CHAPTER 3

FRAGMENTATION AND COMMODITY MARKETS: VULNERABILITIES AND RISKS

Russia's invasion of Ukraine in 2022 caused major commodity markets to fragment, and continued geopolitical tensions could make matters worse. This chapter examines the key channels through which further disruptions in commodity trade could affect prices, economic activity, and the clean energy transition. It finds that commodity markets are particularly vulnerable in the event of fragmentation. Commodity production is often highly concentrated because of natural endowments, and many commodities are difficult to substitute in the short term. Further fragmentation of commodity markets—which had been on the rise even before the war in Ukraine—could cause large price changes and more price volatility. Model simulations suggest that trade disruptions could result in substantial economic impacts in commodity-dependent economies. However, due to offsetting effects across producing and consuming countries, global economic costs appear modest. Crucially, low-income countries with a high reliance on agricultural imports would be disproportionately affected, raising food security concerns. The fragmentation of mineral markets could also make the clean energy transition more costly and lead to lower-than-needed investment in renewable energy and electric vehicles. Taken together, the findings present yet another argument for multilateral cooperation on trade policies. At the very least, agreements on a "green corridor" for critical minerals and a "food corridor" would safeguard the global goals of averting climate change and food insecurity.

Introduction

Since the end of the Cold War, primary commodity markets have become more integrated as a result of trade liberalization, technological innovation, and declines in transportation costs. Integrated commodity markets have provided cheap inputs that have supported global growth and so have helped raise living standards, especially in emerging markets.[1]

However, the war in Ukraine put this process in reverse. For the first time since the 1970s, commodities such as crude oil, natural gas, and wheat were broadly used to exert pressure in a major conflict. Exports were restricted and countersanctions imposed. These disruptions in commodity trade contributed to surging inflation in 2022 in many parts of the world, food insecurity in low-income countries, and slower global growth (IMF 2023).

While most commodity prices have since normalized, geopolitical tensions signal that more severe fragmentation of commodity trade is a major risk.[2] Many countries are trying to reshore commodity supply chains for national security, geopolitical, or other reasons. Measures include those for critical minerals for clean energy technologies, semiconductors, and defense (examples of actions are the US Inflation Reduction Act, the European Chips Act, and China's export restrictions on gallium and germanium).

As a result, concerns about fragmentation, deglobalization, and nearshoring have risen sharply, especially in the commodity sector (Figure 3.1). Text mining analysis of earnings calls reveals that prior to the COVID-19 pandemic, firms barely mentioned keywords related to fragmentation, but usage surged after Russia's invasion of Ukraine.

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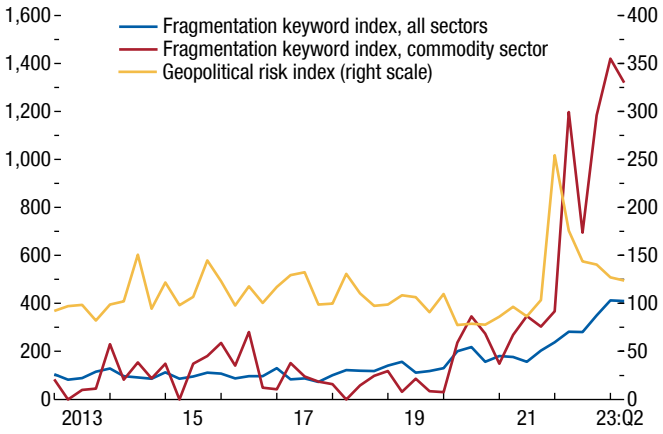
[1]Economic theory suggests that the consumption gains and the more efficient use of resources generated by trade should boost GDP. See Feyrer (2019, 2021) for recent analysis and Irwin (2019) for a review of the literature on trade and growth.

[2]Building on Aiyar and others (2023), the chapter defines geoeconomic fragmentation (referred to as "fragmentation" for brevity in the rest of the chapter) 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 (Arndt and Kierzkowski 2000; Deardorff 2001).

Figure 3.1. Fragmentation Keywords in Earnings Calls
(Indices, 2013–15 = 100)



Sources: Caldara and Iacoviello (2022); Hassan and others (2019); NL Analytics, Inc.; and IMF staff calculations.
Note: Fragmentation indices measure the average number of sentences, per thousand earnings calls, that mention at least one of the following keywords: *deglobalization, reshoring, onshoring, nearshoring, friend-shoring, localization, regionalization.*

There is little consensus on the economic costs of fragmentation in the fast-growing literature. Estimates of long-term output losses from restricting the international flow of goods and services, finance, and technology range from 0.2 percent to 12 percent of global GDP, depending on the scenario and assumptions.[3] Commodity markets could be another important channel through which further disruptions in trade affect activity. Commodity production is hard to relocate, as it is linked to natural endowments such as geological deposits or soil quality. Consumption of commodities is often difficult to substitute in the short term. Moreover, many commodities are crucial inputs for manufacturing and technologies, including those related to the clean energy transition.

Against this backdrop, the chapter studies the main channels through which further fragmentation of markets for energy, agricultural, and mineral commodities could affect economies and global public goods—namely, the energy transition. It focuses on the following questions:

- What makes commodity markets vulnerable in the event of fragmentation?
- Is there fragmentation in commodity markets, and if so, what form does it take?
- Which commodities are most vulnerable to disruptions in international trade?
- What would be the economic impact of commodity market fragmentation across blocs and countries, as well as on the global economy?
- What might be the implications of such fragmentation for the clean energy transition?

The chapter covers nearly all countries and focuses on 48 commodities, including agricultural goods, energy commodities—namely, coal, crude oil, and natural gas—and other mineral commodities. It builds a unique database of commodity output, use, and bilateral trade, and employs a combination of descriptive statistics, empirical analysis, and model simulations.

The chapter simulates a highly stylized risk scenario, in which commodity trade between two geopolitical blocs is persistently disrupted, to illustrate the channels through which commodity market fragmentation could affect prices and output. The main scenario defines the two theoretical blocs by using the 2022 United Nations (UN) vote on the war in Ukraine as a transparent starting point. However, the chapter examines alternative scenarios, including the role of neutral countries and the impact of countries' switching blocs, given the sensitivity of the analysis to bloc configurations and the difficulty of assessing bloc configurations' plausibility.[4]

[3]See Aiyar and others (2023) for an overview of potential channels of impact. Recent studies that quantify aggregate losses from restricting trade include Albrizio and others (2023); Attinasi, Boeckelmann, and Meunier (2023); Bolhuis, Chen, and Kett (2023); Fally and Sayre (2018); Felbermayr, Mahlkow, and Sandkamp (2022); Hakobyan, Meleshchuk, and Zymek (2023); and Javorcik and others (2022). Chapter 4 of the April 2023 *World Economic Outlook* examines the consequences of restrictions on investment, and Chapter 3 of the April 2023 *Global Financial Stability Report* does the same for portfolio flows, whereas Cerdeiro and others (2021) and Góes and Bekkers (2022) quantify the losses once technological decoupling is also considered.

[4]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 chapter. The two-bloc scenario presented here is meant to provide a clearly defined baseline and to make the exercise comparable to those in the recent literature. Introducing neutral countries reduces the impact of fragmentation, as discussed later in the chapter.

Online Annex 3.1 provides details on the commodities and countries and their allocation across blocs as well as data sources. Online Annex 3.5.2 discusses the robustness of some of the key findings to different bloc configurations. All online annexes are available at www.imf.org/en/Publications/WEO.

The main findings are as follows:

- *Commodities are vulnerable in the event of fragmentation.* The importance of natural endowments for production can lead to high geographic concentration of output. For example, the three biggest suppliers of minerals account for about 70 percent of global production, on average. Coupled with low demand elasticities and their upstream use in many manufacturing processes and key technologies, this means that commodities are highly traded. However, many importers rely on just a few suppliers. These features raise the cost of trade disruptions.
- *There is rising fragmentation in commodity markets.* Measures restricting commodity trade surged in 2022, much more than those restricting trade in other goods. For selected commodities, price differentials across geographic markets have widened. And commodity sector foreign direct investment (FDI) and cross-border mergers and acquisitions were on the decline even prior to the war in Ukraine.
- *Fragmentation could cause large 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. Illustrative partial equilibrium model simulations suggest that price effects could be particularly strong for some minerals critical for the green transition and some highly traded agricultural goods. Spikes in agricultural commodity prices could be concerning for many low-income countries reliant on imports to feed their population.
- *Fragmented commodity markets would also lead to higher price volatility.* Smaller markets in a fragmented world would provide fewer buffers against commodity supply and demand shocks, leading to larger price responses than under free trade. Moreover, commodity producers would have powerful incentives to switch allegiances given potentially significant differences in commodity prices among blocs. This would induce more supply shocks, volatility, and uncertainty in commodity markets, challenging fiscal, monetary, and financial stability.
- *For many commodity-dependent economies, fragmentation would lead to sizable macroeconomic impacts.* For some low-income countries and emerging market economies, illustrative trade model simulations point to long-term output losses exceeding 2 percent. Due to vastly different and often offsetting impacts across net commodity-producing and net commodity-consuming countries, however, economic losses appear relatively modest at the global level. This should not lead to complacency: the chapter quantifies only the restriction of commodity trade between blocs. Should the world fragment into isolated blocs, the flows of other goods and services, finance, technology, and know-how would most likely also be disrupted, amplifying global economic costs (Aiyar and others 2023). The higher volatility and uncertainty brought on by commodity market fragmentation would complicate policymaking and add to costs, a channel that is also not captured. Moreover, within countries, offsetting effects on commodity consumers and producers imply strong distributional impacts even absent large aggregate output effects. Fragmentation in agricultural commodity markets could raise food insecurity in low-income countries, with high social and humanitarian costs that are not included in the chapter's model simulations. In sum, commodity market fragmentation could deliver a sizable economic blow in an already challenging environment of slow global growth, tight financial conditions, and high debt in many vulnerable countries.
- *Fragmentation in mineral markets could make the clean energy transition more costly.* Demand for critical minerals is projected to rise severalfold in a net-zero-carbon-emissions scenario. These minerals are highly concentrated geographically, and their elasticities of demand and supply are low, so trade disruptions could add to upward pressure on mineral prices in the bloc where demand exceeds supply after fragmentation. But the mineral-rich bloc cannot reap the benefits from oversupply, as refining capacity cannot be scaled up quickly. In the illustrative simulation, fragmentation results in up to 30 percent lower-than-needed investment in renewables and electric vehicles (EVs) at the global level by 2030.

