CHAPTER 3

COMMODITY PRICE CYCLES

Drivers and Policies

Commodity prices soared in 2021 following the broad-based decline in early 2020, with prices of several commodities reaching all-time highs. In part, this reflected the strong rebound of demand from the 2020 global recession. Energy and metal prices generally move in line with global economic activity, and this tendency has strengthened in recent decades. Looking ahead, global macroeconomic developments and commodity supply factors will likely continue to cause recurring commodity price swings. For many commodities, these may be amplified by the transition away from fossil fuels. To dampen the associated macroeconomic fluctuations, the almost two-thirds of emerging market and developing economies (EMDEs) that are commodity exporters need to strengthen their policy frameworks and reduce their reliance on commodity-related revenues by diversifying exports and, more importantly, national asset portfolios.

Introduction

Commodity prices soared in 2021, in large part rebounding from the sharp declines that occurred in the global recession of 2020 (figure 3.1). The broad-based surge, led by energy and metals, was driven by a strong recovery in aggregate global demand, easy financial conditions, and fiscal expansions in advanced economies. It was amplified by weather-related supply disruptions for both fossil and renewable fuels. In 2021, crude oil prices rose by nearly 82 percent, with the monthly average price of Brent climbing to about $84 a barrel for the first time in seven years. Natural gas and coal prices also surged. Metal prices were up about 28 percent, supported by the recovery in global manufacturing, improved prospects for a significant increase in infrastructure investment in advanced economies, and pandemic-related supply disruptions. Agricultural prices increased about 14 percent, with food prices rising the most in low-income countries (LICs).

Rising commodity prices, coupled with pandemic-related supply-demand mismatches, have contributed to a jump in headline inflation rates in many EMDEs and advanced economies. Upward price pressures are expected to persist for some time in EMDEs, especially LICs, on the back of elevated food prices, lagged effects of higher oil prices, and higher import prices resulting from currency depreciations. Policy trade-offs have become increasingly complex, particularly in many EMDEs, as inflation has been rising even as employment has remained below pre-pandemic levels.

The recent commodity price upswing has once again brought to the fore the susceptibility of EMDEs to large fluctuations in commodity prices. Macroeconomic performance in commodity exporters has historically varied closely in line with commodity price cycles. This is especially so for EMDEs that rely on a rather narrow set of commodities.[1] Commodities are critical sources of export and fiscal revenues for almost two-thirds of EMDEs, and three-quarters of LICs, and more than half of the world's poor reside in commodity-exporting EMDEs (figure 3.2; World Bank 2018a). Dependence on commodities is particularly high for oil exporters. On average, oil exports accounted for 33 percent of total goods exports by oil exporters over 2017-20—considerably more than the 20 percent share for metals and the 15 percent share for agricultural commodities for metals and agricultural exporters, respectively.[2]

Terms-of-trade shocks arising from commodity price movements cause changes in relative prices and have accounted for as much as half of the variation in economic activity in EMDEs (Di Pace, Juvenal, and Petrella 2020; Kose 2002). The impact of terms-of-trade shocks can also be asymmetric, with export price shocks being twice as important as import price shocks for domestic

Note: This chapter was prepared by Alain Kabundi and Garima Vasishtha, with contributions from John Baffes, Wee Chian Koh, and Peter Nagle.

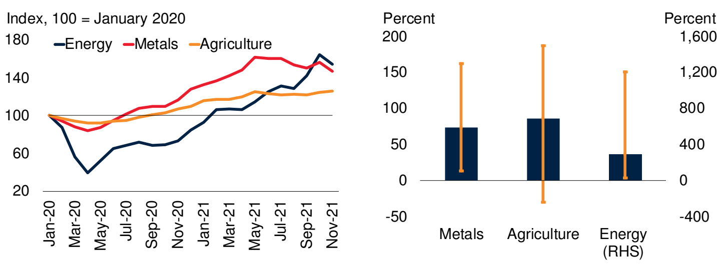
[1] See IMF (2015a); Jacks, O'Rourke, and Williamson (2011); Richaud et al. (2019); World Bank (2009); and World Bank (2020d).

[2] Commodity exporters are defined as countries where more than 20 percent of exports were concentrated in an individual commodity, on average over 2017-2020.

FIGURE 3.1 Commodity prices

Commodity prices soared in 2021, partly reflecting rebounds from the sharp declines during the global recession of 2020. Among commodity groups, energy prices registered the sharpest rebounds since their trough in April 2020.

A. Commodity prices **B. Commodity price growth since April 2020**



Source: World Bank.

A. Monthly average commodity prices, in U.S. dollar terms. Last observation November 2021.

B. Bars show commodity price growth for each group from the trough in April 2020 to November 2021. Orange whiskers show the range of price increases across commodities for each group. For energy commodities, the minimum and maximum values indicate the increases in the price of liquified natural gas in Japan and Europe, respectively. For metals, the minimum and maximum price increases were for iron ore and tin, respectively. For agriculture, Thai rice prices increased the least while Palm kernel prices increased the most.

business cycles. There are three main macro-financial channels through which commodity price fluctuations can affect economic activity.

- *Currency channel and inflation.* Commodity price movements can be a source of currency volatility for economies where a few commodities represent a significant share of exports. They can also trigger inflationary pressures, notably for commodity-importing LICs for which food and fuel constitute a large fraction of consumption. Exchange rate changes as well as inflationary pressures can pose challenges for monetary policy (Drechsel, McLeay, and Tenreyro 2019; Ha, Kose, and Ohnsorge 2019; World Bank 2020a).

- *Fiscal channel.* In commodity exporters, declines in commodity prices can trigger procyclical cuts in public expenditures because of reduced revenue from commodity production and exports, while conversely, increases in commodity prices can trigger procyclical increases in public spending. Fiscal policy thus often accentuates the impact of the commodity price cycle on economic growth and increases the amplitude of cycles in economic activity (Mendes and Pennings 2020; Riera-Crichton, Végh, and Vuletin 2015).

- *Financial channel.* In commodity exporters, commodity booms are often associated with strong growth in bank credit and increases in lending to borrowers who may prove less creditworthy during normal times. Rising commodity prices can also lead, in commodity exporters, to currency appreciation, lower country risk premiums, and larger capital inflows. These surges in capital inflows, if not invested wisely, can lead to financial crises when commodity prices collapse, and financial conditions tighten. A notable example is the Latin American debt crisis of the 1980s (Eberhardt and Presbitero 2021; Kose et al. 2021; Reinhart, Reinhart, and Trebesch 2016).

Recent events have highlighted how global trade and supply disruptions as well as climate-related events can amplify commodity price movements and their impact on economic activity. Countries dependent on fossil fuels are vulnerable, like other countries, to climate change and to the global efforts to mitigate it (Peszko, van der Mensbrugghe, and Golub 2020). A better understanding of commodity price movements can, therefore, help policy makers design effective stabilization policies, ensure financial stability, and undertake policies to improve development outcomes.

Against this background, this chapter asks the following questions:

- What are the main features of commodity price movements?

- How does the recent recovery in commodity prices compare with such episodes after previous global recessions and downturns?

- What are the key drivers of commodity price cycles?

- What are the policy implications?

Contribution to the literature. This chapter contributes to the literature along four dimensions. *First*, it expands on the earlier literature on commodity cycles by using a much larger set of commodities and a period that includes the COVID-19 pandemic.[3] *Second,* it is the first study to compare the rebound in commodity prices after the COVID-19-induced global recession in 2020 with the price recoveries after past recessions and slowdowns. *Third,* using a cutting-edge econometric approach, the chapter examines both global and commodity-specific cycles for a large number of commodities as well as their underlying drivers. This contrasts with earlier literature that either focuses only on a small set of commodities, or examines commodity demand and supply rather than aggregate demand and supply, or simply documents the existence of comovement without identifying the underlying drivers.[4] *Fourth*, the chapter presents a rich menu of policy options available to commodity-exporting EMDEs for dealing with commodity price volatility.

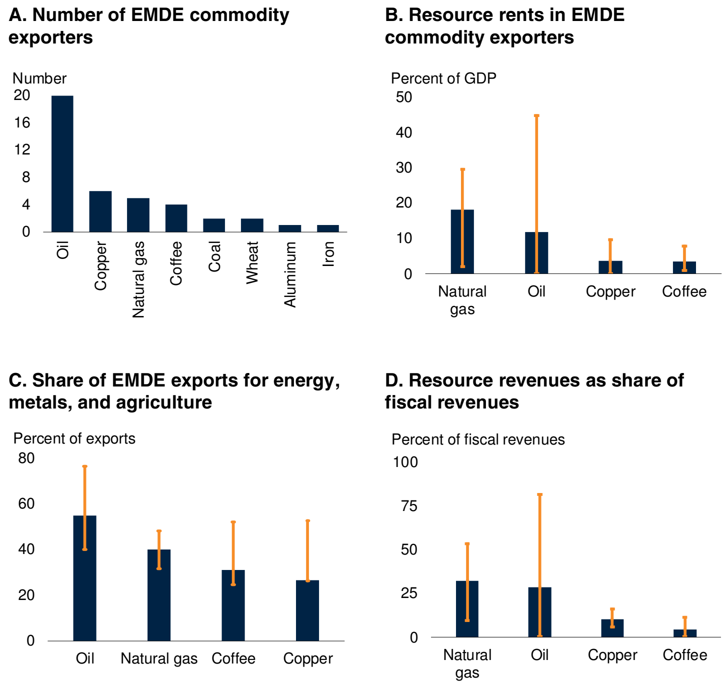
Main findings. This chapter offers the following main findings.

First, over the past five decades, commodity prices have undergone repeated cycles. On average, from peak to peak, cycles lasted almost six years. Prices rose and fell by 1-4 percent per month over the course of the average cycle. Price slumps lasted somewhat longer (39 months) than booms (30 months). Booms, on average, were steeper (4 percent per month) than price slumps (1 percent per month).

Commodity price cycles have been highly synchronized across commodities. On average, all commodity prices were in the same cyclical phase 60 percent of the time. For commodities intensively employed in industry, such as copper and aluminum, prices were in the same phase about 80 percent of the time. This synchronization was reflected statistically in a common factor that accounted, on average, for roughly 15-25 percent of price variability for energy and metals, but only 2-10 percent of price variability for agricultural commodities and fertilizers. For industrial commodities (which here include energy, metals, and rubber), the synchronization has become more pronounced over time. Since the mid-1990s, on average, the common factor accounted for about 30-40 percent of the

FIGURE 3.2 Importance of commodities

Many EMDEs are heavily reliant on commodity exports. The average energy exporter is more reliant on energy exports than the average agriculture- and metal-reliant EMDE. Resource revenues are also an important source of fiscal receipts, particularly for energy exporters.



Sources: Comtrade (database); International Monetary Fund; UNU-Wider (database); WITS (database); World Bank.

Note: EMDEs = emerging market and developing economies.

A. Figure lists the number of EMDEs that primarily export a specific commodity. An EMDE is defined as a commodity exporter if, on average in 2017-20, the value of exports of an individual commodity accounted for 20 percent or more of total exports.

B. Unweighted average of resource rents as percent of GDP for EMDE commodity exporters of natural gas (13 countries), oil (44 countries), copper (14 countries), and coffee (13 countries). Total natural resource rents of exporters of each commodity included in the figure are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents. Countries relying on the export of multiple commodities are included in the averages for each commodity. As an example, a country identified as a natural gas exporter may be deriving resource rents from exports of both natural gas and oil; its share of resource rents is included in the averages for both oil and natural gas since the breakdown of resource rents by individual commodity is not available.

C. Figure shows the median share of exports accounted for by oil, natural gas, copper, and coffee for EMDE exporters of that commodity. Oil includes 20 EMDEs, copper 6, natural gas 5, and coffee 4. Blue bars show medians and orange whiskers show interquartile ranges.

D. Unweighted average of resource revenues as a share of fiscal revenues for EMDE commodity exporters of natural gas (5 countries), oil (25 countries), copper (4 countries), and coffee (5 countries). Countries relying on the export of multiple commodities are included in the averages for each commodity. Orange whiskers indicate the range between the minimum and maximum values.

[3] For the earlier literature, see, for example, Cashin, McDermott, and Scott (2002); Roberts (2009); and Rossen (2015).

[4] For studies of commodity cycles, see Charnavoki and Dolado (2014) and Ha et al. (2019); for the roles played by demand and supply shocks, see Jacks and Stuermer (2020), Kilian and Murphy (2014), and Stuermer (2017, 2018); and, for the comovement of cycles, see Chiaie, Ferrara, and Giannone (2017).

variability in industrial commodity prices—twice as much as during the full period since 1970.

Second, the rebound in prices from their trough in April 2020 was faster and steeper than that after previous recessions for almost all major commodity groups. The recovery in energy prices was particularly sharp—about 50 percent in the three months after their 2020 trough, with prices surpassing their pre-crisis peak in about a year. In contrast, after previous recessions, the median recovery in energy prices was less than 5 percent over a 13-month period. This reflected the extraordinarily strong economic rebound from the COVID-19-induced global recession, along with difficulties in quickly restoring supply.

Third, for metals—the commodity group for which demand is most sensitive to economic activity—the global business cycle has been the main driver of prices. Energy and metal prices were in the same cyclical phase as the global business cycle about 60 percent of the time, compared with about half the time for agricultural commodity prices. About one-third of price troughs coincided with global recessions.

Since 1996, global macroeconomic shocks have been the main source of commodity price volatility—which includes both cyclical and shorter-run movements. Global demand shocks have accounted for 50 percent, and global supply shocks for 20 percent, of the variance of global commodity prices. In contrast, during 1970-96 supply shocks specific to particular commodity markets—such as the 1970s and 1980s oil price shocks—were the main source of variability in global commodity prices. These results suggest that the role played by developments specific to commodity markets in driving commodity price volatility may have diminished over time.

Fourth, the gyrations in commodity prices in 2020-21 are a reminder of the need for policies to manage and contain the economic consequences of such volatility, especially in the case of EMDEs. Almost two-thirds of these countries rely heavily on primary commodities for government and export revenues. Real incomes in both commodity exporters and importers have been severely affected by changes in the terms of trade resulting from commodity price movements. In the years ahead, the challenges are likely to be compounded by the effects on commodity prices of the transition away from fossil fuels. Countries relying heavily on commodities face two types of policy challenges, which are related: first, smoothing macroeconomic volatility induced by commodity price swings and, second, reducing their reliance on commodities. The former requires the strengthening of fiscal, monetary, and macro-prudential frameworks. The latter, progress with which will help achieve the former, requires structural measures, such as encouraging economic diversification, particularly of exports, building human capital, promoting competition, strengthening institutions, and reducing distorting subsidies.

Main features of commodity cycles

Over the past five decades, global commodity prices have been characterized by repeated cycles. Energy and metal prices have tended to comove particularly closely with global economic activity. The rebound in prices from their trough in April 2020 has been faster and steeper than that after previous recessions for most major commodity groups.

