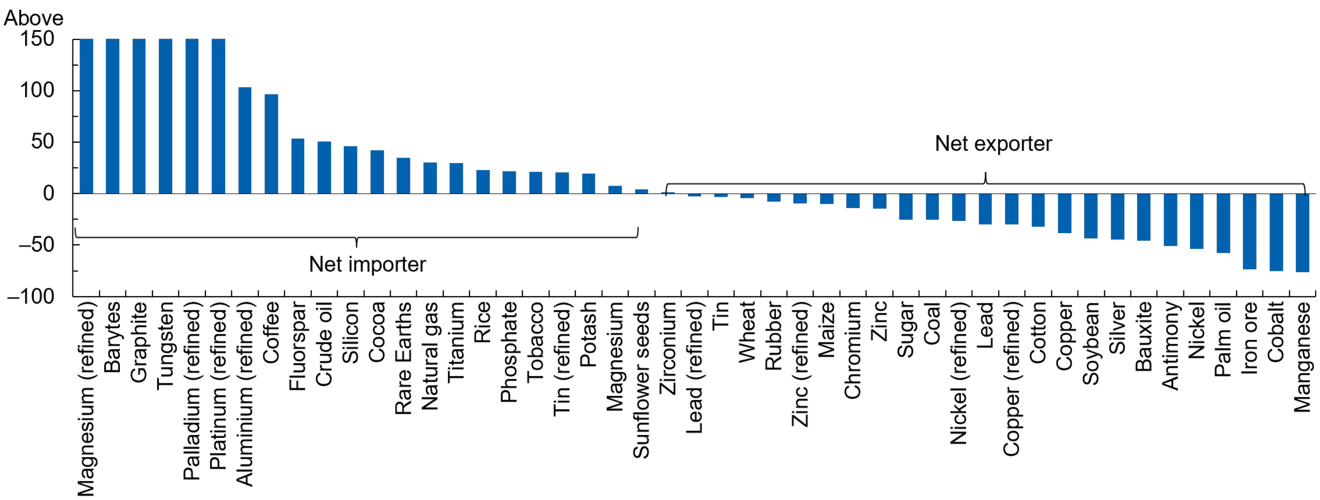
Commodity	**Short-Run Demand Elasticity**	**Short-Run Supply Elasticity**	**Source**
Fluorspar	-0.17	0.52	Average elasticity across mineral commodities
Graphite	-0.17	0.52	Average elasticity across mineral commodities
Iron ore	-0.09	0.59	Fally and Sayre (2018)
Lead	-0.17	0.97	Fally and Sayre (2018)
Lead (refined)	-0.17	0.97	Fally and Sayre (2018)
Lithium	-0.17	0.52	Average elasticity across mineral commodities
Magnesium	-0.17	0.52	Average elasticity across mineral commodities
Magnesium (refined)	-0.17	0.52	Average elasticity across mineral commodities
Manganese	-0.10	0.52	Average elasticity across mineral commodities
Nickel	-0.04	0.82	Fally and Sayre (2018)
Nickel (refined)	-0.04	0.82	Fally and Sayre (2018)
Palladium (refined)	-0.20	0.52	Fally and Sayre (2018); Average elasticity across mineral commodities
Phosphate	-0.17	0.52	Average elasticity across mineral commodities
Platinum (refined)	-0.49	0.52	Fally and Sayre (2018); Average elasticity across mineral commodities
Potash	-0.17	0.52	Average elasticity across mineral commodities
Rare Earths	-0.17	0.52	Average elasticity across mineral commodities
Silicon	-0.17	0.52	Average elasticity across mineral commodities

Commodity	**Short-Run Demand Elasticity**	**Short-Run Supply Elasticity**	**Source**
Silver	-0.04	0.52	Fally and Sayre (2018); Average elasticity across mineral commodities
Tin	-0.17	0.21	Fally and Sayre (2018)
Tin (refined)	-0.17	0.21	Fally and Sayre (2018)
Titanium	-0.16	0.52	Fally and Sayre (2018); Average elasticity across mineral commodities
Tungsten	-0.15	0.13	Fally and Sayre (2018)
Zinc	-0.06	0.92	Fally and Sayre (2018)
Zinc (refined)	-0.06	0.92	Fally and Sayre (2018)
Zirconium	-0.17	0.52	Average elasticity across mineral commodities
Energy			
Natural gas	-0.50	0.08	Fally and Sayre (2018)
Crude oil	-0.04	0.14	Fally and Sayre (2018)
Coal	-0.50	0.06	Fally and Sayre (2018)

Note: The calibration of demand and supply elasticities is using the median values in the literature survey from Fally and Sayre (2018). For commodities with no available estimate, we use the average of the others within the food/mineral category.

Figure C.8: Price Changes by Commodity across Blocs - Median Elasticities from Fally and Sayre (2018) (Percent)