What Makes Commodities Vulnerable in the Event of Fragmentation?

This section documents several features of commodity markets that would raise the economic costs of disrupting their trade, despite commodities' homogeneity and fungibility.

Production Concentration

The first production stage of commodities depends on natural endowments, which can be heavily concentrated geographically. For instance, the extraction of minerals and energy commodities requires cost-effective geological deposits. Availability of fertile soil, water, and an adequate climate can constrain agricultural production and yields. As a result, the three largest-producing countries account for about 65 percent of the global output of agriculture, about 50 percent of that of energy, and about 70 percent of that of mineral commodities on average (Figure 3.2, panel 1).[5]

Minerals represent a special case: production is concentrated both at the first stage (mining) because of the geographic concentration of deposits, and also at the second (processing) stage. Relocating production at the mining stage may be impossible over the short and medium term, given the importance of natural endowments.

Elasticities of Supply and Demand

The price elasticity of supply, which measures how output responds to price changes, is relatively low for commodities in the short term (Figure 3.2, panel 2). Scaling up production requires large investments, environmental permitting, and community consultations 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 2021). Discovering new deposits is also costly and takes time.[6]

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). These help explain the geographic concentration at the refining and processing stages.

On the demand side, many commodities are inputs for key technologies and products or are essential to household consumption (food, heating, cooking, and transportation are examples). Disruptions to their supply can cause ripple effects across sectors and value chains. As upstream inputs for the production of a vast array of goods and services (Figure 3.2, panel 3), they are often hard to substitute, and demand responds little to swings in prices. This is reflected in their low price elasticity of demand, particularly in the short term.

Importance of Trade

With production highly concentrated and demand often broadly spread across countries, commodities are heavily traded. Their homogeneity and fungibility—despite low demand and supply elasticities, commodities have a high elasticity of substitution across suppliers—also contribute to market integration. The share of production traded internationally is higher for most commodities than the ratio of world trade to gross output (Figure 3.2, panel 4). On average across agricultural and energy commodities, about 30 percent of output is dedicated to trade and about 45 percent for minerals, with the shares substantially higher for many commodities.[7]

As a result, imports satisfy a large part of the demand for commodities. However, many countries depend on only a handful of suppliers (Figure 3.2, panel 5). For example, roughly half of the world's countries rely on three or fewer exporting countries for their imports of minerals, and a quarter on only one. This leaves them vulnerable to supply disruptions in the near term.[8]

[5]The chapter focuses on countries and not firms. Commodity extraction is often undertaken by multinationals or firms owned by foreign investors (Leruth and others 2022). Firm-level concentration could be different from country-level concentration. 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, Spiro, and Van Benthem 2019). The chapter also focuses on production rather than reserves owing to lack of data availability. Reserves and production are highly correlated (USGS 2023).

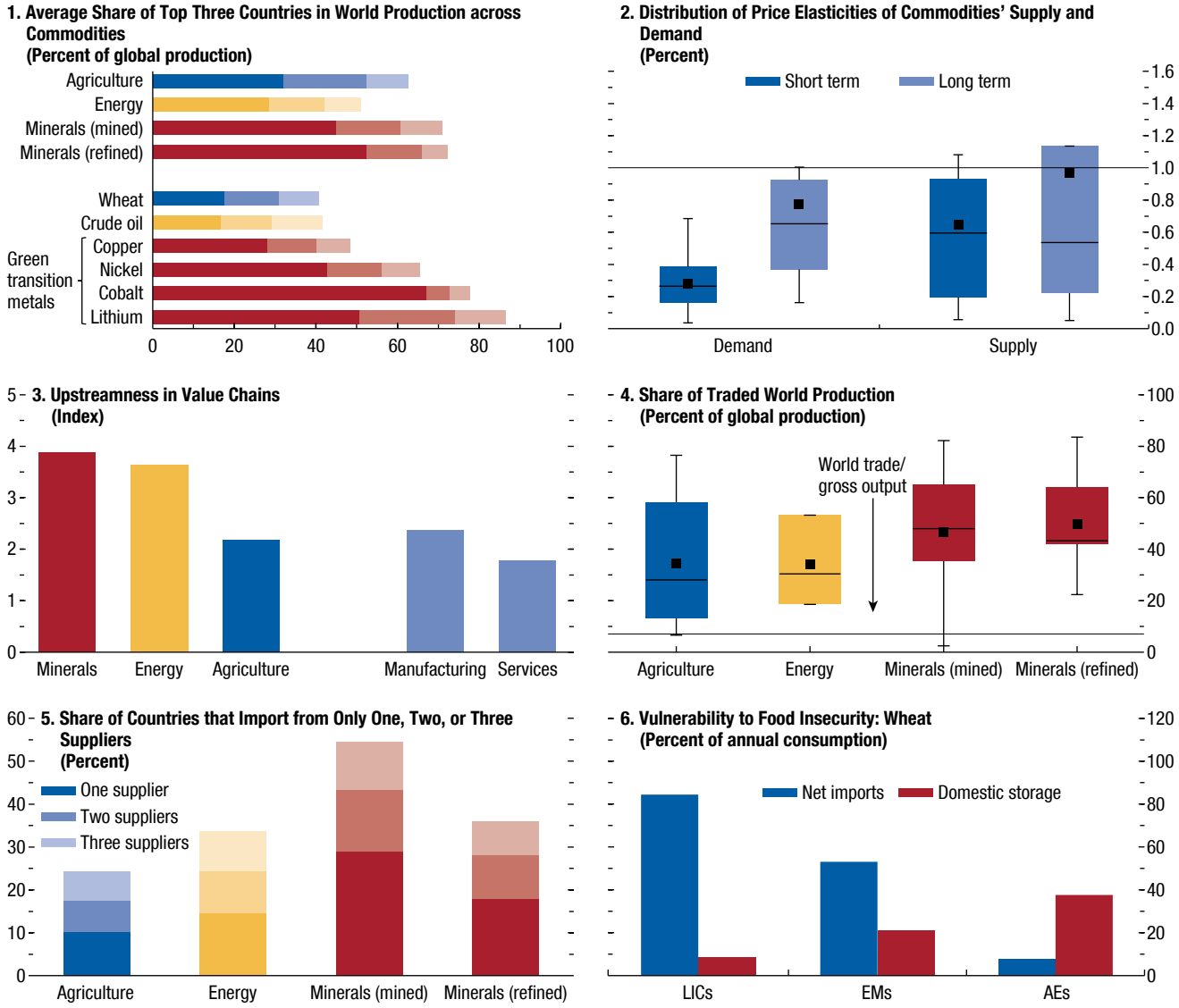
Online Annex 3.2 provides the production and import concentration and the share of trade in output for the commodities. Concentration of production is also apparent at the firm level, with a few countries taking stakes in key firms (Leruth and others 2022).

[6]Elasticities below 1 are generally considered low. See Fally and Sayre (2018) and Dahl (2020) for a literature review on supply and demand elasticities across commodities. Arezki, van der Ploeg, and Toscani (2019) analyze the responsiveness of resource discoveries to market incentives. It is worth noting that the sizable investments needed to expand the supply of commodities may be hindered by the disruptions in external capital flows and higher uncertainty that geoeconomic fragmentation might trigger, as discussed in the April 2023 *World Economic Outlook* and April 2023 *Global Financial Stability Report*.

[7]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 declined from roughly 45 percent in the first half of the 20th century to about 13 percent in 2019–21 (Online Annex Figure 3.2.4).

[8]Historically, countries were often able to adapt to trade disruptions over the medium to long term by finding alternative suppliers, because of commodities' homogeneity, or by developing substitutes (see Box 3.2).

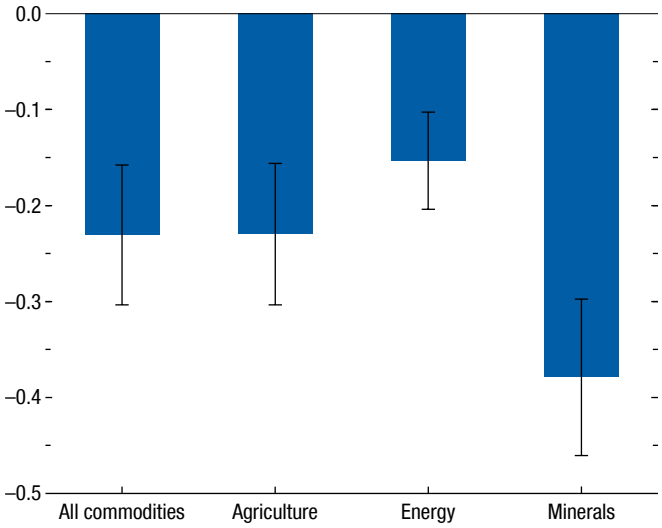
Figure 3.2. Commodities: Key Characteristics



Sources: Antràs and others (2012); British Geological Survey; Dahl (2020); Fally and Sayre (2018); Food and Agriculture Organization of the United Nations; Gaulier and Zignago (2010); International Energy Agency; US Department of Agriculture; US Geological Survey; and IMF staff calculations.
Note: "Energy" refers to coal, natural gas, and crude oil. This figure uses 2019 data due to data availability and to avoid biases caused by the pandemic. Panel 1 provides the share of global production that the top three producing countries account for (see Online Annex Figure 3.2.2) and gives averages across commodity types. In panels 2 and 4, the horizontal lines in the bars represent the median, the squares the average, the bars the interquartile range, and the whiskers the minimum and maximum values across commodities in the group. In panel 3, sectoral upstreamness is based on Antràs and others (2012) and is computed as the weighted average position of an industry's output in the value chain. The upstreamness index captures how far a specific sector is from the final end usage, with a lower index value (minimum value of 1) implying that the sector is closer to final demand. Panel 4 does not include palladium and platinum due to data quality. Panel 5 depicts the simple average across commodities of each group. Panel 6 depicts the simple average across countries within each income group, for 2019. AEs = advanced economies; EMs = emerging markets; LICs = low-income countries.