Empirical approach

Methodology. Standard techniques used to study business cycles are applied to 67 global commodity prices (see table A3.4.1 for the list of commodities and their groupings). Specifically, the procedure applied is a widely used algorithm for dating business cycles, and largely follows Harding and Pagan (2002) and Cashin, McDermott, and Scott (2002) (annex 3.1).[5] The algorithm is applied to real commodity price series at the monthly frequency. The sample includes

[5] Other studies that have used this technique for commodity price cycles include IMF (2012), Roberts (2009), and Rossen (2015), with the latter two focusing only on metals. Note that this technique is designed to analyze short-run cycles in commodity prices. For identifying cycles at different frequencies, other techniques may be more appropriate (for example, Baffes and Kabundi 2021).

commodities spanning energy (10 prices), metals and minerals (7 prices), precious metals (3 prices), agriculture (food, beverages, and oil; 34 prices), fertilizers (5 prices), and raw materials (8 prices). To better capture the behavior of different agricultural commodities, separate indexes were constructed for the prices of annual and perennial agricultural commodities.[6]

Definitions. A *boom* in commodity markets is defined as a trough-to-peak rise in commodity prices; a *slump* as a peak-to-trough decline. A *cycle* consists of both a boom and the subsequent slump. The number of months between troughs and peaks, and the magnitude of changes in commodity prices during this period, are the *duration* and *amplitude*, respectively. *Slope* is defined as the average monthly amplitude (that is, amplitude divided by the duration). Synchronization of phases between commodity prices (as well as between commodity prices and economic activity) is assessed by the *concordance* statistic, which measures the proportion of time that two series are concurrently in the same phase (see annex 3.2).

Data. Monthly average price data, in U.S. dollar terms, are taken from the World Bank Commodities Price Data (the *Pink Sheet*) for the period January 1970 to October 2021. Real price series are obtained by deflating the nominal series by the U.S. consumer price index (CPI) published monthly by the Bureau of Labor Statistics (BLS). The beginning of the sample period is chosen to ensure that the price formation process reflects the post-Bretton Woods exchange rate arrangements (with the transition to generalized floating among the major currencies in 1971-73) while the monthly data enable the measurement of high-frequency fluctuations. As an illustration of commodity price cycles, six major commodities are examined in detail—coal, crude oil, aluminum, copper, maize, and coffee. These commodities are the most traded ones in their respective commodity groups. The exercise yields a total of 538 peaks and 573 troughs since 1970, about 17 on average per commodity—17 per base metals and minerals commodity, and 15 per energy and agricultural commodity. The number of completed peak-to-peak cycles ranges from 2 (rubber) to 12 (logs) for individual commodities (table A3.4.1). The average number of cycles ranges from five for precious metals to eight for metals and minerals.

Features of commodity price cycles

Duration. On average in the period January 1970-October 2021, price booms lasted 30 months and slumps lasted 39 months (table A3.4.1 and figure 3.3). The difference between the average duration of booms and slumps is particularly large for some agricultural commodities.[7] The relatively long duration of slumps in agricultural commodities could be driven by the relative persistence of negative shocks, such as those related to weather and/or plant diseases, that do not generally affect the prices of energy and metals (IMF 2012).

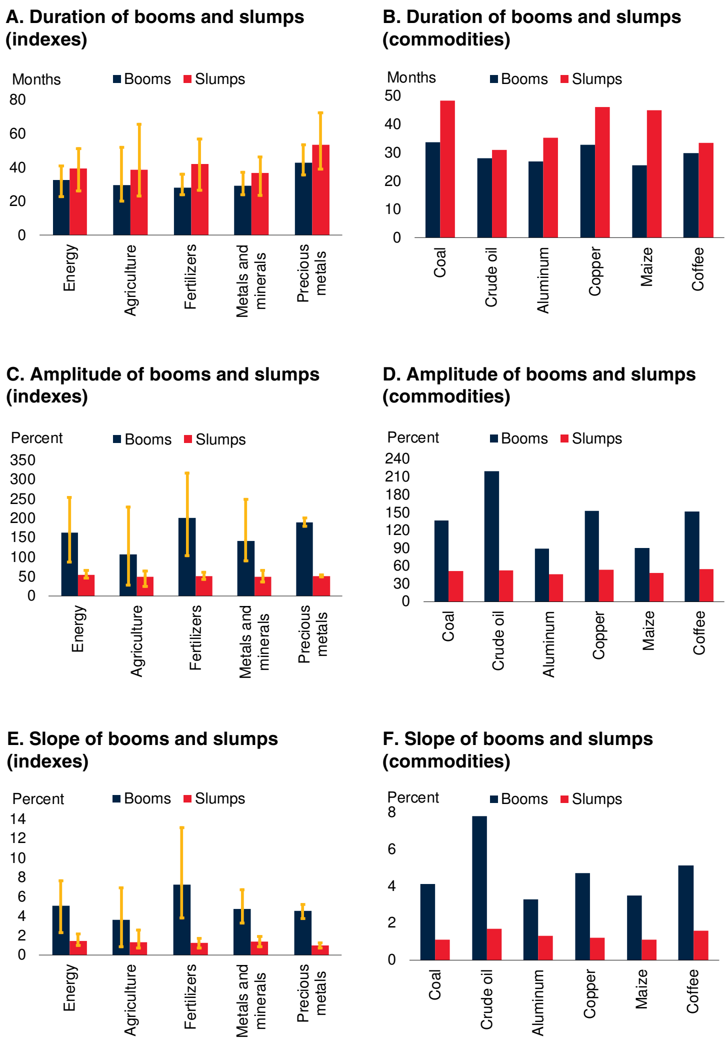
Amplitude and slope. For all commodity groups, the amplitude and slope of price booms were larger than those for price slumps. The average price increase during commodity price booms was larger than the average price decline during slumps (figure 3.3). On average, the monthly speed of commodity price rises in booms (4 percent a month) was much faster than that for commodity price declines in slumps (1 percent a month). For some commodities the difference in the speed of price increases and decreases was particularly large. For instance, the average rise in real oil prices in booms was about 8 percent a month while the average fall in oil prices in slumps was about 2 percent.

[6] The annual agriculture index comprises cotton, maize, rice, soybean meal, soybean oil, and wheat. These commodities, often termed crop commodities, are produced on an annual basis so that land use (and other factor inputs) can change each crop year, depending on demand and supply conditions. The perennial agriculture index comprises cocoa, coffee Arabica, coffee Robusta, natural rubber, and tea. These commodities are produced by trees, often termed tree crops, and therefore cannot be substituted on an annual basis. Both indexes are constructed using the weights specified in the World Bank's *Pink Sheet*.

[7] The somewhat longer duration of slumps than booms is consistent with findings in the related literature (see Cashin, McDermott, and Scott 2002; IMF 2012; Roberts 2009; and Rossen 2015). It is also in line with earlier literature that found agricultural commodity prices to be characterized by long periods of doldrums interrupted by shorter-lived spikes (Deaton and Laroque 1992).

FIGURE 3.3 Duration, amplitude, and slope

On average, price slumps have been longer in duration than price booms for most commodities. The difference is especially pronounced among some agricultural commodities. Price booms have been more pronounced than price slumps, on average. The speed of commodity price rises in booms was also much faster than that for declines in slumps.



Source: World Bank.
Note: Data from January 1970 to October 2021. Yellow whiskers indicate minimum and maximum range.
A.B. Duration measures the average length (in months) of a phase (booms or slumps).
C.D. Amplitude measures the average real price change (in percentage terms) from trough to peak for booms and from peak to trough for slumps.
E.F. Slope refers to the average monthly amplitude (i.e., amplitude divided by the duration).

Comovement in commodity cycles. Commodity prices have been highly synchronized: More than 60 percent of the time, on average, all commodity prices in the sample were in the same cyclical phase. This price synchronization reflects a number of factors. Since several sets of commodities are close substitutes in demand, being used for the same purposes, demand surges or supply disruptions in one commodity market affect the prices of similar commodities. For annual agriculture commodities, prices may be synchronized because of the substitutability of inputs to production, including land, labor, and machinery. Energy is a key input in the production of some metals (such as aluminum) and an important cost component for most grains and oilseed crops. Thus, increases in energy prices will tend to put upward pressure on the costs of production (and hence the prices) of these commodities (Baffes 2007).

The highest degrees of synchronization were between copper and aluminum (81 percent of the time), and between copper and crude oil (73 percent of the time) (table A3.2.1). This likely reflects the strong response of these commodities to global economic activity as well as their joint use in a wide range of applications. These results are consistent with earlier findings that, among energy commodities and metals, consumption of aluminum, copper, and crude oil exhibited the strongest responses to per capita income growth (Baffes, Kabundi, and Nagle 2021; World Bank 2018a).

Comovement with global economic activity. Commodity prices are positively correlated with the global business cycle. The share of troughs that occurred during global recessions and slowdowns was about 23 percent for both metals and minerals as well as agriculture, followed by energy (10 percent) (figure 3.4).[8] The share of peaks preceding global recessions was the highest for energy (20 percent), followed by agriculture, and metals and minerals. Energy and metal prices comoved more strongly than agricultural commodities with global industrial production. Energy and metal prices, on average, were in the same cyclical phase as global industrial production about 60 percent of the time. This contrasts with the limited synchronization of food commodity prices with global industrial production: Maize,

[8] The episodes of past global recessions and slowdowns are taken from Kose, Sugawara, and Terrones (2020).

for example, was in the same phase roughly 40 percent of the time (figure 3.4).[9]

Recent commodity price movements compared with historical experience

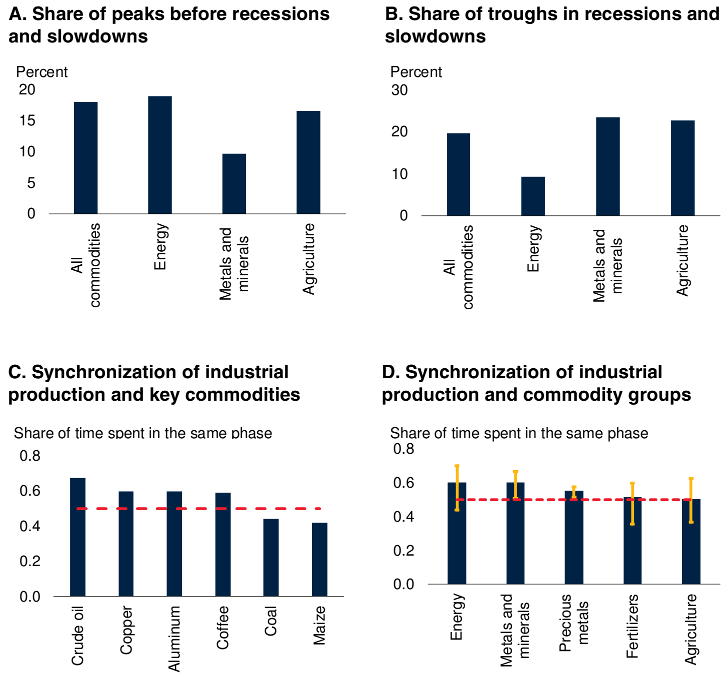
Event study. An event study is used to compare the behavior of commodity prices during the 2020 global recession with price movements around global recessions and slowdowns over the past 50 years. For brevity, the results are presented for the six major commodity indexes. During the 2020 global recession, the troughs in commodity prices generally coincided with those in global economic activity. This is in sharp contrast with previous, more prolonged recessions, where commodity prices continued to decline for several months after the trough in economic activity.

Energy and metal prices. The collapse in the energy price index in early 2020 was the steepest of any during global recessions in the past five decades, and the subsequent recovery was likewise the steepest (figure 3.5). Energy prices rebounded by about 50 percent within three months of their early 2020 trough, and surpassed their pre-crisis peak in about a year. In comparison, the median recovery after previous recessions was less than five percent in 13 months. Likewise, for metal and mineral prices, the pandemic-driven decline in 2020 was steeper than that during most of the previous global recessions. The subsequent price recovery was also faster than in previous episodes. This was mostly a reflection of the relatively short-lived nature of the pandemic-related recession, a rebound in demand from China due to strong industrial activity, and supply disruptions in Latin America.

Agricultural commodity prices. Prices for annual agricultural commodities declined only slightly during the pandemic but increased sharply in late 2020 and early 2021. This surge in prices was mostly driven by strong demand from China, in part because of the recovery in demand for animal feed after the Africa swine flu outbreak in 2019, and higher energy costs (and, hence, fertilizer costs). For the perennial agricultural price index—which comprises coffee, rubber, and tea—the price decline in 2020 was broadly in line with historical episodes, while the subsequent recovery was faster.

FIGURE 3.4 Synchronization of commodity price cycles

Commodity price cycles tend to comove with the global business cycle. Energy and metals comove strongly with global industrial production, while agricultural commodities are less correlated with industrial production.



Sources: Haver Analytics; World Bank.
A. Share of peaks in a 6-month window before global recessions and slowdowns.
B. Share of troughs in a 6-month centered window around global recessions and slowdowns.
C.D. Synchronization is measured by the concordance statistic which is defined as the proportion of time that two price series are in the same phase. It is equal to one if both series are in the same phase at any time. See Annex 3.2 for details. Dashed red line indicates 0.5. The global industrial production series is derived by aggregating country-level industrial production series (from Haver Analytics) with "industry value added" (from the World Bank's World Development Indicators) used as weights. The series is incorporated in level terms.
D. Yellow whiskers denote minimum and maximum range.

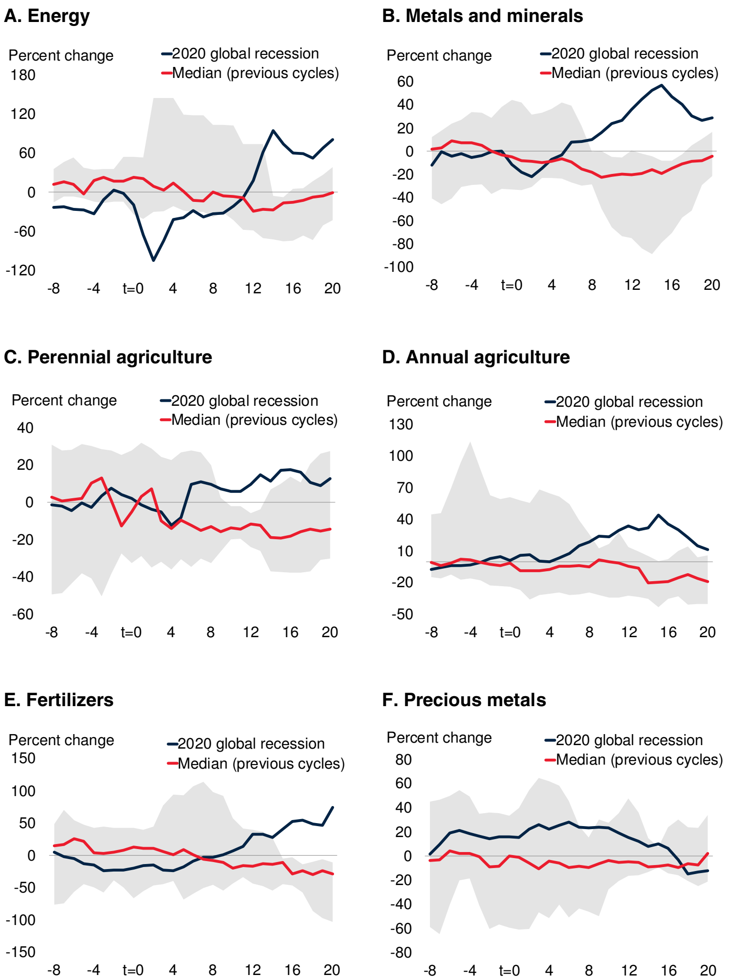
Evolution of commodity cycles

Since 1970, slumps in the prices of crude oil, coal, aluminum, and copper have been associated mainly with declines in global economic growth, geopolitical events affecting supply, and the emergence of new producers. In contrast, slumps in the prices of

[9] Taken together, these findings are consistent with studies showing that demand for energy and industrial metals is driven primarily by economic growth, whereas demand for agricultural commodities is driven mainly by population growth (Baffes, Kabundi, and Nagle 2021; World Bank 2018a).

