

## CHAPTER 4

# Causes and Consequences of Industrial Commodity Price Shocks

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*The 2020 global recession triggered by the COVID-19 pandemic and the subsequent war in Ukraine in 2022 roiled commodity markets. As demand dropped in the first four months of 2020, global energy prices plunged 61 percent and metal prices fell 16 percent. When global economic activity rebounded and pandemic disruptions to production subsided, energy and metal prices recovered quickly and reached multi-decade highs in the wake of Russia's invasion of Ukraine in 2022. Such large price movements have significant macroeconomic implications for commodity exporters. More than half of emerging market and developing economies (EMDEs) rely heavily on industrial commodity sectors for export earnings and fiscal revenues. Energy exporters are particularly reliant on resource sectors. Both oil and metal price shocks have asymmetric effects on economic activity in energy and metal producers: Price increases are associated with small, temporary growth accelerations; price declines are associated with pronounced and lasting slowdowns. These effects underscore the importance of robust policy frameworks in energy and metals-producing EMDEs that can smooth global commodity price shocks. Structural reforms that favor growth and more diversified economic activity would reduce vulnerability to external shocks.*

### Introduction

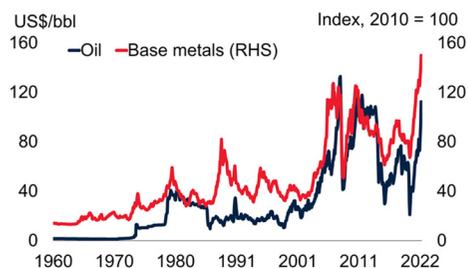
Since early 2020, industrial commodity prices have been on a rollercoaster ride. At the start of the COVID-19 pandemic, between January and April 2020, global energy prices dropped 61 percent and base metal prices tumbled 16 percent. Beginning in May 2020, however, they recovered quickly amid rebounding economic activity and an array of supply disruptions (World Bank 2021). Base metal prices regained their pre-pandemic levels by August 2020 and energy prices fully recovered by February 2021. Energy and metal prices continued to rise through 2021. Base metal prices rose for 19 consecutive months, their longest unbroken increase on record. In 2021, the prices of natural gas, coal, copper, iron ore, and tin reached record highs. Russia's invasion of Ukraine further lifted the prices of natural gas, coal, wheat, barley, various seed oils, some types of fertilizer, copper, and tin to their highest levels since 1960 and raised other energy and food prices to their highest levels in 15 years.

Global recessions—such as those in 2020 caused by the COVID-19 pandemic and in 2009 caused by the global financial crisis—and subsequent recoveries as well as wars and geopolitical tensions can generate large and synchronized commodity price swings (figure 4.1; chapter 3; Bilgin and Ellwanger 2017; Chiaie, Ferrara, and Giannone 2017; Helbling 2012; World Bank 2020a). In addition, less synchronous commodity price swings are often generated by commodity-specific supply disruptions such as those occasionally caused by the pandemic during 2020; policy changes of commodity cartels

### FIGURE 4.1 Oil and base metal prices

Base metal and oil prices typically move together, although OPEC policy supported the oil price during 2010-14 when metal prices were weakening.

**A. Base metal and oil prices, from 1960**



**B. Base metal and oil prices, from 2010**



Sources: World Bank *Pink Sheet*; World Bank.

Note: Oil is an average price of Brent, West Texas Intermediate, and Dubai. The base metal index is an export-weighted average of aluminum, copper, lead, nickel, tin, and zinc prices. Last observation is April 2022.

such as those by the Organization of Petroleum-Exporting Countries (OPEC) in 2014 or in 1985; or structural changes that shift commodity demand.

In addition to such short-term shocks, medium-term trends are shaping commodity markets. In particular, as global energy consumption transitions away from fossil fuels, metals heavily used in electric vehicles and in renewable electricity generation and storage are expected to become considerably more important (figure 4.2; Boer, Pescatori and Stuermer 2021; World Bank 2020b). This structural shift in output and consumption could have a long-lasting impact on energy- and metal-exporting economies. About a quarter of emerging market and developing economies (EMDEs) rely heavily on oil for export earnings and fiscal revenues and about a third are similarly dependent on base metals. For these economies, commodity price movements are a key source of macroeconomic volatility (Jacks, O'Rourke, and Williamson 2011). By some estimates, terms-of-trade shocks account for up to half of their business cycle fluctuations (Kose 2002). Because the commodity composition of imports is much more diverse than that of exports, export price shocks generally have a much larger impact on the terms of trade, and the domestic economy, than do import shocks (Di Pace, Juvenal, and Petrella 2021; Richaud et al. 2019). Prospects for these commodity-reliant economies depend significantly on the type of commodity they export.

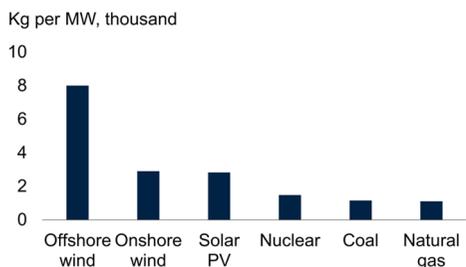
This chapter analyzes the impact of energy and metal price shocks on energy and metal exporters and importers. It addresses the following questions:

- How important are energy and metals for the global economy and EMDEs?
- What have been the drivers of energy and metal price swings over the past seven decades?
- What are the implications of movements in energy and metal prices for economic activity in EMDEs?

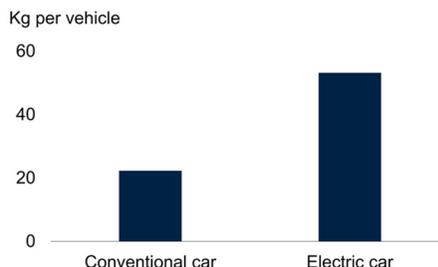
## FIGURE 4.2 Copper use

*Low-carbon technologies are more metals-intensive than traditional technologies.*

### A. Copper use in electricity generation



### B. Copper use in car production



Sources: International Energy Agency (2022); World Bank.

A. Kg per MW stands for kilograms per megawatt.

B. The values for vehicles are for the entire vehicle including batteries, motors and glider.

This chapter makes several contributions to the literature.

*First*, it compares the structure of global energy and metal markets, including how much producers in each market rely on commodities for export earnings and fiscal revenues and to generate economic activity. To the authors' knowledge, such a detailed comparison has not been conducted elsewhere.<sup>1</sup> Yet, this information is critical to assessing the differential macroeconomic implications of commodity price fluctuations in different regions.

*Second*, the chapter analyses energy and metal demand, supply, and price shocks together. This allows a cross-commodity comparison that previous studies have not offered. In particular, it illustrates how different market structures have different implications for the behavior and impact of individual commodity markets.

*Third*, the chapter is one of a few recent studies to identify econometrically the main drivers of swings in metal prices. It cross-checks the identified drivers against historical narratives.<sup>2</sup> The estimation uses a structural vector autoregression (SVAR) model with sign restrictions. This type of model has often been deployed to decompose oil price swings into those caused by demand, supply, and oil price shocks—using data for oil prices, oil production, economic activity, and, sometimes, inventories.<sup>3</sup> The estimates

<sup>1</sup> UNCTAD (2021) regularly provides data on country dependence on commodity exports, but not for fiscal revenue or economic activity.

<sup>2</sup> A separate literature documents commodity price cycles, but not their drivers (e.g., Baffes and Kabundi 2021).

<sup>3</sup> Beidas-Strom and Pescatori (2014); Kilian (2009); Kilian and Park (2009); and Kilian and Murphy (2014) decompose monthly oil price swings into demand, supply, and oil price shocks using data on oil prices, oil production, and economic activity (proxied by industrial production or an index largely based on it). Some of these studies also include inventories to identify a speculative demand shock (Beidas-Strom and Pescatori 2014; Kilian and Murphy 2014). Baffes et al. (2015) and Blanchard and Arezki (2014) decompose daily oil price swings into demand and supply shocks using data on stock market indexes (as proxies for economic activity), oil prices, and exchange rates.

typically find that oil prices are driven by demand shocks, stemming either from variations in the level of aggregate output or from short-run speculative activity. SVAR approaches have also been applied to up to a dozen non-energy commodity prices in three previous studies (Stuermer 2017; Stuermer 2018; Jacks and Stuermer 2020).<sup>4</sup> These studies, which cover the years 1870–2013, find that global aggregate demand shocks have been the main source of commodity price fluctuations. While these studies examine a long time frame, they cover only the markets for copper, lead, tin, and zinc. This chapter adds aluminum and nickel to the list and explicitly compares results for metal prices with those for oil prices in a consistent framework.

*Fourth*, the chapter empirically estimates the response of output in metal exporters and importers to metal price shocks. It does this using the local projections technique, an alternative to the commonly employed SVAR approach for the macroeconomic analysis of oil price changes (Gervais 2019; Sheng, Gupta, and Ji 2020).

The chapter offers the following findings.

*First*, although more than half of EMDEs rely heavily on their resource sectors for export earnings and fiscal revenues, and to generate economic activity, metal exporters are much less dependent on metal sectors than oil exporters are on oil sectors, for now.

*Second*, global metal production and consumption are considerably more concentrated geographically than that for oil. China, for example, is the single largest consumer and producer of all refined base metals. It accounts for roughly 50 percent of global consumption of metals, while it consumes just 15 percent of global crude oil output.

*Third*, except for aluminum and tin, demand and supply shocks contributed in almost equal measure to the variability of commodity prices. Demand collapses during global recessions were the main drivers of sharp declines in energy and metal prices. During the global recession of 2009, which was triggered by the global financial crisis, the faster drop in demand relative to production worsened price declines for oil and most metals. In contrast, during the global recession of 2020, which was triggered by the COVID-19 pandemic, initial disruptions in metal production due to the disease, and a limited production cut agreed by OPEC and its partners, temporarily offset some of the downward price pressures that were caused by the collapse in demand.

*Fourth*, oil and metal price shocks appear to have asymmetric impacts on output growth in energy and metal exporters. While price *increases* have been associated with small, temporary accelerations in output growth, price *declines* have been associated with more pronounced or longer-lasting growth slowdowns. But these results mainly pertain to oil and copper, exporters of which are particularly commodity-reliant. Output growth in oil and copper exporters, for example, declined significantly several years after oil or copper

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<sup>4</sup>Jacks and Stuermer (2020) identify shocks using both short-run and long-run zero restrictions. Stuermer (2017, 2018) identify shocks using long-run zero restrictions.

prices fell. In contrast, there is no evidence of statistically significant output gains (or losses) in aluminum exporters after increases (or decreases) in aluminum prices. Among commodity importers, too, changes in metal or oil prices have had negligible effects on output.

The next section describes the reliance of EMDEs on commodities for export earnings, fiscal revenues, and to generate economic activity. It identifies which countries are considered commodity exporters for the purposes of this chapter. Section III presents the SVAR analysis of the main drivers of metal prices. Section IV offers estimates of a local projection model for the response of output growth in metal exporters and importers to metal price shocks. The final section deals with policy implications.

## EMDEs' reliance on commodities

### Classification of energy and metal exporters

Commodity exporters are defined as countries in which an individual commodity accounts for 5 percent or more of total goods exports (annex 4A). Metal exports include both industrial ores and refined metals—aluminum, copper, lead, nickel, tin, and zinc. Precious metals (gold and silver) are excluded because they are driven to an unusual extent by special factors in financial markets. Under this construct, 62 EMDEs (out of 153) meet the threshold where oil accounts for at least 5 percent of goods exports and 58 EMDEs meet the threshold where industrial metals (of all types and including iron ore) account for at least 5 percent of goods exports.<sup>5</sup>

With regard to individual metals, there are 14 copper-exporting EMDEs, 10 aluminum exporters, five zinc exporters, three nickel exporters, and only one country classified as a lead exporter and another as a tin exporter (table 4.1). With the exception of Tajikistan, none of these EMDEs export more than one metal that exceeds the 5 percent threshold. In Tajikistan, aluminum, copper, lead, and zinc each account for 5 percent or more of total exports.

For four of the six metals, the world's largest exporter of a metal was not classified as a metal exporter. This is because the largest exporter of the metal is a relatively large, diversified economy, and the metal in question amounts to a small share of its total exports. For example, Indonesia accounted for one-third of global tin exports in 2019, but tin comprised less than 1 percent of the country's total goods exports that year. Russia exported about one-quarter of the world's nickel in 2019 but that represented just over 1 percent of Russia's total exports.