Import dependence in agricultural commodities can lead to food insecurity in case of trade disruptions, particularly in low-income countries. For instance, the average low-income country imports more than 80 percent of the wheat it consumes. Given low storage capacity, consumption smoothing can be difficult in these countries, exposing populations to large swings in prices or food shortages (Figure 3.2, panel 6). The ramifications of food commodity shocks, which have been linked to social unrest, conflict, and migration (Kelley and others 2015; Missirian and Schlenker 2017; Burke and McGuirk 2020), go beyond the economic analysis that follows.

Figure 3.3. Commodity Trade and Distance of Military Alliances
(Coefficients)



Sources: Food and Agriculture Organization of the United Nations; Gaulier and Zignago (2010); Leeds and others (2002); Signorino and Ritter (1999); and IMF staff calculations.
Note: "Energy" refers to coal, natural gas, and crude oil. The bars in the figure denote the point estimates, and the vertical lines represent 95 percent confidence intervals. Standard errors are clustered at the importer country level. Estimates are based on an inverse hyperbolic sine specification to account for zeros. Distance of military alliances is measured using the similarity between countries' portfolios of military alliances and standardized so its standard deviation is 1 in each year. A standardized military distance of 1 is approximately the distance between India and Morocco in 2018.

Sensitivity to Geopolitics

Analysis of trade patterns suggests that commodity trade is historically associated with countries' geopolitical alignment. Gravity equations, estimated for the commodities in the sample and augmented to include the similarity between countries' portfolios of military alliances, show that bilateral commodity trade flows are negatively associated with military distance (Figure 3.3).[9] However, notable differences are apparent in the strength of the relationship across types of commodities: a one-standard-deviation increase in the distance of military alliances (approximately the distance between India and Morocco in 2018) is associated with a decrease in trade in energy commodities by about 15 percent but it is associated with a more than 35 percent decline in minerals trade. The exercise suggests that changes in military alliances because of rising geopolitical tensions could go hand in hand with disruptions of trade flows and fuel fragmentation of commodity trade.

Fragmentation in Commodity Markets

This section takes stock of various measures of fragmentation. The number of new interventions in commodity trade has risen every year since 2018, with the increase initially fueled by tensions between China and the United States and the COVID-19 pandemic. In 2022, Russia's war in Ukraine caused a major spike in new trade restrictions for commodities: there were more than six times more new restrictions affecting trade in commodities in 2022 than the 2016–19 average. In contrast, trade-restricting measures on overall trade increased 3.5 times (Figure 3.4, panel 1).[10]

Price dispersion across locations can also be a symptom of fragmentation: as commodities are homogeneous goods, they should trade under one price after transportation costs are accounted for. However, price dispersion increased in major commodity markets in 2022, especially in those for some minerals, such as lithium, and energy commodities (Figure 3.4, panel 2). For example, Russian coal traded at a price almost three times lower than Australian coal in September 2022. Price dispersion for crude oil and natural gas also rose as the war in Ukraine and associated sanctions disrupted trade. Box 3.1 documents shifts in trade flows using real-time vessel-tracking data.

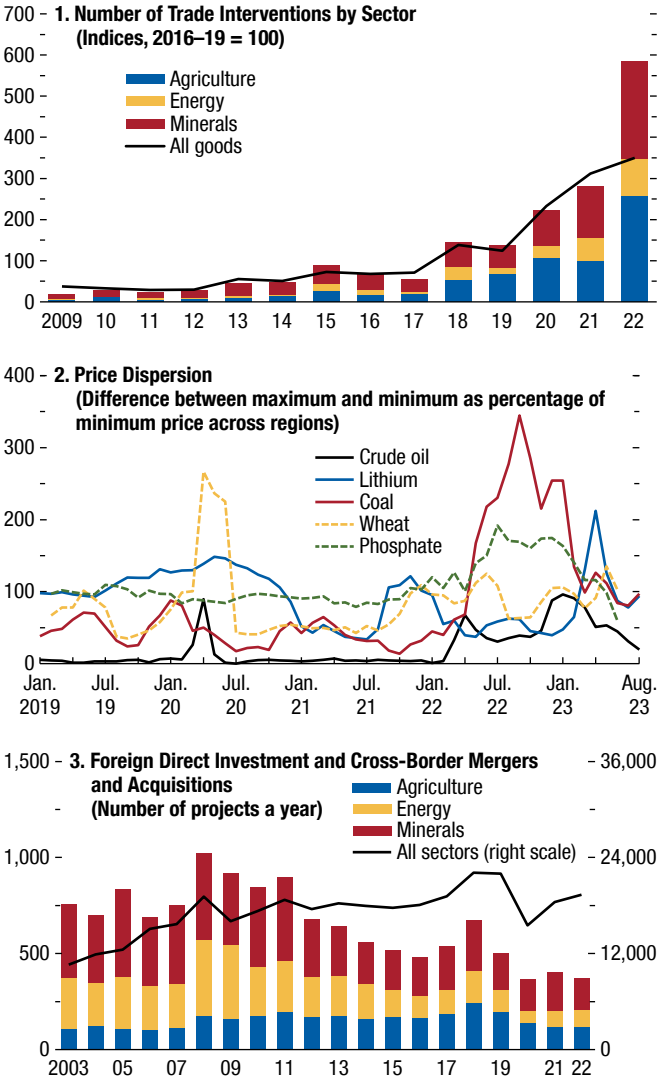
Other proxies for fragmentation are changes in the number of FDI projects and cross-border mergers and acquisitions, which are also indicators of future trade. They were declining in the energy and mineral sectors even before the war in Ukraine, which could presage a slowdown in commodity trade (Figure 3.4, panel 3).[11] Shifts have also occurred in the origin and destination

[9]The gravity model is widely used to explain bilateral trade flows based on country and country pair characteristics that capture trading costs, such as geographic distance or a common border, language, or currency. Online Annex 3.3 provides details and robustness checks. Distance in military alliances is associated with lower trade in minerals across specifications. The results are more sensitive for other measures of geopolitical alignments, namely, the ideal point distance based on UN votes, used in Chapter 4 of the April 2023 *World Economic Outlook* in a similar analysis for FDI flows (see also Jakubik and Ruta 2023). Hakobyan, Meleshchuk, and Zymek (2023) examine distance in military alliances and sectoral trade flows.

[10]Trade interventions in the Global Trade Alert database, the source for the data in Figure 3.4, panel 1, include both measures that increase fragmentation, such as import tariffs and export restrictions, and measures that aim to limit the economic fallout from fragmentation by encouraging diversification, such as subsidies for local producers, local-content requirements, and the like—although a strict distinction between the two is difficult.

[11]Following Chapter 4 of the April 2023 *World Economic Outlook*, the analysis focuses on the number rather than the value for FDI and cross-border mergers and acquisitions. Data on values are limited and often estimated. However, FDI values suggest a similar decline in the commodity sector.

Figure 3.4. Signs of Fragmentation



Sources: Argus Media, Inc.; Bloomberg Finance L.P.; FDI Markets; Global Trade Alert database; Refinitiv Eikon; UN Comtrade; and IMF staff calculations.
Note: Policy interventions are adjusted for reporting lags, and trade-liberalizing interventions are excluded from calculations. Prices for crude oil, coal, and lithium are market prices in different regional markets as retrieved from Bloomberg Finance L.P. Wheat and phosphate price dispersion is estimated based on export prices for countries that account for more than 5 percent of global exports, based on export data from UN Comtrade. Panel 3 presents the total number of foreign direct investment and cross-border mergers and acquisitions projects at the global level. The bars provide a breakdown by commodity group.

of commodity FDI and cross-border mergers and acquisitions. US and EU investors are increasingly targeting projects in advanced economies, whereas China and Russia have increased their investments in Africa (see Online Annex Figure 3.2.5).[12]

[12]Chapter 4 of the April 2023 *World Economic Outlook* documents FDI flows are increasingly concentrated among geopolitically aligned countries, particularly in strategic sectors.

No measure of fragmentation is perfect. It is still too early to assess how long-lasting price dispersion will be. The decline in FDI could reflect moderation in commodity prices since 2015, following the decade-long commodity boom, and it is not clear, on account of lagging data, to what extent trade-restricting measures have affected trade flows (Goldberg and Reed 2023). However, taken together, these measures suggest rising commodity market fragmentation.

Which Commodities Are Most Vulnerable?

To assess individual commodities' vulnerability in the event of fragmentation, this section presents results from a single-commodity, multicountry partial equilibrium model based on Alvarez and others (2023) (see also Online Annex 3.4 for details). It computes price changes that would occur if trade for each of the 48 commodities included in the analysis were banned across two blocs.

For illustrative purposes, the main scenario assumes that the two theoretical blocs are constructed based on the 2022 UN vote on Russia's war in Ukraine. The bloc comprising countries that voted for Russia to withdraw from Ukraine is labeled the "US-Europe+ bloc"; the remaining countries are in the "China-Russia+ bloc."[13] The exercise assumes, in a highly stylized and extreme way, that there is no trade in a particular commodity between blocs, whereas intrabloc trade of the commodity is unaffected. Box 3.2 discusses more fluid experiences of fragmentation; investigating the impacts of those intermediate scenarios is beyond the scope of the chapter. Rather, the chapter's goal is to identify relative vulnerabilities across commodity markets and to illustrate transmission channels, with the recognition that partial interactions between blocs and arbitrage opportunities could mute the economic effects implied by the model simulations.

