SPECIAL FOCUS

Causes and consequences of metal price shocks

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The 2020 global recession triggered by the COVID-19 pandemic delivered a major shock to commodity markets. Although they have since rebounded, oil prices fell by 60 percent between pre-pandemic levels and their trough in April and metal prices fell by 16 percent. These sharp moves in prices can have significant macroeconomic impacts for commodity exporters, with many emerging market and developing economies highly reliant on metals, especially copper and aluminum, for export revenue. Metal price shocks appear to have asymmetric impacts, with price increases associated with small, temporary expansions in activity, but price declines associated with more pronounced growth slowdowns and fiscal and export revenue losses. These results highlight the importance of counter-cyclical policy measures when responding to commodity price changes.

Introduction

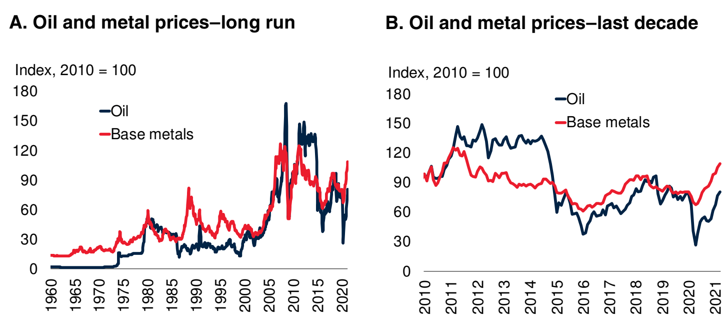
The COVID-19 pandemic had divergent impacts on different commodity groups (World Bank 2020a). Energy prices, particularly crude oil, plunged at the start of the pandemic, with the price of Brent crude oil declining by more than 60 percent from $64/bbl in January 2020 to a low of $23/bbl in April 2020. In contrast, metal prices declined by only 16 percent over the same period and quickly regained their pre-pandemic peak. By March 2021, several metal prices had reached their highest level in a decade.

Oil and metal prices can be affected by common shocks, such as global recessions and their subsequent recoveries, such that prices move in tandem (figure SF.1; Bilgin and Ellwanger, 2017; Chiaie, Ferrara, and Giannone, 2017). For example, both energy and metal prices declined during the 2009 global recession and rose during the subsequent recovery. These periods of synchronized price movements can occur both in the short-run and in the long-run—the price cycles of oil and metals coincided in the early 1970s to mid-1980s, and the early 2000s to late 2010s, although metal prices went through an additional cycle in the mid-1990s (Helbling 2012; World Bank 2020b).

Sometimes, however, oil and metals react differently to a common shock or are buffeted by commodity-specific shocks, including shocks to supply and technological change (Baffes and Kabundi, forthcoming). The COVID-19 pandemic is one example, with oil being significantly more affected than metals due to lockdown measures that disproportionately impacted travel.

FIGURE SF.1 Oil and metal prices

Oil and metal prices have similar drivers, notably economic growth. As such, they tend to follow one another closely, particularly around major economic events like global recessions and recoveries. However, they can also vary significantly as they are affected by other factors, including supply shocks. Notable periods of deviation include the mid-1980s, 2011-2014, and most recently the COVID-19 pandemic.



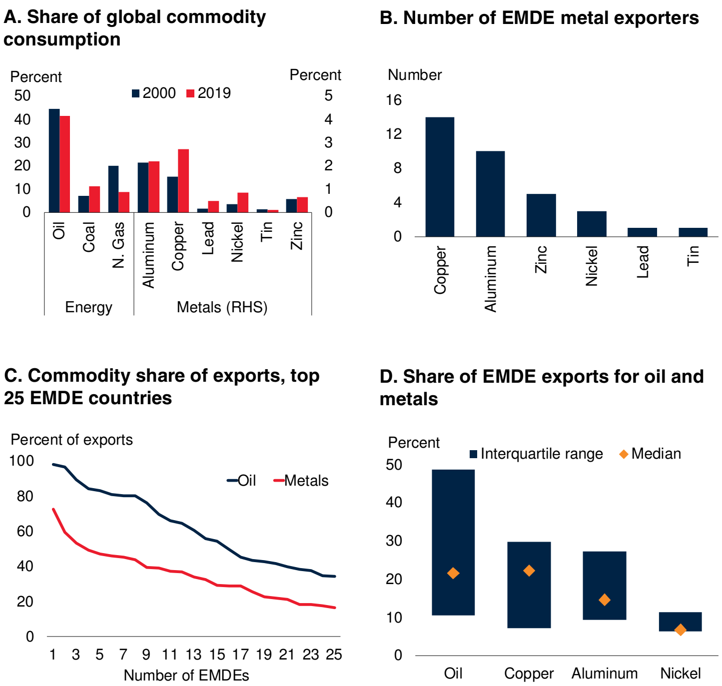
Sources: Bloomberg, World Bank.
Note: Both price series are taken from the World Bank's Pink Sheets. Oil refers to an average of Brent, WTI, and Dubai. Base metals index includes aluminum, copper, lead, nickel tin, and zinc.

Commodity price movements are a key source of macroeconomic volatility in EMDEs (Jacks, O'Rourke, and Williamson 2011). Terms-of-trade shocks can account for up to half of business cycle fluctuations, and the impact of shocks can be asymmetric, with export price shocks having a much larger impact than import price shocks (Di Pace, Juvenal, and Petrella 2020; Kose 2002; Richaud et al. 2019).