In other metals, the largest exporter is by no means the largest producer. For example, China produces half of the world's lead ore but exports virtually none of it, using it

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<sup>5</sup>Note that this results in a somewhat larger number of exporters than the definition in World Bank (2022), which sets a threshold of 20 percent of total exports since it refers to broader commodity groups.

instead in domestic manufacturing. China accounted for only 0.4 percent of global lead ore exports in 2019. The leading exporters of lead ore were Australia and Korea.

The dataset used in this chapter includes annual data on consumption and production for 153 EMDEs during the period 1970 to 2020. The UN *Comtrade* database and the *Observatory of Economic Complexity* are the sources for commodity import and export data. Prices for the six metals are drawn from the World Bank's *Pink Sheet* database.

### Commodity reliance of EMDE commodity exporters

As the transition away from fossil fuels progresses, metals are expected to play an increasingly important role in the global economy because they are essential to the generation of renewable electricity and the production of electric vehicles. This increase in demand for metals will be accompanied by sagging global demand for such fossil fuels as oil, natural gas, and coal. For EMDEs that are heavily reliant on fossil fuel-based energy commodities and on metals, the energy transition will have significant implications for long-run growth prospects—good for metal exporters and poor for exporters of fossil fuels.

For now, metal exporters tend to be less reliant on metals than oil exporters are on oil (figure 4.3). Metal exports account for 20 percent of total goods exports among metal-reliant exporters; for oil exporters, petroleum accounts for 32 percent of total exports on average. In the 10 most metal-reliant EMDEs, metal exports average 48 percent of their total goods exports. In comparison, oil averages 84 percent of exports for the 10 most oil-reliant EMDEs. Among metal producers, export dependency is particularly high for copper producers, with copper accounting for a median share of 22 percent of their goods exports. In the case of the most copper-reliant economy, Zambia, the metal represents 73 percent of exports. Aluminum is next in export dependency. It has a median share of 15 percent of exports, and in the most dependent economy, Guinea, it accounts for 48 percent of exports.

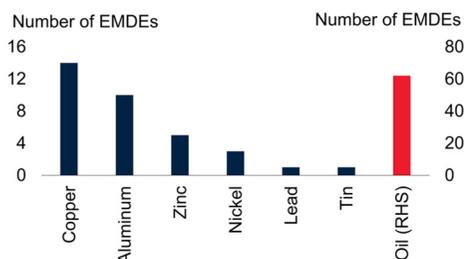
The contrast between oil- and metal-exporters is similar for fiscal revenue. Metal exporters are generally less dependent on resource revenues than are oil exporters. On average, resource revenues account for 28 percent of total fiscal revenue in oil-reliant exporters, compared to just over 10 percent in aluminum- and copper-reliant exporters, and less than 4 percent in zinc- and nickel-reliant exporters. There was not enough data available to assess lead and tin exporters. Guinea is the aluminum exporter that is most reliant on resource revenues, which account for 18 percent of the country's fiscal revenues. Mauritania, a copper exporter, is close, with 16 percent of its revenue stemming from resource sectors. For countries that export both oil and copper, dependence on resource revenues can be very high, reaching 80 percent of fiscal revenue for the Republic of Congo.

The resource sector is also less important to total economic activity for metal-reliant exporters than it is for oil-reliant exporters. Of the countries included in the sample,

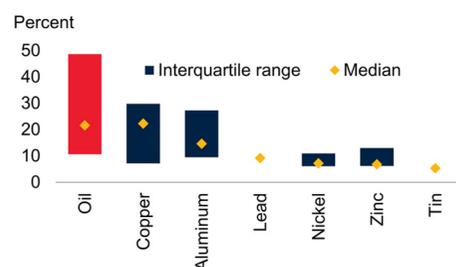
### FIGURE 4.3 Resource reliance of oil and base metal exporters

Half as many EMDEs are reliant on a single metal as are reliant on oil. Metal exporters depend less than oil exporters on a resource sector for exports, fiscal revenues, and output.

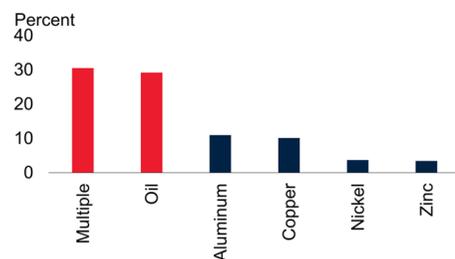
#### A. Number of base metal and oil exporters



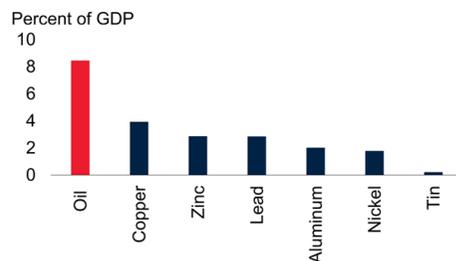
#### B. Share of oil or metal exports in total exports, oil and metal exporters



#### C. Share of resource revenues in total government revenues, oil and metal exporters



#### D. Share of commodity resource rents in output, oil and metal exporters



Sources: UN Comtrade; World Bank Pink Sheet; World Bank.

Note: An EMDE is defined as an exporter if exports of a given commodity are 5 percent of more of total exports in a single year between 2018-19.

B.-D. Chart shows the median and interquartile range of the share of exports (B), share of fiscal revenues (C), and share of output (D) accounted for by resource sectors for EMDE exporters of that commodity. Oil includes 62 EMDEs, copper 14, aluminum 10, zinc 5, nickel 3, and lead and tin each have 1.

B. Due to small sample size, lead and tin do not have an interquartile range. Data are from 2019 or 2020, depending on data availability.

C. "Multiple" includes exporters that export both oil and copper. Data for lead is unavailable. Data are from 2018 or 2019, depending on availability.

D. Chart shows natural resource rents from oil for oil exporters and minerals for base metal exporters, in percent of GDP. If a country is an exporter of more than one metal, they are included in each category. Data are from 2018.

resource rents (that is, value added in the resource sector) account for 8 percent of GDP, on average, in oil exporters, whereas they account, on average, for 4 percent of GDP in copper-reliant exporters, which are the most resource reliant of the metal exporters. Once again, there is significant variation within groups. Among oil exporters, resource rents account for more than 40 percent of GDP in Republic of Congo, Iraq, Kuwait, and Libya. Of the metal exporters, Guinea (an aluminum exporter) is again the most exposed; resource sector rents account for just over 10 percent of GDP in Guinea. Mongolia (a copper exporter) is close behind.

## Concentrated location of metal ore reserves

Global ore reserves, ore production, and refined metals production are concentrated in a limited number of countries. For each of the six metals, the top four countries in terms of known reserves account for 50–75 percent of the world total (figure 4.4; U.S. Geological Survey 2022). Chile accounts for 23 percent of known copper reserves, while Australia and Peru have around 10 percent each (U.S. Geological Survey 2022). Guinea has 23 percent of the world's reserves of bauxite, the most common raw material for aluminum. With 22 percent of the total, Indonesia has the world's largest nickel ore reserves. Australia has the world's largest lead ore reserves (41 percent) and zinc ore deposits (27 percent). China has the world's largest tin ore reserves (22 percent).

The discussion thus far has referred to reserves that are economical to extract using current technologies. In general, as reserves that contain a higher concentration of a metal are depleted, production shifts to lower-grade, previously uneconomical reserves. For example, bauxite is the preferred source of alumina, the intermediate product from which aluminum is derived. However, there are vast, currently uneconomic sources of alumina in clay deposits. The U.S. Geological Survey estimates that the world has an essentially inexhaustible supply of resources of aluminum in materials other than bauxite (U.S. Geological Survey 2021). For metals more broadly, technological innovations that make it easier to access reserves have dampened price pressures over the past three centuries, despite rapid demand growth (Schwerhoff and Stuermer 2019).

## Concentration of crude oil, metal ore, and refined production

Global metal ore production is considerably more concentrated than global crude oil production (figure 4.4).<sup>6</sup> Although it does not have the world's largest ore reserves, China is now the largest producer of lead, tin, and zinc ores, and the second-largest producer of bauxite (figure 4.5). China has only about 3 percent of the world's known reserves of bauxite/aluminum, copper, and nickel; around 20 percent of known reserves of lead and zinc; and 22 percent of tin ore reserves. But it is mining these ores at a much faster pace than are other countries. As a result, it accounts for between 18 and 54 percent of global production of bauxite, lead, tin, and zinc ores.

Global refined metal production is also highly concentrated, much more so than global refined oil production. China is the world's largest producer of all refined metals, accounting for between 29 percent and 57 percent of global production, depending upon the metal. Aluminum refining is the most concentrated, with China accounting for 57 percent of global production, even though it has only 3 percent of bauxite reserves and 19 percent of bauxite production. Nickel refining is the least concentrated of metal production. Again, the biggest producer is China, which accounts for 29 percent of global output, followed by Indonesia, which accounts for 25 percent. Metal refining is

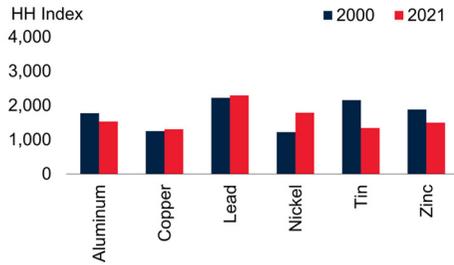
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<sup>6</sup>The United States, the world's largest producer of oil, accounts for 18 percent of global crude oil production. If OPEC were counted as a single producer, oil market concentration would increase significantly.

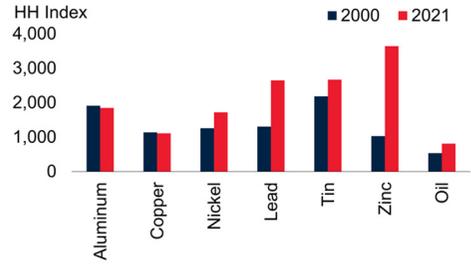
**FIGURE 4.4 Geographical concentration of oil and base metal production and consumption**

Global metal ore reserves are concentrated geographically and have changed little over the past two decades. In contrast, the concentration of metal production and consumption has risen sharply over the past two decades and is now higher than for crude oil production and consumption.

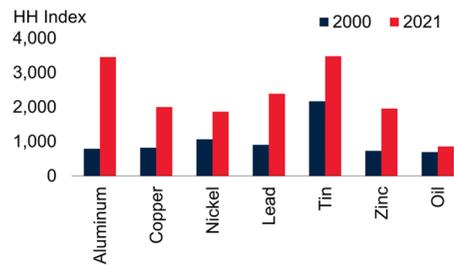
**A. Concentration of metal ore reserves**



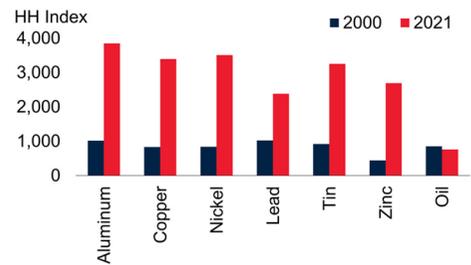
**B. Concentration of metal ore and crude oil production**



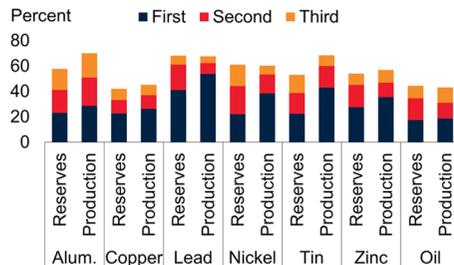
**C. Concentration of refined metal and refined oil production**



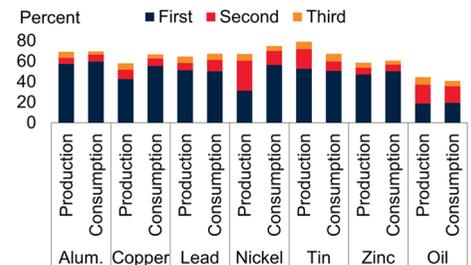
**D. Concentration of refined metal and crude oil consumption**



**E. Share of top 3 countries in global ore and crude oil reserves and production**



**F. Share of top 3 countries in refined metal and refined oil production and consumption**



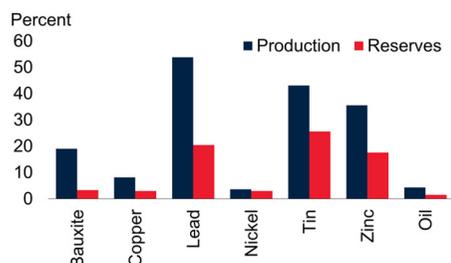
Sources: BP Statistical Review; U.S. Geological Survey; World Bank; World Bureau of Metal Statistics.