For each commodity, the model's initial calibration is based on observed 2019 trade flows. They are assumed to reflect an integrated world, where goods are traded at one global price.[14] The trade ban across

[13]See also Chapter 3 of the October 2022 *Regional Economic Outlook: Asia and Pacific*. More details on the countries in each bloc and sensitivity checks for other bloc configurations are in Alvarez and others (2023) and Online Annexes 3.1.2 and 3.5.2.

[14]The assumption of perfect trade integration in the baseline oversimplifies reality, as markets for some commodities were not perfectly integrated globally even before the war in Ukraine.

blocs yields bloc-specific prices that clear bloc-level supply and demand.

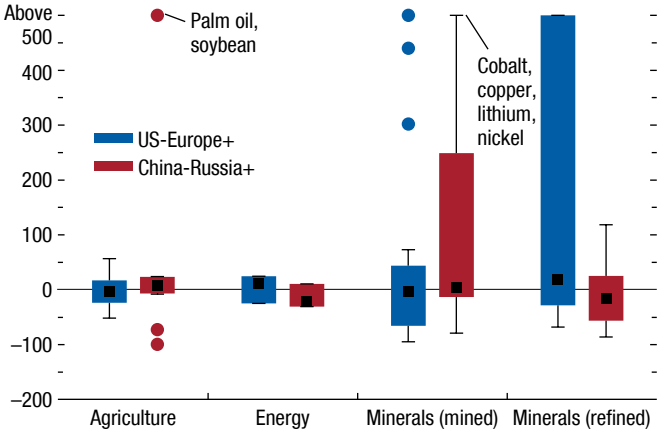
Fragmentation would induce opposite price effects across blocs. The price of a commodity falls in the bloc that used to be a net exporter of that commodity and increases in the net importing bloc. The size of price changes depends on (1) bloc-level supply-and-demand imbalances prior to fragmentation—that is, the extent to which a bloc relies on imports to satisfy its demand at the integrated world price—and (2) the capacity of demand and supply to respond to changing prices (the price elasticities of demand and supply). Commodities with inelastic demand and supply and with high imbalances across blocs are more vulnerable to price changes.[15]

Model simulations suggest that the potential price impact of fragmentation would vary significantly across commodities, with some potentially experiencing very large price increases (Figure 3.5; see Online Annex Figure 3.5.1 for the underlying commodity-specific results).[16] In the China-Russia+ bloc, the price of mined minerals, including cobalt, lithium, copper, and nickel, which are critical for the green transition, would rise substantially. Production of these minerals would be concentrated in a handful of countries in the US-Europe+ bloc, but they are largely used as inputs in the China-Russia+ bloc (see Online Annex Figure 3.2.6). At the same time, the US-Europe+ bloc could experience similar increases in the prices of refined minerals, which are processed mostly in China, Russia, and South Africa.

In contrast, the potential price changes for energy and most agricultural commodities are more subdued in the main simulation. Since the production of these commodities is less geographically concentrated, supply and demand are more balanced across the two blocs. However, palm oil and soybean represent two important outliers: more than 80 percent of production would occur in the US-Europe+ bloc, whereas most of the consumption would take place in the China-Russia+ bloc.

Because of high geographic concentration, the vulnerability of commodities in the event of fragmentation depends on the distribution of key exporters (and importers) across blocs. Simulations based on different country compositions of the two hypothetical blocs, described in Online Annex 3.5.2, suggest that, in a way similar to what occurs in the main simulation, fragmentation would lead to significant price increases for minerals at the mining stage and for key agricultural staples (such as soybeans) in the China-Russia+ bloc. In an alternative bloc scenario, in which all emerging market and developing economies, excluding India, Indonesia, and Latin American countries, are assigned to the China-Russia+ bloc, the US-Europe+ bloc could experience large price increases for some minerals. This is because key producers are allocated to the other bloc. It could also become more vulnerable in case of trade restrictions on some agricultural commodities (such as cocoa) and crude oil.

Figure 3.5. Price Changes Due to Fragmentation in Individual Commodity Markets
(Percent)



Sources: British Geological Survey; Food and Agriculture Organization of the United Nations; Gaulier and Zignago (2010); International Energy Agency; United States Geological Survey; and IMF staff calculations.
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. For the underlying complete information on commodity-specific price changes, see Online Annex Figure 3.5.1. The bloc including the countries that voted for Russia's withdrawal from Ukraine in the 2022 UN vote is labeled the "US-Europe+ bloc," and the remaining countries are included in the "China-Russia+ bloc."

Higher Commodity Price Volatility

Fragmented commodity markets would lead to higher price volatility (see Jacks, O'Rourke, and Williamson 2011, for historical evidence). This would challenge public finances and fiscal and monetary frameworks, giving rise to potential procyclicality of fiscal and monetary policies and hurting economic

[15]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, Rausser, and Smith (2011) provide a literature review.

[16]The following partial equilibrium results are based on Alvarez and others (2023).

stability (Cavalcanti, Mohaddes, and Raissi 2015; IMF 2023). Fragmentation can affect price volatility through at least two channels: smaller market sizes and countries switching blocs.[17]

Smaller Market Sizes

In a fragmented world, markets would become smaller and bloc-level prices more responsive to country-level shocks (see also Albrizio and others 2023). In the partial equilibrium model, the price response is proportional to the supply shock's size relative to the overall market. Thus, by restricting the set of countries with which they trade, countries would face larger price increases in response to the same negative supply shocks.[18] In an illustrative example, Figure 3.6 compares the price impact of a three-standard-deviation shock to the US wheat harvest in an integrated market with that in a fragmented market.[19] The same supply shock doubles the impact on wheat prices when trade is fragmented into two smaller blocs. This is important, as climate change is expected to raise the variability of agricultural output. A fragmented world, in which the price response to supply shocks is amplified, would be less able to cope with this challenge.

Countries Switching Blocs

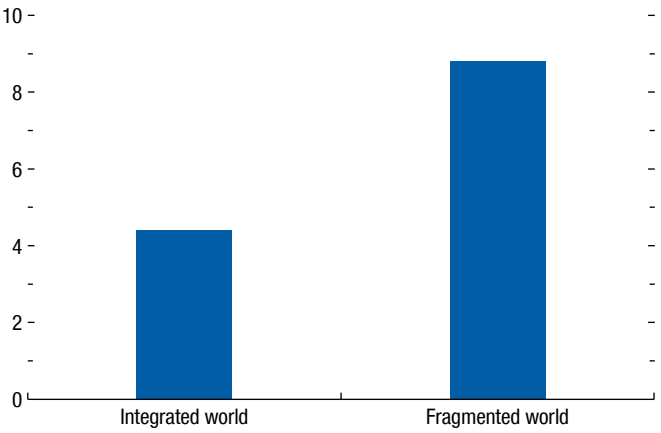
In a fragmented world, major commodity producers would face powerful incentives to switch geopolitical allegiances, with such switching representing a new source of supply shocks and price volatility. For highly concentrated commodity markets, a single exporting country switching to the other bloc could lead to a large supply gap and trigger hefty price changes. Uncertainty about a country's geopolitical alignment could itself lead to price volatility as traders update their priors regarding potentially large fragmentation-induced price swings.

[17]Other channels could include the impact on the financial ecosystem linked to commodities, such as derivatives and insurance (FSB 2023).

[18]In the single-commodity model, the price change in response to a supply shock is $Price\ Change = -\frac{Size\ of\ Supply\ Shock\ Relative\ to\ Market}{Elasticity\ of\ Supply - Elasticity\ of\ Demand}$, with $Elasticity\ of\ Demand < 0$ (Alvarez and others 2023).

[19]The United States accounts for about 7 percent of global and 15 percent of US-Europe+ bloc wheat production. A three-standard-deviation US harvest shock corresponds to about 60 percent of US wheat production, or 4 percent of global output, with wheat prices held constant. The exercise uses a price elasticity of supply of 0.2 and a price elasticity of demand of –0.85 (see Alvarez and others 2023). Lower elasticities would lead to higher price impacts, and fragmentation would still double the price impact in this example.

Figure 3.6. Wheat Price Increase in the US-Europe+ Bloc due to a Harvest Shock
(Percent)



Sources: Food and Agriculture Organization of the United Nations; and IMF staff calculations.
Note: The bars in the figure depict the change in the price of wheat in the US-Europe+ bloc (those countries that voted for Russia to withdraw from Ukraine in the 2022 UN vote on the Ukraine war) from a three-standard-deviation negative shock to US wheat production. The figure compares the price increases in the bloc in a free-trade world to those in a fragmented world.

To illustrate price sensitivity to countries switching blocs, Figure 3.7 shows the distribution of the greatest price increases each commodity can experience in a bloc when a single exporting country switches its alliance.[20] Minerals at the mining stage tend to be the most sensitive, given their highly concentrated production. For example, South Africa produces one-third of the world's manganese, a metal used in steelmaking and batteries. If South Africa switched to the US-Europe+ bloc, the price of manganese in the China-Russia+ bloc could rise more than 800 percent.

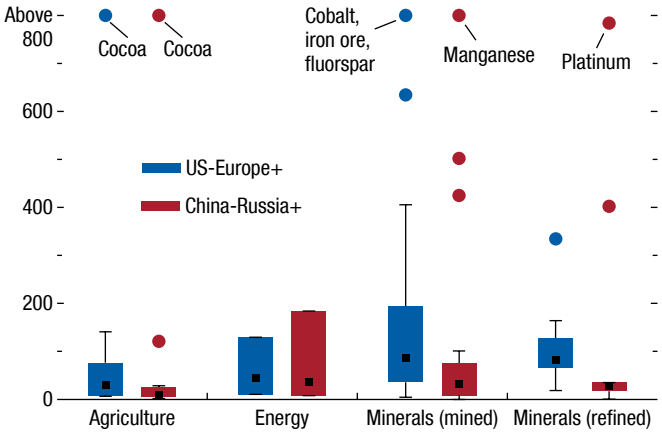
Economic Impacts of Commodity Market Fragmentation

This section sheds light on the macroeconomic impacts of fragmenting commodity markets on individual economies, blocs, and the global economy. Three complementary analytical approaches are used.[21]

[20]These results are based on Alvarez and others (2023). Online Annex Figure 3.5.2 zooms into the results in Figure 3.7 by showing the 15 commodities whose prices are most vulnerable to a single exporter switching blocs and the implied price changes.