Energy and metal commodities are critical sources of export and fiscal revenue for almost two-thirds

FIGURE SF.2 The importance of energy and metals

Global crude oil consumption is six time larger than global base metal consumption. Among base metals, aluminum and copper account for the largest share of global commodity consumption. Metal exporters tend to be less reliant on metal exports than oil exporters are on oil exports. However, a number of countries are nonetheless heavily dependent on metal exports, especially some copper and aluminum exporters.



Sources: BP Statistical Review, Observatory of Economic Complexity, UN Comtrade; World Bank, World Bureau of Metal Statistics.

A. Value of commodity consumption calculated as the product of energy and metals consumption multiplied by their respective prices. Metals refers to the value of refined metals only.

B.D. 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. Number of exporters among EMDEs of a given metal.

C. Chart shows the share of crude oil in total goods exports for 25 oil exporters, sorted by those with the highest share of oil in total exports in blue, and the equivalent for metals in red. Metals include both metal ores and refined metals.

D. Chart shows the median and interquartile range of the share of exports accounted for by oil, copper, aluminum, and nickel, for EMDE exporters of that commodity. Oil includes 62 EMDEs, copper 14, aluminum 10, and nickel 5. Lead, tin, and zinc are not shown due to small sample size.

of emerging market and developing economies (EMDEs). Prospects for these economies can vary significantly depending on the type of commodities they export, given the divergence in prices. Yet while a significant body of research has examined the impact of oil price shocks on the global economy, oil exporters, and oil importers, the literature on the impact of metal price shocks is much smaller, particularly for EMDEs.

Against this background, this *Special Focus* examines the importance of metals for EMDEs and analyzes the impact of metal price shocks on metal exporters and importers. It addresses the following questions:

i. How important are metals for the global economy and EMDEs compared to energy commodities?

ii. What are the drivers of metal price shocks?

iii. What are the implications of movements in metal prices for economic activity in EMDEs?

Definition of commodity exporter. For this Special Focus, exporters of individual commodities (oil, aluminum, copper, tin, nickel, lead, and zinc) are defined as countries in which the individual commodity accounts for 5 percent or more of goods exports (annex SF). This yields 62 EMDE oil exporters and 58 EMDE metal exporters. For the individual base metals, copper has the largest number of exporters (14), followed by aluminum (10), zinc (5), nickel (3), and lead and tin (1 each; figure SF.2). Although many of these EMDEs export multiple metals, almost all do not export enough for more than one metal to reach the exporter threshold. Tajikistan is a notable exception, exporting aluminum, copper, lead, and zinc. For four of the six base metals, the largest exporter of the metal was not classified as a metal exporter either because its economy was highly diversified, or because the value of the exported metal was small compared to its other exports. For example, Indonesia accounted for one-third of global tin exports in 2019, but these made up less than 1 percent of the country's total goods exports that year. Similarly, Russia accounted for around one-quarter of global nickel exports in 2019 but these accounted for just over 1 percent of Russia's total exports.

The importance of metals for EMDEs

While base metals may not currently play as large a role in global economic activity as oil—at least as measured in terms of global commodity consumption—they play an important role in economic activity in about one-third of EMDEs. In addition, as the energy transition away from fossil fuels unfolds, base metals' role in the global economy is expected to increase considerably since base metals are heavily used in both renewable electricity generation and in electric vehicles.

Metals' role in global commodity consumption. Globally, base metals account for 7 percent of global commodity demand in value terms, about one-sixth of crude oil, which accounts for 42 percent of global commodity demand (BP 2020). Of this, copper and aluminum accounted for 3 percent and 2 percent of global commodity consumption, respectively (World Bureau of Metal Statistics 2021).[1] Since 2000, the share of copper, lead, nickel, and tin in global commodity consumption has increased, while that of aluminum remained broadly constant reflecting a sharp rise in volumes but relatively stagnant prices. Some base metals play an outsized role in global economic activity, notwithstanding their small share of global commodity consumption. For example, tin accounts for less than 0.1 percent of global commodity consumption but is an essential input into the electronics industry (Baffes, Kabundi, and Nagle 2020).

Commodity reliance of EMDE commodity exporters. In general, oil exporters tend to be more reliant on oil than metal exporters are reliant on metals. On average, oil exports accounted for 32 percent of total goods exports among oil exporters in 2019—considerably more than the 20 percent average for metal exporters overall. In the ten most-oil-reliant EMDEs, oil exports account for 84 percent of total goods exports, on average, compared with metals accounting for 49 percent for the ten most metal-reliant EMDEs, on average. Among base metal exporters, the most commodity-dependent exporters were copper exporters, with a median share of 22 percent of goods exports and a maximum share of 73 percent of goods exports for the most concentrated exporter, Zambia. Aluminum exporters were the second most concentrated, with a median share of 15 percent of exports and a maximum share of 48 percent of exports for Guinea.

Concentration of metal ore reserves. Global ore reserves, ore production, and refined production are highly concentrated in a limited number of countries and are significantly less diversified than, say, global oil production (figure SF.3).[2] For each of the six base metals, the top four countries with the largest share of reserves account for 50-75 percent of total reserves (USGS 2020a-f). Chile accounts for 23 percent of known copper reserves, while Australia and Peru have 10 percent each (USGS 2020a). Guinea has the world's largest reserves of bauxite, which is used in aluminum production (25 percent of the world's total); Indonesia the world's largest nickel ore reserves (24 percent); Australia the world's largest lead ore reserves (40 percent) and zinc ore deposits (27 percent); and China the world's largest tin ore reserves (23 percent).