A.-D. Charts show Herfindahl–Hirschman Index, a measure of market concentration. It is calculated by squaring the market share of each country and then summing the resulting numbers. The HHI can range in value between 0 and 10,000, where a value close to zero would indicate many countries with equal shares, while a value of 10,000 would indicate a single country accounted for all of global production or consumption. Data are for 2021 for metals and 2020 for oil.

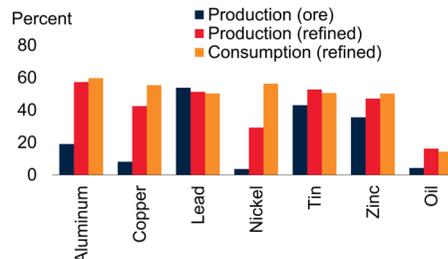
## FIGURE 4.5 China's role in oil and base metal markets

After two decades of rapid growth, China is now the single largest consumer and producer of all base metals. Its share of global production and consumption of oil is much lower.

**A. China's share of global metal ore and crude oil production and reserves**



**B. China's share of global metal and oil production and consumption**



Sources: BP Statistical Review; U.S. Geological Survey; World Bank; World Bureau of Metal Statistics.

Note: Data as of 2021 for metals and 2020 for oil.

B. For oil, production (ore) refers to crude oil production, while production (refined) refers to refined oil production.

far more concentrated than oil refining. The United States, as the largest global oil refiner, accounts for just 20 percent of the total.

Moreover, with rapid growth in China, the concentration of global production of all refined metals, and some metal ores, has risen sharply over the past two decades. Since 2000, China's share of global production of bauxite and lead has tripled and has nearly doubled for copper and zinc. China's share of global production of refined nickel has risen six-fold, its share of refined copper and aluminum production has risen five-fold, and its share of refined lead production has risen three-fold; and, for zinc, it has doubled. By 2020, China was the largest producer of all refined metals.

### Concentration of global metal consumption

Global consumption of refined metals has also been transformed over the past two decades because of growth in China. In 2000, the United States was the single largest consumer of most metals, accounting for between 15 and 25 percent of the world total, depending on the metal. The only exception was zinc, of which China was already the largest consumer. However, China's commodity consumption has risen dramatically since then, and it is now by far the single largest consumer of all refined metals. At this point, for all the six metals considered here, China accounts for more than half of global refined metal consumption. In contrast, the United States is the largest consumer of oil, but accounts for only 20 percent of global consumption and 12 percent of imports.

For lead and, to a lesser extent, tin and zinc, China's demand can largely be met by domestic production. For copper and nickel, China relies heavily on imports,

accounting for around one-third of global copper imports and one-fifth of nickel imports. China's consumption of aluminum far exceeds what it can produce from its bauxite reserves. As a result, China relies heavily on imported raw materials to produce aluminum, and accounts for about 70 percent of global bauxite imports.

The next section examines the evolution of price in these markets. It decomposes oil and metal price fluctuations into those driven by shocks to commodity demand and supply.

## Sources of metal price fluctuations

Global oil and metal markets have frequently been buffeted by demand and supply shocks over the past three decades. This section decomposes the variability of oil and metal prices into contributions from demand and supply shocks. It examines how the impact of these shocks on industrial commodity prices differs with the global market structure. For example, compared to other metals and oil, supply shocks have played a smaller role in the price variability of aluminum, which has by far the most concentrated global production structure.

### Methodology and data

For oil and each of the six metals—aluminum, copper, lead, nickel, tin, and zinc—a structural vector autoregression (SVAR), similar to Kilian and Murphy (2014), is used to model global prices (annex 4B).<sup>7</sup> The SVAR includes global metal or oil production, real global metal or oil prices, and real global industrial production. All variables are expressed in month-on-month logarithmic changes.

Two shocks—demand and supply—are examined for their impact on each of the three variables. Sign restrictions on the contemporaneous impact of each shock on the three variables help identify the type of shock. Depending on the direction in which each of the three variables moves, a shock is classified as either a demand or supply shock. A *positive demand shock* is defined as a shock that raises global industrial production and at the same time increases both commodity prices and commodity production. A *positive metals supply shock* is defined as a shock that lowers metal prices while raising metal output and global industrial production.

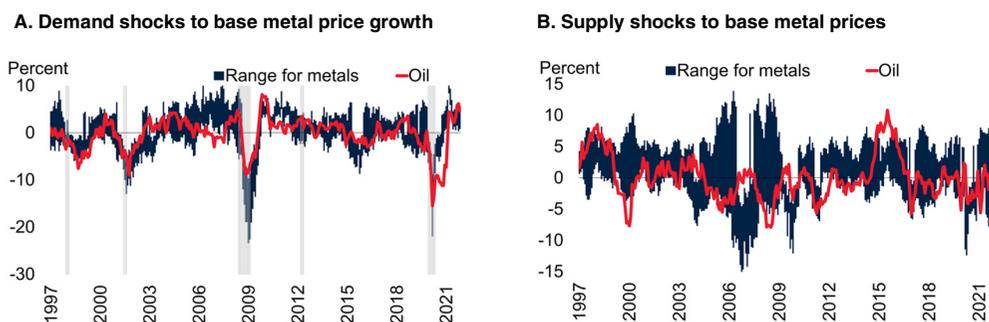
The dataset uses monthly data from February 1996 to December 2021. Global industrial production is the production-weighted average of industrial output in 31 advanced economies and 47 EMDEs. Global oil production data come from the International Energy Agency (IEA). Real prices for the six metals are derived by deflating their U.S.-dollar prices, as reported by the World Bank's *Pink Sheet*, by the U.S. consumer price index.

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<sup>7</sup> Similar models have been used by Jacks and Stuermer (2021), Peersman (2005), and Peersman and Straub (2006).

## FIGURE 4.6 Shocks to oil and base metal price growth

*Demand shocks to oil and base metal price growth are highly synchronized with each other and the global business cycle, such that the price shocks across commodities fall within a narrow band. Metal supply shocks deviate from oil supply shocks and are more dispersed across individual base metals; the wider band suggests that supply shocks are more idiosyncratic.*



Sources: World Bank *Pink Sheet*; World Bank.

Note: Blue areas show the range of demand and supply shocks to year-on-year price growth for six base metals (aluminum, copper, lead, nickel, tin, and zinc). Gray areas indicate global recessions (2009, 2020) and global slowdowns (1998, 2001, 2012), as defined by Kose, Sugawara, and Terrones (2020).

### Demand and supply shocks

The model identifies a series of demand and supply shocks to prices of the six metals and oil from 1996 onward (figure 4.6). These shocks exhibit some clear patterns.

For oil and the six metals, demand shocks were highly synchronized with one other. Large negative demand shocks were associated with global recessions (in 2009 and 2020) and global slowdowns (in 1998, 2001, and 2012). Large positive global demand shocks often occurred during the final stage of an expansion—the year before the global economy began to slide into a recession or slowdown.

In contrast to the highly synchronized demand shocks for all six metals and oil, supply shocks varied widely across oil and the different metals, reflecting specific events that had differing effects on individual commodities. For example, nickel supply surged with the opening up of the Russian economy in the 1990s. In recent years there were several episodes of negative supply shocks, relating to extreme weather, government policy, and industrial disputes. These events included the flooding of copper mines in Peru, Indonesia, Mexico, and Mongolia in 2015; and export bans for nickel ore in Indonesia in 2014 and 2019 (U.S. Geological Survey 2014, 2019). On the other hand, in 2020, COVID-19 outbreaks caused supply shocks that helped offset some of the demand collapse, with mine closures and production disruptions in such countries as Bolivia (lead, tin, zinc), Brazil (tin), Indonesia (tin), Kazakhstan (lead), Mexico (lead, zinc), Myanmar (tin), and Peru (copper, lead, tin, zinc). The decision of OPEC and its partners in April 2020 to cut its production quotas also supported oil prices somewhat amid a steep collapse in demand.

## Response of oil and metal prices to shocks

The estimated impulse response functions of oil and metal prices to these shocks suggest the following patterns. First, for almost all metals, demand shocks had stronger effects than did similarly sized supply shocks and dissipated sooner. In the oil market, demand and supply shocks had somewhat more symmetric effects on prices but, again, the effects of demand shocks dissipated sooner than those of supply shocks. Second, the effects of demand shocks were broadly comparable for nickel prices and oil prices but were smaller for other metal prices; the effects of supply shocks on all metal prices were smaller than those on oil prices.

A demand shock that increased global economic growth by 1 percentage point raised global oil prices by 11 percentage points and global metal prices by between 4 and 10 percentage points, cumulatively, within about half a year (figure 4.7). The impact was particularly strong on nickel prices, possibly reflecting rapidly growing Chinese demand for stainless steel, an alloy that requires nickel. Conversely, aluminum prices responded the least—with a peak impact about half that on nickel prices—possibly reflecting the relatively limited demand for aluminum in China’s rapidly expanding infrastructure investment. The impact peaked around six months after the initial shock for all the metal prices except tin, whose price peaked around a year later. While larger in magnitude, the price impact for oil shocks peaked earlier (four months after the shock) and receded faster than did similarly sized metal price shocks.

A supply shock that reduced growth in global oil or metals production by 1 percentage point resulted in a 10 percentage point increase in oil prices and an increase of between 1 and 3 percentage points for metals within six months (figure 4.8). For aluminum and copper prices, responses to supply shocks peaked somewhat earlier than the responses to demand shocks, whereas the reverse was true for lead, nickel, and zinc. Copper prices seemed to be the most responsive to changes in supply conditions. Aluminum prices were the least responsive. The sluggishness of aluminum prices may reflect Chinese policy interventions to smooth prices. China is the predominant actor in all aspects of global aluminum markets, far more important than in other global metal markets. Supply shocks have a smaller impact on global metal prices than they do on global oil prices. One explanation is that metals have no equivalent body to OPEC and its partners whose policy decisions have at times been associated with considerable shifts in production and prices.

## Contributions of global shocks to global commodity price variation

Demand and supply shocks make important contributions to the variability of global commodity prices. For oil, copper, nickel, and zinc, demand and supply shocks each account for about half of the price variability, whereas for aluminum and tin, demand shocks are a larger source of price variation (figure 4.9).<sup>8</sup> Specifically, demand shocks

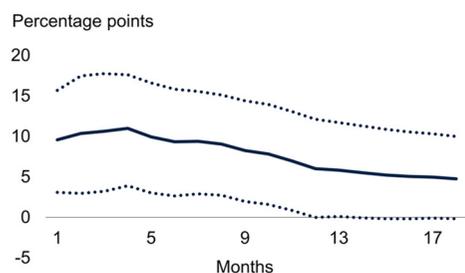
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<sup>8</sup>The predominant role of demand shocks in the variability of commodity prices is in line with Jacks and Stuermer (2020); Kilian and Murphy (2014); and Boer, Pescatori, and Stuermer (2021).

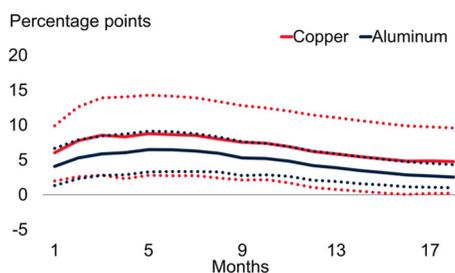
### FIGURE 4.7 Impact of demand shocks on oil and base metal prices

*Demand shocks lift nickel and, with a delay, tin prices about as much as oil prices, but other metal prices by less.*

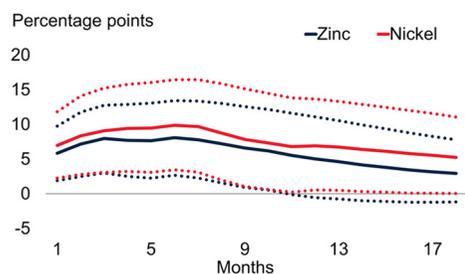
#### A. Impact of demand increase on oil price growth



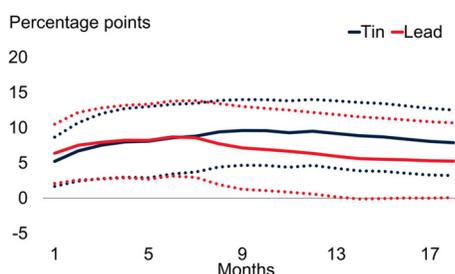
#### B. Impact of demand increase on aluminum and copper price growth



#### C. Impact of demand increase on nickel and zinc price growth



#### D. Impact of demand increase on tin and lead price growth



Sources: World Bank *Pink Sheet*; World Bank.