[21]Online Annexes 3.4–3.6; Alvarez and others (2023); and Bolhuis, Chen, and Kett (2023) discuss the assumptions, calibration, and additional results of each model. None of the approaches consider the impact of fragmentation on productivity and innovation. The role of the financial sector is also outside of the scope of the chapter.

Figure 3.7. Largest Price Increases Induced by a Single Exporter Switching Blocs
(Percent)



Sources: British Geological Survey; Food and Agriculture Organization of the United Nations; Gaulier and Zignago (2010); International Energy Agency; United States Geological Survey; and IMF staff calculations.
Note: Price effects are capped at 800 percent in the figure for readability. "Energy" refers to coal, natural gas, and crude oil. 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 also that the US (China) is 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; the commodities representing the largest outliers are labeled. For the underlying complete information on commodity-specific price changes, see Online Annex Figure 3.5.2. The bloc including the countries that voted for Russia's withdrawal from Ukraine in the 2022 UN vote is labeled the "US-Europe+ bloc," and the remaining countries are included in the "China-Russia+ bloc."

First, the partial equilibrium model discussed earlier is leveraged to compute changes in producer and consumer surplus due to fragmentation in individual commodity markets. The resulting change in total surplus is used as an indicator of economic impact. This approach identifies the most macro-relevant commodities. It accounts for the changes in price and quantities consumed or produced of each commodity because of fragmentation. However, due to its partial equilibrium nature, the approach does not account for sectoral spillover effects, nor does it allow for the simultaneous disruption of trade in many commodities, which could have opposing or reinforcing effects within the same country.

Two general equilibrium models in the chapter overcome these shortcomings. A static multicountry, multisector trade model, which accounts for all input-output linkages across sectors, is used to simulate the long-term GDP losses associated with fragmenting all commodity trade and to examine the role of neutral blocs (see Box 3.3). Finally, the dynamic effects on GDP and inflation are examined in a multiregion dynamic stochastic general equilibrium model that includes energy and critical minerals.

Evidence from the Partial Equilibrium Model

Several findings emerge from the partial equilibrium approach. First, inefficiencies associated with restricting trade result in losses in bloc-level total surplus: the global economy is worse off from the fragmentation of trade in individual commodities (see Figure 3.8, panel 1).[22]

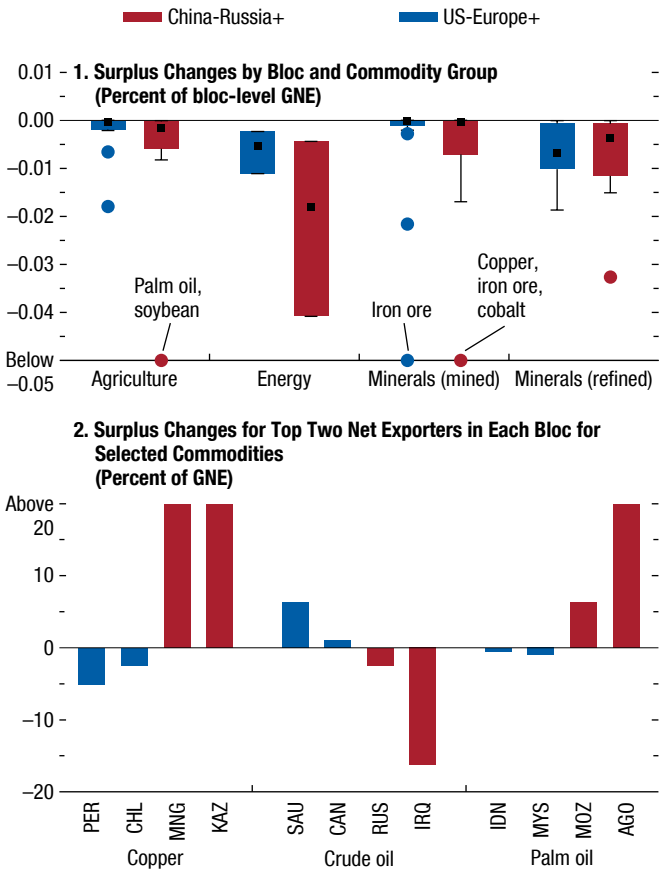
Second, bloc-level changes in total surplus are generally small (with some notable exceptions[23]), masking important heterogeneities across countries. Within each bloc, some countries would experience an increase in surplus (net-exporting countries in a net-importing bloc and net-importing countries in a net-exporting bloc), and some experience a decline. Such changes would be small for most countries as a share of gross national expenditure but could be very sizable for a few commodity importers and exporters, as shown in Online Annex Figure 3.5.4. For instance, fragmentation of copper at the mining stage would reduce surplus by as much as 2.5 to 5 percent of gross national expenditure in Chile and Peru, both exporters of copper to the US-Europe+ bloc, in which prices would fall. At the same time, it would lead to large surplus gains in Kazakhstan and Mongolia, which would scale up exports at higher prices to the copper-scarce China-Russia+ bloc (Figure 3.8, panel 2).

Third, restricting trade in commodities that are less price-vulnerable could still generate sizable

[22]This result and the following are based Alvarez and others (2023). They also provide the analytical proof. In an integrated world, trade patterns reflect the efficient allocation of resources globally, with countries specializing in commodities for which they have comparative advantage (cost-effective deposits or suitable climate conditions). After fragmentation, trade patterns no longer reflect these comparative advantages.

[23]Online Annex Figure 3.5.3 shows the five largest surplus losses at the bloc level from the fragmentation of a single commodity. Such data points are marked as outliers in Figure 3.8, panel 1, capped at –0.05 percent of gross national expenditure. In the main simulation, trade fragmentation of palm oil or copper at the mining stage could lead to surplus losses in the China-Russia+ bloc of more than 1 percent of gross national expenditure, and trade fragmentation of iron ore or soybeans to surplus losses of more than 0.5 percent.

Figure 3.8. Surplus Changes due to Fragmentation in Individual Commodity Markets



Sources: British Geological Survey; Food and Agriculture Organization of the United Nations; Gaulier and Zignago (2010); International Energy Agency; United States Geological Survey; and IMF staff calculations.
Note: "Energy" refers to coal, natural gas, and crude oil. 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. The bloc including the countries that voted for Russia's withdrawal from Ukraine in the 2022 UN vote is labeled the "US-Europe+ bloc," and the remaining countries are included in the "China-Russia+ bloc." Data labels in the figure use International Organization for Standardization (ISO) country codes. GNE = gross national expenditure.

surplus declines. For example, energy commodities are not particularly vulnerable under the baseline bloc configuration, but the associated declines in surplus would be more significant, because energy commodities are widely consumed and produced. In contrast, minerals could experience strong price changes, but the surplus impact would be more subdued, given their (so far) more limited relevance in most countries' production and consumption.

Finally, surplus declines would generally be larger in the hypothetical China-Russia+ bloc. Commodities that are most vulnerable are more broadly consumed in this bloc (Online Annex Figure 3.5.3).[24]

Evidence from the Trade Model

The general equilibrium multicountry, multisector trade model presented in Box 3.3 simulates long-term GDP effects from the disruption of all commodity trade. Broad differences are seen in the impact across countries, with some experiencing sizable losses. Low-income countries could suffer deeper losses, on average estimated at 1.2 percent, given their high dependence on agricultural trade. For some of these countries losses could amount to more than 2 percent of GDP. Consistent with the single-commodity exercise, the hypothetical China-Russia+ bloc is more affected by fragmentation, yet the global GDP loss, at roughly 0.3 percent, is modest as a result of offsetting effects across countries.[25]

The economic impact can be greatly reduced if commodity trade is only partially restricted. Illustrative simulations, in which countries that abstained from the UN vote on Ukraine are assumed to trade commodities freely, point to much smaller effects of trade barriers between the US-Europe+ and the China-Russia+ blocs. Long-term changes in global GDP from this scenario would be negligible, with meaningful losses only in Russia. This is in line with historical evidence on the ability of demand and supply of commodities to adjust in response to trade restrictions (Box 3.2).

Evidence from the Dynamic Macroeconomic Model

This subsection uses a dynamic stochastic general equilibrium framework to assess the dynamic GDP and inflation effects of commodity fragmentation. The model is based on an augmented version of the

[24]Sensitivity checks in Online Annex 3.5.2 show that this holds for a bloc configuration based on existing trade relationships. Alternatively, if all emerging market and developing economies, excluding India, Indonesia, and Latin American countries, are assigned to the China-Russia+ bloc, the US-Europe+ bloc could experience larger surplus losses, mainly on account of oil market disruptions.

[25]Global GDP losses from restricting commodity flows between blocs constitute about 15 percent of the loss from restricting all trade. In comparison, commodities represent only 10 percent of total trade. The larger losses from fragmenting energy and agricultural markets in Bolhuis, Chen, and Kett (2023) stem from the assumption of full autarky compared with the no-trade-between-blocs scenario in the chapter.

IMF's Global Macroeconomic Model for the Energy Transition.[26] It includes the production, consumption, and trade of energy from fossil and renewable sources as well as four minerals critical to the energy transition. Commodities include crude oil, coal, natural gas, copper, nickel, cobalt, and lithium, capturing about 70 percent of the value of global commodity trade. Fragmentation is modeled as a ban on trading these commodities between the two hypothetical blocs, which comprise six different regions.