(a) US-Europe+ Bloc



(b) China-Russia+ Bloc

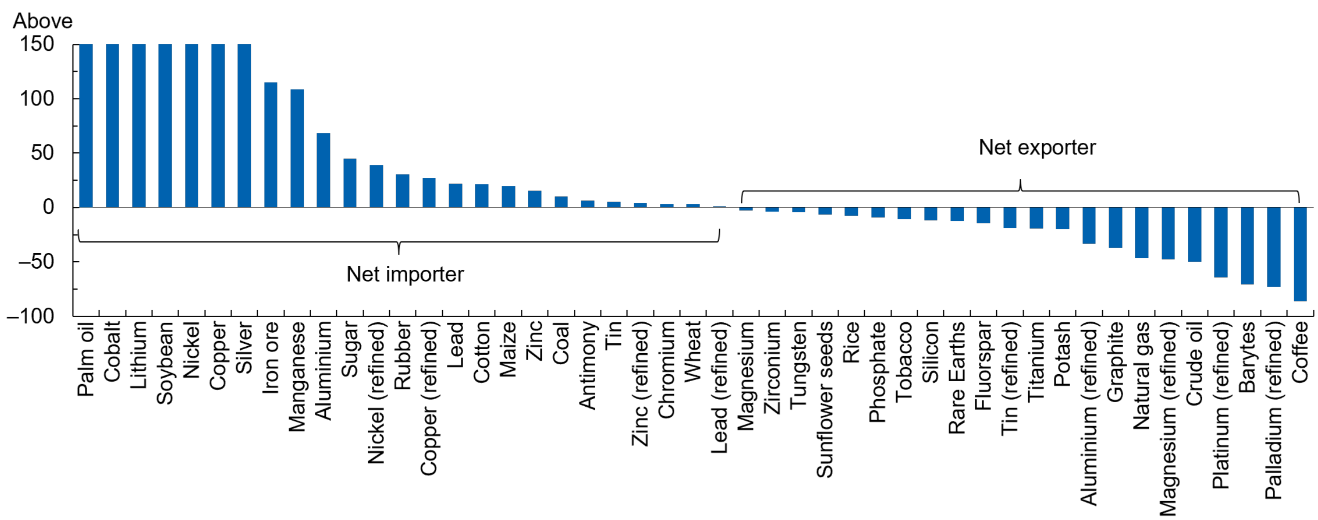
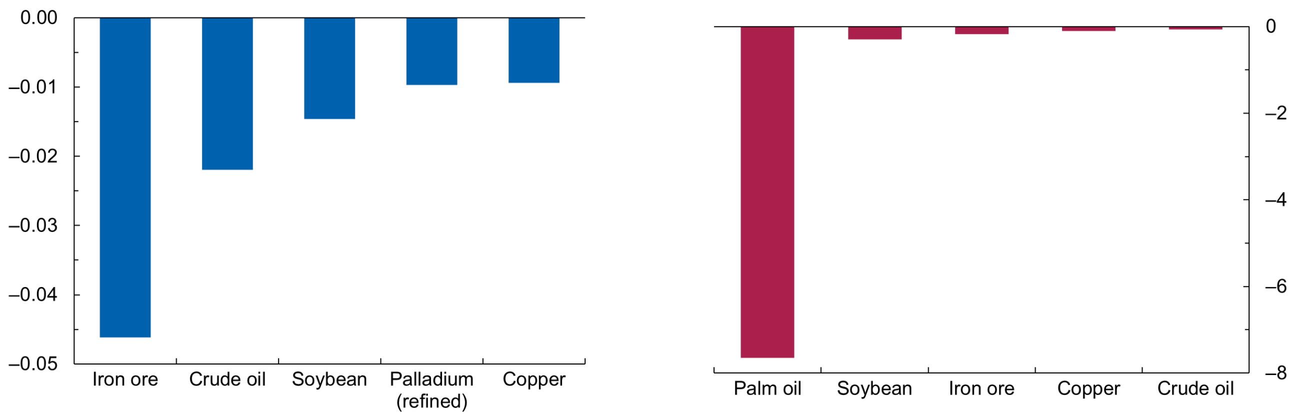


Figure C.9: Top 5 Largest Changes in Bloc-Level Total Economic Surplus - Median Elasticities from Fally and Sayre (2018) (Percent of Bloc-Level GNE)

(a) US-Europe+ Bloc

(b) China-Russia+ Bloc



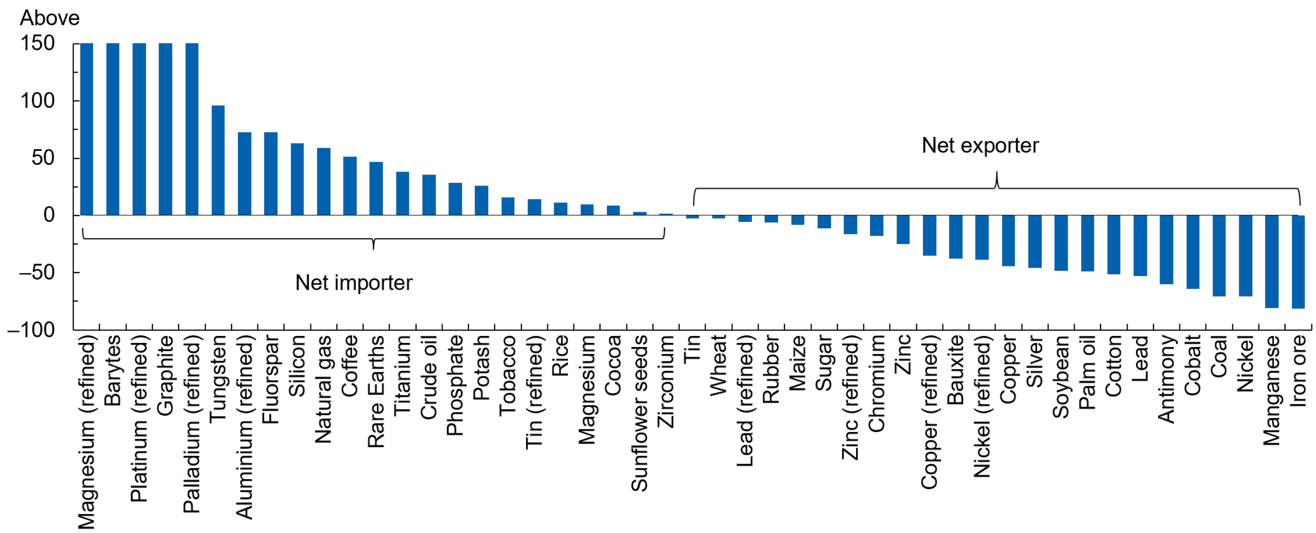
Note: Each bar represents the decline in bloc-level total economic surplus from fragmenting trade of the corresponding commodity in the axis. GNE = gross national expenditure.