Note: Figures show impulse response of log price of six base metals and oil to a positive demand shock equivalent to a 1 percentage point increase in global industrial production growth, based on structural vector autoregression model in which sign restrictions identify shocks. A demand shock raises global industrial production, global metal or oil production, and global metal or oil prices. Solid lines indicate median impulse responses; dashed lines indicate 16-84th credible intervals.

account for 50 percent of the forecast error variance of oil price growth and from 46 percent (nickel, zinc) to 71 percent (aluminum) for metal price growth.<sup>9</sup> The exceptionally small contribution of supply shocks to aluminum price variation may reflect widespread government policies aimed at steering domestic aluminum industries. These include policies aimed at influencing production and investment decisions, notably through government management of input prices and the flow of credit to aluminum producers (OECD 2019). Such policies may act to smooth price fluctuations that would otherwise result from production disruptions.

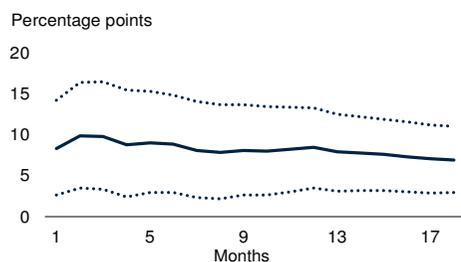
Global recessions, especially the one in 2020 that was associated with the COVID-19 pandemic, were associated with severe demand weakness, and price collapses for oil and all six metals (figure 4.10). Production cuts, as reflected in negative supply shocks, at

<sup>9</sup>These numbers refer to the variance decompositions for one-year-ahead forecast errors of oil or base metal price growth.

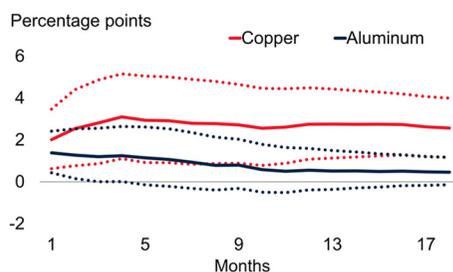
### FIGURE 4.8 Impact of supply shocks on oil and base metal price growth

Supply shocks have lasting impacts on growth of oil prices and most metal prices, except for aluminum. For all metals, the short-run impact of supply shocks is smaller than that of demand shocks and considerably less than for oil prices. For oil prices, the effects of supply and demand shocks are more symmetric.

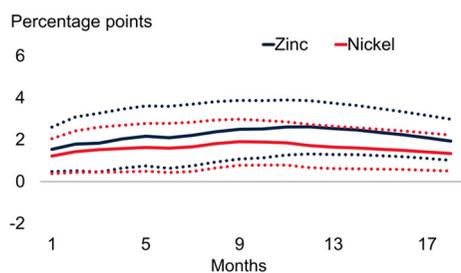
#### A. Impact of a supply decline on oil price growth



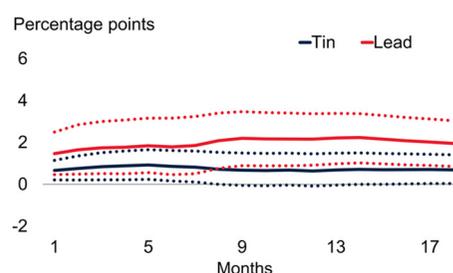
#### B. Impact of a supply decline on aluminum and copper price growth



#### C. Impact of a supply decline on nickel and zinc price growth



#### D. Impact of a supply decline on tin and lead price growth



Sources: World Bank *Pink Sheet*; World Bank.

Note: Figures show impulse response of log price of six base metals and oil to a positive supply shock equivalent to a 1 percent decline in the respective metal production growth, based on a structural vector autoregression model in which sign restrictions identify shocks. A supply shock is defined to reduce global industrial production and global metal or oil production but raise global metal or oil prices. Solid lines indicate median impulse responses; dashed lines indicate 16-84th credible intervals.

most dampened these steep price declines somewhat. However, prices typically rebounded swiftly. In 2009, for example, coordinated G-20 policy stimulus, which included large-scale infrastructure investment in China, helped spur a quick recovery in global activity and commodity prices. Similarly, the robust rebound in global economic activity after the pandemic-induced recession of 2020 also support a bounce back in industrial commodity prices. The more moderate global growth slowdowns (of 1998, 2001, and 2012) depressed metal prices to a lesser extent, as would be expected from smaller demand shocks. Price increases after a slowdown also tended to be more gradual than after a recession; prices did not fully recover for at least a year.

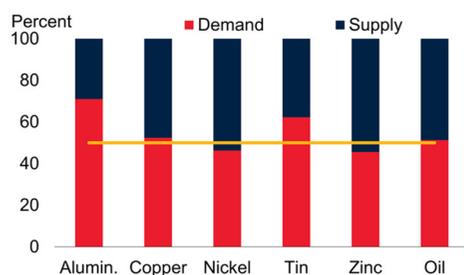
### Robustness

Similar SVAR exercises, using alternative proxies of global economic activity, indicate that the estimates of the model are qualitatively robust to the choice of proxy for global

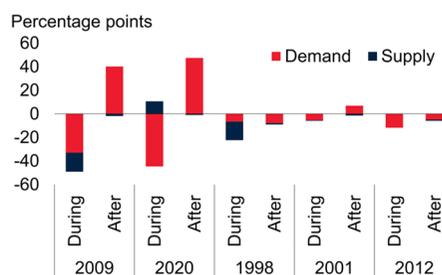
## FIGURE 4.9 Contribution of shocks to commodity price variability and oil price growth

*Oil and base metal price variability was predominantly driven by global demand shocks. These were especially pronounced during global recessions, when demand collapsed. The subsequent unwinding of these demand collapses supported price recoveries.*

**A. Forecast error variance decomposition of metal and oil price growth**



**B. Contributions to oil price growth during global recessions and slowdowns**



Sources: World Bank *Pink Sheet*; World Bank.

A. Variance decomposition of 12-month-ahead forecasts of month-on-month price growth of six base metals and oil based on SVAR model of commodity prices, industrial production, commodity production, and commodity inventories. Shocks are identified using sign restrictions as described in annex 4B. Orange line indicates 50 percent.

B. Cumulative historical decomposition of oil price growth into demand and supply shocks between the last month before global recessions (2009, 2020) or global slowdowns (1998, 2001, 2012) and the last month of global recessions or slowdowns (“During”) as well as between the last month of the global recession or slowdowns and 12 months later (“After”). Global recessions and slowdowns are defined as in Kose, Sugawara, and Terrones (2020).

economic activity (annex 4C). These alternatives involved: a commodity-specific demand-weighted average of industrial production in the world’s 30 largest economies; JP Morgan’s Global Manufacturing and Composite Purchasing Manager Indexes; and the Global Economic Conditions indicator of Baumeister, Korobilis, and Lee (2020).

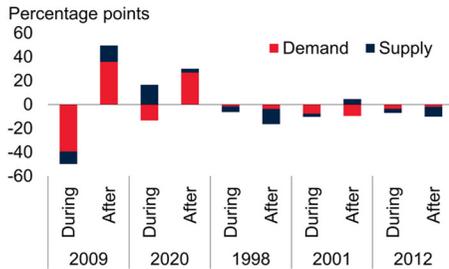
## Macroeconomic impact of metal price shocks

Commodity price fluctuations have been both symptom and cause of global and national swings in the business cycle. Metal prices, especially of copper, have often been considered barometers and leading indicators of global economic activity (Bernanke 2016; Hamilton 2015). For some commodities, such as crude oil, sharp price movements can cause business cycle fluctuations both globally and at the country level, although the effects have generally been short-lived (Baumeister, Peersman, and Van Robays 2010; Kilian 2009). Other commodities, such as tin, may not cause global business cycle fluctuations, but are critical inputs for some sectors—such as the electronics industry—and are important for the small number of countries, such as Rwanda, that produce or export them. This section estimates the impact of commodity price shocks on output growth and identifies asymmetries that are consistent with adverse aggregate growth effects of all types of price shocks.

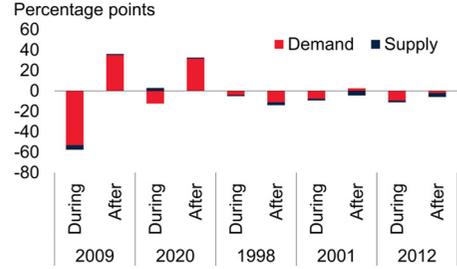
**FIGURE 4.10 Contribution of shocks to base metal price growth**

*Demand shocks were especially pronounced during global recessions, when demand collapsed. The subsequent unwinding of these demand collapses supported price recoveries.*

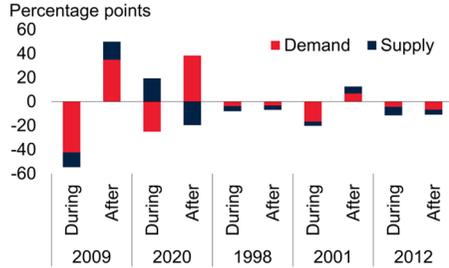
**A. Contributions to copper price growth during global recessions and slowdowns**



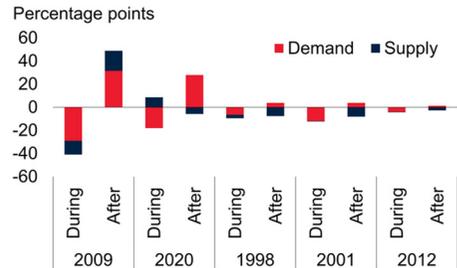
**B. Contributions to aluminum price growth during global recessions and slowdowns**



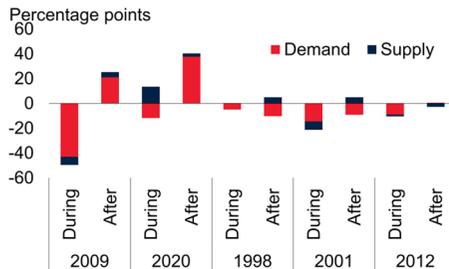
**C. Contributions to nickel price growth during global recessions and slowdowns**



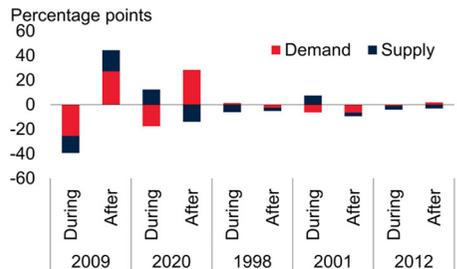
**D. Contributions to zinc price growth during global recessions and slowdowns**



**E. Contributions to tin price growth during global recessions and slowdowns**



**F. Contributions to lead price growth during global recessions and slowdowns**



Sources: World Bank *Pink Sheet*; World Bank.

Note: "During" refers to the cumulative historical decomposition of base metal price growth into demand and supply shocks between the last month before global recessions (2009, 2020) or global slowdowns (1998, 2001, 2012) and the last month of global recessions or slowdowns. "After" encompasses the last month of a global recession or slowdown and 12 months later. Global recessions and slowdowns are defined as in Kose, Sugawara, and Terrones (2020).

## Methodology and data

To assess the impact of oil or metal price shocks on EMDEs, a local projection model is estimated (annex 4D).<sup>10</sup> The model examines the impact of oil or metal price changes on real output over the period 1970–2019 under two different specifications. The first version of the model assumes that the impact is symmetric for price increases and decreases. The second version allows price increases and decreases to have asymmetric impacts. For metals, the estimates provide measures of the impact of shocks to an aggregate index of metal prices on both metal exporters and importers, as well as measures of the impact of shocks to aluminum and copper prices individually. The data sources are described in annex 4D.

## Features of large metal price jumps and collapses

The largest jumps and collapses of oil and metal prices—those that exceed 20 percent over a six-month period—were clustered around major economic events. These include four global recessions (1974–75, 1981–82, 1990–91, and 2008–09), and three global slowdowns (1998, 2001, and 2012) since 1970 (Kose, Sugawara, and Terrones 2020). In general, such large oil and metal price increases occurred in the years just prior to global recessions and slowdowns (such as 1973, 1980, 2006, and 2018), or in the years when global recoveries were getting underway (such as in 1983, 1999, and 2009). In contrast, large price collapses tended to occur in the midst of global recessions and slowdowns (such as in 1974, 1991, and 2008). For oil, large collapses also occurred after OPEC changed its strategy from targeting a price to targeting market share, such as in 1985 and 2014 (Baffes et al. 2015; Kabundi and Ohnsorge 2020). The clustering of large swings in oil and metal prices around global recessions is consistent with earlier findings about the considerable role of aggregate demand in driving prices.