In the model, fragmentation affects activity through several channels. First, the trade ban induces expenditure switching and trade diversion. Second, temporary imbalances between supply and demand within blocs emerge until prices adjust to clear markets. Such imbalances generate swings in commodity prices. Finally, rigidities affect the speed of adjustment of output, use, and trade, as well as overall macroeconomic effects.

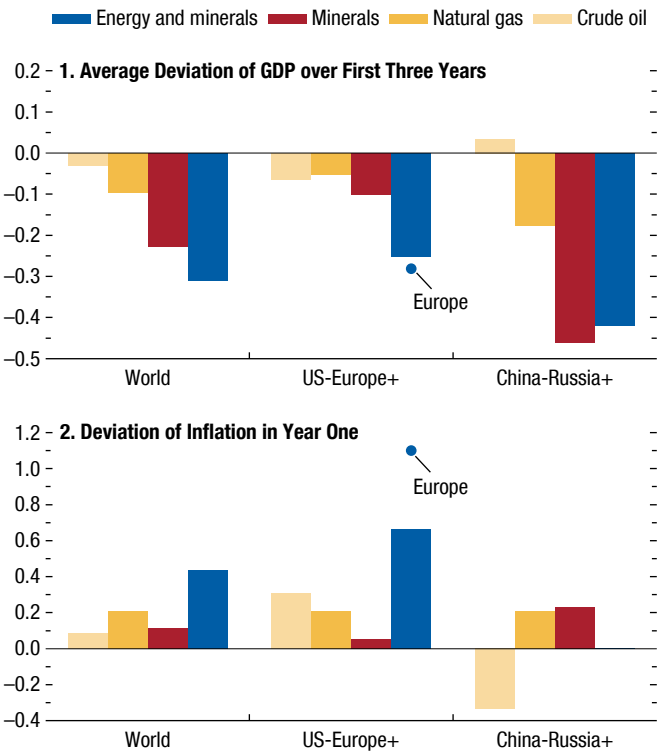
The output and inflation effects could vary significantly across regions, blocs, and commodities (Figure 3.9). Comparison of the impact on individual commodities highlights the channels at play. The effects of fragmenting trade in oil and gas would be quite different, even though the distribution of oil and gas consumption and production would be similar across blocs. For oil, countries could quickly switch to trading partners within their bloc, with limited impact on GDP. By contrast, rigidities such as the need for pipelines or other structures would constrain natural gas trade diversion, with more pronounced effects on GDP. GDP would decline and inflation would increase in both blocs.

In the case of minerals, simulations highlight the importance of the geographic distribution of mining production and rigidities in scaling up refining capacity. On the one hand, fragmentation could lead to a steep rise in prices in the China-Russia+ bloc and sizable declines in real GDP. Roughly 80 percent of the supply of the four minerals is mined in the US-Europe+ bloc, and minerals are used intensively in the China-Russia+ bloc's sizable manufacturing and construction sector. On the other hand, the US-Europe+ bloc would not be able to benefit from the relative oversupply of minerals at the mining stage because it would take several years to scale up refining capacity. That bloc would also experience a GDP decline from mineral market fragmentation.

Trade fragmentation of all seven commodities would be associated with a global GDP loss of about 0.3 percent. However, as in the partial equilibrium and trade models, sizable differences are observed across and within blocs. The simulated losses would be larger in the China-Russia+ bloc. Within the US-Europe+ bloc, Europe could experience a sizable impact on inflation (as much as 100 basis points or more) and GDP, with that impact driven mainly by the fragmentation of oil and gas markets.

Several caveats are worth highlighting. Whereas the model provides regional granularity, it masks the heterogeneity of effects across countries, given the

Figure 3.9. Impact of Fragmentation on Real GDP and Inflation
(Percent deviation from baseline)



Sources: British Geological Survey; Food and Agriculture Organization of the United Nations; Gaulier and Zignago (2010); Global Macroeconomic Model for the Energy Transition; Organisation for Economic Co-operation and Development, Inter-Country Input-Output Tables; United States Geological Survey; and IMF staff calculations.
Note: "Energy" refers to coal, natural gas, and crude oil. Region-level results are aggregated to the bloc and world levels using weights based on GDP at purchasing power parity. The bloc including the countries that voted for Russia's withdrawal from Ukraine in the 2022 UN vote is labeled the "US-Europe+ bloc," and the remaining countries are included in the "China-Russia+ bloc."

[26]The model was first used in Chapter 3 of the October 2022 *World Economic Outlook*. It is augmented here by (1) including the possibility of segmenting tradable energy markets and (2) explicitly modeling two types of mineral aggregates composed of copper and nickel as well as cobalt and lithium, respectively. The augmented model has six regions: the United States, the European Union, US-EU-leaning countries, China, Russia, and China-Russia-leaning countries.

highly concentrated nature of commodity production. Second, modeling and data constraints allow for the inclusion of only a subset of commodities. Third, the model does not capture the cost from a more volatile inflationary regime, which could make monetary policy more difficult. Finally, the model, like the two complementary analyses preceding it, uses prepandemic data on mineral usage and trade flows. Given the sizable projected increase in demand for these minerals throughout the green transition, the macroeconomic relevance of disrupting trade in these commodities will probably be greater—as discussed in the next section.

Implications for the Clean Energy Transition

Fragmentation of commodity markets could affect the cost of decarbonization. Minerals such as copper, nickel, cobalt, and lithium are key inputs for the energy transition. They are used in EVs, in batteries and wiring, and in renewable-energy technologies such as solar panels and wind turbines. Demand for these critical minerals could increase substantially (IEA 2023), and they could become as important to the world economy in a net-zero-emissions scenario as crude oil (Boer, Pescatori, and Stuermer 2023).

Under the scenario of net zero emissions by 2050, the IEA (2023) projects demand for copper to grow by a factor of 1.5, that for nickel and cobalt to double, and that for lithium to increase six times by 2030. This could raise prices substantially, as mining and refining are hard to scale up and are highly concentrated geographically (Figure 3.2, panel 1; Online Annex Figure 3.2.2). For example, Chile and Peru mine more than a third of the world's copper, and Indonesia and the Philippines about half its nickel.

Using the augmented Global Macroeconomic Model for the Energy Transition, this section illustrates the potential effects of mineral market fragmentation on energy transition dynamics.[27] The analysis focuses on minerals because they are key inputs for green technologies. The study of fragmentation of other commodity markets relevant for the green transition (such as oil and natural gas markets) is left to future research. The analysis uses projected increases in demand for key critical minerals in a net-zero-emissions scenario (IEA 2023), with the projections assuming that policy incentives stimulate investment in renewable-energy technologies and EVs. It first assumes free commodity trade. With policies left unchanged, it then compares the results with those under a counterfactual scenario of complete mineral market fragmentation across the two hypothetical blocs.

In the integrated-world baseline, the model indicates that world prices of the four key minerals considered could rise by about 90 percent, on average, along the net-zero-emissions-scenario path to 2030. If critical mineral markets are fragmented, the inability of the hypothetical China-Russia+ bloc to import copper, nickel, lithium, and cobalt from countries such as Chile, the Democratic Republic of the Congo, and Indonesia would lead to an additional price increase in that bloc of 300 percent, on average. Acquiring minerals would be more expensive, which would lead to lower investment in solar panels and wind turbines and fewer EVs (Figure 3.10). In this net zero scenario, there would be about 70 percent fewer new EVs in the China-Russia+ bloc in a fragmented world than in an integrated world.[28]

Fragmentation would cause an oversupply of minerals in the hypothetical US-Europe+ bloc. However, the time needed to scale up mineral refining capacity is assumed to constrain the use of minerals in that bloc. Hence, fragmentation generates only small gains in the US-Europe+ bloc, with a slightly higher number of EVs produced, but no gains in renewable-energy capacity, by 2030.

On balance, global net investment in renewable technology and production of EVs would be roughly 20 percent lower compared with the baseline because of mineral market fragmentation.[29] This shortfall

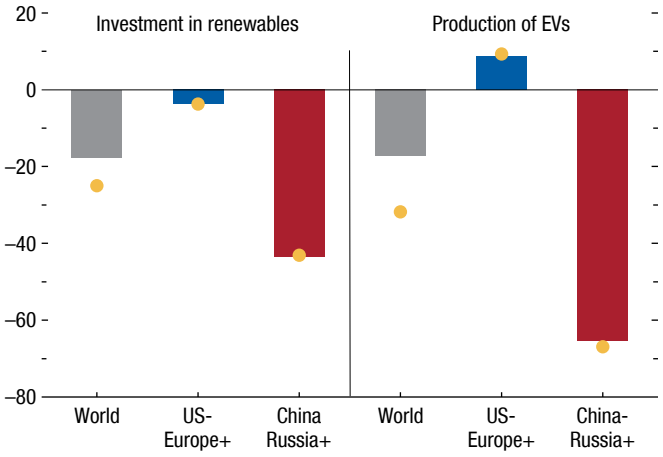
[27]Modeling the net effects of fragmentation on innovation and government policies in green technologies, in the more efficient use of commodities, in substitution, and in extraction technologies is beyond the scope of this chapter. There could be competing long-term effects within and across blocs that are not captured by the supply and demand elasticities used in the model (see Acemoglu 2002; Acemoglu and others 2012; Schwerhoff and Stuermer 2020; Hassler, Krusell, and Olovsson 2021; Góes and Bekkers 2022; and Lemoine, forthcoming).

[28]In the fragmentation scenario, China's fiscal cost of supporting investment in reverting to the net-zero-emissions path would be 1½–2 percent of GDP. Quantifying the impact of fragmentation on emissions reduction is outside the scope of this chapter.

[29]These findings are robust to assuming that technological progress would improve the substitutability of minerals with other inputs. Doubling the elasticity of substitution of the four minerals would reduce the decline in investment in renewable technology from 20 percent to 12 percent, for instance. The shortfall in global green investment because of fragmentation would be more muted, however, if key producers of minerals (Chile, the Democratic Republic of the Congo, Peru) were assigned to the China-Russia+ bloc instead. See the exercise on countries switching blocs earlier in the chapter.