In general, reserves of metal ores do not "run out". Instead, higher-grade supplies that contain a higher concentration of the metal are gradually depleted, but substantial lower-grade, currently uneconomical, ores remain. In the case of aluminum, bauxite is currently the preferred source of alumina, the intermediate product from which aluminum is derived. However, there are vast sources of other, currently uneconomic sources of alumina. The U.S. Geological Survey estimates that the world has an essentially inexhaustible supply of subeconomic resources of aluminum in materials other than bauxite (USGS 2020a). Some argue that innovation in extraction technology exploits a geological law where greater quantities of a resource are found in progressively lower-grade deposits (Schwerhoff and Stuermer 2019). The result is increasing resource production to meet growing global demand.

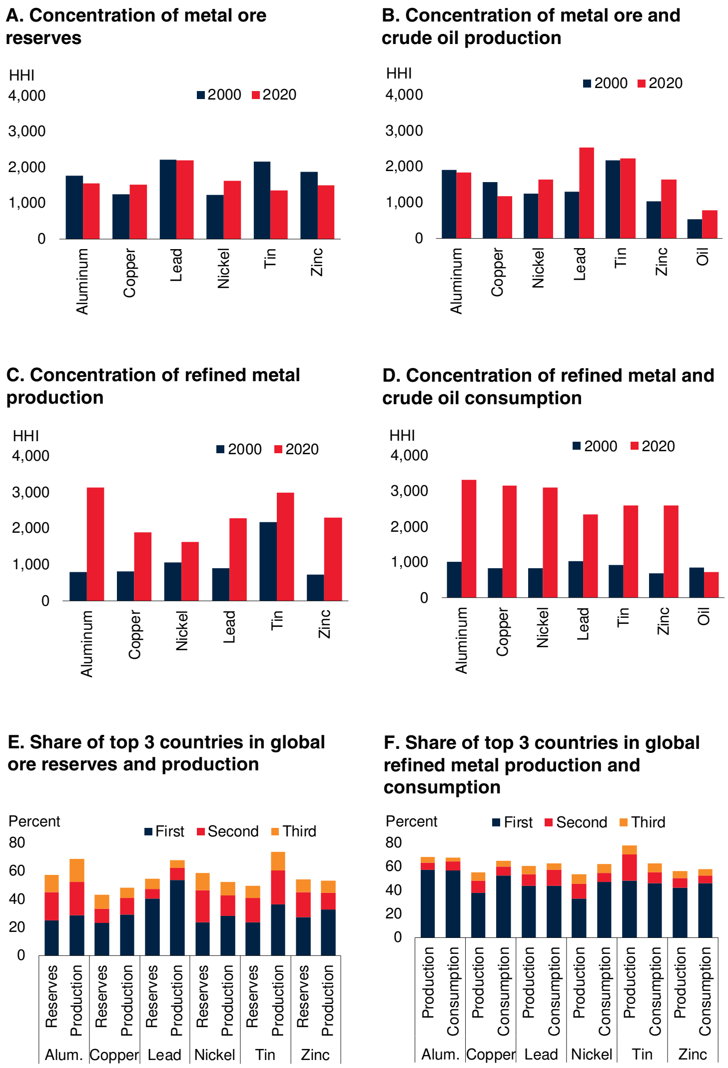
Concentration of metal ore production. While the concentration of ore reserves and production is due in large part to the nature of geographical deposits, refined production is less anchored to resource endowments. Although not the location of the world's largest reserves of all metals, China is now the largest producer of lead, tin, and zinc

[1] This value only includes refined base metals and does not include the value of metal ore production.

[2] If counting OPEC as a single producer, the concentration of the oil market would increase significantly.

FIGURE SF.3 Global market concentration of metal reserves, production, and consumption

The global concentration of ore reserves is high, given geographical deposits, and has changed little since 2000. In contrast, the concentration of refined metal production and consumption has increased sharply. This change has been driven by China, which now accounts for around half of consumption of base metals.



Sources: BP Statistical Review, World Bank, World Bureau of Metal Statistics
A.D. HHI stands for Herfindahl–Hirschman Index, and is 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 low scores indicate widespread production or consumption, while a value of 10,000 would indicate a single country accounted for all of global production or consumption. The higher the number, the more concentrated the market.

ores, and the second-largest producer of bauxite. China has around 3 percent of the world's known reserves for bauxite/aluminum, copper, and nickel, and roughly one-fifth of known reserves of lead, tin, and zinc. However, it is mining these ores at a much faster pace than other countries. As a result, it accounts for 20-47 percent of global production of bauxite, lead, tin, and zinc ores.

Concentration of refined metal production. Global refined metal production is also highly concentrated. China is the world's largest producer of all refined base metals, accounting for between 35-55 percent of global production. Aluminum is the most concentrated metal, with China accounting for 55 percent of global production, despite only accounting for 3 percent of bauxite reserves and 20 percent of bauxite production. Nickel is the least concentrated metal, with China accounting for 35 percent of production, followed by Indonesia with 12 percent.

Evolution of concentration over the 2000s. The concentration of global production of all refined metals and some metal ores has risen sharply over the past two decades, largely because of rapid production growth in China. Since 2000, China's share of global production of refined nickel has risen nearly eight-fold, its share of refined aluminum and copper production has risen four-fold, while its share of global production of refined lead has tripled and zinc has doubled. Among the metal ores, China's share of global production has tripled in bauxite, and nearly doubled for copper, lead, and zinc.