In general, metal price jumps and collapses were more frequent, but of smaller magnitude, than oil price shocks (figure 4.11). This may have contributed to the more muted impact of metal price shocks on metal exporters than the larger effect of oil price shocks on EMDEs that rely heavily on oil exports.

## Impact of oil or metal price shocks

For EMDE energy exporters, assuming symmetric impacts, a 10 percentage point increase in the growth of oil prices was associated with a statistically significant 0.2 percentage point increase in output growth over the subsequent two years (figure 4.12).<sup>11</sup> The estimated adverse effects from higher oil prices on economic activity in EMDE energy importers were small and built up so gradually that they became

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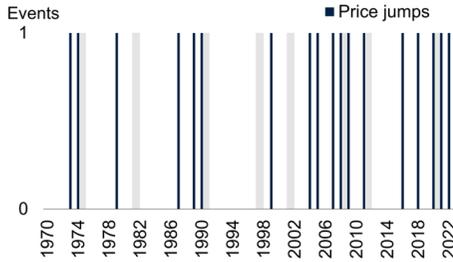
<sup>10</sup> Other metals are not included in the analysis due to the small number of exporters even at lower thresholds (4 for zinc, 3 for nickel, and 1 for lead and tin).

<sup>11</sup> These results are consistent with the literature on energy-exporting EMDEs (Abeyasinghe 2001; Caldara, Cavallo, and Iacoviello 2019; Lippi and Nobili 2012; and Mohaddes and Raissi 2017, 2019) or energy-exporting advanced economies (Peersman and Van Robays 2012).

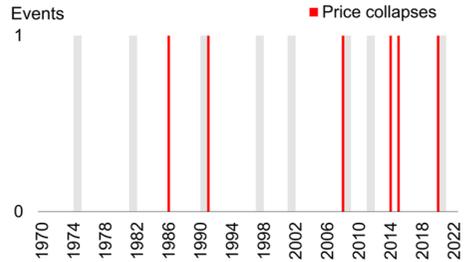
**FIGURE 4.11 Oil and metal price shocks**

Large oil and metal price jumps often occurred in the years prior to global recessions and slowdowns, and in the years following them when global recoveries were underway. Metal price shocks were typically more frequent, but smaller, than oil price shocks.

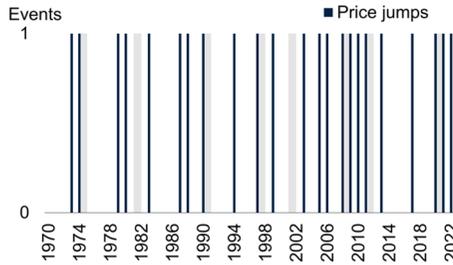
**A. Oil price jumps**



**B. Oil price collapses**



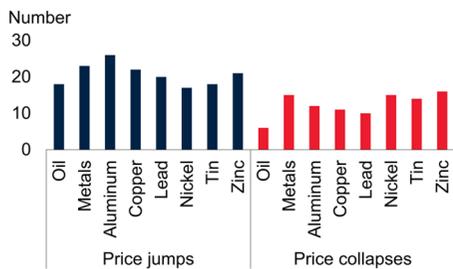
**C. Metal price jumps**



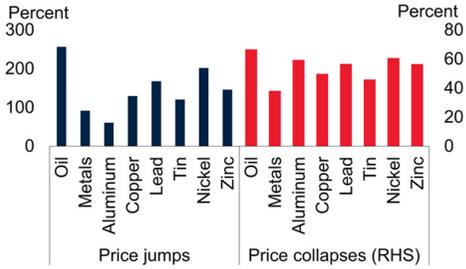
**D. Metal price collapses**



**E. Number of metal and oil price shocks**



**F. Magnitude of metal and oil price shocks**



Sources: World Bank *Pink Sheet*; World Bank.

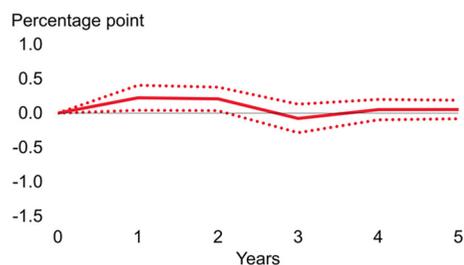
Note. A price jump is an increase of one standard deviation over a 6-month period while a price collapse is a decline of one standard deviation over a 6-month period. Shaded areas indicate period of global recessions (1975, 1982, 1991, 2009, 2020) or slowdowns (1998, 2001, 2012).

F. The bars represent the absolute average trough-to-peak or peak-to-trough price change for price jumps and collapses. Price collapses are shown as absolute averages, so 50 percent indicates a 50 percent fall in prices.

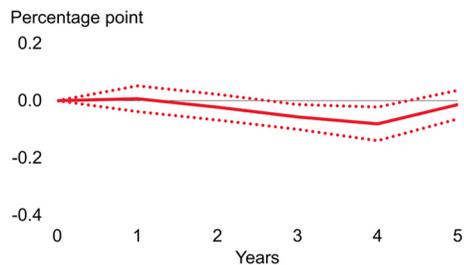
### FIGURE 4.12 Impact on EMDE output growth of oil price shocks

*In energy-exporting EMDEs, oil price increases generated short-lived output gains, but oil price declines generated much larger and more lasting output losses. In energy-importing EMDEs, oil price increases were associated with small output losses and oil price declines were associated with statistically insignificant output gains.*

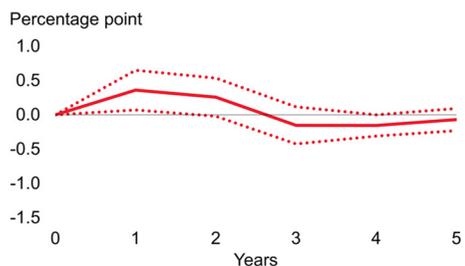
**A. EMDE energy exporters: Symmetric impact of 10 percentage point change in oil price growth**



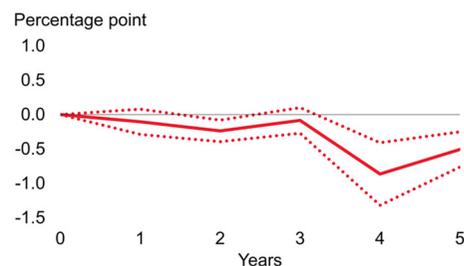
**B. EMDE energy importers: Symmetric impact of 10 percentage point change in oil price growth**



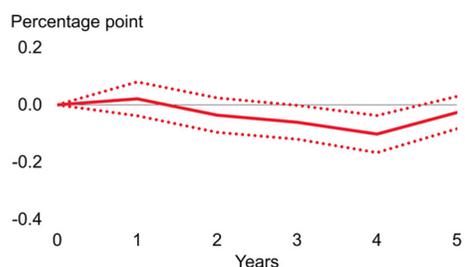
**C. EMDE energy exporters: Asymmetric impact of 10 percentage point higher oil price growth**



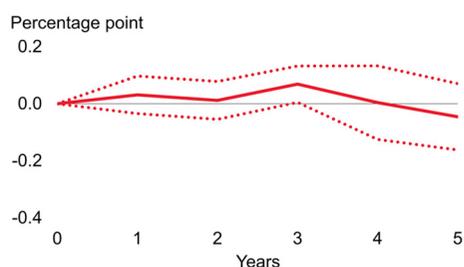
**D. EMDE energy exporters: Asymmetric impact of 10 percentage point lower oil price growth**



**E. EMDE energy importers: Asymmetric impact of 10 percentage point higher oil price growth**



**F. EMDE energy importers: Asymmetric impact of 10 percentage point lower oil price growth**



Sources: World Bank.

Note: Cumulative impulse responses of output growth for 153 EMDEs, of which 34 are energy exporters, from a local projection estimation. Dependent variable is output growth after 10 percentage point change in oil price growth. Solid lines are coefficient estimates and dotted lines are 95 percent confidence bands based on heteroscedasticity consistent standard errors and Driscoll-Kraay standard errors. Panels A and B are estimated assuming symmetric effects of metal price changes; Panels C, D, E, and F are estimated accounting for asymmetric effects of price increases and price declines.

statistically significant only after three-to-four years, perhaps because policy room to buffer higher oil import prices was gradually eroded.

For EMDE metal exporters, a 10-percentage-point increase in the growth in metal prices was followed by a gradual rise in output, by a statistically significant 0.1 percentage point, after two years. But the effect declined gradually, fading to insignificance after three years (figure 4.13). For EMDE metal importers, there was no statistically significant effect from a price increase, reflecting the small amount of metal they import. On average, metals account for only 5 percent of their total imports.<sup>12</sup> Even for China, the largest consumer of all the six metals in the sample, these metals account for only 4 percent of China's imports. By contrast, oil accounts for about 14 percent of China's imports.

### *Asymmetric impacts of oil or metal price shocks*

The aggregate results mask the asymmetric impacts of oil or metal price increases and declines. For both oil and metal exporters, output gains from price increases were short-lived, while output losses after price declines were longer-lasting and larger (although, for energy exporters, these losses were delayed by several years). The impact of a metal price shock remained smaller than that of an oil price shock.

Specifically, a 10 percentage point increase in the growth of oil prices raised output growth in energy exporters by about 0.3–0.4 percentage point for two years, whereas a similarly sized decline in oil price growth was associated with a statistically insignificant slowdown in output growth for several years. But four years after the price decline, the slowdown in output growth steepened to 0.9 percentage point and remained statistically significant thereafter.<sup>13</sup> This pronounced and lasting effect of oil price declines in energy-exporting EMDEs is consistent with the damage to potential output growth caused by persistent declines in investment occasioned by the price decline (Aguilar and Gopinath 2007). Meanwhile, energy importers suffered small but delayed output losses several years after an oil price increase but did not benefit from statistically significant output gains after oil price declines.

Similarly, while a 10 percentage point increase in growth in metal prices was followed by an increase in economic activity in metal exporters, the effects were small and short-lived (less than 0.1 percentage point increase in output growth after a couple of years). Price declines had much bigger effects—eight times greater than those from price increases, reaching 0.4 percentage point in the first year and lasting twice as long. In contrast,

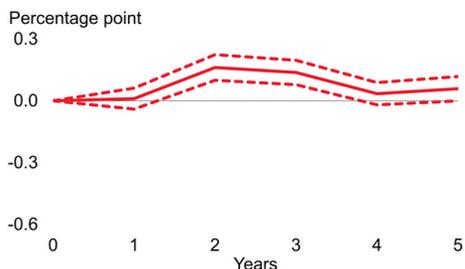
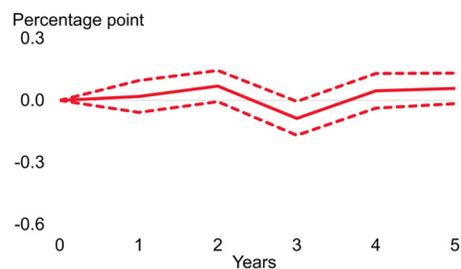
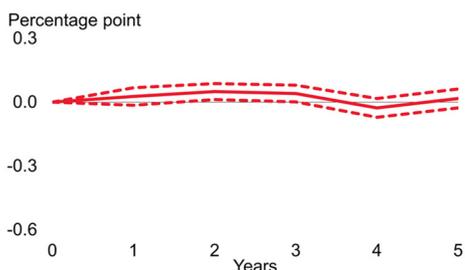
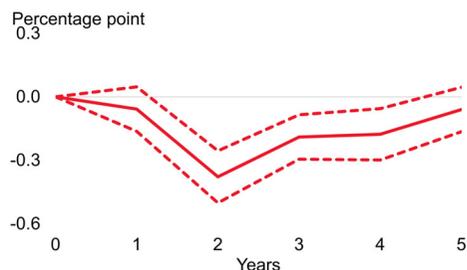
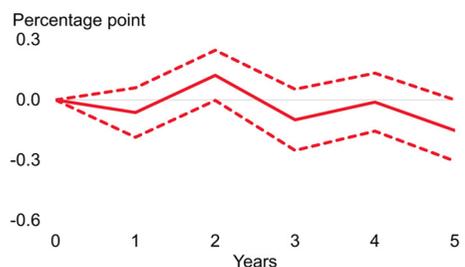
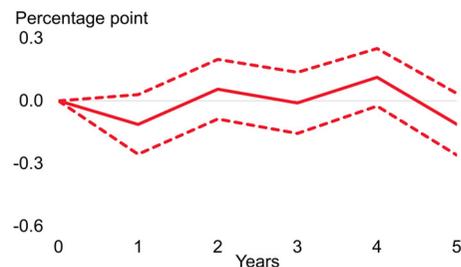
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<sup>12</sup> These results are consistent with Di Pace, Juvenal, and Petrella (2021) who find evidence of a positive and statistically significant effect of export price shocks on output growth in EMDEs but a smaller impact of import price shocks.