FIGURE 3.5 Commodity prices around global recessions and downturns

The recovery in commodity prices since the COVID-19 recession is in stark contrast to those following previous recessions. The rebound in prices has been exceptionally fast for most major commodity groups.



Source: World Bank.

Note: The horizontal axis represents the time period in months, where t=0 denotes the peak of global industrial production before global recessions and downturns since 1970, as in Kose, Sugawara, and Terrones 2020. See table A3.4.2 for the specific episodes. The vertical axis measures the percent change in the commodity price series from a year earlier. The blue line shows the trajectory of the current commodity cycle around the COVID-19 recession, while the red line is the median of previous cycles around a global recession or downturn. Gray shaded areas represent the range of observed values in previous cycles. Data from January 1970 to October 2021.

agricultural commodities, such as coffee, have been associated mostly with commodity-specific supply and policy shocks and less so with aggregate demand shocks.

Crude oil

Oil prices (represented by the unweighted average of Brent, Dubai, and West Texas Intermediate—WTI—prices, in real terms) have experienced eleven troughs since 1970 (table A3.1.1 and figure A3.1.1). The troughs were associated primarily with global recessions and Organization of the Petroleum Exporting Countries' (OPEC) decisions/agreements (figure 3.6).[10]

Global recessions. Four of the identified troughs (1975, 1998, 2001, 2020) in oil prices were associated with global recessions or slowdowns. The global recession and oil price slump of 1975 followed the shock to world oil prices from the OPEC price hike and the Arab oil embargo initiated in October 1973. The sharp decline in oil prices in 1998 was associated mostly with weakening global demand stemming partly from the 1997-98 Asian financial crisis, although continued expansion of OPEC production until mid-1998 may have been another contributing factor (Fattouh 2007). The trough in oil prices in 2001 was triggered by weakening global growth following the bursting of the dot.com bubble, exacerbated by the disruptions and uncertainty set off by the September 11 terrorist attacks in the United States (Baffes et al. 2015; World Bank 2015a). The most recent trough, in April 2020, followed the steepest price collapse on record. Global oil demand dropped due to the deepest global recession since the Second World War as well as the widespread restrictions on transport and travel, which account for about two-thirds of global oil demand (Kabundi and Ohnsorge 2020; Wheeler et al. 2020).

OPEC decisions/agreements. The oil price slump in 1986 can mostly be attributed to changing supply conditions as OPEC reverted to a production target of 30 million barrels per day after cutting production significantly in the early 1980s (Baffes et al. 2015; World Bank 2015a). Real oil prices dropped by almost 60 percent from

[10] Major spikes in oil prices have been associated with geopolitical events affecting supply. For instance, during the 1973 Yom-Kippur War, OPEC's member countries cut production, and Arab suppliers imposed an oil embargo against Canada, Japan, the Netherlands, the United Kingdom, and the United States. Average real oil prices in 1974 were more than four times their 1973 level. Subsequent disruptions in oil supplies following the war between Iraq and the Islamic Republic of Iran, and the Iranian revolution caused oil prices to more than double in 1979 compared to the previous year.

January to July 1986, followed by a prolonged period of low oil prices during the next two decades. Likewise, the slide in oil prices after 2014 was triggered by a change in OPEC's policy objective, from price targeting to preserving market share. Muted demand and rising oil supply from non-OPEC producers, including U.S. shale oil, Canadian oil sands, and biofuels also contributed to the decline in prices at this time (figure 3.6).

Coal

Coal prices underwent eight troughs since 1970 (table A3.1.1). The troughs can mainly be attributed to global recessions and slowdowns, policy-driven changes in China's growth model, and the emergence of new producers.

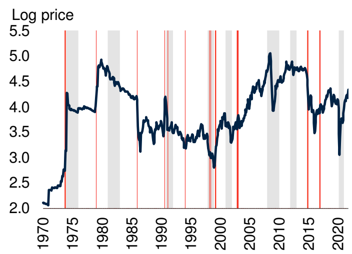
Global recessions. The global financial crisis of 2007-09 and the subsequent global recession resulted in a sharp fall in coal prices (figure 3.7). Prices bounced back rapidly in 2010-11 as the global economy recovered, with China driving the increase in demand. In 2020, the COVID-19 pandemic and the associated global recession caused a drop in demand for coal, with its price falling by nearly 30 percent between January and August. While demand subsequently rebounded in 2021 alongside the economic recovery, production was slower to recover, with weather events, including flooding in China and Indonesia, causing disruptions (World Bank 2021a).

Policy-driven changes in China's growth model. The coal market changed significantly in the 2000s as rapid economic growth in China led to a surge in demand for coal, both for power generation and for metallurgical uses. To meet the surging demand, China rapidly increased its domestic production as well as its imports of coal. These developments slowed and went into reverse in the 2010s, as China's growth moderated and shifted from investment and manufacturing toward less energy-intensive consumption and services. This contributed to a steady decline in prices from 2011-15, with prices reaching a trough by end-2015.

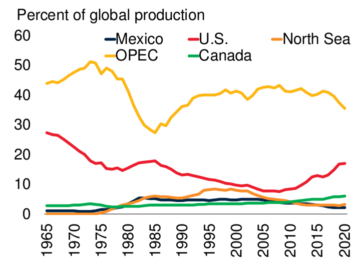
FIGURE 3.6 Crude oil

Crude oil prices have experienced 11 troughs since 1970. These troughs have been associated with global recessions and events related to the Organization of the Petroleum Exporting Countries (OPEC). The declines in oil prices in 1985-86 and after 2014 were triggered by changes in OPEC's policy objective, in each case from price targeting to preserving market share. Both episodes followed rapid expansions in non-OPEC oil supplies—Alaska, North Sea, and Mexico (1985-86) and U.S. shale oil, Canadian oil sands, and biofuels (2014-16).

A. Oil price



B. Oil production



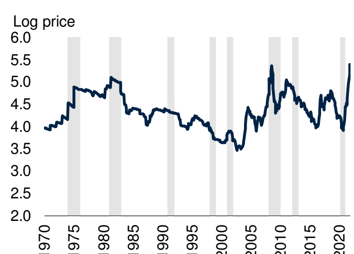
Sources: BP Statistical Review; World Bank.

A. Real price of crude oil (unweighted average of Brent, Dubai, and WTI oil prices) in logs. Shaded areas indicate global recessions and downturns as in Kose, Sugawara, and Terrones (2020), and the global recession of 2020. Data from January 1970 to October 2021. Red lines indicate OPEC-related episodes in 1973, 1979, 1985, 1990, 1991, 1994, 1998, 1999, 2002, 2003, 2014, and 2016.

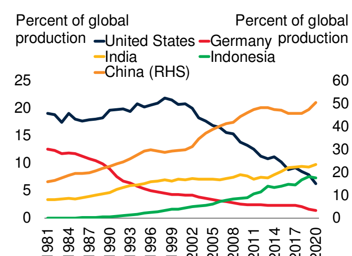
FIGURE 3.7 Coal

Coal prices have experienced eight troughs since 1970. The troughs have mainly been associated with global recessions, the emergence of new producers, and policy-driven changes in China's growth strategy involving a shift toward services and less energy-intensive consumption.

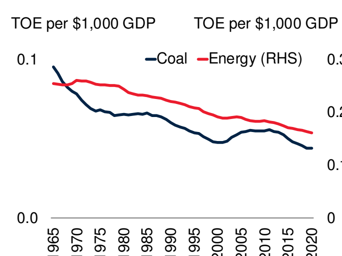
A. Coal price



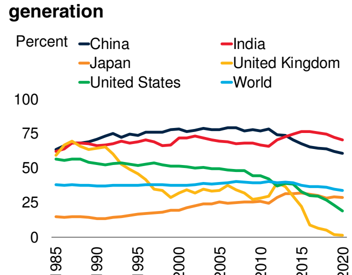
B. Coal production



C. Energy intensity of global GDP



D. Share of coal in electricity generation



Sources: BP Statistical Review; Our World in Data (database); U.S. Energy Information Administration; World Bank.

A. Real price of coal in logs. Shaded areas indicate global recessions and downturns as in Kose, Sugawara, and Terrones (2020), and the global recession of 2020. Data from Jan. 1970 to Oct. 2021.

B. Share of coal production in global production.

C. Energy includes coal, natural gas, and oil. ToE stands for tonnes of oil equivalent. Aggregates calculated using GDP weights at average 2010-19 prices and market exchange rates.

D. Share of electricity that comes from coal.

Emergence of new producers. After increasing steadily through the 1970s, real coal prices declined through much of the 1980s and 1990s. The fall in prices through the 1980s in part reflected the emergence of additional coal producers, particularly China and Indonesia (figure 3.7). By the 1990s, China had overtaken the United States as the world's largest coal producer, although technological improve-ments, such as automated longwall mining systems and draglines, sharply reduced the cost of producing coal in the United States and ensured the country remained a leading producer: the United States remained the world's second largest producer of coal until about 2016, when it was overtaken by India. In 2020, China accounted for about 50 percent of global coal production, while India accounted for less than 10 percent.

Aluminum

Aluminum prices saw ten troughs since 1970. Price cycles for major industrial metals, such as aluminum, copper, zinc, and lead generally follow global economic cycles since demand for them is closely related to global economic activity, particularly industrial production. These metals are used in a wide range of applications, with changes in usage and related structural changes in demand occurring only slowly over time. The troughs in real aluminum prices have generally been associated with global recessions and slowdowns, and the emergence of new producers and consumers.

Global recessions. Three of the identified troughs in aluminum prices (1982, 2009, 2020) were associated with global recessions. In addition, the global slowdown associated with the 1997-98 Asian financial crisis was accompanied by a sharp decline in aluminum prices. The most recent trough, in April 2020, was associated with the pandemic-related recession, with real aluminum prices falling to their lowest level over the past half-century. Prices have since rebounded with the global economic recovery.

Emergence of new producers. In the early 1970s, aluminum production was highly concentrated in a few countries, notably the United States, the Soviet Union, and Japan. Since then, major shifts have occurred in the geographic location of production with the arrival of new private producers and conglomerates of state-owned enterprises. The collapse in prices in the early 1990s was caused by the breakup of the Soviet Union: countries that had been members of the bloc opened up and joined the global aluminum market, which resulted in a large increase in supply, especially from the Russian Federation. In the 2000s, China emerged as the world's largest aluminum producer, accounting for more than half of global production compared to just 1 percent in 1970 (figure 3.8). Despite environmental curbs in China (aluminum production is energy-intensive) and tariffs imposed by the United States, Chinese aluminum production—55 percent of global supply—has continued to rise, even during the COVID-19 pandemic.

Emergence of new sources of demand. Since 2000, the intensity of aluminum use in global GDP has risen, reflecting strong demand from EMDEs, rapidly growing aluminum-intensive industries, and replacement for tin in canning, and for copper in electrical wiring. Between 2000 and 2010, China's consumption of aluminum as a share of global consumption increased threefold. As China's aluminum production expanded, the support to aluminum prices from these factors faded.

Copper

Copper prices experienced eight troughs since 1970 (table A3.1.1). The troughs have generally been associated with global recessions or slowdowns, technological innovations, shifts in demand away from copper to other materials for some uses, and the emergence of new producers. Additionally, U.S.-China trade tensions contrib-uted to a steep decline in prices in the second half of 2018.

Global recessions. The price troughs of 1999 and 2001 stemmed, respectively, from the global recession associated with the Asian financial crisis and the global slowdown of 2001. Similarly, copper prices fell sharply during (and in some cases after) the global recessions of 1982, 1992, and 2020.

Technological innovations. During the 1980s and 1990s, technological innovations reduced costs of copper production. An important breakthrough was the development of the solvent extraction and electrowinning technology, which extracted copper through dissolution and subsequent electrolysis instead of mining. By 1995, this process accounted for 27 percent of U.S. primary copper output, up from 6 percent in 1980 (Radetzki 2009).

Shifting demand. Over the past half century, copper demand has been dampened by substitutions toward aluminum, plastics, and glass fiber. Aluminum has been the predominant substitute, gaining substantial market share and suppressing copper's relative price (Radetzki 2009).

Emergence of new producers. After a decade of largely stagnant mine production, the discovery of new supply sources and new technologies, that reduced processing costs, played an important role in driving down copper prices from 2011 to 2015. During this period mine supply grew strongly, particularly in the Democratic Republic of Congo, Kazakhstan, Peru, and Zambia (figure 3.8). Between 2010-16, copper mine production increased by 27 percent, almost three times as fast as between 2004-10.

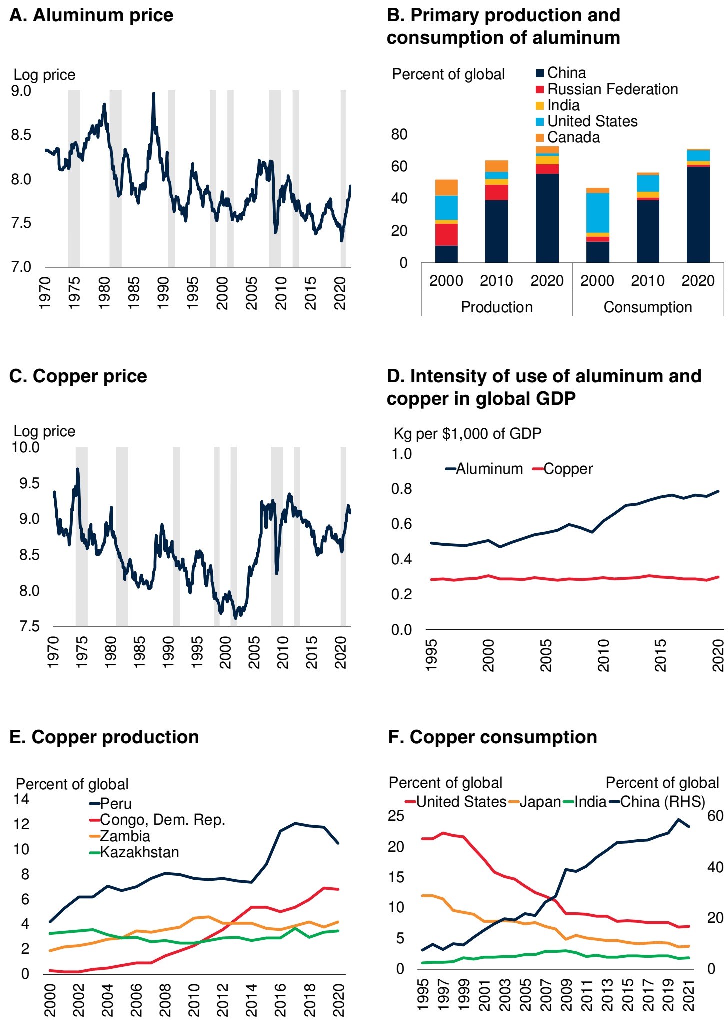
Coffee

The methodology identifies ten troughs for coffee (Arabica) prices since 1970 (table A3.1.1). The troughs were associated mostly with weather-related supply shocks and the emergence of new producers. The most recent, pre-pandemic trough in 2019 was driven largely by prior surplus production in Brazil, the world's largest coffee producer.