Figure 3.10. Impact of Fragmentation of Critical Mineral Markets on Investment in Renewables and Electric Vehicles, 2030

(Percent deviation from net-zero-emissions scenario without fragmentation)



Sources: British Geological Survey; Gaulier and Zignago (2010); IMF, Global Macroeconomic Model for the Energy Transition; International Energy Agency; United States Geological Survey; and IMF staff estimates.
Note: The bars and dots in the figure report the change in real investment in renewable energy and the production of EVs in a fragmented world relative to the net-zero-emissions path, with demand for cobalt, copper, lithium, and nickel increasing as projected by the International Energy Agency's net-zero-emissions scenario (in an integrated world). Country-level variables are aggregated to the bloc and world levels using weights based on GDP at purchasing power parity in the bars and on greenhouse gas emissions in the dots. The bloc including the countries that voted for Russia's withdrawal from Ukraine in the 2022 UN vote is labeled the "US-Europe+ bloc," and the remaining countries are included in the "China-Russia+ bloc." EVs = electric vehicles.

would increase to about 30 percent if one uses greenhouse gas emissions to weigh the regional response of investment in renewables and EVs. The measure accounts for the greater emissions intensity of activity in the China-Russia+ bloc and hence the greater effort needed to achieve global emissions mitigation goals.[30] Decarbonizing the world economy would be more difficult if the market for minerals is fragmented.

Summary and Policy Implications

Commodity markets are an important channel through which geopolitical fragmentation can affect the economy. Many features of commodities underpin their vulnerability in the event of fragmentation: their highly concentrated and difficult-to-relocate production, hard-to-substitute consumption, and critical role as inputs for manufacturing and key technologies. Fragmentation in commodity markets is on the rise. Measures restricting commodity trade surged in 2022, price differentials across geographic markets have widened for selected commodities, and FDI flows in commodity sectors are in decline—the latter a trend that started before the war in Ukraine.

Illustrative model simulations suggest that more severe fragmentation could cause large changes in commodity prices, depending on the resulting supply-and-demand imbalances and commodities' elasticities of supply and demand. Critical minerals for the energy transition and some highly traded agricultural goods are highly vulnerable in the event of fragmentation.

A fragmented world would be more volatile. Commodity price volatility could intensify as a result of smaller market sizes and the incentives for producers to switch geopolitical allegiances. This could result in volatile inflation dynamics, making monetary policy more complex.

The potential impacts of fragmentation differ vastly across countries, with offsetting effects across consumer and producer countries resulting in modest output losses at the global level. Low-income countries, on average, would experience significantly deeper long-term output declines. Given the heavy reliance on agricultural imports among many low-income countries, fragmentation of agricultural commodities would raise important food security concerns. Illustrative model simulations suggest that a hypothetical China-Russia+ bloc could be more affected economically than a US-Europe+ bloc, although the economic impact would be reduced if commodity trade was only partially restricted or there was a nonaligned bloc. Overall, further fragmentation of commodity markets could deliver an additional blow in an already challenging environment of slow global growth, tight financial conditions, and high debt, a blow that would be particularly harsh for some of the most vulnerable economies.

Fragmentation in critical mineral markets could make the clean energy transition more costly, raising the risks of delaying necessary climate change mitigation. It could add to the upward price pressure in the mineral-scarce bloc in the chapter's illustrative model simulation. The mineral-rich bloc in the simulation could not reap the benefits from oversupply in the near term because it would be unable to scale up refining and processing capacity quickly. In the simulation,

[30]The China-Russia+ bloc accounted for more than half of greenhouse gas emissions in 2020, but only a third of global GDP. Hence, global investment losses are significantly larger when bloc-level changes are aggregated using emissions (the yellow dots in Figure 3.10) rather than purchasing-power-parity-weighted GDP (the bars in Figure 3.10).

fragmentation results in lower-than-needed global investment in renewables and EVs by 2030 by as much as 30 percent.

Given these findings, should advanced economies try to keep commodity trade open? Should emerging market and developing economies be concerned about the potentially higher cost of the green transition? For both questions, the answer is yes.

Even if the simulations suggest that commodity fragmentation would not result in very deep aggregate output losses in a US-Europe+ bloc, the threat of derailing the global green energy transition should give advanced economies pause. With more than half of worldwide emissions generated by the hypothetical China-Russia+ bloc, averting climate disaster globally hinges on the ability of the economies in that bloc to make a successful and timely clean energy transition. On the other hand, many low- and medium-income countries, whose main objective is raising living standards, may want to think twice, considering the threat of lower output and higher inflation from commodity market fragmentation.

All countries would suffer from the greater volatility and uncertainty that fragmented commodity markets would bring. A protracted process of fragmentation, driven by complex and hard-to-predict policy measures and fluid implementation, would also heighten uncertainty, depressing private investment and potentially diverting scarce public resources toward a suboptimal reshoring of commodity supply.

Preventing fragmentation of commodity markets is the first-best response. Multilateral cooperation can provide guardrails and prevent a vicious spiral of countries imposing restrictions as a risk management effort to mitigate the economic fallout from fragmentation. First-best multilateral solutions include enhanced rules within the World Trade Organization on quantitative restrictions, export tariffs, discriminatory subsidies, local-content requirements, and other commodity-related trade measures (see Bown 2023). This is crucial for food commodities, as food insecurity affects a large swath of the population in low-income countries.[31]

[31]Giordani, Rocha, and Ruta (2016) show that on top of the usual distortionary effects, trade-restricting measures for food can have multiplier effects. High food prices can trigger export restrictions while importers reduce import tariffs. These policies exacerbate tensions in world food markets and could generate another round of trade restrictions.

Second-best solutions can also be considered. Given the potentially adverse effects of fragmentation on the energy transition, a minimum "green corridor" agreement should be established to preserve integrated markets for minerals that are critical for decarbonization. Safeguarding the flow of these minerals can be part of a foundational minimum agreement across countries. Without underestimation of the political difficulties, such a corridor agreement could be easier to agree on, because it would focus on a smaller set of commodities and countries. Similar "food corridor" agreements could provide guardrails in essential agricultural commodity markets, ensure equal access to food across countries of all income levels, and reduce the likelihood of humanitarian disasters in a world of more frequent supply shocks.

While many minerals used in clean energy technologies are bound to become critical for the global economy, the paucity of data on their consumption, production, and inventories raises uncertainty for producers and consumers and could hide potential risks for financial markets. In this respect, the international community could facilitate the green transition and support energy security by setting up a platform or organization to improve sharing and standardization of international data on mineral production, consumption, and inventories. The initiative could be similar to the Joint Organisations Data Initiative for fossil fuels and the Agricultural Market Information System for food commodities.

Even as policymakers strive to mitigate the risk of fragmentation, countries can take steps to minimize the potential economic fallout. The geographic concentration of production and lack of diversification of commodity suppliers call for (1) fostering investment in domestic mining, exploration, and recycling of critical minerals; (2) diversification of supply sources; and (3) investing in infrastructure to reduce trade costs and improve market integration. Support for innovation to speed technological progress—and develop substitutes—would enhance efficiency in the use and buildup of strategic reserves. Multilateral cooperation would enhance efficiency and prevent negative cross-country spillovers.

Broader policies that strengthen countries' resilience to shocks can help mitigate the effects of commodity shocks. These include strengthening macroeconomic, structural, and fiscal policy frameworks; building fiscal and financial buffers; and developing preparedness plans in case of sudden disruptions in

commodity supply. Countries should also reinforce social safety nets to protect vulnerable households from higher commodity prices and volatility. Since fragmentation in physical commodity markets could exacerbate financial market volatility and result in sharp exchange rate adjustments, policy measures that prevent disruptions in commodity-derivatives markets and financial instability may be warranted (April 2023 *Global Financial Stability Report*).

Industrial policies are only the third-best approach and must be designed carefully to ensure equal treatment of firms across competitive markets to avert adverse cross-country spillovers, minimize distortions and inefficiencies, and mitigate fiscal risks and harmful political economy outcomes. "Friend-shoring" policies can also be market distorting and costly. Both sets of policies should be used only under particular conditions, such as in the presence of clear market failures or narrowly defined national security concerns. Domestic and global costs are more limited—and economies more resilient to shocks—if restriction-free trade applies to larger economic zones. Country-based restrictions on domestic content are suboptimal, because they can interfere with price signals, reduce competition, and therefore lower productivity. Developing a framework for international consultations on friend-shoring practices could help identify negative cross-border spillovers and mitigate adverse consequences.

Box 3.1. Commodity Trade Tensions: Evidence from Tanker Traffic Data

Since its invasion of Ukraine, Russia's oil exports have been subject to sanctions and have been voluntarily shunned by firms. What has been the impact on oil trade flows? Granular real-time data on tanker shipping patterns from the Automatic Identification System[1] uncover significant shifts in routes, resulting in economic inefficiencies.

The European Union, United Kingdom, and United States banned most imports of crude oil and petroleum products from Russia after Russia's invasion of Ukraine. Western restrictions on dollar payments have been reported to be a barrier to shipments. Group of Seven (G7) members also prohibited transportation and insurance services to tankers carrying Russian commodities above certain price thresholds.