Concentration of global metal consumption. Global consumption of refined base metals has also been transformed over the past two decades by growth in China. In 2000, the United States was the single largest consumer of most metals (except zinc where China was the largest consumer) but only accounted for 15-25 percent of base metal consumption. However, China's commodity consumption has risen dramatically over the past two decades such that it is now the single largest consumer of all refined base metals, accounting for 45-57 percent of global consumption (figure SF.4). For lead, and to a lesser extent tin and zinc, China's demand can largely be met with domestic production. For copper and nickel, China relies heavily on imports, accounting for around one-third and one-fifth of global imports respectively. For aluminum, China's consumption far outstrips what can be produced from its bauxite reserves. It therefore relies heavily on imports of bauxite and alumina to produce aluminum, and accounts for about 70 percent of global imports of bauxite.

Literature review: Drivers of metal price shocks

With almost two-thirds of EMDEs heavily reliant on commodities for fiscal and export revenues, their macroeconomic and financial stability has at times been threatened by large commodity price swings. Lasting commodity price changes have sometimes required wrenching macroeconomic adjustments, but even temporary price changes have also at times caused severe downturns (Baffes et al. 2015).

These factors have been explored in a large literature that splits into two branches. The first considers price cycles, typically decomposing these into transitory and permanent components, but without determining the drivers of prices. In general, this literature confirms the existence of price cycles that affect all commodities, while transitory shocks affect individual commodities differently. Metal prices are typically the most affected by short-term, business cycle shocks. The second branch of the literature focuses on the drivers of commodity prices, decomposing price changes into aggregate demand, commodity-specific demand, and commodity-specific supply shocks. Most of this literature has focused on oil prices. The literature on the drivers of metal prices is smaller, but there is greater consensus within the literature that aggregate demand is the main driver of metal price shocks.

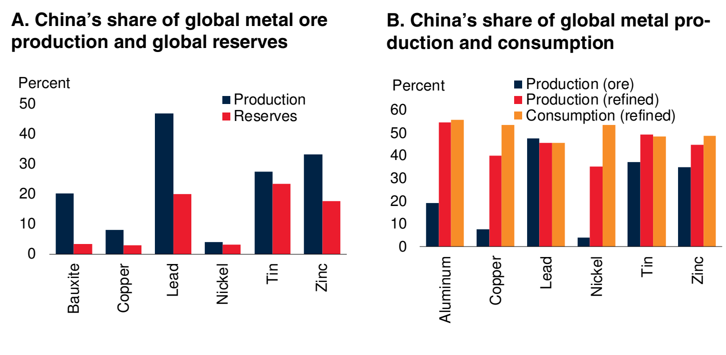
Price cycles. While much of the early literature on commodity price movements focused on the role of long-term trends in prices, subsequent research in the aftermath of the 2000s commodity price boom investigated the existence of common price cycles across many commodity groups (annex table SF.1). This literature typically decomposed price movements into transitory and permanent components or trends. This includes short-term or business cycles, medium-term cycles (of between 8 -20 years), and "supercycles," which span many commodities and last for several decades. For metals, in particular, the price cycle literature finds that the business cycle component of shocks accounts for a much greater share of their variability than for other commodities—about twice as much of the variance in metal prices compared to energy and agriculture (Baffes and Kabundi, forthcoming).

The short- and medium-term cycles are driven by transitory shocks, which can originate from several sources, including recessions, such as the 2007-09 global financial crisis, as well as accidents (e.g., the 2019 Vale accident in Brazil which disrupted iron ore supplies), conflicts (such as the first Gulf war, when Iraq/Kuwait oil production was halted), or terrorist attacks (e.g., the attacks on Saudi Arabian oil facilities in 2019, which temporarily disrupted oil exports). In contrast, permanent shocks, such as technology and policies, can exert a lasting impact on commodity markets—and prices. The development of shale technology in the natural gas and crude oil industries rendered the United States a net energy exporter in 2019 and the world's largest oil producer, for the first time since 1952 (EIA 2020).

Determinants of commodity price shocks. In general, the literature investigating the drivers of commodity price shocks builds on the study by Kilian (2009), which uses a structural vector autoregression (SVAR) model with sign

FIGURE SF.4 China's impact on metal markets

To meet its rapid increase in metal demand, China has sharply boosted its production of metal ores and refined metals. China is the single largest consumer of global metals and accounts for a large share of global refined lead, tin, and zin production.



Source: USGS, World Bank, World Bureau of Metal Statistics.
B. Calculated as current known metal ore reserves divided by current production levels (2019).

restrictions to identify the relative importance of different drivers of oil price shocks. Utilizing data on commodity prices, demand, and supply (and occasionally inventories), price shocks are decomposed into aggregate global demand shocks, commodity-specific supply shocks, and commodity-specific demand shocks. Aggregate global demand shocks include global recessions (such as the one associated with the 2008-09 global financial crisis), as well as pronounced expansions, which typically result from industrialization or urbanization (such as China's expansion in the 2000s). Commodity-specific supply shocks include accidents, strikes, conflicts, cartel production decisions, government policies, and weather events.[3] Commodity-specific demand shocks are typically captured as the residual component of the SVAR model, and incorporate the role of inventories (resulting from government stockpiling, producer inventories, and market-driven purchases), as well as that of technological changes, shifts in consumer preferences, and the impact of government policies (for example, a carbon tax).