Weather. Following historically low levels in the early 1970s, real coffee (Arabica) prices tripled during 1975-77 and reached a record high in April 1977, following a major frost in Brazil (Akiyama and Varangis 1990). As supplies recovered, and producing countries failed to extend the International Coffee Agreement, real coffee prices declined, reaching a trough in late 1992.[11] More recently, in 2016, the end of a drought supported

FIGURE 3.8 Aluminum and copper

Aluminum prices have experienced 10 troughs while copper prices have undergone 8 since 1970. The troughs in aluminum and copper prices have generally been associated with global recessions or slowdowns and the emergence of new producers.



Sources: World Bank; World Bureau of Metal Statistics.

A.C. Real price of aluminum and copper in logs, respectively. Shaded areas indicate global recessions and downturns as in Kose, Sugawara, and Terrones (2020), and the global recession of 2020. Data from January 1970 to October 2021.

B. Aluminum production and consumption as shares of global production and consumption, respectively.

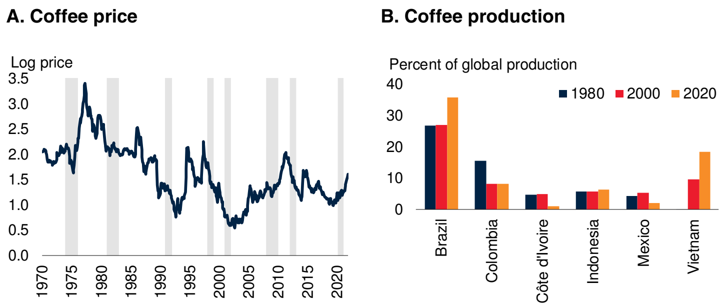
D. Aggregates calculated using GDP weights at average 2010-19 prices and market exchange rates.

E.F. Percent of global copper production and consumption, respectively. Figures show yearly averages using monthly data.

[11] The International Coffee Agreement operated an export-quota system, which was first implemented in 1963, and continued intermittently until 1989.

FIGURE 3.9 Coffee

Coffee prices have seen 10 troughs since 1970. The troughs have been associated mostly with commodity-specific supply and policy shocks and less so with variations in global aggregate demand.



Sources: U.S. Department of Agriculture; World Bank.
A. Real prices in logs. Shaded areas indicate global recessions and downturns as in Kose, Sugawara, and Terrones (2020), and the global recession of 2020. Data from January 1970 to October 2021.
B. Major coffee producers and their share of global production since 1980.

the coffee harvest in Brazil and contributed to the trough in coffee prices in that year.

New producers. Following a price recovery with peaks in 1994 and 1997, both associated with weather events (frost in Brazil and El Niño in Peru, respectively), prices began declining again in response to supplies from a new entrant—Vietnam. Vietnam's emergence as a major Robusta coffee producer altered the landscape of the global coffee market for the long term: Vietnam now accounts for nearly 20 percent of global coffee supplies, up from less than 0.1 percent in 1980 (figure 3.9). A few smaller coffee producers have increased supplies as well, including Honduras, Nicaragua, and Peru.

Drivers of commodity cycles

Since the mid-1990s, movements in commodity prices, especially those of industrial commodities, have become more synchronized. A common global factor explains about one-third to two-fifths of the variation in industrial commodity prices, but only one-eighth of the variation in agricultural commodity prices. Both aggregate demand and supply shocks have been important drivers of this common global factor, together accounting for almost two-fifths of its variability.

Global commodity prices

Methodology. A dynamic factor model in the spirit of Kose, Otrok, and Whiteman (2003) is adopted to analyze the comovement of commodity prices (box 3.1 and annex 3.3). The common factor derived from 39 commodity price series (in real terms) represents global commodity price growth (henceforth referred to as the global factor).

Main components of global commodity prices. The global factor plays an important role in driving fluctuations in industrial commodity prices. During 1970-2021, it accounted for as much as 22-37 percent of the variation in the prices of base metals, rubber (used in tires and tubes), and platinum (used in catalytic converters), and 18 percent of the variation in energy prices, on average. In contrast, only 2-14 percent of the variation in the prices of agricultural commodities (excluding rubber), precious metals, and fertilizers, on average, is accounted for by the global factor. The relatively larger contribution of the global factor in explaining the variation in the prices of industrial commodities reflects the strong response of metal and energy consumption to industrial activity (Baffes, Kabundi, and Nagle 2021). This is in contrast to agricultural commodities (food and beverages) where supply shocks, resulting mainly from weather conditions and policies, typically play a larger role than demand-side factors.

Components of global commodity prices over time. The contributions of the global factor to industrial commodity prices increased considerably over time. For energy, base metals, and platinum prices, its estimated contribution was roughly twice as large for the 1996-2021 period as for the whole sample period, 1970-2021. This increased comovement in global commodity prices from the mid-1990s accompanied a broader trend toward greater comovement in macroeconomic variables, such as inflation and output (Eickmeier and Kühnlenz 2018; Ha, Kose, and Ohnsorge 2019). The increased synchronization of commodity prices can partly be attributed to trade liberalization and the

BOX 3.1 Drivers of commodity cycles

Commodity prices have exhibited increasingly synchronized booms and busts in the past five decades. Macroeconomic shocks have become the main source of the greater comovement in a broad set of industrial commodity prices (energy, base metals, platinum, and natural rubber).

Introduction

The widespread collapse in commodity prices in early 2020, triggered by the pandemic-induced global recession, was followed by a synchronized sharp rebound, with several prices reaching all-time highs. Synchronized booms and busts in commodity prices have been common in recent decades: the most recent preceding boom was the prolonged, broad-based rise in prices in the early 2000s resulting from the increase in the global demand for commodities that was triggered by strong growth in EMDEs, especially China (Alquist, Bhattarai, and Coibion 2020; Baffes and Haniotis 2010; World Bank 2015b). This upswing in prices was disrupted by the global financial crisis of 2007-09, with prices declining in unison to early-2006 levels by the end of 2008.

Several studies have examined common cycles in commodity prices and their underlying causes. A popular view in the literature that attempts to provide a macroeconomic explanation for this phenomenon is that there is a common component of commodity price fluctuations that may be captured by measures of the ebbs and flows in global economic activity (Alquist, Bhattarai, and Coibion 2020; Byrne, Sakemoto, and Xu 2020; Chiaie, Ferrara, and Giannone 2017; and Marañon and Kumral 2019). However, fluctuations in global economic activity alone do not explain the evolution of commodity prices. Other factors, particularly supply conditions within and across commodity markets, are likely to be key determinants of commodity price cycles (Borensztein and Reinhart 1994; Cashin, McDermott, and Scott 2002). For example, the 2006-08 spike and the 2014-16 collapse in commodity prices were caused by factors other than global demand.

Fluctuations in factor input costs, for example the prices of oil and other energy products, could affect a wide range of commodity markets simultaneously. Energy is both a key input in the production of metals and an important cost component for most grain and oilseed crops, through both direct (fuel prices) and indirect channels (chemical and fertilizer prices). Thus, when energy prices increase, the costs of these commodities go up concurrently (Baffes 2007). Similarly, for annual crops, prices could be synchronized because of input substitutability. Often weather patterns (for example, the El Niño or La Niña phenomena) increase or reduce production across a number of commodities (World Bank 2015b). Yet another strand of the literature has argued that the comovement in commodity prices is partly a response to the financialization of commodities, especially following the price boom of the late 2000s (Le Pen and Sévi 2018; Ohashia and Okimoto 2016).

Against this background, this box asks the following questions:

- How has commodity price comovement evolved over the past five decades?
- What have been the main drivers of common cycles in commodity prices?
- How have the main drivers of common commodity price fluctuations differed during historical episodes of commodity booms and slumps?

Global commodity prices

Data and methodology. Global commodity prices are defined as the common factor among 39 monthly commodity prices, derived from a dynamic factor model as in Kose, Otrok, and Whiteman (2003).[a] The commodity price data are obtained from the World Bank Commodities Price Data (the *Pink Sheet*), which covers more than 70 commodity prices and indices. All price series are expressed in real terms by deflating the nominal series, in U.S. dollar terms, by the U.S. Consumer Price Index CPI). Series that

Note: This box was prepared by Alain Kabundi, and is based on Kabundi and Zahid (forthcoming).

a. A number of other studies use a similar framework to examine determinants of commonalities in commodity prices; see, for instance, Byrne, Fazio, and Fiess (2013); Lombardi, Osbat, and Schnatz (2010); Poncela, Senra, and Sierra (2014); and Vansteenkiste (2009). However, they focus on a subset of commodities.

BOX 3.1 Drivers of commodity cycles (*continued*)

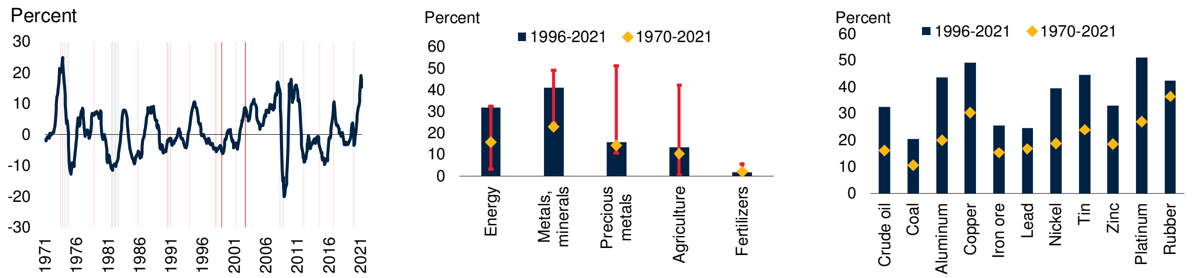
FIGURE B3.1.1 Global commodity prices

Movements in global commodity prices have often been associated with global cyclical developments as well as developments specific to commodity markets. Industrial commodity prices, such as those of energy and metals and minerals, have been largely driven by global commodity price movements. Industrial commodity prices have become more synchronized since the mid-1990s.

A. Global commodity price growth

B. Commodity price variation due to the global factor, 1970-2021 and 1996-2021 (indexes)

C. Commodity price variation due to the global factor, 1970-2021 and 1996-2021 (commodities)



Sources: Baumeister and Hamilton (2019); Ha, Kose, and Ohnsorge (2021); World Bank.

A. Year-on-year increase in global commodity prices (in U.S. dollars), defined as the common factor of 39 commodity prices in a one-factor dynamic factor model as in Kose, Otrok, and Whiteman (2003). Gray bars indicate global recessions as identified in Kose, Sugawara, and Terrones (2020). Red lines indicate events specific to commodity markets, including the first oil price shock of October 1973; the Iranian revolution in January 1979; the beginning of the Gulf War in August 1990; the memorandum of understanding between Australia, Canada, the European Union, Norway, the Russian Federation, and the United States to cut aluminum production; OPEC meetings to ease production quotas (December 1985 and November 2014); and selected OPEC meetings to reestablish production quotas (December 2016, 1998-1999).

B.C. Share of variation in month-on-month growth of 39 commodity prices—3 energy commodities, 7 metal and mineral commodities, 3 precious metals, 5 fertilizers, and 21 agricultural commodities—accounted for by the global factor and derived from a one-factor dynamic factor model as in Kose, Otrok, and Whiteman (2003). Bars show consumption-weighted averages. Whiskers indicate range from minimum to maximum during 1996-2021 (B).

are either averages or close substitutes of other series are excluded to avoid introducing price comovement by construction. This leaves 39 commodity prices. The resulting common factor is a standardized (demeaned with unit standard deviation) representation of global commodity price growth.

Evolution of global commodity prices. Global commodity prices often increased and declined with the global business cycle but also with specific events, in particular those related to commodity markets (figure B3.1.1). For example, prices peaked just before the global recessions of 1975, 1982, 1991, 2009, and 2020, dropped during those recessions, and subsequently rebounded. In addition, global commodity prices underwent large swings around specific commodity market events, such as the oil price jumps of 1973-74, 1978-79, and 1990-91.

Main components of global commodity prices. The global factor has played an important role in driving fluctuations in industrial commodity prices. During 1970-2021, it accounted for 18 percent of the variation in energy prices, on average, and 22-37 percent of the variation in the prices of base metals, rubber (used in tires and tubes), and platinum (used in catalytic converters). It accounted for only 2-14 percent of the variation in agricultural commodity prices (excluding natural rubber), precious metal, and fertilizer prices. The larger contribution of the global factor in explaining the variation in industrial commodity prices reflects the strong response of metal and energy consumption to industrial activity, a relationship that has been established by several studies.[b] Indeed, metal prices, especially copper, are often considered barometers and leading indicators of global economic activity (Bernanke 2016; Hamilton 2015). This is in sharp contrast to agriculture where supply shocks (primarily driven by weather conditions and policies) dwarf demand shocks. These results are consistent with other studies which find that the dynamics in industrial commodity prices are mainly explained by transitory

b. See, for example, Davutyan and Roberts (1994); Labys, Achouch, and Terraza (1999); Marañon and Kumral (2019); Roberts (2009); and Sturmer (2018).

BOX 3.1 Drivers of commodity cycles (*continued*)

shocks, whereas agricultural commodities respond more to long-term shocks (for example, Baffes and Kabundi 2021).

Main components of commodity prices over time. In recent decades, the contribution of the global factor to industrial commodity prices has increased considerably: it doubled for energy prices and nearly doubled for base metal and platinum prices during 1996-2021 compared with 1970-2021. This increased comovement in global commodity prices from the mid-1990s was part of a broader trend toward greater comovement in macroeconomic variables such as inflation and output (Ha, Kose, and Ohnsorge 2019; Eickmeier and Kühnlenz 2018). Trade liberalization and expanding use of financial instruments for commodity market trading have also contributed to the increased synchronization of commodity prices.