<sup>13</sup> These results are consistent with a recent study by Di Pace, Juvenal, and Petrella (2021) that found that positive export price shocks raise domestic output growth in EMDEs, particularly in oil-exporting EMDEs. Mohaddes and Raissi (2017, 2019) also find similar lasting output losses in the Gulf Cooperation Council (GCC) countries of just over 2 percent from an oil supply shock, equivalent to a 10–12 percent drop in price.

**FIGURE 4.13 Impact on EMDE output growth of metal price shocks**

*Metal price shocks do not have a significant impact on metal-importing EMDEs and have an asymmetric impact on metal-dependent EMDEs. Price increases are associated with higher output in EMDE metal exporters but the response is modest and short-lived. Output declines after price declines are stronger and longer-lasting.*

**A. EMDE metal exporters: Symmetric impact of 10 percentage point change in metal price growth****B. EMDE metal importers: Symmetric impact of 10 percentage point change in metal price growth****C. EMDE metal exporters: Asymmetric impact of 10 percentage point higher metal price growth****D. EMDE metal exporters: Asymmetric impact of 10 percentage point lower metal price growth****E. EMDE metal importers: Asymmetric impact of 10 percentage point higher metal price growth****F. EMDE metal importers: Asymmetric impact of 10 percentage point lower metal price growth**

Source: World Bank.

Note: Cumulative impulse responses of output growth in 153 EMDEs, of which 31 are metal exporters, from a local projections model. Dependent variable is output growth after 10 percentage point changes in metal price growth. Solid lines are coefficient estimates and dotted lines are 95 percent confidence bands. Panels A and B are estimated assuming symmetric effects of metals price changes; Panels C, D, E, and F are estimated accounting for asymmetric effects of price increases and price declines.

among metal importers, neither metal price increases nor declines were associated with any statistically significant output responses.

This asymmetry for energy and metal exporters may reflect the procyclicality of fiscal policy in EMDEs (Alesina, Campante, and Tabellini 2008; Frankel 2010). Increased fiscal spending during resource booms adds fuel to a domestic economic expansion and can go towards less productive purposes, while fiscal consolidation during price collapses exacerbates the depth of a recession (Frankel 2011; Medas and Zakharova 2009). This can have lasting negative effects on growth, because public investment, such as infrastructure spending, is typically the first element of public spending to be cut (Richaud et al. 2019). For example, after the 2014–16 commodity-price collapses, the sharp decline in fiscal revenues forced abrupt cuts in government spending that exacerbated the economic slowdowns (Stocker et al. 2018).<sup>14</sup>

### *Impact of copper price shocks*

Copper is often regarded as the bellwether metal for the world economy, and copper exporters tend to be considerably more resource-reliant than exporters of other metals. The results from the model for shocks to the price of copper are therefore of special interest.

The effects of copper price shocks are similar to those for the broad group of industrial metals. Copper exporters benefit from short-lived output gains after copper price increases but encounter longer-lasting and larger output losses after price declines (Figure 4.14). The effects of copper price declines are somewhat larger than those of general metal price shocks. Among copper importers, neither price declines nor increases were associated with any statistically significant output gains or losses, as was also the case for metal importers more generally.

### *Contrast with aluminum price shocks*

In contrast to copper, the results suggest that aluminum price shocks are not followed by statistically significant output changes, either in EMDE aluminum exporters or importers.<sup>15</sup> These differences may arise because aluminum exporters rely less on aluminum exports than copper exporters do on copper exports. For the average aluminum exporter in the sample, aluminum accounted for 15 percent of exports, almost one-third less than the 22 percent export share of copper for the average copper exporter. In eight of the copper exporters, copper accounted for 20 percent or more of exports, compared to just three of the aluminum exporters.

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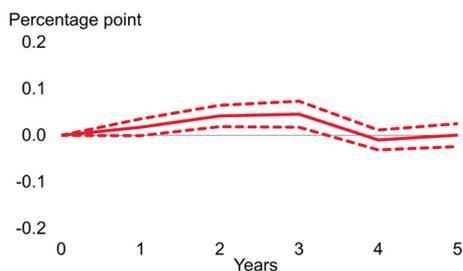
<sup>14</sup>The asymmetric results are unlikely to simply reflect the nature of commodity price cycles. On average, commodity price increases have tended to be considerably larger and faster, although not much longer, than commodity price decreases (chapter 3).

<sup>15</sup>Since all results are statistically insignificant, they are not separately shown but are available upon request.

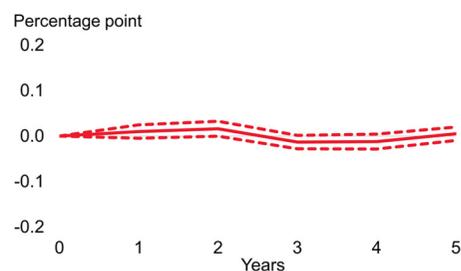
**FIGURE 4.14** Impact on EMDE output growth of copper price shocks

Copper price shocks have an asymmetric impact on copper-dependent EMDEs. Copper price increases are followed by shorter-lived and more modest output expansions than the output contractions after copper price declines.

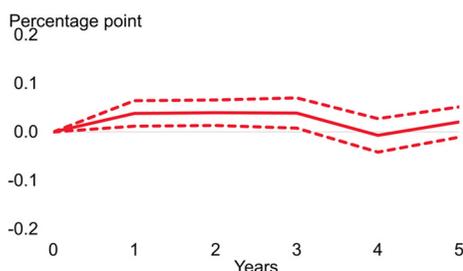
**A. EMDE copper exporters: Symmetric impact of a 10 percentage point change in copper price growth**



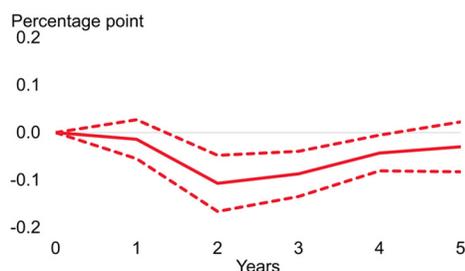
**B. EMDE copper importers: Symmetric impact of a 10 percentage point change in copper price growth**



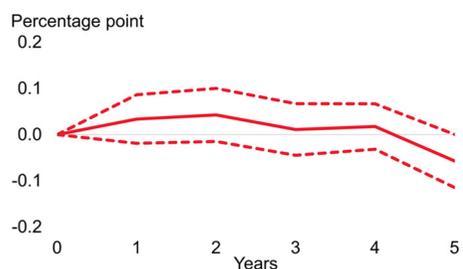
**C. EMDE copper exporters: Asymmetric impact of a 10 percentage point increase in copper price growth**



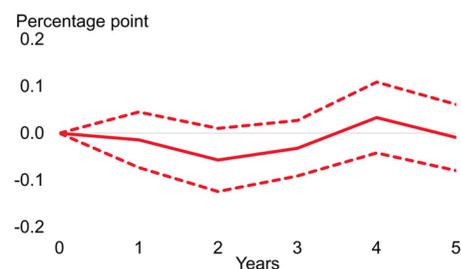
**D. EMDE copper exporters: Asymmetric impact of a 10 percentage point decrease in copper price growth**



**E. EMDE copper importers: Asymmetric impact of a 10 percentage point increase in copper price growth**



**F. EMDE copper importers: Asymmetric impact of a 10 percentage point decrease in copper price growth**



Source: World Bank.

Note: Cumulative impulse responses of output growth in 153 EMDEs, of which 14 are copper exporters, from a local projections model. Dependent variable is output growth after 10 percentage point changes in copper price growth. Solid lines are coefficient estimates and dotted lines are 95 percent confidence bands. Panels A and B are estimated assuming symmetric effects of metals price changes; Panels C, D, E, and F are estimated accounting for asymmetric effects of price increases and price declines.

## Conclusion and policy implications

Many EMDEs rely on energy commodities or metals for a significant share of export earnings and fiscal revenue. This chapter examines the extent to which this reliance makes their macroeconomic stability vulnerable to changes in oil or metal prices on world markets.

It presents econometric analyses showing that global demand and supply shocks have typically contributed about equally to oil and metal price swings. An exception was the price of aluminum. With the most concentrated global market among these commodities and the largest role of China in production and consumption, supply shocks were only a minor source of aluminum price volatility. That oil and metal price swings are themselves heavily driven by global demand shocks suggests that, at least in part, oil and metal prices serve as a conduit and amplifier of global business cycles on commodity-exporting EMDEs.

The impact of commodity price volatility has not been symmetric. Increases in oil or metal prices have been associated with short-lived output gains in energy or metal exporters. But declines in oil or metal prices have been associated with longer-lasting and larger (although sometimes delayed) output losses in energy or metal exporters. These effects have been particularly pronounced for copper exporters, which are among the least diversified of EMDE commodity exporters.

For policy makers in metal exporters, these results indicate a need for counter-cyclical policies to better shield an economy from global commodity-price volatility (see also the introduction to this volume). The temporary nature of commodity price booms calls for a framework that avoids increasing spending in good times and slashing it when conditions deteriorate. Such a framework would ensure that surplus revenue should be saved so that resources are available to support activity when prices collapse. Stronger fiscal frameworks, including fiscal rules, and structural budget rules, can help resist pressures to spend revenue windfalls, or reduce non-resource taxes. An independent process for setting the guidelines for such rules—such as determining when to have surpluses and when to run deficits—is critical to successful stabilization policies (Frankel 2011). Sovereign wealth funds can be useful mechanisms to save windfall revenues during price upswings and provide a cushion of assets that can be drawn down during price slumps. Reforms to monetary policy, with flexible exchange rates anchored by credible medium- and long-run inflation targets, could help foster resilience to commodity price fluctuations and ensure smoother adjustment of real exchange rates (Frankel 2018; Torvik 2018). Improved access to international assistance would help provide timely short-term relief to low-income countries suffering from global commodity price declines.

The empirical exercises conducted in this chapter suggest that greater economic diversification could blunt some of the impact of commodity price shocks. Policies to promote raising standards of living in EMDEs—such as investment in human capital, improving institutions, modernizing infrastructure, and promoting higher value-added

activities in resource sectors—would promote diversification of economic activities, even if export diversification *per se* is unrealistic (World Bank 2015, 2022).

The findings in this chapter point to several avenues for future research. First, the results suggest the presence of important asymmetries in macroeconomic outcomes that depend on the nature of the commodity price shock. Future research could examine other asymmetries, such as what drives price shocks. Second, the analysis used the largest cross-country dataset available to derive broadly applicable results. This restricted the analysis to annual data. Future research could examine more granular patterns in responses of macroeconomic outcomes using quarterly data.

## ANNEX 4A Stylized facts: Data

The dataset includes annual data for 153 EMDEs for 1970–2019. UN Comtrade and the Observatory of Economic Complexity were used as the source of commodity import and export data. Annual data on real GDP and world per capita GDP are available from the World Bank’s *World Development Indicators* database. Metal prices data are taken from the World Bank’s *Pink Sheet* database. Nominal price indexes are calculated by taking a weighted average of aluminum, copper, lead, nickel, tin, and zinc prices (from the *Pink Sheet*), and weighting them using EMDE export shares. The real price is obtained by deflating the nominal metal price (in U.S. dollars) with the U.S. consumer price index (CPI). The real metal price was converted into annual growth rates. The control variables are composed of global demand and domestic inflation computed as the annual growth rate of the CPI for each country. Data on the CPI are taken from the IMF’s *World Economic Outlook*.

For the purposes of the stylized facts section, an EMDE is classified as a commodity exporter if its exports of a given commodity are 5 percent or more of total goods exports. Note that this results in a larger number of exporters than would be obtained using the definition in World Bank (2020b), which sets a threshold of 20 percent of total exports since it refers to broader commodity groups. In identifying metal exporters, all exports of industrial metal ores and refined metal exports were included. Exports of precious metals such as gold and silver were not included. This identification provides a total of 58 exporters of industrial metals of all types (including iron ore)—of which 14 are copper exporters and 10 aluminum exporters.

Similarly, an EMDE is classified as a metal importer if its imports of a metal accounted for 0.1 percent or more of total imports. This definition resulted in 50 metal importers—including 31 copper and 38 aluminum importers. The average concentration of metal imports as a share of total imports is much smaller than that of exporters.