While there is now an ample literature for oil prices, the literature is scarcer for metal prices. Two notable exceptions in this regard are Stuermer (2018), and Jacks and Stuermer (2020), which utilize a dataset of commodity supply and demand (and prices) for six and twelve commodities, respectively, from 1870-2013. Their analysis finds that for metals, aggregate demand shocks and commodity-specific demand shocks play a larger role than supply shocks and that their impact has increased over time. Supply shocks were found to have an impact for copper and tin only. The greater role for aggregate demand found by these two studies is consistent with other studies that find a strong response of metal consumption to industrial activity (Roberts 2009; Stuermer 2017; Marañon and Kumral 2019).

[3] Weather supply shocks mostly affect agriculture, such as the recurring El Niño and La Niña episodes, as well as droughts, and floods. However, industrial commodities can also be affected. For example, the oil facilities off the Gulf of Mexico are periodically disrupted by hurricanes. For metals, flooding can lead to temporary closures of open-pit mining facilities.

Macroeconomic impact of metal price shocks

Commodity price shocks can have major repercussions for the global economy or for individual countries.[4] For some commodities, such as crude oil, sharp price movements can cause business cycle fluctuations both globally and at the country-level, although effects have generally been found to be short-lived (Baumeister, Peersman, and Robays 2010; Kilian 2009). Other commodities, such as tin, may not cause global business cycle fluctuations but are critical inputs for some sectors (e.g. tin, in the electronics industry), and are important for the small number of countries that produce or export them.

Methodology. To assess the impact of metal price shocks on EMDEs, a local projections model is estimated for 153 EMDEs, of which 58 are metal exporters, 14 are copper exporters, and 10 are aluminum exporters (annex SF). The model examines the impact of metal price changes on real output over the period 1970-2019 under two different specifications.

- *Symmetric impact.* The model is first estimated to examine the impact of a change in metal prices (in aggregate) on both metal exporters and importers assuming that the impact is symmetric for price increases and decreases. The model is then repeated for aluminum and copper price shocks separately.

- *Asymmetric impact.* The model is extended by identifying large price shocks as an increase or decrease of 20 percent or more ("price jump" for increases, and "price collapse" for decreases). The model is estimated for these shocks separately, allowing an investigation of whether price increases and decreases have asymmetric impacts. This specification is repeated for aluminum and copper.

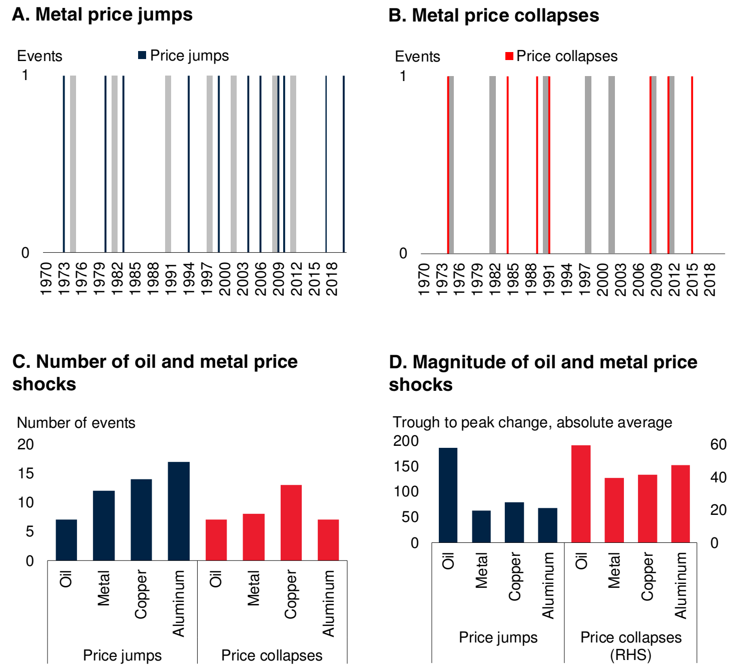
[4] Conversely, metals prices, especially copper, are also often considered barometers and leading indicators of global economic activity (Bernanke 2016; Hamilton 2015).

Features of large metal price jumps and collapses. The metal price jumps and collapses are clustered around major economic events, notably the four global recessions (1974-75, 1981-82, 1990-91, and 2008-09), and three global slowdowns (1998, 2001, and 2012) which have occurred since 1970 (figure SF.5; Kose, Sugawara, and Terrones 2020). A global recession also occurred in 2020 but is not included here. In general, the metal price jumps occurred in the years prior to global recessions and slowdowns (such as 1973, 1980, and 2006), and in the years following these when global recoveries were underway (such as in 1983, 1999, and 2009). In contrast, price collapses tended to occur during global recessions and slowdowns (such as in 1974, 1991, and 2008). This is consistent with earlier findings about the considerable role of aggregate demand in driving prices. Metal price jumps were fairly synchronized before and after recessions and slowdowns, as were price collapses during recessions and slowdowns. In general, metal price shocks are more frequent, but of smaller magnitude, than oil price shocks.

Impact of metal price shocks. For EMDE metal exporters, a positive metal price shock resulted in a gradual rise in output that became statistically significant after two years, declined gradually, and became statistically insignificant after four years (figure SF.6). The results indicate that a 20 percent increase in metal prices was followed by a 0.32 percent rise in economic activity two years after the shock. For EMDE metal importers, there was no statistically significant impact.[5] For metal importers, metal imports are typically a relatively small share of total goods imports (around 5 percent, on average in the sample) which may account for the lack of a statistically significant impact of metal price shocks. The shares of individual base metals are even smaller, at 0.6 percent for copper and 0.4 percent for aluminum. Even for China, the largest consumer of all metals considered here, metals accounted for a small share of imports, with copper the largest of the base metals at around 3 percent of total goods imports. This is a significant difference to oil, which accounts for a much larger share of EMDE imports, for example, it accounts for around 14 percent of China's imports.