Drivers of commodity prices

Data and methodology. A factor-augmented vector autoregression (FAVAR) model is estimated with three global variables—global consumer price inflation, global industrial production growth, and global commodity price growth—all expressed in month-on-month log changes over 1970-2021, in seasonally adjusted terms, with twelve lags (annex 3.3). By construction, the methodology is designed to analyze the links between short-term fluctuations in the global economy and global commodity markets, not long-term trends. Global commodity prices are defined as the common factor among 39 commodity prices. Global industrial production is defined as the global economic activity index of Baumeister and Hamilton (2019).[c] Global consumer price inflation is defined as the median headline CPI inflation in up to 143 economies from Ha, Kose, and Ohnsorge (2021).[d]

Identification of shocks. While the specific nature of shocks changes over time, they can be grouped into three categories: Global demand shocks, global supply shocks, and commodity price shocks. The shocks are identified using a set of sign restrictions on interactions between the three variables in the FAVAR on impact (annex 3.3). The restrictions to identify the structural shocks are consistent with theoretical predictions (Fry and Pagan 2011) and follow other empirical studies in the literature (Charnavoki and Dolado 2014; Peersman 2005; Peersman and Straub 2006).

- A positive global demand shock is assumed to increase global industrial production, inflation, and commodity prices.
- A positive global supply shock is assumed to raise global industrial production and reduce global inflation; in commodity markets, it lifts global consumption of commodities and, hence, raises commodity prices.
- A positive commodity price shock is defined as raising commodity prices and global inflation but depressing global industrial production. Such shocks could reflect a wide range of commodity market developments that are unrelated to global demand or supply, including geopolitical risks, financialization of commodity markets, and expectations of future demand or supply pressures.

Note that these global demand and supply shocks differ materially from the commodity demand and supply shocks modelled in Kilian and Murphy (2014) and others (Baumeister and Hamilton 2019; Jacks and Stuermer 2020). Here, 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. Either of these two global shocks drives up commodity demand, consistent with the definition of a commodity demand shock in Kilian and Murphy (2014). But, in the latter an increase in both economic activity and commodity prices reflects a commodity demand shock, in contrast to a commodity supply shock which is associated with an increase in commodity prices but a decline in economic activity.

Evolution of global demand, supply, and commodity shocks. The model identifies a series of global demand, global supply, and commodity price shocks from 1970

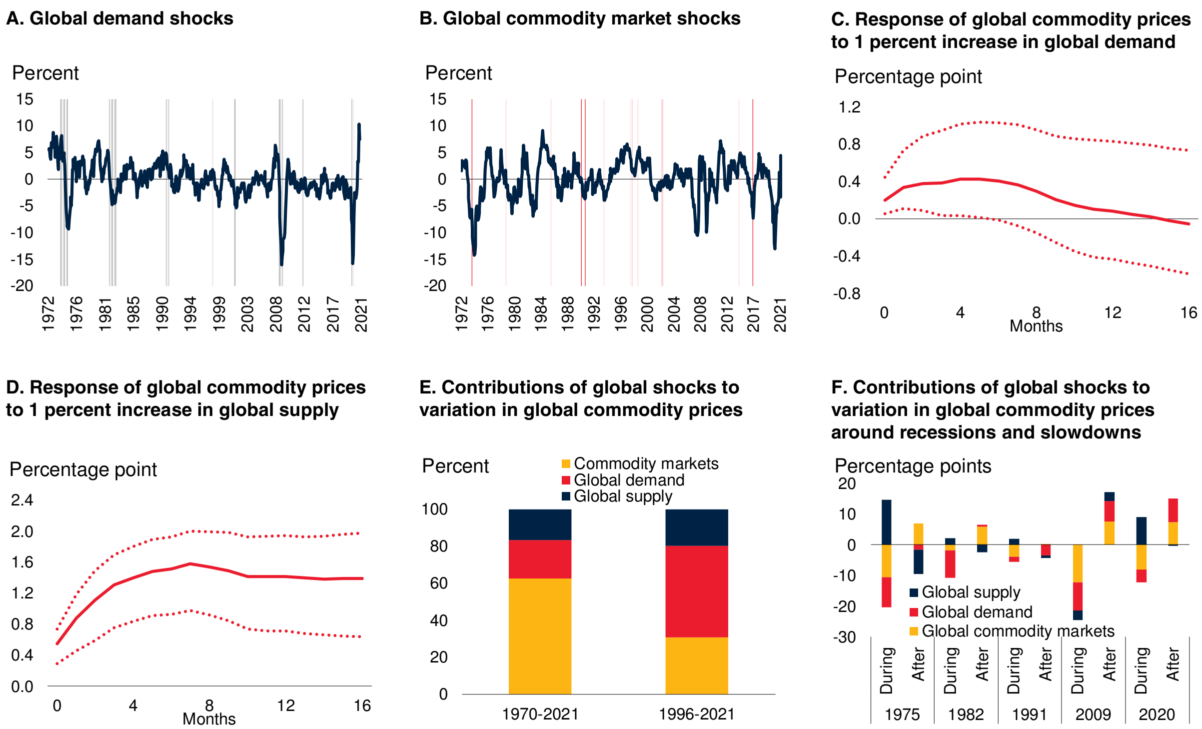
c. While the baseline regression relies on industrial activity as a measure of economic activity, a robustness test is conducted using the global composite purchasing managers' index. The index is available at monthly frequency and includes services activity. The results are qualitatively robust to the use of this indicator.

d. The results remain qualitatively similar when CPI inflation for the Organisation for Economic Co-operation and Development (OECD) countries or the common factor of headline CPI inflation for 143 countries is used as a measure of global inflation.

BOX 3.1 Drivers of commodity cycles (*continued*)

FIGURE B3.1.2 Contributions of global shocks to commodity prices

Global supply shocks have had larger and more persistent effects than global demand shocks on global commodity prices. Since the mid-1990s, global demand and supply shocks have accounted for the lion's share of global commodity price volatility. In the global recession of 2020, both global demand and commodity market shocks depressed commodity prices, while supply shocks supported commodity prices.



Sources: Baumeister and Hamilton (2019); Ha, Kose, and Ohnsorge (2021); World Bank.

Note: Global demand, supply, and commodity shocks identified using sign restrictions in a FAVAR of month-on-month, seasonally adjusted changes in global inflation, global commodity prices, and global industrial production. All in year-on-year growth rates.

A. Gray shades indicate quarters with global recessions (1975, 1982, 1991, 2009, 2020) and global slowdowns (1998, 2001, 2012) as defined in Kose, Sugawara, and Terrones (2020).

B. Red lines indicate events specific to commodity markets, including the first oil price crisis in October 1973; the Iranian revolution in January 1979; the beginning of the Gulf War in August 1990; the memorandum of understanding between Australia, Canada, the European Union, Norway, the Russian Federation, and the United States to cut aluminum production; OPEC meetings to ease production quotas (December 1985 and November 2014); and selected OPEC meetings to reestablish production quotas (December 2016, 1998-1999).

C. D. Solid line indicates cumulative median response of global commodity price growth to a 1 standard deviation (about 1 percent) increase in global demand (C), or global supply (D). Dotted lines indicate 16-84th credible intervals.

E. Contribution of global demand, supply, and commodity market shocks to variance of month-on-month growth in commodity prices, based on sample covering 1970-2021 and sample covering 1996-2021.

F. Cumulative historical decomposition of global commodity price growth into global demand, supply, and commodity market shocks between the last month before global recessions and the last month of global recessions ("During") as well as between the last month of the global recession and 12 months later ("After"). Global recessions are defined as in Kose, Sugawara, and Terrones (2020).

onward. These shocks have often been associated with turning points in the global business cycle and sharp movements in oil prices (figure B3.1.2).

- *Global demand shocks.* Negative global demand shocks were associated with global recessions (1975, 1982, 1991, and 2009) and slowdowns (1998, 2001, and 2012). Large positive global demand shocks often occurred in the year before the global economy began to slide into a global recession or slowdown.

- *Global supply shocks.* The widespread rise in inflation amid slow growth during the 1970s and early 1980s has been partly attributed to negative global supply shocks—such as the 1973-74 and 1978-79 oil price shocks and productivity growth slowdowns that reflected expanding government

BOX 3.1 Drivers of commodity cycles (*continued*)

sectors, macroeconomic volatility, and regulatory uncertainty (Bjork 1999; Charnavoki and Dolado 2014; CBO 1981). The global economic recovery starting in the late 1990s, however, has been attributed to positive global supply shocks associated with rising productivity growth linked to advances in information technology, rapidly rising investment, as well as widespread trade liberalization and global value chain integration in EMDEs, especially China.[e]

- *Commodity price shocks.* Positive commodity price shocks were associated with the oil price crises in 1974 and 1979, the beginning of the Gulf war in 1990, a memorandum of understanding among major producers to cut aluminum production in 1994, and a general strike in República Bolivariana de Venezuela in 2002-03 that disrupted oil production. Organization of the Petroleum Exporting Countries (OPEC) agreements to ease production cuts in December 1985 and November 2014, both in response to the emergence of new producers, were associated with negative commodity price shocks. In addition, new producers entered global markets for several commodities in the 1980s (for example, coal and palm oil), the 1990s (for example, aluminum, coffee, and grains), and in the 2010s (for example, copper, soybeans, and shale oil), reflected declining or negative commodity price shocks.

Drivers of global commodity prices

Responses of global commodity prices to global shocks. Since 1970, on average, a 1 percent increase in global demand has raised global commodity price growth by up to 0.4 percent over the subsequent six months but the impact has dissipated thereafter. In contrast, global supply and commodity market shocks had longer-lasting impacts (figure B3.1.2). The persistence of the response of commodity prices to commodity market shocks can partly be attributed to a low elasticity of supply because of considerable lead times between resource discovery and production (World Bank 2016). A 1 percent increase in global supply raised global commodity price by 1.6 percentage points over the following 7 months and the effect remained statistically significant for a year and a half. Similarly, a 1 percent global commodity market shock that raises commodity prices was followed by more than 1.1 percent higher commodity prices within 12 months of the shock that persisted for at least a year and a half.[f]

Contributions of global shocks to global commodity prices. In the full data period since 1970, shocks specific to commodity markets have been the main source of variability in global commodity prices, accounting for more than 60 percent of the variance of global commodity prices.[g] These shocks have included major disruptions to oil markets, the collapse of the Soviet Union in the case of agricultural and metals markets, and the emergence of new producers of metals and agricultural commodities in the 1970s, 1980s, and 1990s. Since 1996, however, global macroeconomic shocks have been the main source of commodity price volatility: global demand shocks account for 50 percent and global supply shocks for 20 percent of the variance of global commodity prices.[h]

Evolution of the contributions of global shocks to commodity prices. Global recessions have typically been associated with demand weakness and supply disruptions (outside commodity markets) that depressed commodity prices—although sometimes offset by commodity-specific market developments; these unwound in the rebounds of activity that followed global recessions. Outside global recessions, in the 1970s and 1980s, positive global supply shocks have often depressed global commodity prices; this reversed temporarily between 2000 and the global financial crisis when rapid global value chain integration and productivity growth—positive supply shocks—lifted commodity prices. During global recessions, demand

e. The important role played by supply shocks in the late 1990s is consistent with other studies; see Charnavoki and Dolado (2014); Dieppe (2020); Kabundi and Zahid (forthcoming); Kotwal, Ramaswami, and Wadhwa (2011); Topalova and Khandelwal (2011); World Bank (2020c); and Zhu (2012).

f. The magnitude of these estimates appears to be somewhat larger than in Charnavoki and Dolado (2014), possibly because they restrict the elasticities of commodity demand to economic activity.

g. The predominant role of commodity-specific shocks in the variability of commodity prices is in line with Charnavoki and Dolado (2014), Ha et al. (2019), and Jacks and Stuermer (2020).

h. These numbers refer to the variance decompositions for one-year-ahead forecast errors of global commodity price growth. Over a medium- to long-term (5-10 years) forecasting horizon, the variance contribution of the global commodity shocks (57 percent) is greater than that of global demand shocks (28 percent) since global commodity shocks are more persistent than demand shocks.

BOX 3.1 Drivers of commodity cycles (*continued*)

pressures on commodity prices were compounded by supply pressures specific to commodity markets (1975, 1991, 2020); in 1975 and 2020, these were offset by supply pressures resulting from large-scale trade embargoes (1975; Jacks and Stuermer 2020) or wide-spread supply chain disruptions (2020; Mahajan and Tomar 2020). Commodity price increases in recoveries from global recessions were driven by an unwinding of supply or commodity market shocks and, since 2000, also by rebounds in demand. The most recent surge in commodity prices can be explained by the growth of demand, combined with supply bottlenecks.

Conclusion

The results provide evidence of a global cycle in commodity prices whose global determinants have become more important over time: the global commodity factor has accounted for an increasing fraction of commodity price volatility over the past two decades. The role of the global factor in capturing price movements is largest, and has increased the most, for industrial commodities, consistent with the close link between demand for these commodities and global economic activity. In contrast, it explains a smaller fraction of fluctuations in agricultural crops and fertilizers, since demand for these commodities is less closely linked to global economic activity. These results suggest that a synchronized surge in industrial commodity prices will likely have widespread effects on a large set of EMDEs that are heavily dependent on commodities for revenues.

Global macroeconomic shocks have become the main source of fluctuations in commodity prices, accounting for more than two-thirds of the variance of global commodity price growth. Collapses in commodity prices during global recessions have been driven by weaknesses in demand and supply disruptions outside commodity markets. The recent rebound in prices following the COVID-19 recession is attributed to the growth of demand, combined with supply disruptions.

expanding use of financial instruments for commodity market trading.[12]

Drivers of commodity prices

Methodology. To analyze the links between short-term fluctuations in global economic activity and global commodity prices, a factor-augmented vector autoregression (FAVAR) model is estimated with three global variables—global consumer price inflation, global industrial production growth, and global commodity price growth—over 1970-2021 (annex 3.3 and box 3.1). Global demand shocks, global supply shocks, and commodity price shocks are identified using a set of sign restrictions on the interactions between these three variables on impact.

Responses of global commodity prices to global shocks. Since 1970, global supply and commodity market shocks have had longer-lasting impacts on global commodity price growth than global demand shocks. The persistent response of commodity prices to commodity market shocks can partly be attributed to a low elasticity of supply resulting from the considerable lead times between resource discovery and production (World Bank 2016). It can take anywhere from a few years to several decades to develop resources, depending on the type of resource, the size and grade of the deposit, financing conditions, and country-specific factors (UNECA 2011).

Contributions of global shocks to global commodity prices. Since 1996, global macro-economic (demand and supply) shocks have been the main source of commodity price volatility. Global demand shocks have accounted for 50 percent and global supply shocks for 20 percent of the variance of global commodity price growth.[13]

[12] See, for example, Alquist, Bhattarai, and Coibion (2020); Fernández, Schmitt-Grohé, and Uribe (2020); Stuermer (2017 and 2018); and Tang and Xiong (2012).