Automatic Identification System data reveal that the traffic patterns of Russia's tankers have since changed substantially (Figure 3.1.1). Tanker shipments from Russian ports to Japan, the United States, and the European Union declined between April–June 2019 and the same period in 2023. Other countries are also now providing oil supplies. For example, the European Union receives more shipments from countries such as Norway, the United Arab Emirates, and the United States, but this extends the length of tanker routes by 20 percent.[2]

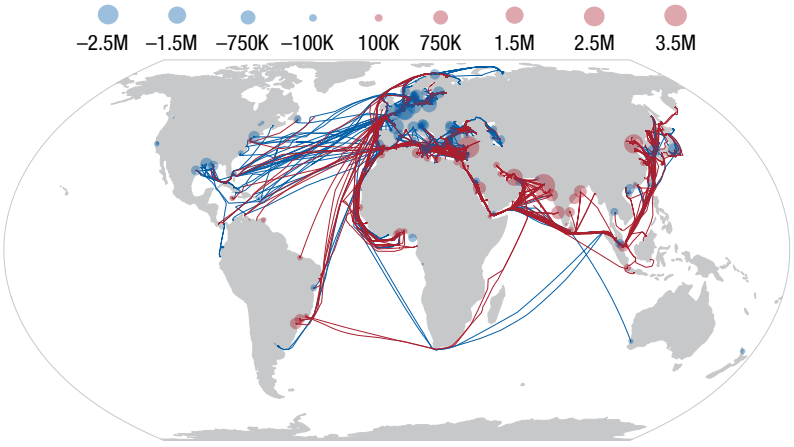
On the flip side, Russian oil shipments rose after the invasion to countries such as China, India, Türkiye, and the United Arab Emirates. About 35 to 40 percent of India's crude oil imports came from Russia during April–June 2023, a stark rise from less than 5 percent before the war in Ukraine. While India's oil exports (mostly petroleum products) are small relative to its oil imports (mostly crude oil), India increased its oil exports to the European Union substantially.

The authors of this box are Seung Mo Choi and Alessandra Sozzi.

[1]The Automatic Identification System is a mandatory self-reporting system for all ships above 300 gross tons. It has been used to construct real-time trade indicators (examples are included in Arslanalp, Marini, and Tumbarello 2019; Cerdeiro and others 2020; and Arslanalp, Koepke, and Verschuur 2021). PortWatch (https://www.imf.org/portwatch) is an online platform that monitors trade disruptions and assesses spillovers through port-to-port links.

[2]UNCTAD (2022) documents a rise in tanker freight rates following the Russian invasion of Ukraine.

Figure 3.1.1. Changes in Tanker Shipments from Russia's Ports from 2019:Q2 to 2023:Q2
(Metric tons, decreases in blue and increases in red)



Sources: Natural Earth; UN Global Platform; and IMF staff calculations.
Note: The bubble size indicates the magnitude of the change for the destination port. Lines indicate travel routes.

Box 3.2. Commodity Market Fragmentation in History: Many Shades of Gray

History points to a fluid range of experiences of fragmentation in commodity markets: from full trade disruption during World War II, to limited and controlled trade during the Cold War, to trade embargoes and other export restrictions. Fragmentation has rarely lasted, given commodities' fungibility and arbitrage opportunities.

During World War II, trade among the three major blocs—German-controlled Europe, Japanese-controlled Asia, and the rest of the world (the Allies)—stopped (Findlay and O'Rourke 2007).[1] Some blocs faced commodity shortages: for example, shortages of crude oil (produced mostly by the Allies) in Germany and Japan and of natural rubber (produced mostly by Japan) in the Allies (Tuttle 1981). In both cases, governments worked with firms to alleviate shortages. Germany developed a coal-based synthetic fuel industry. By 1940, the fuel it produced accounted for nearly half of Germany's oil supply and 95 percent of its aviation fuel (Painter 2012). The US government stockpiled natural rubber and worked with industry to develop synthetic rubber (ACS 1998).

During the Cold War, trade between the US-led and the Soviet Union–led blocs was limited as a result of the Soviet strategy of self-sufficiency.[2] The Soviet Union traded crude oil, natural gas, and some metals for manufactured and agricultural goods, especially wheat. Traders often skirted government policies to facilitate this exchange (Farchy and Blas 2021). Political considerations also dominated trade. For example, after the Soviet invasion of Afghanistan, US President Jimmy Carter imposed a partial embargo on US grain exports to the Soviet Union.[3] The embargo, however, was ineffective due to the global nature of grain markets. While Soviet imports of US wheat fell sharply, they were replaced by imports from other countries, especially Argentina (Oki 2008).

Commodity market embargoes have often been used to apply political pressure. The Arab members of the Organization of the Petroleum Exporting Countries (OPEC) initiated an export embargo against the United States and other countries in 1973 during the Arab-Israeli war and announced a 25 percent cut in output. Oil prices more than quadrupled between September 1973 and January 1974. The oil market was significantly disrupted; however, the disruption was short-lived, as traders diverted oil to embargoed countries and production from non-OPEC countries rose (McNally 2017). Importers also took steps to reduce vulnerability, for example, by mandating efficiency improvements and creating strategic oil inventories (Baffes and Nagle 2022).

Another embargo example is that of South Africa during apartheid. Several governments implemented wide-ranging bans on exports to South Africa, particularly crude oil. However, sanctions were blunted by traders who were willing to risk violating sanctions to supply oil at high prices (Farchy and Blas 2021). Overall, the historical examples showcase the ability of fungible commodities to find their way from producers to consumers, absent near-absolute trade barriers.

The author of this box is Peter Nagle.

[1]Trade between blocs and neutral countries was affected by the war. For example, the United Kingdom and United States bought much of the Spanish tungsten output to raise its price and limit availability for Germany. Between 1941 and 1943, the price of tungsten rose 13-fold (Caruana and Rockoff 2001).

[2]East-West trade was sharply reduced by the Cold War, from three-quarters of trade by the East in 1938 to 14 percent in 1953. In contrast, within-bloc trade and interdependence rose (Spulber and Gehrels 1958; Foreman-Peck 1995).

[3]In 1980, the Soviet Union planned to import 35 million metric tons of grain—25 million of that from the United States. It ended up importing only 8 million tons, committed to under a previous treaty (JEC 1980).

Box 3.3. The Uneven Economic Effects of Commodity Market Fragmentation

Fragmentation of commodity markets affects countries and households differently. This box demonstrates that low-income countries are more vulnerable in the event of fragmentation, especially of agricultural commodities, owing to their greater reliance on food imports. The finding raises important food security concerns should further fragmentation materialize.

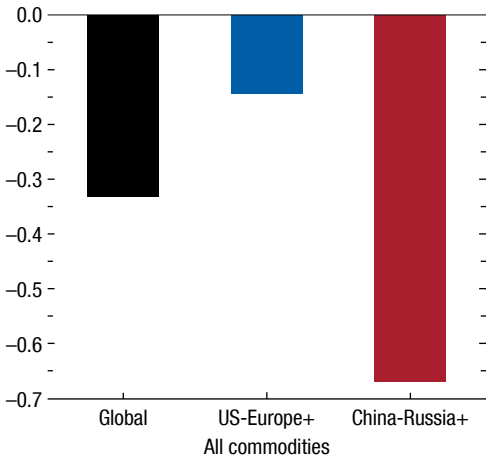
To quantify the impact on long-term GDP of fragmentating trade in multiple commodities simultaneously, a multicountry, multisector trade model is used in this box, following Caliendo and Parro (2015). Bolhuis, Chen, and Kett (2023) augment the model to account for trade and production of 133 commodities across 145 countries. Labor is the only factor of production, and productivity is exogenous. Commodities are used as intermediate inputs, with a long-term supply elasticity of 1. The model accounts for the input-output structure of global trade and assumes low elasticity of substitution between commodities and other inputs in the production of manufactured goods. Trade costs are set such that there is no commodity trade between blocs.

Results show that the aggregate impact of commodity fragmentation would be moderate, with a global GDP loss of 0.3 percent (Figure 3.3.1). However, there would be large differences within and across blocs. Some economies might benefit from trade diversion as competitors lose access to export markets. Most would experience permanent output declines. Losses would be larger in countries where commodity trade with the other bloc was significant. The China-Russia+ bloc and low-income countries—whose economies are more commodity-intensive—would lose more.

Low-income countries' high dependence on imports of agricultural goods would make them particularly vulnerable (Figure 3.3.2). Disrupting trade in food commodities alone would lead to losses of 1 percent of GDP. Commodity fragmentation could also have high social and humanitarian costs and would be particularly harmful for lower-income households, which spend a large share of their incomes on food and fuel.

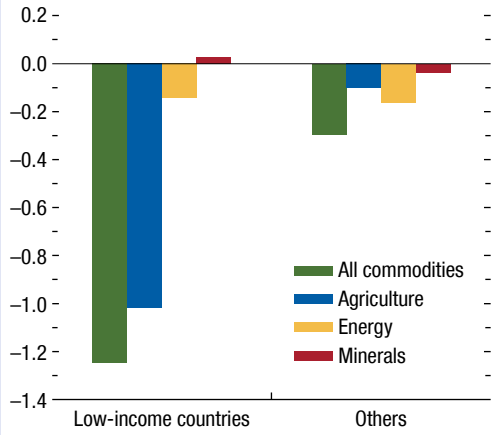
The authors of this box are Marijn Bolhuis, Jiaqian Chen, and Benjamin Kett. See Bolhuis, Chen, and Kett (2023) for further details.

Figure 3.3.1. Estimated Output Losses
(Percent deviation from baseline)



Sources: British Geological Survey; Eora Global Supply Chain database; Food and Agriculture Organization of the United Nations; Gaulier and Zignago (2010); US Geological Survey; and IMF staff calculations.
Note: The bars represent the losses in GDP relative to baseline from eliminating trade in commodities across hypothetical blocs. Country-level losses are aggregated using weights based on GDP at purchasing power parity. For details, see Bolhuis, Chen, and Kett (2023).

Figure 3.3.2. Estimated GDP Losses in Low-Income Countries and Others
(Percent deviation from baseline)



Sources: British Geological Survey; Eora Global Supply Chain database; Food and Agriculture Organization of the United Nations; Gaulier and Zignago (2010); US Geological Survey; and IMF staff calculations.
Note: The bars represent the losses in GDP relative to baseline from eliminating trade in groups of commodities across hypothetical blocs. Country-level losses are aggregated using weights based on GDP at purchasing power parity. For details, see Bolhuis, Chen, and Kett (2023).

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