Table C.8: Constant Elasticities within Each Category of Commodities

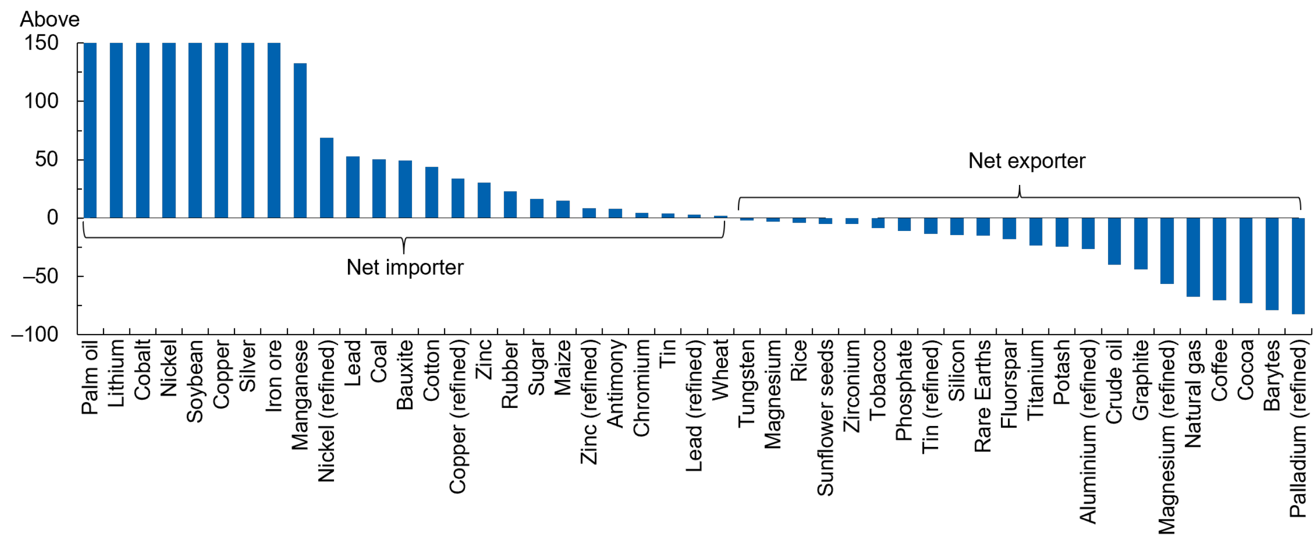
	Demand Elasticity	**Supply Elasticity**
Agriculture	-0.376	0.259
Energy	-0.348	0.092
Minerals	-0.271	0.266

Figure C.10: Price Changes by Commodity across Blocs - Constant Elasticities (Percent)

(a) US-Europe+ Bloc

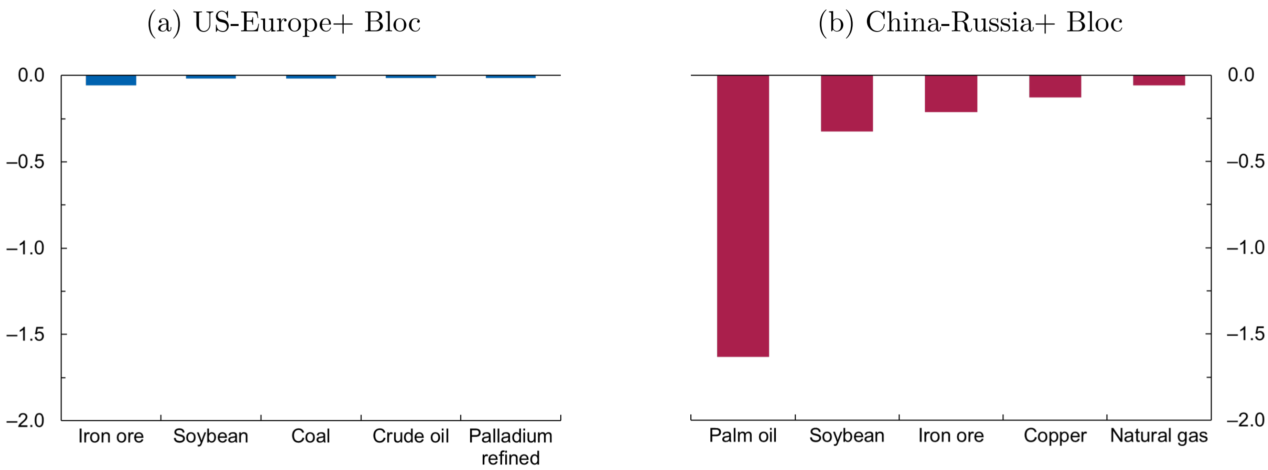


(b) China-Russia+ Bloc



Note: Each bar represents the commodity price change in each bloc induced by fragmentation of commodity trade. Price effects are capped at 150 percent for ease of exposition.

Figure C.11: Top 5 Largest Changes in Bloc-Level Total Economic Surplus - Constant Elasticities (Percent of Bloc-Level GNE)



Note: Each bar represents the decline in bloc-level total economic surplus from fragmenting trade of the corresponding commodity in the axis. GNE = gross national expenditure.