[13] These numbers refer to the variance decompositions for one-year-ahead forecast errors of global commodity price growth.

This is in contrast to the 1970-96 period when shocks specific to commodity markets—such as the 1970s and 1980s oil price shocks—were the main source of variability in global commodity markets, accounting for more than 60 percent of the variance of global commodity price growth. The responsiveness of commodity prices to demand shocks may have increased over time on account of the rapid global trade and financial integration that occurred during the late 1990s and the 2000s.

Evolution of the contributions of global shocks to commodity price movements. Global recessions were associated with demand weakness and supply disruptions that depressed commodity prices—although sometimes offset by commodity-specific market developments. During global recessions, global demand pressures on commodity prices were compounded by pressures specific to commodity markets (1975, 1991, 2020); in 1975 and 2020, these were partly offset by supply pressures resulting from large-scale trade embargoes (1975; Jacks and Stuermer 2020) or widespread supply chain disruptions (2020; Mahajan and Tomar 2020). Commodity price increases in recoveries from global recessions were driven by an unwinding of supply or commodity market shocks and, since early 2000, also by rebounds in demand. Consistent with this, the surge in commodity prices in 2020-21 can be explained by a strong resurgence of demand, and unusually widespread supply bottlenecks.

Policy options

EMDEs generally need to take policy steps to place them on a firmer footing to manage future commodity price shocks, including those stemming from the energy transition and the effects of climate change on weather patterns. Countries can adjust their fiscal, monetary, and macroprudential policy frameworks to cushion the impacts of commodity price movements. They can also take structural policy measures to reduce reliance on commodities by encouraging diversification of exports and national asset portfolios, and reducing distortions arising from subsidies.

Need for policy action

The preceding analysis finds evidence of substantial comovement between different commodity prices and between commodity prices and global economic activity, and these comovements appear to have intensified over time. With commodity dependence—in relation to fiscal and export revenues, and economic activity-—being a persistent characteristic of many EMDEs, these findings again bring to the fore the complex challenges faced by these countries in maintaining economic resilience in the face of commodity price fluctuations. In LICs, these challenges are compounded by severely constrained fiscal space and weak institutions. The wide commodity price swings of the past two years have further underscored the vulnerabilities of the many EMDEs highly dependent on commodity-based exports.

Countries whose exports are heavily concentrated in one or a few commodities tend to experience high volatility in their terms of trade and output growth (Baxter and Kouparitsas 2005; Blattman, Hwang, and Williamson 2007; Lederman and Xu 2007). Such macroeconomic volatility increases uncertainty about prospects for growth, relative prices, and the real exchange rate, which in turn is detrimental to private investment. Governments have had difficulties in establishing macro-economic policy frameworks that are effective in helping maintain steady growth in the face of commodity price swings (IMF 2015b; UNCTAD 2021). This chapter provides evidence that price booms, on average, have been more pronounced than price slumps for all major commodity groups. One of the policy lessons is that countries can take steps before a crisis caused by a price slump to reduce their exposure and create policy space to prepare for future shocks, including by saving windfall revenues and building fiscal buffers during good times, such as the recent surge in commodity prices.

Further, the rise in inflationary pressures during 2020-21 has pushed up near-term inflation expectations in many EMDEs, prompting several central banks—in both commodity-exporting and -importing countries—to raise policy interest rates. Remaining vigilant about incoming economic data and being prepared to act quickly, as needed, will be paramount if inflation expectations become de-anchored.

Commodity cycles have often created financial market booms and busts in EMDEs. These involve international capital flows and the supply of domestic credit. Commodity booms have frequently encouraged a surge in capital inflows, and a build-up of debt by domestic borrowers that proved excessive when the bust arrived. Strong growth in domestic credit has usually exacerbated the resulting financial stability issue. Such capital inflows have also caused real appreciations of the domestic currency—whether through nominal currency appreciation or domestic inflation—that damaged the competitiveness of the non-commodity sector, and hence held back economic diversification. Surges in capital inflows and greater risk tolerance by lenders, stemming from commodity price booms, can thus lead to financial crises when commodity prices collapse and financial conditions tighten.

The insights from this study, together with the recent impacts on commodity-dependent EMDEs of the commodity price fluctuations and global trade and supply disruptions triggered by the pandemic, present an opportunity to consider policy options for coping with commodity price cycles, including the one currently underway. Recent events have also highlighted how climate change is a growing risk, including to energy markets, affecting both demand and supply (World Bank 2021a). Countries have multiple policy options to smooth the near- and long-term effects of commodity price swings and, more broadly, to reduce their reliance on commodities. These options naturally depend on country-specific circumstances, but they can be grouped into macroeconomic and regulatory policies, and structural policies to encourage diversification of national assets (human and physical capital, and institutions) and exports.

Macroeconomic and regulatory policies

Fiscal, monetary, and regulatory frameworks can be constructed to moderate business cycles associated with commodity price booms and slumps. Fiscal rules, appropriate exchange rate regimes, prudential and regulatory policies, and capital flow management measures are among the policy options.

Fiscal frameworks

Challenge: Procyclical fiscal policy. Swings in commodity-based fiscal revenues in EMDEs tend to result in procyclical fiscal policy: spending typically rises when commodity prices are high and falls when commodity prices decrease.[14] This leads to instability in public investment—one of the few sources of discretionary spending in many countries. This spending procyclicality has been attributed to governments' inability to resist the temptation to increase spending in response to a (possibly temporary) rise in government receipts from taxes or royalties in booms (Frankel 2017). In addition, this procyclicality tends to be asymmetric between booms and slumps: spending typically rises more than proportionately during a resource boom but falls less than proportionately during a slump, reducing net public savings (Gill et al. 2014). For EMDEs, limited financial depth during crises constrains government borrowing and limits the use of fiscal policy as a counter-cyclical policy instrument (Caballero and Krishnamurthy 2004).

Fiscal rules and stabilization funds. A number of commodity-exporting EMDEs have enacted fiscal rules that work in conjunction with stabilization funds. These signal the intent of the government to dampen, if not eliminate, the procyclicality of government spending and safeguard long-term fiscal plans. In practice, the effectiveness of stabilization funds in moderating fluctuations in government spending, and hence output, has varied across countries (Gill et al. 2014). While stabilization funds in many EMDEs have not been deployed successfully, in part on account of poor fiscal governance, the experience has been positive,

[14] This historical procyclicality is well-documented. See, for example, Arezki, Hamilton, and Kazimov (2011); Cuddington (1989); Frankel, Végh, and Vuletin (2013); Gavin and Perotti (1997); Ilzetzki and Végh (2008); Talvi and Végh (2005); and Tornell and Lane (1999).

on the whole, for smoothing the path of government spending (Sugawara 2014).[15] Among oil-exporting countries, stabilization funds have been associated with reduced macroeconomic variability and lower inflation (Shabsigh and Ilahi 2007). A firm long-term political commitment, and an appropriate institutional framework, provide the key to their effectiveness (Asik 2017; Bagattini 2011; Ossowski et al. 2008).[16] The latter includes transparent governance of the stabilization fund itself, and prudent constraints on the discretion of fund managers. Cross-country evidence shows a strong causal link running from better institutions to less procyclical or more counter-cyclical fiscal policy in EMDEs (Frankel, Végh, and Vuletin 2013).

In sum, stabilization funds provide a tool that can be used to help implement a fiscal policy that promotes macroeconomic stability and that is sustainable over time. But their mere existence does not guarantee that governments will use them in this way. Long-term political commitment to a steady and sustainable fiscal policy, a sound debt management framework, debt transparency, and good governance are essential to the effective use of stabilization funds.

In addition to fiscal rules and stabilization funds, the risk to fiscal revenues from commodity price fluctuations can be mitigated through financial hedging instruments. State-contingent debt instruments can, in principle, also be used to help better manage public debt in the face of macroeconomic uncertainty. In practice, however, these novel instruments face obstacles from high premiums demanded by investors in the early stages of market development, costly state verification, and the possibility of moral hazard (Benford, Best, and Joy 2016).

Country examples. The experiences of Chile and Norway underscore the importance of the good governance of institutions and sound macroeconomic management for the functioning of stabilization funds. Both countries have managed relatively successfully their dependence on natural resources by virtue of their institutional capital and good fiscal frameworks, offering useful lessons for other resource-rich countries (Gill et al. 2014). Chile's economic performance in recent decades is an example of sound macroeconomic management, underpinned by a combination of inflation targeting, a fiscal rule, a free-floating exchange rate, an open capital account, and sovereign wealth funds (SWFs). Chile's Fiscal Responsibility Law is supported by the fiscal rule and two formal SWFs (to manage budget surpluses arising from copper price booms). While there is broad consensus that these mechanisms have helped limit the impact of external shocks on fiscal spending and the business cycle, trade-offs have been apparent in the operation of these funds: rules leave substantial space for discretion and their implementation requires judgements (Addison and Roe 2018).

Norway is another example where fiscal rules have helped discipline policies, while providing the necessary flexibility to respond to shocks. An example of financial hedging instruments is provided by Mexico's oil hedging program. Mexico's government has been hedging oil-related risks to public finances for at least two decades through this program.[17]

Monetary policy frameworks

Challenge: Constraints on monetary policy. A challenge facing central banks of commodity-exporting countries relates to the effects of booms in the prices of their export commodities on incomes and, hence, domestic demand. Tightening monetary policy in the face of a commodity price boom can stem the demand for credit and lead to an appreciation of the exchange rate. These responses will, if well calibrated, appropriately dampen the build-up of inflationary pressures. However, in the case of temporary

[15] Political instability has been found to be detrimental to the success of stabilization funds. Changes in government can lead to modifications to the rules and operations of the stabilization fund, or its discontinuation (for example, post-2002 Républica Bolivariana de Venezuela or post-2003 Ecuador).

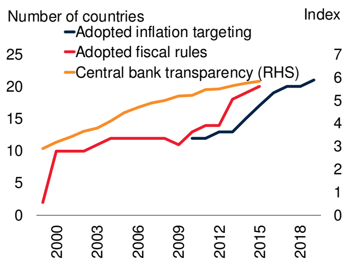
[16] This is in line with the "voracity effect," where countries with the weakest institutions tend to spend more during revenue windfalls (Tornell and Lane 1999).

[17] Ecuador, Ghana, and Uruguay have also relied on hedging instruments to guard against oil price volatility.

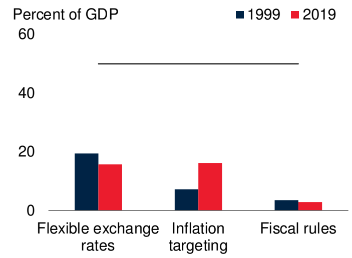
FIGURE 3.10 Structural policies and capital flow volatility in EMDEs

Commodity-exporting EMDEs have undertaken significant reforms of monetary, fiscal, and financial sector policy frameworks over the last two decades, particularly since the 2007-09 global financial crisis. Capital flow volatility tends to be somewhat higher for commodity exporters than importers, highlighting the need to further develop macroprudential tools.

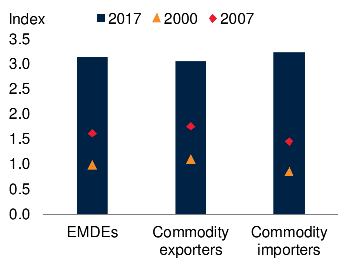
A. Commodity-exporting EMDEs with fiscal rules or inflation targeting



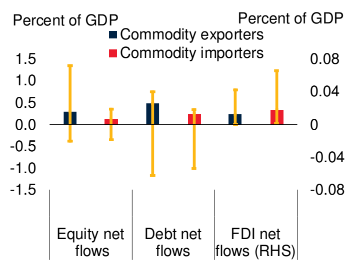
B. Commodity-exporting EMDEs governed by fiscal rules, inflation targeting, or flexible exchange rates



C. Macroprudential policy in EMDEs



D. Volatility of capital inflows to EMDEs, 1970 to 2020



Sources: Ceruti, Claessens, and Laeven (2017); Dincer, Eichengreen, and Geraats (2019); Ha, Kose, and Ohnsorge (2019); International Monetary Fund; World Bank.

Note: EMDEs = emerging market and developing economies.

A. B. An economy is considered to be implementing a fiscal rule if it has one or more fiscal rules on expenditure, revenue, budget balance, or debt. Inflation targeting as classified in the International Monetary Fund's Annual Report of Exchange Arrangements and Exchange Restrictions. Index of central bank transparency is the sum of the scores for answers to the fifteen questions (min = 0, max = 15) as specified in Dincer, Eichengreen, and Geraats (2019).

B. Flexible exchange rate regimes are defined as "floating" or "freely floating" exchange rate regimes. GDP aggregation at 2010 prices and exchange rates. Gray line indicates 50 percent.

C. Sample includes 123 emerging market and developing economies (EMDEs). Unweighted average of the Macroprudential Policy Index of Cerutti, Claessens, and Laeven (2017). The Macroprudential Policy Index measures the number of tools used by authorities and is based on a simple sum of up to 12 including, but not limited to, the countercyclical capital buffer and loan-to-value ratios.

D. Bars indicate the standard deviation of net equity, debt, and foreign direct investment (FDI) inflows as percent of GDP. Net inflows are defined as net acquisition of financial assets minus net incurrence of liabilities. Yellow whiskers indicate the range of minimum and maximum net inflows in percent of GDP.

shocks, there is a risk that a hike in interest rates, with the associated increase in short-term capital inflows and appreciation of the domestic currency, may negatively affect demand and activity in the nonresource sector and add to economic volatility. If the shock is permanent, policy measures to boost investment and productivity in the nonresource sector may be called for (Masson 2014).

Exchange rate flexibility, inflation targeting. Terms-of-trade volatility makes a country less suited to a fixed exchange rate and more suited to a flexible exchange rate regime, since it allows accommodation of such shocks and, hence, a countercyclical monetary policy.[18] For example, during a commodity price collapse, an inflation-targeting central bank under a floating exchange rate regime can continue to focus squarely on keeping domestic inflation on target over the medium term. In contrast, a central bank in a fixed rate regime would be forced to tighten policy in response to a negative terms of trade shock, exacerbating its negative domestic macroeconomic impact. For such reasons, many EMDEs have adopted an inflation-targeting, floating exchange rate regime (figure 3.10). While inflation targets are typically based on the CPI, some studies have argued for other forms of inflation targeting—pegging the export price, pegging an export price index, and product price targeting—where prices of export commodities are given greater weight (Frankel 2011).

In contrast, for very small, very open economies or for LICs with less developed financial and foreign exchange markets, a fixed exchange rate can offer some advantages (Frankel 2017). In particular, if the central bank is not able to commit credibly to an inflation target, an exchange rate pegged to the currency of a country whose central bank has such credibility may provide an alternative, highly visible, nominal anchor for the economy. However, persistently high inflation, which remains a key challenge in many EMDEs, is incompatible with both credible inflation-targeting and a fixed exchange rate. In such cases, the adoption of a coherent, consistent, and clearly communicated set of policies, including sustainable fiscal policies, will be required to establish credibility and reduce inflation inertia (Drechsel, McLeay, and Tenreyro 2019).