**TABLE 4.1 Commodity exporters**

	Oil	Copper	Aluminum	Zinc	Nickel	Lead	Tin
Albania	Libya	Armenia	Bahrain	Bolivia	Madagascar	Tajikistan	Rwanda
Algeria	Malaysia	Bulgaria	Bosnia and Herzegovina	Burkina Faso	Papua New Guinea		
Angola	Maldives	Chile	Guinea	Namibia	Zimbabwe		
Antigua and Barbuda	Mexico	Congo, Rep.	Guyana	Peru			
Azerbaijan	Mongolia	Congo, Dem. Rep.	Jamaica	Tajikistan			
Bahamas	Niger	Kazakhstan	Montenegro				
Bahrain	Nigeria	Lao PDR	Mozambique				
Barbados	Oman	Mauritania	Sierra Leone				
Belarus	Panama	Mongolia	Solomon Islands				
Brazil	Papua New Guinea	Namibia	Tajikistan				
Brunei Darussalam	Peru	Papua New Guinea					
Bulgaria	Qatar	Peru					
Cameroon	Russian Federation	Tajikistan					
Chad	Rwanda	Zambia					
Colombia	Samoa						
Congo, Rep.	Sao Tome and Principe						
Cote d'Ivoire	Saudi Arabia						
Croatia	Senegal						
Djibouti	Seychelles						
Ecuador	South Sudan						
Egypt, Arab Rep.	St. Lucia						
Equatorial Guinea	Sudan						
Fiji	Syrian Arab Republic						
Gabon	Timor-Leste						
Ghana	Togo						
India	Trinidad and Tobago						
Iraq	Tunisia						
Jamaica	Turkmenistan						
Kazakhstan	United Arab Emirates						
Kuwait	Venezuela, RB						
Liberia	Yemen, Rep.						

## ANNEX 4B SVAR: Methodology and data

### 4.2.1 Econometric model

The SVAR model of the global oil or metal market is written as

$$B_0 Y_t = \sum_{i=1}^{12} B_i Y_{t-i} + \varepsilon_t \quad (\text{A1})$$

where  $Y_t$  is the vector of endogenous variables,  $\varepsilon_t$  represents the structural shocks which follow a standard normal distribution.  $B_i, i = 0 \dots \dots, 12$  denotes the coefficient matrices. The structural shocks are comprised of supply, demand, and residual shocks. Endogenous variables are  $Y_t = [\Delta q_t, \Delta y_t, p_t]'$ , where  $\Delta q_t$ ,  $\Delta y_t$ , and  $p_t$  denote the log-differences of metal production, global economic activity indexes, and metal prices.

### 4.2.2 Data

Real prices of oil and base metals are drawn from the World Bank's *Pink Sheet* database deflated by the U.S. CPI from the Federal Reserve Economic Data (FRED) database maintained by the St. Louis Federal Reserve Bank. Global industrial production is the production-weighted average of industrial production in 31 advanced economies and 47 EMDEs (unbalanced sample depending on availability) from Haver Analytics. Production data are from the World Bureau of Metal Statistics. The data set uses monthly data from February 1996 to July 2021.

### 4.2.3 Identification through sign restrictions

The structural representation (A1) can be expressed as the reduced-form representation (A2) as follows,

$$Y_t = \sum_{i=1}^{12} A_i Y_{t-i} + e_t, \quad (\text{A2})$$

where  $e_t$  is errors with mean zero, zero autocorrelation, and variance covariance matrix  $\Sigma_e = \mathbb{E}[e_t e_t']$ . The identification problem consists in finding a mapping from the errors in the reduced-form representation to its structural counterpart:

$$e_t = B_0^{-1} \varepsilon_t \quad (\text{A3})$$

Next, the following relation is exploited:

$$\Sigma_e = \mathbb{E}[e_t e_t'] = \mathbb{E}[B_0^{-1} \varepsilon_t (B_0^{-1} \varepsilon_t)'] = B_0^{-1} \mathbb{E}[\varepsilon_t \varepsilon_t'] (B_0^{-1})' = B_0^{-1} \Sigma_\varepsilon (B_0^{-1})' = B_0^{-1} (B_0^{-1})' \quad (\text{A4})$$

To explore  $\tilde{B}$ , the estimate of  $B_0^{-1}$ , we generate the random orthogonal matrix  $QQ' = I$  and consider Cholesky factor  $\Sigma_e = PP'$  as follows:

$$\Sigma_e = PQQ'P' = (PQ)(PQ)' \quad (\text{A5})$$

Relating equation (A4) to (A5), we consider the matrix  $\tilde{B} = PQ$  as a valid candidate.

$\tilde{B}$  should also satisfy the sign restrictions in table 4B.1. A positive demand shock on impact will raise the real price of oil or metals and stimulate oil or metal production, but lower global economic activity. A positive supply shock will lower oil or metal production on impact. It also will lower global economic activity while increasing the real price of oil or metals.

Note that these commodity demand and supply shocks differ materially from the global demand and supply shocks modelled in Charnavoki and Dolado (2014) and Ha, Kose, and Ohnsorge (2019). In these approaches, an increase in both economic activity and commodity prices can reflect either a global demand or global supply shock—depending on movements in global inflation (table 4B.2). Either of these two global shocks drives up commodity demand, consistent with the definition of a commodity demand shock used here and in Kilian and Murphy (2014). Both here and in Kilian and Murphy (2014), a simultaneous increase in economic activity, commodity production, and prices reflects a commodity demand shock. An oil or metal supply shock is associated with an increase in oil or metal prices and a decline in economic activity and commodity production.

We simulate impulse responses based on a candidate  $\tilde{B}$ . The candidate  $\tilde{B}$  is retained if the resulting impulse responses meet the sign restrictions, otherwise they are discarded.

The integrated steps are as follows:

1. Estimate an unrestricted VAR and find  $\tilde{\Sigma}_e$ . Implement Cholesky decomposition to extract  $P$ .
2. Draw a random orthogonal matrix  $Q$  and compute  $\tilde{B} = PQ$ .
3. Compute impulse responses using  $\tilde{B}$  calculated in step 2. If all implied impulse response functions satisfy the sign restrictions, retain  $\tilde{B}$ . Otherwise discard  $\tilde{B}$ .
4. Repeat the first two steps 50,000 times, recording each  $\tilde{B}$  that satisfies the restrictions and record the corresponding impulse response functions (table 4B.3). About one-fifth of the draws are discarded.

**TABLE 4B.1 Sign restrictions on impulse responses**

	Supply shocks	Demand shocks
Oil or metal production	–	+
Global economic activity	–	+
Real price of oil or metals	+	+

**TABLE 4B.2 Comparison of the estimation framework**

Study	Structural shocks	Endogenous variables	Endogenous variables
<b>World Bank 2022 (this study)</b>	Sign restriction	Supply; Demand; Residual	Prices (log level); Economic activity (cycle); Production (log difference)
<b>Kilian and Murphy (2014)</b>	Sign restriction; Elasticity restriction	Supply; Demand; Speculative demand; Residual	Prices (log level); Economic activity (cycle); Production (percent change); Inventories (difference)
<b>Jacks and Stuermer (2020)</b>	Zero long-run restrictions	Supply; Demand; Commodity specific demand	Prices (log level); Economic activity (percent change); Production (percent change)
<b>Stuermer (2018)</b>	Zero long-run restrictions	Commodity common supply; Commodity common demand; Commodity specific demand	Prices (log level); Economic activity (percent change); Production (percent change)

**TABLE 4B.3 Impulse responses**

Metals	Shocks	Month				
		1 (Initial Impact)	3	6	9	12
<b>World Bank (this study)</b>	Supply	-2.66	-3.71	-3.85	-3.59	-3.63
Copper	Demand	3.05	4.30	4.35	3.80	3.14
Aluminum	Supply	-1.92	-1.67	-1.48	-1.11	-0.77
	Demand	2.30	3.29	3.63	2.97	2.36
Zinc	Supply	-2.90	-3.45	-3.95	-4.71	-4.92
	Demand	3.40	4.14	4.20	3.43	2.61
Nickel	Supply	-3.82	-4.77	-5.00	-5.97	-5.38
	Demand	3.76	4.90	5.32	4.22	3.72
Tin	Supply	-2.55	-3.23	-3.30	-2.60	-2.45
	Demand	2.80	4.03	4.57	5.13	5.08
Lead	Supply	-3.12	-3.70	-3.80	-4.67	-4.58
	Demand	3.40	4.23	4.63	3.80	3.38
Oil	Supply	-4.03	-4.75	-4.28	-3.93	-4.11
	Demand	4.60	5.10	4.48	3.96	2.88
<b>Kilian and Murphy (2014)</b>	Supply	-2.34	-3.38	-1.71	-0.78	-0.53
Oil	Demand	3.16	6.56	7.25	6.59	7.38
<b>Jacks and Stuermer (2020)</b>	Supply	–	–	–	–	-0.088
Copper	Demand	–	–	–	–	0.082
<b>Stuermer (2018)</b>	Supply	–	–	–	–	-0.041
Copper	Demand	–	–	–	–	0.078

Note: The impulse responses values of the preceding studies (listed above) are simulated by their appendix codes. The size of shocks is one standard deviation.

## ANNEX 4C SVAR: Robustness tests

The baseline results are tested for robustness to different proxies of economic activity. They include the following measures:

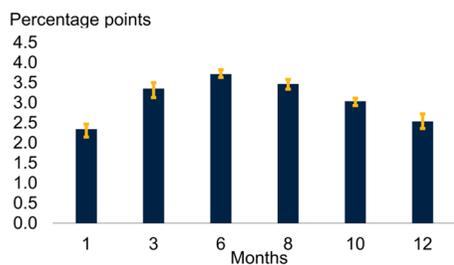
- The GECON index proposed by Baumeister, Korobilis, and Lee (2020), which is the common factor of many monthly activity indicators;
- A commodity consumption-weighted average of industrial production for 48 countries;
- J.P. Morgan's global manufacturing PMI; and
- J.P. Morgan's global composite PMI.

The global composite PMI is included to capture the role of the services sector in economic activity.

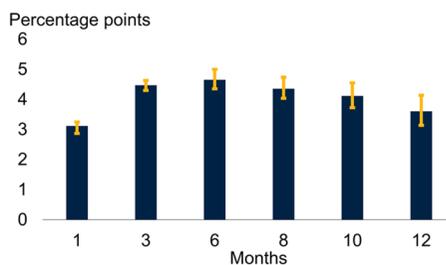
The baseline results are robust to all four alternative proxies. The results yield qualitatively similar impulse response functions (IRFs) in shape and magnitude (figures A.4C.1 and A.4C.2 for metal prices; figure A.4C.3 for oil prices). They depict small dispersion around the mean for all horizons (i.e., on impact, after 6 months, and over a year). Forecast error variance decompositions (FEVD) also show little dispersion for supply and demand, and across all commodities (figure A.4C.4). For supply shocks, the maximum range is 17 percent (copper) and the minimum is 8 percent (aluminum, nickel).

**FIGURE A.4C.1** IRFs for demand shocks with different proxies of economic activity

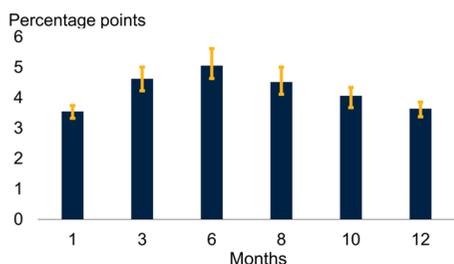
**A. Aluminum**



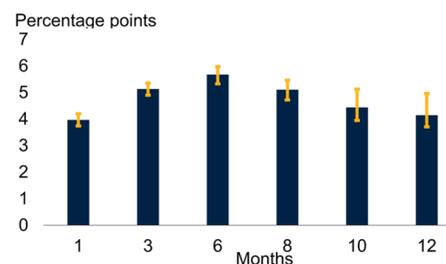
**B. Copper**



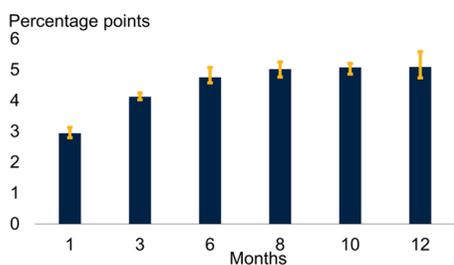
**C. Lead**



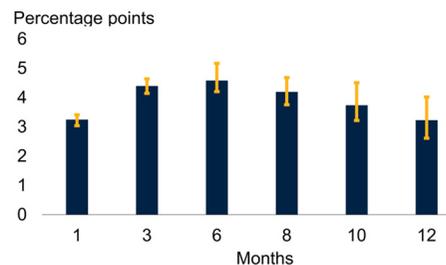
**D. Nickel**



**E. Tin**



**F. Zinc**

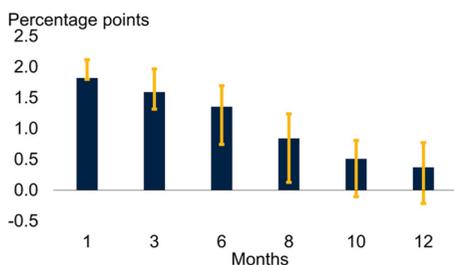


Source: World Bank.