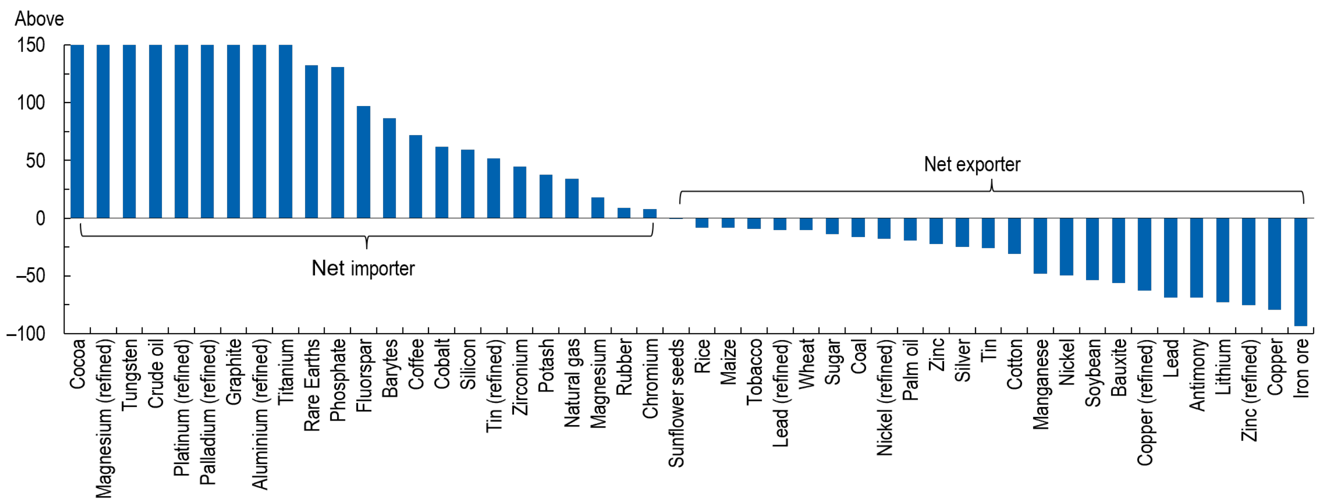
Table C.9: Alternative Blocs Configurations

	US-Europe+ Bloc	**China-Russia+ Bloc**
Bloc Configuration I	Andorra; Argentina; Aruba; Australia; Austria; Belgium; Brazil; Bulgaria; Canada; Chile; Colombia; Costa Rica; Croatia; Cyprus; Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Hungary; Iceland; India; Indonesia; Ireland; Israel; Italy; Japan; Korea; Latvia; Lithuania; Luxembourg; Malta; Mexico; Netherlands; New Zealand; Norway; Peru; Poland; Portugal; Romania; Serbia; Slovak Republic; Slovenia; Spain; Sweden; Switzerland; Tuvalu; United Kingdom; United States	Afghanistan; Albania; Algeria; Angola; Antigua and Barbuda; Armenia; Azerbaijan; the Bahamas; Bahrain; Bangladesh; Barbados; Belarus; Belize; Benin; Bhutan; Bolivia; Bosnia and Herzegovina; Botswana; Brunei Darussalam; Burkina Faso; Burundi; Cabo Verde; Cambodia; Cameroon; Central African Republic; Chad; China; Comoros; Democratic Republic of the Congo; Republic of Congo; Côte d'Ivoire; Djibouti; Dominica; Dominican Republic; Ecuador; Egypt; El Salvador; Equatorial Guinea; Eritrea; Eswatini; Ethiopia; Fiji; Gabon; Gambia; Georgia; Ghana; Grenada; Guatemala; Guinea; Guinea-Bissau; Guyana; Haiti; Honduras; Iran; Iraq; Jamaica; Jordan; Kazakhstan; Kenya; Kiribati; Kuwait; Kyrgyz Republic; P.D.R. Lao; Lebanon; Lesotho; Liberia; Libya; Macao SAR; Madagascar; Malawi; Malaysia; Maldives; Mali; Marshall Islands; Mauritania; Mauritius; Micronesia; Moldova; Mongolia; Rep. of Montenegro; Morocco; Mozambique; Myanmar; Namibia; Nauru; Nepal; Nicaragua; Niger; Nigeria; North Macedonia; Oman; Pakistan; Palau; Panama; Papua New Guinea; Paraguay; Philippines; Qatar; Russia; Rwanda; Samoa; San Marino; São Tomé and Príncipe; Saudi Arabia; Senegal; Seychelles; Sierra Leone; Singapore; Solomon Islands; Somalia; South Africa; South Sudan; Sri Lanka; St. Kitts and Nevis; St. Lucia; St. Vincent and the Grenadines; Sudan; Suriname; Syria; Tajikistan; Tanzania; Thailand; Timor-Leste; Togo; Tonga; Trinidad and Tobago; Tunisia; Türkiye; Turkmenistan; Uganda; Ukraine; United Arab Emirates; Uruguay; Uzbekistan; Vanuatu; Venezuela; Vietnam; Yemen; Zambia; Zimbabwe