FIGURE SF.5 Metal price shocks

In general, metal price jumps occurred in the years prior to global recessions and slowdowns (such as 1973, 1980, and 2006), and in the years following these when global recoveries were underway (such as in 1983, 1999, and 2009). In contrast, price collapses tended to occur in the global recessions and slowdowns (such as in 1974, 1991, and 2008). This is consistent with the greater role of aggregate demand for metals prices than oil prices found in the literature. In general, metal price shocks are more frequent but smaller than oil price shocks.



Source: World Bank.

A.B. Lines show the dates of a metal price jump or collapse, defined as an increase or decrease in prices over a 6-month period of 20 percent or more. Shaded areas indicate period of global recessions or slowdowns.

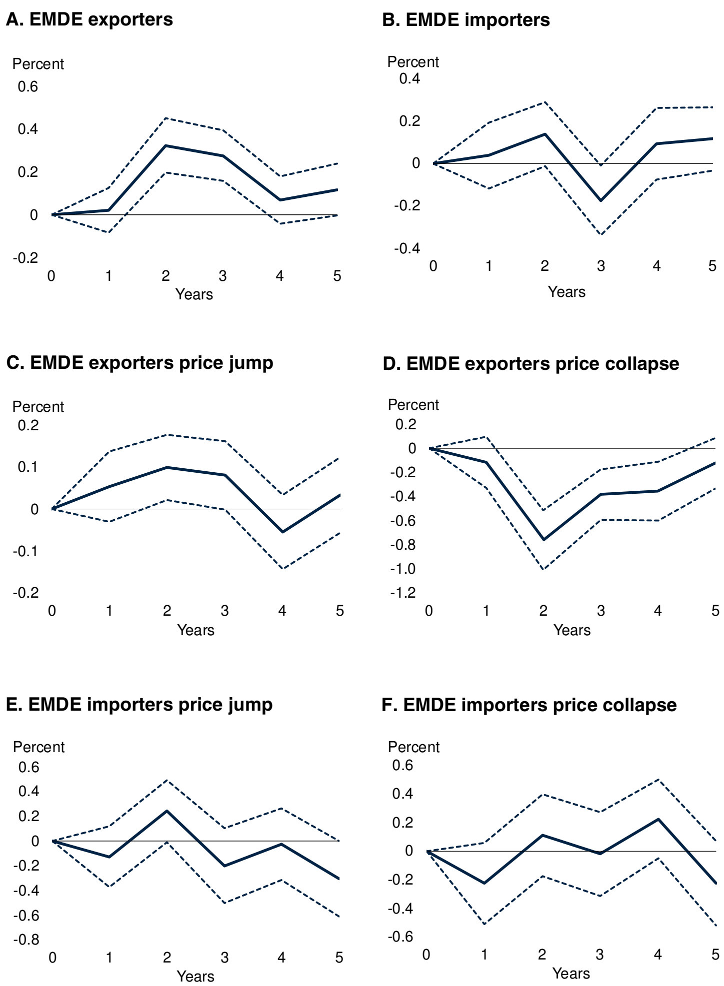
D. Figure shows the average peak-to-trough price change for price jumps and collapses. Price collapses are shown in absolute averages, so a reading of 50 percent would indicate a 50 percent fall in prices.

Asymmetric impacts of metal price shocks. The aggregate results mask asymmetric impacts of metal price jumps and metal price collapses, defined as price changes of more than 20 percent. While price jumps resulted in an increase in economic activity in metal exporters, the effects were small and short-lived (0.1 percent increase in output after two years). Price collapses, however, had much bigger effects—eight times more than

[5] These results are consistent with Di Pace, Juvenal, and Petrella (2020) who find evidence of a positive and statistically significant effect of export price shocks on output growth in EMDEs but find a smaller impact of import price shocks on output.

FIGURE SF.6 Metal price shocks to EMDE metal exporters and importers

Metal price shocks have an asymmetric impact on metal-dependent EMDEs. Price jumps are associated with temporarily higher output in metal exporters, however the response is small and short-lived. However, output tends to fall more strongly after price collapses than it raises after price jumps, and these effects last longer. There is little impact for metal importers.



Source: World Bank.
Note: Cumulative impulse responses to a 20 percent price shock for 153 EMDEs, of which 58 are metal exporters, from a local projections model. Dependent variable is output growth after changes in metal prices. Solid lines are coefficient estimates and dotted lines are 95 percent confidence bands.

in the case of price jumps, reaching 0.76 percent in the second year, and lasting twice as long. The effects for metal importers remained insignificant.

Potential reasons for asymmetric impacts. This disproportionately larger impact of price collapses than price jumps may reflect the procyclicality of fiscal policy in EMDEs (Alesina, Campante, and Tabellini 2008; Frankel 2010). Increased fiscal spending during booms can go toward unproductive purposes such as higher public sector wages, while fiscal consolidation during price collapses can exacerbate the depth of a recession (Frankel 2011; Medas and Zakharova 2009). This can also have lasting negative effects on growth, as public investment, such as infrastructure spending, is typically the first element of public spending to be cut (Richaud et al. 2019). For example, in the aftermath of the 2014-16 oil price collapse the sharp decline in government revenues forced abrupt cuts in government spending that exacerbated the economic slowdown (Stocker et al. 2018).