Country examples. Several commodity-exporting EMDEs, including Indonesia, Thailand, South Africa, and many Latin American economies, have

[18] See, for example, Berg, Goncalves and Portillo (2016); Broda (2004); Céspedes and Velasco (2012); Edwards and Levy-Yeyati (2005); and Rafiq (2011).

made progress toward enhancing their monetary policy frameworks by adopting inflation targeting. The Central Bank of Chile was an early adopter of inflation targeting in 1990, when inflation stood at about 25 percent. Under the regime, which for several years included capital controls to restrain exchange rate appreciation, inflation fell gradually, reaching 5 percent by 1998 (Drechsel, McLeay, and Tenreyro 2019). Judicious management of the flexible exchange rate enabled Chile to avoid the real exchange rate misalignments that plagued Latin American countries with fixed rate regimes. The policy framework acquired substantial credibility such that from 1999 the government was able to remove capital controls and allow the currency to float freely.

Prudential and financial regulatory policies

Challenge: Procyclical capital flows. Commodity price fluctuations often lead to sharp movements in asset and credit markets, and in international capital flows, that amplify business cycles in commodity-exporting countries (IMF 2012). Capital flows to developing countries tend to be pro- rather than countercyclical (for example, Kaminsky, Reinhart, and Végh 2004). The concentration of wealth in one sector in many commodity exporters can exacerbate systemic risk, highlighting the need for prudential tools to promote financial stability (Arezki et al. 2018).

Micro- and macroprudential policies, capital flow management measures. Since 2008, there has been a significant push toward the enhancement of microprudential policies to strengthen the resilience of individual institutions as well as macroprudential tools to limit systemic risk. Macroprudential policies include capital and liquidity requirements for banks and other financial institutions, countercyclical capital buffers, restrictions on foreign currency borrowing, limits on loan-to-value ratios in housing finance, and limits on the accumulation of short-term debt. These policies might be more important for resource-dependent countries than others, given the higher volatility in resource-related revenues and capital flows (Beck 2018; figure 3.10). At the same time, microprudential regulation and supervision can be strengthened to protect the safety and soundness of individual financial institutions.

Another type of measure to manage volatility in capital flows in certain circumstances is capital controls which, unlike macroprudential measures, are explicitly designed to limit capital flows and the financial risks arising from these flows. However, like other tools aimed at addressing risks associated with capital flows, capital controls have limitations and may have unintended side effects. For instance, macroprudential policy measures aimed at banks may encourage the provision of credit by entities not covered by the regulations and operating under less transparent or effective regulatory frameworks, such as foreign and non-bank institutions.

Country examples. Chile has implemented a number of macroprudential policies that have helped foster financial stability since the 1980s. Chile's General Banking Act and its supervisory approach to banking have strong macroprudential components. Additionally, Chile's monetary policy framework, underpinned by a credible inflation-targeting regime and a flexible exchange rate, helps to prevent the accumulation of financial vulnerabilities. Peru—another commodity exporter—raised reserve requirements on bank's short-term foreign exchange liabilities in 2007. This resulted in a lengthening of the maturity of foreign exchange liabilities, in turn reducing the country's vulnerability to swings in capital flows (Armas, Castillo, and Vega 2014).

With regard to the use of capital controls, Brazil is the most cited example, because of its size among EMDEs, its active experimentation with many different forms of controls on capital inflows, and its integration with global financial markets. Evidence suggests that the controls on capital inflows implemented between late-2009 and 2014 had some success in segmenting the Brazilian financial market from global financial markets (Chamon and Garcia 2016).

Structural policies

In addition to implementing policy frameworks to mitigate the macroeconomic consequences of commodity reliance, commodity exporters can reduce their commodity reliance itself. Policies to encourage export diversification as well as reduce distortions arising from subsidies can help achieve this objective. Beyond diversifying exports and economic structures, which is difficult in practice and many not be feasible in the short-run, governments could also focus more on diversifying their "national asset portfolios"—the mix of natural resources, human and physical capital, and economic institutions (Gill et al. 2014; World Bank 2021b).

For oil and gas exporters, the prospect of a long-term decline in demand for fossil fuels arising from the energy transition presents an opportunity to increase diversification. At the same time, it brings new structural challenges not least in the form of risks to their narrow revenue and employment base in carbon-intensive activities. The need for diversification is particularly pressing for higher-cost producers of fossil fuels as they will be the first to be affected by stagnant or declining demand. For agricultural exporters, the energy transition and expected increase in biofuels may provide an opportunity to increase production of related crops. It may also lead to higher food prices if rising biofuel production increases competition for land and other inputs.

Encouraging export diversification

Challenge: Investment discouraged by export volatility. Commodity price volatility leads to instability in export earnings for countries that are reliant on production of these commodities. This creates macroeconomic risks that discourage investment by risk-averse firms, and thus hinder long-term growth. Export diversification could, thus, help to stabilize export earnings and promote growth in the long run (Bleaney and Greenaway 2001; Ghosh and Ostry 1994; Hesse 2008).

However, resource-rich countries face significant challenges in achieving diversification (see for example, Harding and Venables 2016). For instance, in oil exporters that are members of the Gulf Cooperation Council (GCC), several factors have impeded diversification, including the effect of oil revenues on governance and institutions, and a tendency for oil revenues to lead to overvalued real exchange rates, which damage the competitiveness of domestic non-oil activities (Callen et al. 2014). Oil exporters have faced challenges in successfully diversifying exports without facing either depletion, secular decline in prices or externally imposed sanctions (for example, Ross 2019).

Domestic investment, vertical and horizontal diversification, business climate reforms. A holistic approach toward reducing commodity reliance might involve the gradual scaling up of domestic fixed investments in real assets while diversifying the tradable sectors (Chang and Lebdioui 2020). A prudent approach to resource rent management can ensure the efficient investment of resource rents towards productive capacity-building and long-term economic development. With regard to the tradable sectors, policies can support export diversification and sophistication by encouraging firms to take on several stages of production (vertical diversification). Governments could also encourage firms to diversify their output mix (horizontal diversification) with an emphasis on innovation and technological upgrading (Cherif and Hasanov 2014).

Successful diversification experiences in three often-cited country cases, Malaysia, Mexico, and Indonesia, have also involved reforms to improve the business environment, develop infrastructure, and support workers in acquiring skills and education to boost productivity (Callen et al. 2014). Cross-country studies find evidence that diversification of exports and government revenues away from commodities strengthens long-term growth prospects and resilience to external shocks.[19]

Country examples. Indonesia, Mexico, and Malaysia have been offered as examples of successful diversification away from oil while Chile has had some success in diversification away from copper (Callen et al. 2014; Cherif and Hasanov 2014; and Salinas 2021). While each country followed its own trajectory, a few common lessons can be drawn. First, diversification took a long

[19] For example, Hesse (2008); Papageorgiou and Spatafora (2012); and World Bank (2018a).

time and took off only when oil revenues began to diminish (for example, in Mexico).[20] Second, these countries created incentives for firms to develop export markets and supported workers seeking to acquire skills and education to help find employment in new areas. Such incentives for firms included the development of high-productivity industrial clusters, and horizontal and vertical linkages within these clusters; attracting foreign capital, including by creating free trade zones, to promote technological transfer; using export subsidies, tax incentives, and easier access to finance to facilitate risk-taking by entrepreneurs; and investment in training (Callen et al. 2014).

Encouraging asset diversification: Building human capital

Challenge: Disincentives for investment in human capital. In several oil exporters, nationals are predominantly employed in the public sector, which typically offers relatively high salaries and benefits. The structure of the labor market does not provide much incentive to invest in human capital and work in the private sector (Callen et al. 2014). The resulting lack of skills hinders the private sector's ability to create high paying jobs to attract workers.

Investment in training and education. Diversification can be facilitated by government investment in training to increase the availability of highly skilled workers. Efforts could include investment in higher education, especially in science and technology and vocational education. Human capital accumulation can promote export diversification partly by promoting innovation, including the development of new products (Giri, Quayyum, and Yin 2019). More generally, education is a key driver of long-term economic growth and poverty reduction, not only through the promotion of innovation, but also through the strengthening of institutions, including through the development of well-informed electorates (World Bank 2018b). Research shows that, in EMDEs, social returns to education are potentially higher than returns to physical capital investment (OECD 2012; Psacharopoulos and Patrinos 2004).

Country examples. The successful diversification experiences of oil exporters are few. They point to the importance of changing the incentive structure for workers and firms, as well as social attitudes toward investment in human capital, entrepreneurship, and private sector employment (Cherif and Hasanov 2014). Malaysia and Mexico—two frequently cited examples of successful diversification—invested in training workers, upgrading their skills, and sponsoring certain workers for specialized foreign training. Malaysia used public agencies to incentivize the continual retraining and skills upgrading of employees. In addition, several agencies were tasked with helping firms, particularly small and medium-sized enterprises, through consulting services in technological upgrading and exporting to international markets. Over time, these efforts contributed to building a more highly skilled workforce (Callen et al. 2014).

Encouraging asset diversification: Reducing barriers to competition

Challenge: Dominance of state-owned enterprises, barriers to entry. In many natural resource-rich countries, state-owned enterprises play an important role in exploiting the resources and managing the extractive sector. For example, in several oil-exporting countries, national companies dominate oil and gas exploration and generate significant revenue for the state while leaving governments with the costs and risks of exploration. Although these companies are among the biggest oil companies in the world, and control more than half of global oil and gas production, some of them are significantly less efficient and profitable than their private counterparts (IMF 2020). More broadly, state-owned enterprises accounted for more than half of all infrastructure project commitments in EMDEs in 2017 (World Bank 2017). The dominance of large state-owned enterprises in major sectors in some EMDEs may prevent private firms from competing on a level playing field. The heavy

[20] For example, Malaysia embarked on its export-oriented strategy in the early 1970s and achieved rapid increases in export sophistication in the next two decades. Nevertheless, it took more than 20 years to reach a level of sophistication comparable to advanced economies.

debts incurred by underperforming state-owned enterprises have also led to some serious fiscal risks.

Integrating the private sector. Diversification could benefit from reducing barriers to entry of private sector firms, including through the break-up or exit of some state enterprises. Establishing a level playing field, facilitating entry of more efficient firms, and encouraging orderly exit of less-efficient firms, can contribute to increased productivity and a more diversified export base.

Country examples. In some examples of technological progress in partnership with the private sector, in commodity-dependent EMDEs (such as, Thailand, Indonesia, and Botswana), the government played a critical role by putting in place mechanisms that enabled the private sector to thrive (UNCTAD 2021). Chile offers examples of public-private partnerships, such as the establishment of the Competitiveness and Innovation Fund in 2005, financed through a levy on mining, which focuses on developing sector clusters with private sector participation and partial funding. In Botswana, the close partnership between the government and the private sector in diamond mining is another example of public-private partnerships. In Malaysia, efforts to promote exports and foreign direct investment were facilitated by a transparent legal framework and business-friendly regulations, which discour-aged rent-seeking and provided a relatively level playing field for domestic and foreign enterprises (Gill et al. 2014).

Undertaking subsidy reforms

Challenge: Costly and poorly targeted subsidies. Subsidies—explicit or implicit—can erode fiscal space and detract from potentially more productive spending, including investment in infrastructure, health, and education, as well as poverty alleviation. Energy subsidies and overconsumption may also lead to a deterioration in the balance of payments due to lower exports (for energy-exporting countries) or higher energy imports (for energy-importing countries). Such subsidies can also crowd out public investment and encourage more intensive use of fossil fuels (Arze del Granado, Coady, and Gillingham 2012).

Cut poorly targeted subsidies. Reforms to poorly targeted subsidies in many EMDEs can help make their economies and public finances more resilient to commodity price fluctuations. Following the 2014-16 oil price plunge, many energy-exporting EMDEs undertook energy subsidy reforms to discourage wasteful energy consumption, reallocate spending to programs better targeted to the poor, and restore fiscal space (IMF 2017; World Bank 2020b; World Bank 2020c). Likewise, energy-importing EMDEs took advantage of lower oil prices during this period to begin dismantling energy subsidies, which tend to disproportionately benefit higher-income groups. Other reforms undertaken by some countries included raising taxes on energy or energy-dependent sectors, such as transportation, alongside measures to prevent energy subsidies from re-emerging if oil prices rebounded. Despite such progress on subsidy reforms, there remains significant further room in both energy exporters and importers to address long-standing inefficiencies and reduce fiscal costs in the long run. To protect the more vulnerable groups, subsidy cuts can be accompanied by strengthened social assistance programs.

Country examples. Morocco embarked on a fixed price fuel subsidy program in late 2000 in response to the then-large increases in oil prices. The government absorbed the cost of administering lower retail prices while trying to limit the regressivity of the scheme. As oil prices continued to rise through the 2000s, the fiscal costs of the subsidies also increased. In early 2012, the government took several measures to reform the price structure of fuels together with other steps to increase funding for public transportation and subsidize medical expenses for the poor. Over the next year and a half, subsidies continued to be reduced, with most cuts occurring before the large fall in oil prices starting in mid-2014. Fuel prices were fully liberalized in 2015.

Conclusion

Commodity price cycles. The preceding analysis finds evidence of substantial comovement between commodity prices, and between commodity prices and global economic activity. These comovements appear to have intensified over time. The role of the common global factor in capturing price movements is largest, and has increased the most, for industrial commodities, consistent with the close link between demand for these commodities and global economic activity. Global demand shocks, such as recessions, have accounted for half of the variability of global commodity prices since the mid-1990s. Commodity price shocks, such as those arising from adjustment to long-term trends in supply and demand have accounted for just under a third of the variability in global commodity prices since the mid-1990s.

Since many EMDEs, and especially LICs, remain heavily reliant on commodities, these findings underscore some complex, shared policy challenges faced by these countries. In the years ahead, the transition away from fossil fuels to low-carbon technologies will cause profound, far-reaching shifts in the pattern of demand and supply for commodities, which can have major macroeconomic consequences, including income effects. For example, demand for metals and minerals required as inputs in renewable energy generation will go up, while increased demand for biofuels might put pressure on food prices. If a synchronized surge in industrial commodity prices were to happen, it will likely have widespread effects on many EMDEs that are reliant on commodities for revenues. In LICs, especially, this would test the strength of institutions and policy frameworks, which tend to be weaker than in other EMDEs. In any event, the energy transition will undoubtedly cause further swings in commodity prices, of a magnitude no less than that of the cycles observed in recent decades.