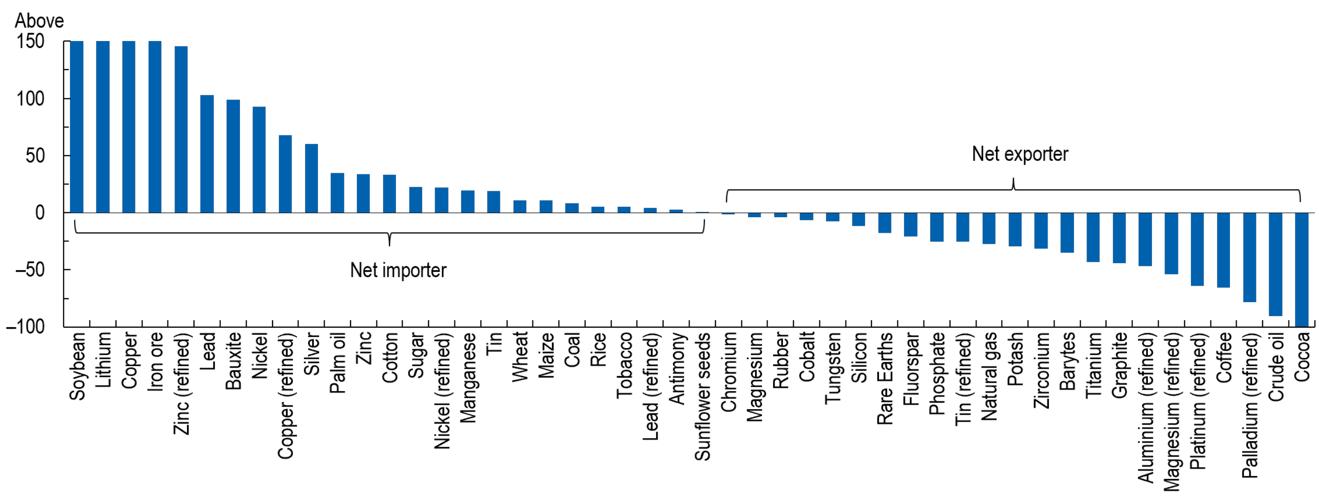
	US-Europe+ Bloc	China-Russia+ Bloc
Bloc Configuration II (main trading partner)	Albania; Algeria; Andorra; Antigua and Barbuda; Argentina; Aruba; Austria; Azerbaijan; The Bahamas; Bahrain; Bangladesh; Barbados; Belgium; Belize; Bhutan; Bolivia; Bosnia and Herzegovina; Botswana; Brazil; Bulgaria; Burkina Faso; Burundi; Cabo Verde; Cambodia; Cameroon; Canada; Central African Republic; Chile; Colombia; Comoros; Costa Rica; Côte d'Ivoire; Croatia; Cyprus; Czech Republic; Denmark; Dominica; Dominican Republic; Ecuador; Egypt; El Salvador; Equatorial Guinea; Estonia; Eswatini; Ethiopia; Fiji; Finland; France; Georgia; Germany; Greece; Grenada; Guatemala; Guinea-Bissau; Guyana; Haiti; Honduras; Hungary; Iceland; India; Ireland; Israel; Italy; Jamaica; Japan; Jordan; Latvia; Lebanon; Lesotho; Libya; Lithuania; Luxembourg; Madagascar; Mali; Malta; Mauritius; Mexico; Micronesia; Moldova; Montenegro, Rep. of; Morocco; Mozambique; Namibia; Nauru; Netherlands; Nicaragua; Niger; Nigeria; North Macedonia; Norway; Pakistan; Palau; Panama; Paraguay; Peru; Poland; Portugal; Qatar; Romania; San Marino; São Tomé and Príncipe; Saudi Arabia; Senegal; Serbia; Seychelles; Sierra Leone; Slovak Republic; Slovenia; South Africa; Spain; Sri Lanka; St. Kitts and Nevis; St. Lucia; St. Vincent and the Grenadines; Suriname; Sweden; Switzerland; Trinidad and Tobago; Tunisia; Türkiye; Uganda; Ukraine; United Arab Emirates; United Kingdom; United States; Venezuela	Afghanistan; Angola; Armenia; Australia; Belarus; Benin; Brunei Darussalam; Chad; China; Congo, Democratic Republic of the; Congo, Republic of; Djibouti; Eritrea; Gabon; Gambia, The; Ghana; Guinea; Indonesia; Iran; Iraq; Kazakhstan; Kenya; Kiribati; Korea; Kuwait; Kyrgyz Republic; Lao P.D.R.; Liberia; Macao SAR; Malawi; Malaysia; Maldives; Marshall Islands; Mauritania; Mongolia; Myanmar; Nepal; New Zealand; Oman; Papua New Guinea; Philippines; Russia; Rwanda; Samoa; Singapore; Solomon Islands; Somalia; South Sudan; Sudan; Syria; Tajikistan; Tanzania; Thailand; Timor-Leste; Togo; Tonga; Turkmenistan; Tuvalu; Uruguay; Uzbekistan; Vanuatu; Vietnam; Yemen; Zambia; Zimbabwe

Figure C.12: Price Changes by Commodity across Blocs - Bloc Configuration I (Percent)

(a) US-Europe+ Bloc

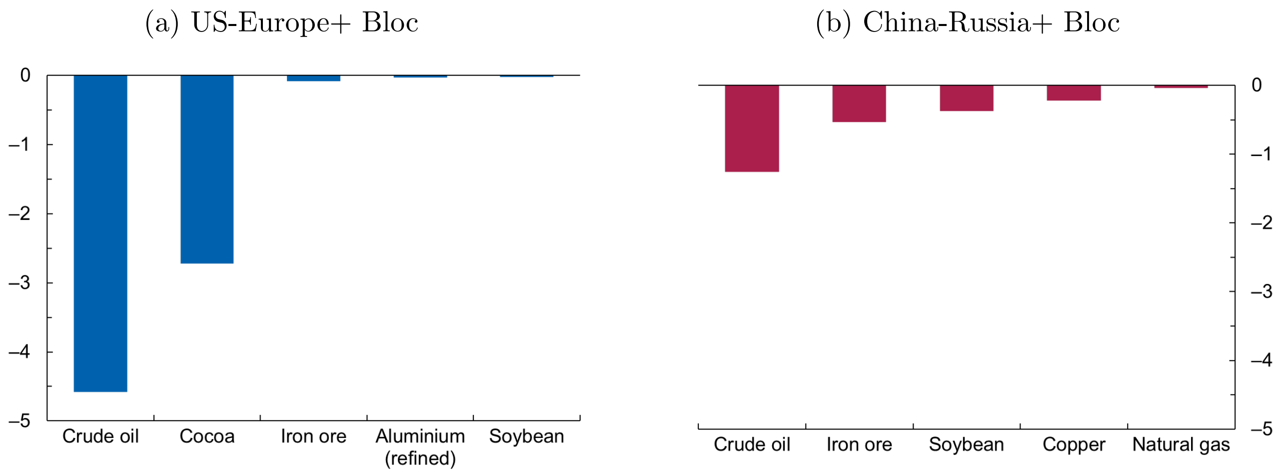


(b) China-Russia+ Bloc



Note: Each bar represents the commodity price change in each bloc induced by fragmentation of commodity trade. Price effects are capped at 150 percent for ease of exposition.