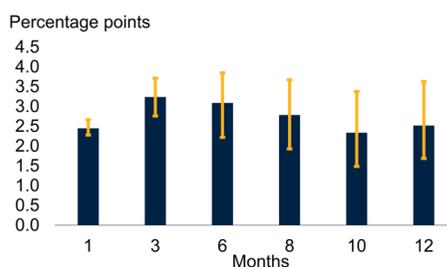
Note: Blue bars show the average impulse responses functions to one standard deviation demand shocks at the 1-month, 3-month, 6-month, 8-month, 10-month and 12-month horizons, as estimated from a structural vector autoregression model described in annex 4B using five different proxies for economic activity: global industrial production, the GECON index, commodity-consumption weighted industrial production, the global manufacturing PMI, and the global composite PMI. Yellow whiskers show the range of estimates from the five specifications with the five different proxies for global economic activity.

**FIGURE A.4C.2** IRFs for supply shocks with different proxies of economic activity

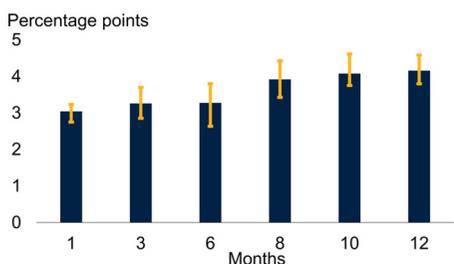
**A. Aluminum**



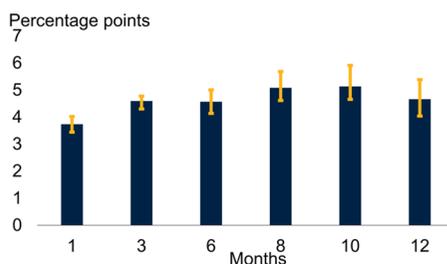
**B. Copper**



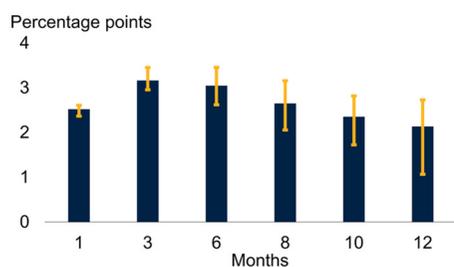
**C. Lead**



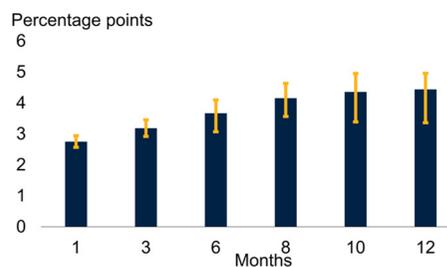
**D. Nickel**



**E. Tin**



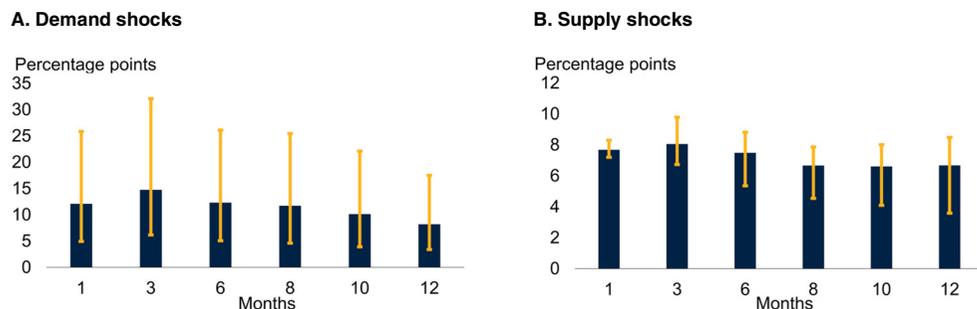
**F. Zinc**



Source: World Bank.

Note: Blue bars show the average impulse responses functions to one standard deviation supply shocks at the 1-month, 3-month, 6-month, 8-month, 10-month and 12-month horizons, as estimated from a structural vector autoregression model described in annex 4B using five different proxies for economic activity: global industrial production, the GECON index, commodity-consumption weighted industrial production, the global manufacturing PMI, and the global composite PMI. Yellow whiskers show the range of estimates from the five specifications with the five different proxies for global economic activity.

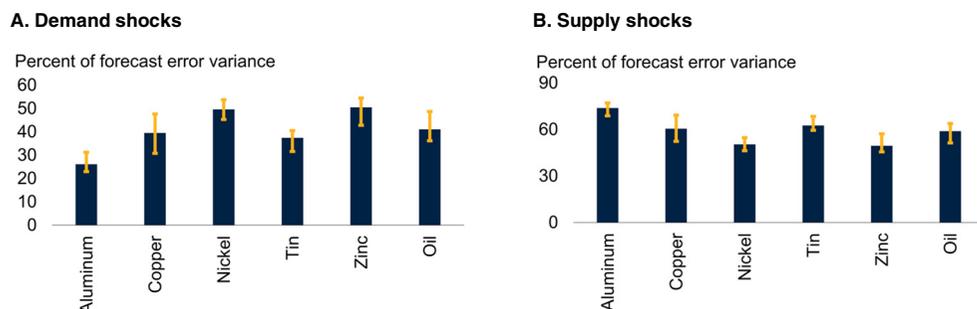
**FIGURE A4C.3 IRFs for demand and supply shocks to economic activity on oil price growth**



Source: World Bank.

Note: Blue bars show the average contribution of demand, supply shocks to the forecast error variance at the 12-month horizon, as estimated from a structural vector autoregression model described in annex 4B using five different proxies for economic activity: global industrial production, the GECON index, the global manufacturing PMI, and the global composite PMI. Yellow whiskers show the range of estimates from the five specifications with the five different proxies for global economic activity

**FIGURE A.4C.4 FEVDs using different proxies of economic activity**



Source: World Bank.

Note: Blue bars show the average contribution of demand, supply shocks to the forecast error variance at the 12-month horizon, as estimated from a structural vector autoregression model described in annex 4B using five different proxies for economic activity: global industrial production, the GECON index, commodity-consumption weighted industrial production (for metals), the global manufacturing PMI, and the global composite PMI. Yellow whiskers show the range of estimates from the five specifications with the five different proxies for global economic activity.

## ANNEX 4D Local projection estimation: Methodology and data

### 4D.1 Methodology

The cumulative responses of real output (real GDP) growth at horizon  $h$ —denoted by  $y_{t+h,j}$ —following shocks to oil or metal price growth  $p_t$  are estimated using the local projection method of Jordà (2005), with the adjustment developed by Teulings and Zubanov (2014). The increasing popularity of local projection estimations in empirical macroeconomic analysis is mainly due to their simplicity and flexibility. They yield outcomes that are similar to those of widely used structural vector autoregressive models (SVAR; Montiel-Olea and Plagborg-Møller 2021; Plagborg-Møller and Wolf 2021). Local projection estimation is broadly robust to misspecification and nonlinearity, whereas an SVAR produces more efficient estimates (Jordà and Salyer 2003). However, Plagborg-Møller and Wolf (2021) demonstrate that local projection estimations attain efficiency similar to that of the SVAR when  $p$  and  $T \rightarrow \infty$ . Finally, local projection models are not subject to stringent identification schemes, such as the Cholesky zero restriction or similar restrictions used in SVARs.

The model is given by

$$y_{i,t+h} = \alpha_{i,h} + \beta_h p_t + \delta'_h X_{i,t} + \sum_{s=1}^q \gamma_{s,h} y_{i,t-s} + \varepsilon_{i,t+h} \quad (1)$$

where  $h = 0, 1, \dots, 4$  is the horizon;  $\alpha_{i,h}$  is country  $i$  fixed effects; and  $\varepsilon_{i,t+h} \sim N(0, \sigma_\varepsilon^2)$  is an *iid* (independent, identically distributed) error term. The coefficient of interest  $\beta_h$  captures the dynamic multiplier effect (impulse response) of the dependent variable with respect to a shock to oil or metal price growth at time  $t$ . Additional control variables, such as global demand (proxied by global industrial production) and domestic consumer price inflation, which are commonly used in SVARs with oil or metal price shocks, are included in a  $n \times r$  matrix  $X_{i,t}$ , while  $\delta_h$  denotes  $n \times r$  matrix parameters. The maximum number of lags for each variable is denoted by  $\hat{q}$  and set to 4. The IRFs are constructed separately using a sequence of estimates  $\beta_h$  for each horizon based on least-squares technique. Heteroscedasticity and autocorrelation consistent standard errors are used to correct for potential effects of heteroscedastic variances and autocorrelation in the error terms. In addition, Driscoll and Kraay (1998) standard errors are used to address cross-sectional and serial correlation.

The local projection estimation allows the investigation of a nonlinear, asymmetric response of domestic economic activity to oil or metal price shocks. Equation (1) is augmented with this nonlinearity:

$$y_{i,t+h} = \alpha_{i,h} + \beta_h^r p_t \times I_t + \beta_h^d p_t \times (1 - I_t) + \delta'_h X_{i,t} + \sum_{s=1}^q \gamma_{s,h} y_{i,t-s} + \varepsilon_{i,t+h} \quad (2)$$

where  $I_t$  is a dummy variable representing increases in oil or metal prices. Specifically,  $I_t$  takes the value of 1 for positive observations of real annual growth rates in metal prices and 0 otherwise. Hence, equation (2) captures an asymmetric response of domestic economic growth ( $y_t$ ) to rises and declines in oil or metal prices. The output response to oil or metal price increases is captured by  $\beta_h^r$ , while that to oil or metal price declines is accounted for by  $\beta_h^d$ .

## 4D.2 Data

The dataset includes annual data for 153 EMDEs for 1970-2019. EMDEs are considered as metal exporters if industrial metal exports (in aggregate) account for 5 percent or more of total exports, and the same for copper and aluminum exporters separately. This identification provides 31 industrial metal exporters, of which 14 are copper exporters and 10 aluminum exporters. The sample of industrial metal exporters is smaller than that presented in annex 4A because of data constraints for the regression and the exclusion of iron ore from the aggregate of industrial metal exports. EMDEs are defined as metal importers if their imports of the specific metal account for 0.1 percent or more of total imports. This provided 50 metal importers, 31 copper importers, and 38 aluminum importers. 34 EMDEs are considered energy exporting (oil, gas, or coal), as defined in World Bank (2020c), while the remainder are considered energy importers. Comtrade and the Observatory of Economic Complexity were used as the source of import and export data.

Annual data on real GDP and world per capita GDP are available from the World Bank's *World Development Indicators* database. Oil and base metal prices data are taken from the World Bank's *Pink Sheet* database. The oil price is the unweighted average of Dubai, West Texas Intermediate, and Brent prices. Metal prices are calculated by taking a weighted average of aluminum, copper, lead, nickel, tin, and zinc. The real price is obtained by deflating the nominal metal price (in U.S. dollars) with the U.S. consumer price index (CPI) from the Federal Reserve Economic Data (FRED) database maintained by the St. Louis Federal Reserve Bank. Real oil and metal prices were transformed into annual growth rates. The control variables comprise of global GDP growth and country-specific consumer price inflation. Data on consumer price inflation are taken from the IMF's *World Economic Outlook*.

Due to limited price data, the estimation of separate local projections model for metal ore exporters and refined metal exporters is not possible. This is a limitation of the research since metal exporters might specialize in different aspects of export—metal ores, metals, or refined metals—embodied in domestic finished goods. A shock affecting the supply of a metal ore could affect metal ore exporters and refined metal exporters differently.

For example, for the Democratic Republic of Congo, exports of refined copper account for more than 50 percent of total exports, while exports of copper ore were around 7 percent. In contrast, for Guinea, exports of bauxite (aluminum ore) accounted for nearly

50 percent of total exports, while exports of alumina (an intermediate product in the refining process) accounted for just under 2 percent of exports and exports of refined aluminum were negligible. Finally, China's production of lead ore accounts for nearly half of global lead ore production. However, this is only a negligible amount of China's exports since most of this ore is used domestically and embodied in exports of manufactured goods.

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