Impact of copper price shocks. When the model was estimated for individual metals, results were broadly similar for copper. In copper EMDE exporters, economic activity increased statistically significantly after a copper price increase; in copper importers, no significant effect was found, in line with the finding for metals more broadly (figure SF.7). Asymmetric responses were also observed in copper exporters: a copper price jump increased output in copper exporting EMDEs by 0.07 percent after two years, but then the effect dissipated; a copper price collapse lowered output by more than three times as much (0.22 percent) two years after the shock and the effect remained significant for three years.

Impact of aluminum price shocks. In contrast to copper, aluminum price shocks were not followed by statistically significant output changes, neither in EMDE exporters nor importers. These differences may reflect the lower reliance on aluminum exports for aluminum exporters than the copper reliance for copper exporters. In 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 in copper exporters. In eight of the copper exporters, copper accounted for 20 percent of exporters or more, compared to just three of the aluminum exporters in which aluminum accounted for the same share.

Conclusion and policy implications

Base metals may not (yet) play as big a role for the global economy as oil, at least in terms of their share of global commodity demand. The average metal exporter is also less reliant on metal exports than the average oil exporter is on oil exports.

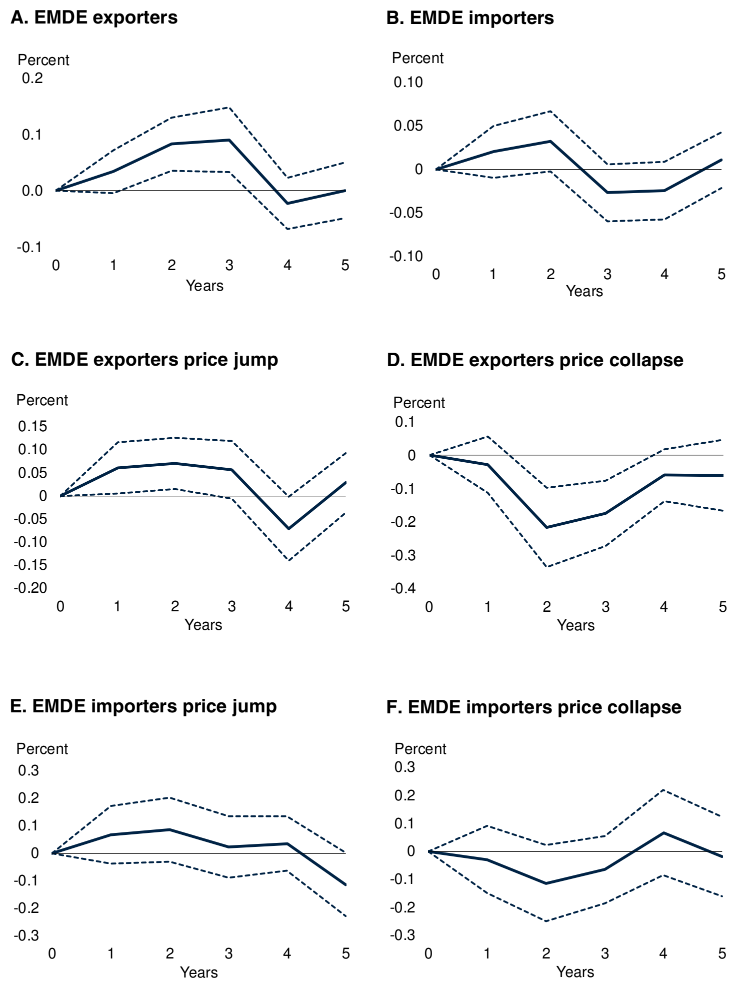
However, in about one-third of EMDEs base metals account for a significant share of total exports. As such, their macroeconomic stability is vulnerable to metal price shocks. Since metal prices are mainly driven by global demand shocks, metal price swings can amplify the impact of global downturns and recessions—or conversely, upturns—for metal exporters. Empirically, this has been particularly the case for copper exporters, which tend to be more reliant on copper for exports than other metal exporters. In copper exporters, copper price collapses have sizable and lasting adverse economic consequences—and copper price jumps had smaller and more fleeting benefits—whereas other metal price jumps or collapses have had largely insignificant effects.

For policymakers in metal exporters, these results indicate the need for counter-cyclical policies to shield the economy from metal price volatility. The temporary nature of price increases suggests that any surplus revenue should be saved such that resources are available to support activity during price collapses. Stronger fiscal frameworks, including fiscal rules, and structural budget rules can help resist pressures to spend revenue windfalls, or reduce non-resource taxes. Making the assumptions behind these rules independent is critical to their success (Frankel 2011). Sovereign wealth funds, including stabilization funds, can also be a useful instrument. Reforms to monetary policy and exchange rate frameworks could help foster resilience to oil price fluctuations and ensure smoother exchange rate adjustments (Frankel 2018; Torvik 2018).

The empirical exercises suggests that greater export diversification may blunt some of the impact of commodity price shocks. Copper exporters are, on average, the most resource reliant of metal exporters and saw large economic impacts from copper price swings, while the impacts of price shocks on other metal exporters were statistically insignificant. For resource-reliant economies, this underscores the need for diversification. Policies to promote human capital accumulation, improve institutions, as well as measures to move into higher value-added activities in resource sectors, can support diversification (World Bank 2015).