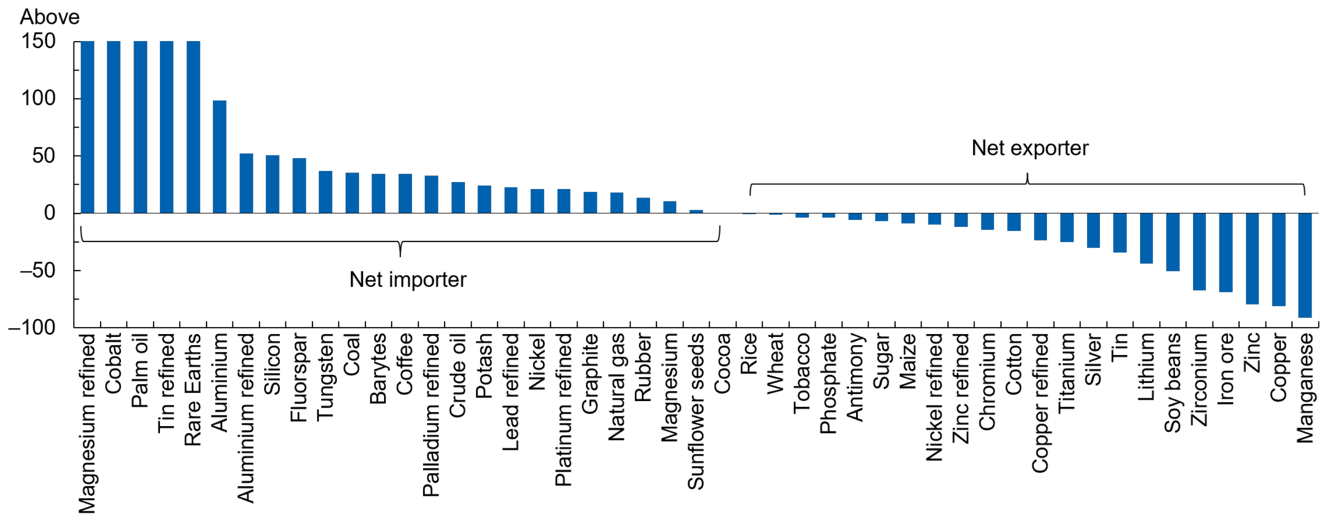
Figure C.13: Top 5 Largest Changes in Bloc-Level Total Economic Surplus - Bloc Configuration I (Percent of Bloc-Level GNE)



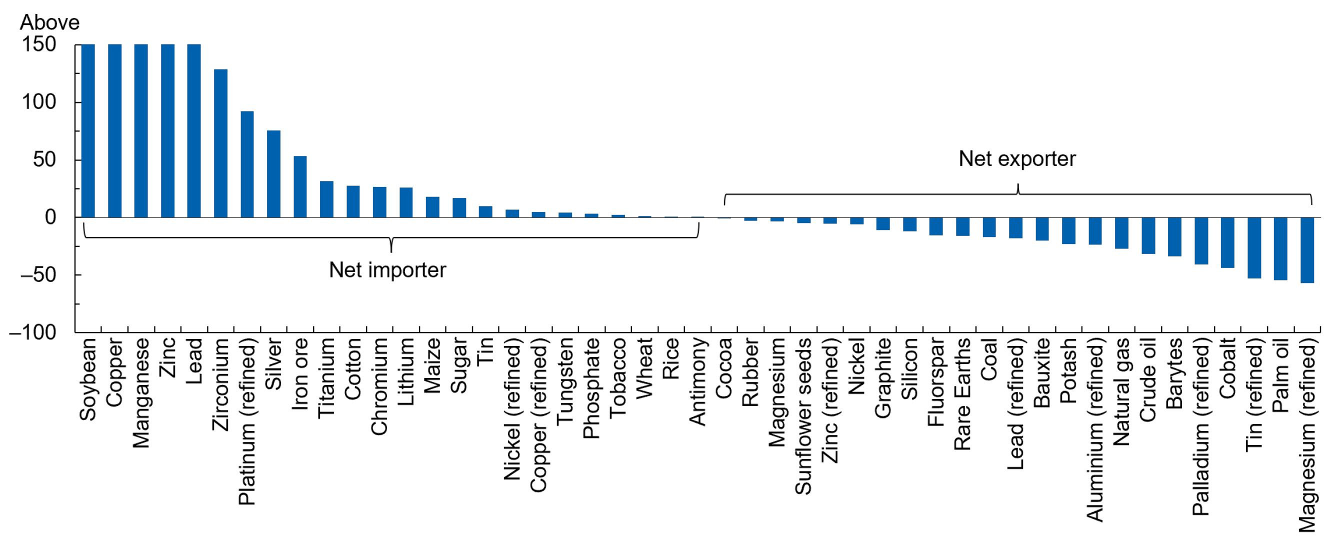
Note: Each bar represents the decline in bloc-level total economic surplus from fragmenting trade of the corresponding commodity in the axis. GNE = gross national expenditure.

Figure C.14: Price Changes by Commodity across Blocs - Bloc Configuration II (Percent)

(a) US-Europe+ Bloc



(b) China-Russia+ Bloc

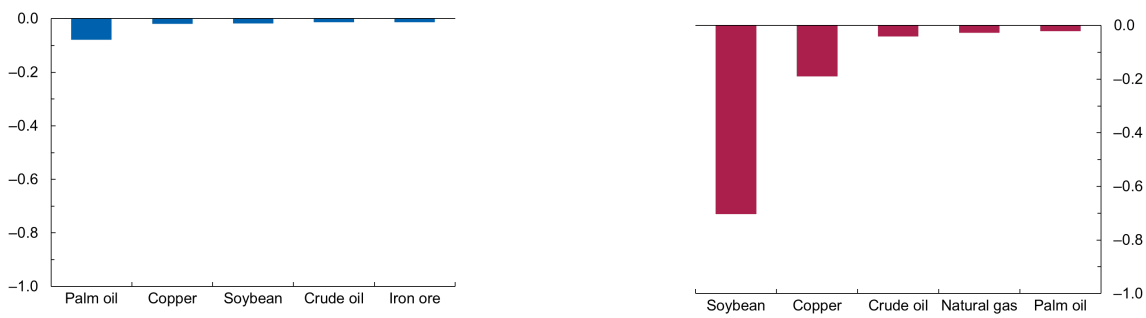


Note: Each bar represents the commodity price change in each bloc induced by fragmentation of commodity trade. Price effects are capped at 150 percent for ease of exposition.

Figure C.15: Top 5 Largest Changes in Bloc-Level Total Economic Surplus - Bloc Configuration II (Percent of Bloc-Level GNE)

(a) US-Europe+ Bloc

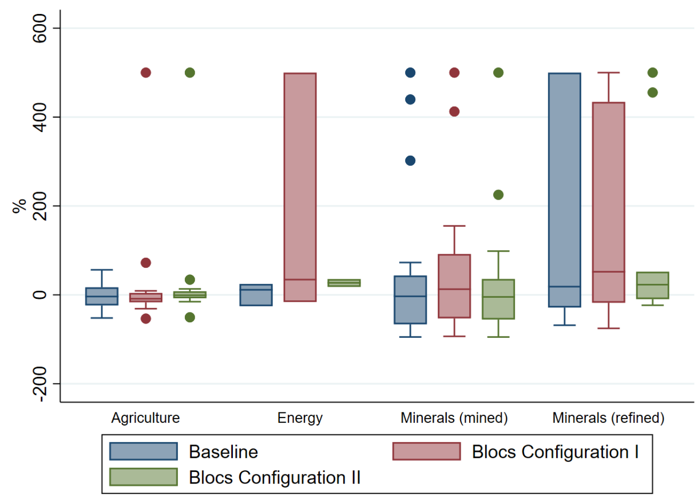
(b) China-Russia+ Bloc



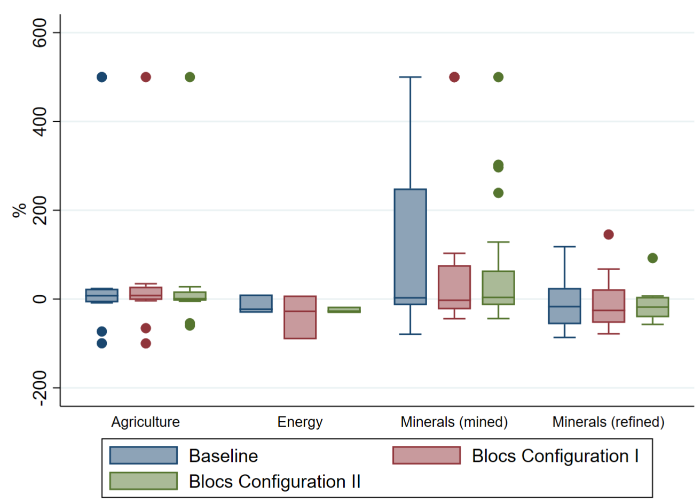
Note: Each bar represents the decline in bloc-level total economic surplus from fragmenting trade of the corresponding commodity in the axis. GNE = gross national expenditure.

Figure C.16: Comparison of Fragmentation-Induced Price Changes Across the Baseline and the Alternative Blocs Configuration

(a) US-Europe+ Bloc



(b) China-Russia+ Bloc



Note: Price effects are capped at 500 percent for readability. "Energy" refers to coal, natural gas, and crude oil. The horizontal bar represents the median, the boxes the interquartile range and the whiskers the data points within 1.5 times the interquartile rage from the 25th or 75th percentile across commodities in the group. The dots indicate outliers.

D The Effects of Fragmentation on Total Surplus

Let the demand and supply in each country be

$$\ln q_c^d = \eta^d \ln p + \gamma_c^d, \tag{15}$$
$$\ln q_c^s = \eta^s \ln p + \gamma_c^s. \tag{16}$$

or

$$q_c^d = e^{\gamma_c^d} p^{\eta^d}, \tag{17}$$
$$q_c^s = e^{\gamma_c^s} p^{\eta^s}. \tag{18}$$

We shall study how a change in p affects the total surplus (consumer+producer) in a country as well as in the whole bloc. The following two equations derive the change in consumer surplus and producer surplus, respectively.