FIGURE SF.7 Copper price shocks to EMDE copper exporters and importers

Similar to aggregate metals, copper price shocks have an asymmetric impact on copper-dependent EMDEs. Price jumps are associated with a small and temporary increase in output, while price collapses have a larger and longer impact. There is again little impact for metal importers.



Source: World Bank.
Note: Cumulative impulse responses to a 20 percent price shock for 153 EMDEs, of which 14 are copper exporters, from a local projections model. Dependent variable is output growth after changes in copper prices. Solid lines are coefficient estimates and dotted lines are 95 percent confidence bands.

ANNEX SF Data

The dataset includes annual data for 153 EMDEs for 1970-2019. Comtrade and the Observatory of Economic Complexity were used as the source of commodity import and export data. Annual data on real GDP and the world per capita GDP are available from the World Bank's World Development Indicators. Metal prices data are taken from the World Bank's Commodity Price database (see Appendix A). Nominal Price Indexes 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 with the U.S. consumer price index (CPI) from the Federal Reserve Economic Data (FRED) database maintained by the St. Louis Fed. The real metal price was converted into annual growth rates. The control variables are comprised of global demand and domestic inflation computed as the annual growth rate of CPI for each country. Data on domestic CPI are taken from the IMF World Economic Outlook.

For the purposes of this Special Focus an EMDE is defined 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 the definition in World Bank 2020b, which sets a threshold of 20 percent of total exports. For the identification of metal exporters, all exports of industrial metal ores and refined metal exports were included. Precious metal exports were not included. This identification provides 58 metal exporters, 14 copper exporters, and 10 aluminum exporters.

EMDEs used in this sample are deemed metal-importers if their imports of the specific metal accounted for 0.1 percent or more of total imports. This provided 50 metal importers, 31 copper importers, and 38 aluminum importers. The average concentration of metal imports as a share of total imports is an order of magnitude smaller than that of exporters.

Metal price jumps and collapses were identified using monthly price data. An event was identified as an increase or decrease in prices of 20 percent or more over a 6-month period. For years where multiple events occurred, the largest event was included. Events could not overlap within a 12-month period. Separate events were identified for aggregate metal, copper, and aluminum prices.

Metal price data limitations prevent estimating the local projections model for metal ore exporters and refined metal exporters separately. This is a limitation of the research since metal exporters can pursue different export strategies: export of metal ores; export of refined metals; or production of refined metals used in domestic manufacturing and exported via finished goods. As such, 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 but only a negligible amount of China's exports since most of this ore is used in domestic manufacturing for export (and China accounts for around 0.4 percent of global lead ore exports).

ANNEX TABLE SF.1 Summary of empirical research on supercycles

Author(s)	Data	Main finding
Cuddington and Jerrett (2008)	Six base metals, 1850-2006, deflated by the U.S. CPI and PPI	Four supercycles (the last was ongoing): 1890-1930, 1930-1962, 1962-1998, 1998-
Jerrett and Cuddington (2008)	Three metals, 1850-2006, deflated by the U.S. CPI	Three supercycles: 1850-1925, 1925-1998, 1998-
Cuddington and Zellou (2012)	Crude oil, 1861-2010, deflated by the U.S. CPI and PPI	Three supercycles after WWII which comove with metals: 1861-1884, 1966-1996, 1996-
Erten and Ocampo (2013)	Prices of 24 commodities and indices, 1865-2010, deflated by the U.S. CPI and MUV index	Four supercycles consistent with the Prebisch-Singer hypothesis: 1890-1930, 1930-1965, 1970-1998, 1998-
Rossen (2015)	Prices of 20 metals, 1910-2011, monthly, deflated by the U.S. CPI	Four supercycles: 1910-1930, 1930-1965, 1970-1998, 1998-
Erdem and Ünalmış (2016)	Crude oil, 1861-2014, deflated by the U.S. CPI	Three supercycles: 1861-1882, 1966-1996, 1996-
Buyuksahin, Mo, and Zmitrowicz (2016)	Bank of Canada commodity index, 1899-2015, deflated by the U.S. PPI	Four supercycles: 1899-1932, 1933-1961, 1962-1995, 1996-
McGregor, Spinola, and Verspagen (2018)	Five price indices, 1960-2016, deflated by the MUV	Two supercycles: 1960-1995, 1996-
Ojeda-Joya, Jaulin-Mendez, and Bustos-Pelaez (2019)	Index, 1865-2013 and 24 commodities, 1962-2010, deflated by the MUV index	Supercycles are synchronized and demand-driven: ***Oil***: 1885-1950, 1965-1995, 1996-; ***Metals***: 1877-1920, 1920-1945, 1945-1995, 1995-; ***Non-oil***: 1895-1937, 1937-1996, 1996-
Jacks (2019)	Indices and 40 commodities, 1900-2015, deflated by the U.S. CPI	Three or four medium-term cycles (depending on the commodity) and modestly increasing trend: 1903-1932, 1965-1996, 1996-
Cordano and Zellou (2020)	Natural gas prices, 1922-2015, deflated by the U.S. CPI	Three supercycles, strongly correlated with oil supercycles: 1948-1970, 1970-1994, 1994-2017

Source: World Bank.
Note: All papers (except Rossen 2015) use annual data and are based on the HP filter, except Erdem and Ünalmiş (2016) who use BP and HP filters. The MUV index (Manufacturing Unit Value) is a measure of dollar-based global manufacturing inflation monitored by the World Bank.

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