$$\Delta CS_c = -\int_{p^0}^{p^1} e^{\eta^d \ln(p)+\gamma_c^d} dp = -\frac{e^{\gamma_c^d}}{1+\eta_d}\left(p^{1+\eta^d}\right)\Big|_{p^0}^{p^1} = -\frac{1}{1+\eta^d} p_0 q_0^d \left(\left(\frac{p_1}{p_0}\right)^{1+\eta^d} - 1\right) \tag{19}$$

$$\Delta PS_c = \int_{p^0}^{p^1} e^{\eta^s \ln(p)+\gamma_c^s} dp = \frac{e^{\gamma_c^s}}{1+\eta_s}\left(p^{1+\eta_s}\right)\Big|_{p^0}^{p^1} = \frac{1}{\eta^s+1} p_0 q_0^s \left(\left(\frac{p_1}{p_0}\right)^{1+\eta^s} - 1\right) \tag{20}$$

where the last equality of each equation follows from (17)–(18), respectively. Summing the two we obtain that total surplus is given by

$$\Delta TS_c = -\frac{1}{1+\eta^d} p_0 q_0^d \left(\left(\frac{p_1}{p_0}\right)^{1+\eta^d} - 1\right) + \frac{1}{\eta^s+1} p_0 q_0^s \left(\left(\frac{p_1}{p_0}\right)^{1+\eta^s} - 1\right) \tag{21}$$

Proposition D.1. *Suppose that the country is a commodity exporter in the global economy, so that $q_c^s > q_c^d$, and that it belongs to a commodity importing bloc. Then, the change of price from the global price to the bloc price increases the total surplus of the country.*

Proof. We shall proceed in two steps. First, in Lemma D.2 we prove that the price of the commodity rises in the commodity importing bloc. Second, in Lemma D.3, we prove that total surplus is increasing in the price of the commodity for a commodity exporter. Therefore, the change of price from the global price to the *bloc price* increases the total surplus of the country. □

Lemma D.2. *Suppose that a bloc is a commodity importer (exporter) in the global economy. Then, the price that would arise as an equilibrium price within the bloc would be higher (lower) than the global price of oil.*

Proof. We will prove for a commodity importer bloc. The proof for the exporting bloc is symmetric. Let the total supply and demand from the bloc be given by Q_B^s and Q_B^d, respectively. We assumed that $Q_B^d > Q_B^s$ in the global economy under p_0. Equilibrium in the bloc arises when $Q_B^d = Q_B^s$. Since Q^d is decreasing in p and Q^s is increasing in p, the bloc equilibrium price must be higher than p_0. □

Lemma D.3. *Suppose a country (or bloc) is a commodity exporter so that $q_c^s > q_c^d$. Then, a rise in the price of the commodity raises the total surplus of the country.*

Proof. Define $\tilde{p} \equiv \frac{p_1}{p_0}$. Then, the total surplus change is given by

$$\Delta TS_c = -\frac{1}{1+\eta^d} p_0 q_0^d \left(\tilde{p}^{1+\eta^d} - 1\right) + \frac{1}{\eta^s + 1} p_0 q_0^s \left(\tilde{p}^{1+\eta^s} - 1\right) \tag{22}$$

Differentiating with respect to $\tilde{p}$ we have

$$\frac{\partial \Delta TS_c}{\partial \tilde{p}} = -p_0 q_0^d \tilde{p}^{\eta^d} + p_0 q_0^s \tilde{p}^{\eta^s}. \tag{23}$$

The derivative is greater than zero if and only if

$$q_0^s \tilde{p}^{\eta^s} > q_0^d \tilde{p}^{\eta^d} \tag{24}$$

Rearranging, we have

$$q_0^s p_0^{-\eta^s} (p_0 \tilde{p})^{\eta^s} > q_0^d p_0^{-\eta^d} (p_0 \tilde{p})^{\eta^d} \tag{25}$$

which can be written as

$$e^{\gamma_c^s} (p_0 \tilde{p})^{\eta^s} > e^{\gamma_d} (p_0 \tilde{p})^{-\eta^d} \tag{26}$$

which can then be written, using the demand and supply functions, as

$$q^s(p_0 \tilde{p}) > q^d(p_0 \tilde{p}). \tag{27}$$

This condition holds because $q_0^s > q_0^d$ together with q^s being an increasing function in p and q^d a decreasing function in p, with $\tilde{p} > 1$. So for all $\tilde{p} > 1$, a rise in the price of the commodity raises the total surplus of the commodity exporting country. Let $\bar{p} > p_0$ be the new equilibrium price. Then, the change in surplus is given by

$$\int_1^{\frac{\bar{p}}{p_0}} \frac{\partial \Delta TS_c}{\partial \tilde{p}} d\tilde{p} > 0, \tag{28}$$

where the inequality follows from $\frac{\partial \Delta TS_c}{\partial \tilde{p}} > 0$ for all $\tilde{p} > 1$. □

Proposition D.4. *Total surplus in each bloc is declining from fragmentation.*

Proof. Using Lemma D.2, we know that that price in the commodity exporting bloc is declining and that in the importing bloc is rising. As shown in Lemma D.3, the derivative of total surplus with respect to the change in price $\tilde{p} \equiv \frac{p_1}{p_0}$ is

$$\frac{\partial \Delta TS_c}{\partial \tilde{p}} = -p_0 q_0^d \tilde{p}^{\eta^d} + p_0 q_0^s \tilde{p}^{\eta^s}, \tag{29}$$

which was shown to be positive if and only if $q^s(p_0 \tilde{p}) > q^d(p_0 \tilde{p})$.

The change in total surplus in a block is given by

$$\int_{1}^{\frac{p_1^b}{p_0}} \frac{\partial \Delta TS_c}{\partial \tilde{p}} d\tilde{p}. \tag{30}$$

We will prove for the commodity importing bloc, the proof for the exporting block is symmetric. In that bloc, $p_1^b > p_0$ so that $\frac{p_1^b}{p_0} > 1$. For all $p \in (p_0, p_1^b)$, we have that $q^s(p) - q^d(p) \leq 0$. This follows from the two boundary conditions $q^s(p_0) - q^d(p_0) < 0$ and $q^s(p_1) - q^d(p_1) = 0$, together with the fact that $q^s(p) - q^d(p)$ is an increasing function of p. Therefore, the integrand is always negative in $(1, \frac{p_1^b}{p_0}$. So that total surplus is negative. □