Macroeconomic policy options. To manage the macroeconomic volatility that often accompanies heavy resource reliance, EMDEs are well advised to adopt fiscal, monetary, and regulatory policy frameworks that safeguard macroeconomic and financial stability. These include a forward-looking fiscal policy framework that smooths government spending during the ups and downs of resource-based revenues. For example, oil exporters could use the current opportunity afforded by higher oil revenues to rebuild policy space and direct spending toward addressing

TABLE A3.1.1 Peaks and troughs in price cycles for selected commodities since 1970

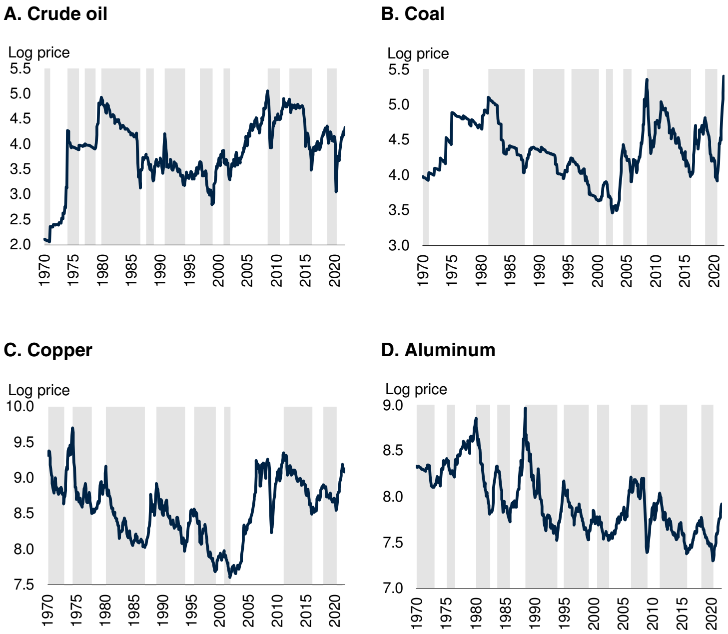
Commodity	Peaks	Troughs
Crude oil	1974M1	1970M12
	1977M1	1975M12
	1979M11	1978M10
	1987M7	1986M7
	1990M10	1988M10
	1996M10	1994M3
	2000M11	1998M12
	2008M7	2001M12
	2012M3	2010M7
	2018M10	2016M1
		2020M4
Coal	1981M4	1970M12
	1988M12	1987M6
	1995M7	1994M4
	2001M7	2000M3
	2004M7	2002M8
	2008M7	2005M11
	2018M7	2016M1
		2020M8
Aluminum	1975M3	1973M1
	1980M2	1976M6
	1983M9	1982M6
	1988M6	1985M11
	1995M1	1993M11
	2000M9	1999M3
Aluminum (cont.)		
	2006M5	2002M8
	2011M4	2009M2
	2018M5	2015M11
		2020M4
Copper	1974M4	1972M10
	1980M2	1977M8
	1988M12	1986M11
	1995M7	1993M11
	2000M9	1999M3
	2011M2	2001M10
	2018M1	2016M1
		2020M4
Coffee (Arabica)		
	1974M2	1971M10
	1977M4	1975M4
	1984M4	1981M6
	1991M3	1989M10
	1994M9	1992M8
	1997M5	1995M12
	2005M3	2002M8
	2011M4	2006M6
	2016M11	2013M11
		2019M5

Source: World Bank.
Note: Data from January 1970 to October 2021. The analysis is based on real commodity prices.

longer-term challenges. With respect to monetary policy, countries practicing credible, flexible, inflation targeting, with a floating exchange rate, have performed relatively well. In addition, a well-designed regulatory framework for the financial sector that fosters financial stability helps moderate the procyclical tendency of capital inflows. Special measures may sometimes be warranted to prevent the excessive build-up of foreign debt.

Structural policy options. To tackle the macroeconomic volatility induced by commodity price cycles at its source, EMDEs can encourage greater diversity of their economic base. Measures include efforts to diversify exports, build human capital, promote competition, and cut distorting subsidies. The appropriate responses are, however, inherently country-specific, and need to be tailored to country characteristics, such as the degree of commodity reliance, fiscal space, the flexibility of markets, and the quality of domestic institutions.

FIGURE A3.1.1 Commodity prices



Source: World Bank.

Note: Log real prices of commodities. Shaded areas denote slump phases (contractions). Turning points are identified using the business cycle algorithm of Harding and Pagan (2002) with a phase of at least 12 months long and a cycle of at least 24 months long. Data from January 1970 to October 2021.

A. The oil price shown is the unweighted average of Brent, Dubai, and WTI oil prices.

ANNEX 3.1 Methodology for dating turning points

Turning points are identified using the algorithm proposed by Harding and Pagan (2002), which is itself based on Bry and Boschan (1971) that was initially set out to identify business cycle consistent with the NBER dating. Peaks (troughs) in series y_t are identified whenever $\{y_t > (<) y_{t+k}\}$ where k = 1, …, K, and K = 12 in line with Cashin, McDermott, and Scott (2002). The minimum cycle is 24 months. From these turning points, a binary variable can be generated such that S_t = 1, when the commodity cycle is in contraction, while S_t = 0 in expansion.

The original Bry-Boschan algorithm is modified to take into account peculiarities of commodity prices, following Harding and Pagan (2002) and Cashin, McDermott, and Scott (2002). Specifically, (1) a phase (from peak to trough or from trough to peak) must be at least 12 months long owing to the dominance of the annual production process in many agricultural commodities; (2) a cycle (peak-to-peak or trough-to-trough) must be at least 24 months, which is the minimum time needed to encompass at least two harvests for annual crops; [21] (3) smoothing is not applied to the original price series; and (4) the algorithm is applied to the actual level of prices (deflated by the CPI), rather than trend-adjusted price series. After dating the turning points, the price series can be separated into boom and slump phases.

ANNEX 3.2 Methodology for estimating concordance

Comovement is measured by the proportion of time that two time series $Y_{i,t}$ and $Y_{j,t}$ spend in the same phase (Harding and Pagan 2002). Let $S_{i,t}$ be a dichotomous variable that takes the value unity when the series $Y_{i,t}$ is in a boom phase and zero when it is in a slump phase. $S_{j,t}$ is defined in the same way for $Y_{j,t}$. The degree of concordance in the cycles of the two series, $Y_{i,t}$ and $Y_{j,t}$, is

$$C_{ij} = \frac{1}{T}\left\{\sum_{t=1}^{T}(S_{i,t}S_{j,t}) + \sum_{t=1}^{T}(1 - S_{i,t})(1 - S_{j,t})\right\}$$

where T is the sample size. Concordance is bounded between 0 and 1, and two independent random walks have a concordance of 0.5.

Harding and Pagan (2006) suggest a simple t-test based on the correlation coefficient ρ between $S_{i,t}$ and $S_{j,t}$. Under the null hypothesis of no concordance, this coefficient is equal to zero. The following regression can be used to estimate ρ and calculate the heteroscedastic and autocorrelation corrected t-statistic:

$$\frac{S_{i,t}}{\hat{\sigma}_{S_i}} = \alpha + \rho\frac{S_{j,t}}{\hat{\sigma}_{S_j}} + \varepsilon_t$$

[21] While different phase and cycle lengths might be more appropriate for certain commodities, the approach adopted here has the advantage of maintaining a consistent set of parameters enabling a systematic examination of commodity prices. Shorter minimum phase lengths were chosen to examine the sensitivity of the identified turning points to the choice of phase length. Although the exercise yielded more turning points, for most commodity price series, at least 70 percent of the identified peaks and troughs overlapped with those identified when the minimum phase of 12 months was used.

TABLE A3.2.1 Concordance matrix of real commodity prices

	Coal	Crude oil	Aluminum	Copper	Maize	Coffee
Coal	1					
Crude oil	0.677***	1				
Aluminum	0.671***	0.634***	1			
Copper	0.713***	0.728***	0.809***	1		
Maize	0.679***	0.635***	0.596*	0.720***	1	
Coffee	0.493	0.546	0.520	0.543	0.506	1

Source: World Bank.
Note: Concordance measures the proportion of time that two price series are in the same phase. It is equal to one if both series are in the same phase at any time. ***, **, and * indicates statistical significance at the 1%, 5%, and 10% level, respectively, based on the hypothesis test proposed by Harding and Pagan (2006). Data from January 1970 to October 2021.

where

$$\rho = \frac{Cov\left(\frac{S_{i,t}}{\sigma_{S_i}}, \frac{S_{j,t}}{\sigma_{S_j}}\right)}{Var\left(\frac{S_{j,t}}{\sigma_{S_j}}\right)} = \frac{Cov(S_{j,t}, S_{i,t})}{\sigma_{S_j}\sigma_{S_i}}$$

$$= \frac{Cov(S_{j,t}, S_{i,t})}{\sqrt{Var(S_{j,t})Var(S_{i,t})}}$$

$\hat{\sigma}_{S_i}$ and $\hat{\sigma}_{S_j}$ are the estimated standard deviation of $S_{i,t}$ and $S_{j,t}$ respectively. The results of the concordance in the cycles of commodity prices are shown in table A3.2.1.

ANNEX 3.3 Methodology: Factor-augmented vector autoregression

Econometric model

Consider a panel of N commodity price series, each of length T. To ensure stationarity, the model is expressed in growth rates. Suppose $y_{i,t}$ represents the growth rate of the price of commodity i at time period t. $y_{i,t}$ is assumed to be decomposed into two components: a common global factor, f_t, that affects all commodity price series, and an idiosyncratic disturbance, $\varepsilon_{i,t}$, that only affects an individual commodity price series i.

The growth rate of commodity price series i at time period t can, thus, be written as

$$y_{i,t} = b_{o,i} + b_{1,i} f_t + \varepsilon_{i,t} \quad \text{(A3.3.1)}$$

where $i = 1, \ldots, N$ and $t = 1, \ldots, T$, and $b_{1,i}$ are factor loadings that reflect the degree to which fluctuations in $y_{i,t}$ can be accounted for by the common global factor. The idiosyncratic disturbance, $\varepsilon_{i,t}$, follows an $AR(q)$ process.

$$\varepsilon_{i,t} = \rho_i(L)\varepsilon_{i,t-1} + \zeta_{i,t} \quad \text{(A3.3.2)}$$

where ρ_i (L) is a lag polynomial operator, $\zeta_{i,t} \sim N(0, \sigma_\zeta^2)$ and $E(\zeta_{i,t}\zeta_{j,t}) = 0$ for all $I \neq j$.

The global factor follows an $AR(p)$ process such that

$$f_t = \phi(L) f_{t-1} + v_t \quad \text{(A3.3.3)}$$

where $\phi(L)$ is a lag polynomial operator, $v_t \sim N(0, \sigma_v^2)$ with σ_v^2 normalized to 1 and $E(\zeta_{i,t} v_t) = 0$, innovations $\zeta_{i,t}$ and v_t are contemporaneously uncorrelated, all comovement is accounted by the common factor. Thus, the growth rate of each commodity price is driven by a global factor that affects all commodity prices and an idiosyncratic disturbance.

To find the contribution of the global commodity factor to the fluctuations in different commodity prices, the variance of each observed variable can be decomposed as follows:

$$var(y_{i,t}) = (b_{1,i})^2 \, var(f_t) \quad \text{(A3.3.4)}$$

The drivers underlying the dynamics of the common factor, f_t, are identified using a factor-augmented vector autoregressive (FAVAR) model. The model comprises, in addition to the common factor estimated by the dynamic factor model described by equations (A3.3.1)-(A3.3.3), a monthly index of world industrial production, q_t, developed by Baumeister and Hamilton (2019), and a measure of global inflation, π_t, proxied by a median inflation rate constructed from the seasonally adjusted consumer price indexes of 143 countries developed by Ha et al. (2019). The data covers the period from January 1970 to September 2021.

We employ the following general form of a structural FAVAR model:

$$B_0 y_t = \sum_{i=1}^{p} B_i y_{t-i} + w_t \qquad \text{(A3.3.5)}$$

where y_t is K × 1 vector that contains the endogenous model variables, w_t is the K × 1 vector of mutually uncorrelated structural shocks, B_0 is the structural impact multiplier matrix that describes the contemporaneous relationships among the model variables, B_i is the matrix of coefficients, and p is the lag length. The reduced form errors can be written as $u_t = B_0^{-1} w_t$, where

$$u_t = y_t - \sum_{i=1}^{p} A_i y_{t-i} \qquad \text{(A3.3.6)}$$

$A_i = B_0^{-1} B_i$ and $E(u_t u_t')=\Sigma_u$ is a K × K reduced form variance-covariance matrix. Thus, given the structural impact multiplier matrix, B_0, the reduced-form innovations can be represented as weighted averages of the mutually uncorrelated structural shocks, w_t. However, since the model parameters are not uniquely identified, further identifying restrictions are required to estimate B_0.

The analysis identifies three shocks: a global demand shock, a global supply shock, and a commodity-specific shock as underlying drivers of the common global factor of commodity prices. The identification scheme is based on sign restrictions applied to the matrix B_0. Specifically, the following sign restrictions are used

$$u_t = \begin{bmatrix} + + - \\ + - + \\ + + + \end{bmatrix} \begin{pmatrix} u_t^{Global\ Demand} \\ u_t^{Global\ Supply} \\ u_t^{Commodity-specific} \end{pmatrix} = B_0^{-1} w_t$$

where signs are imposed on the elements of the inverse of the structural impact multiplier matrix, B_0^{-1}, and all shocks are normalized to increase the commodity price factor.

The impact sign restrictions on B_0 are in line with theoretical predictions and other empirical studies.[22] For example, positive global demand shocks are characterized by positive comovement in the global industrial production index, global inflation, and the common commodity price factor. Examples of positive global demand shocks include an unexpected fiscal stimulus focusing on commodity-intensive investment that increases overall demand for commodities. A positive global supply shock, on the other hand, increases global output, decreases global inflation, and increases commodity prices. Examples of global supply shocks include technological innovation that raises total factor productivity. This would also include productivity-boosting economic reforms such as trade liberalization and privatization measures (Charnavoki and Dolado 2014). An increase in productivity would raise the marginal product of all commodities and increase their overall demand and prices.

A positive commodity-specific shock decreases output, increases global inflation, and increases commodity prices. Commodity-specific shocks are designed to account for innovations to commodity prices that are orthogonal to global demand and global supply shocks, such as unexpected shifts in speculative or precautionary demand for commodities (see Charnavoki and Dolado 2014; and Kilian and Murphy 2014). These can be due to financialization of commodity markets or geopolitical tensions (see Kilian 2009; Tang and Xiong 2012).

A closer look at the above examples of each positive structural shock indicates that all three shocks (i.e., global demand, global supply, and commodity market-specific) increase demand for commodities. This is consistent with the view that a synchronized increase in commodity prices should, typically, be a result of shifts in commodity demand rather than commodity supply (Bilgin and Ellwanger 2017). Commodity supply shifts are generally more idiosyncratic and only affect individual commodities. For example, a labor disruption that curtails steel production may

[22] Charnavoki and Dolado (2014) identify global demand, global supply, and commodity market shocks to examine their effects on macroeconomic aggregates for a small commodity-exporting economy. Ha, Kose, and Ohnsorge (2019) employ a similar identification scheme to investigate the drivers of global inflation.

not impact mine output for aluminum. An exception is disruptions in supply of crude oil. Since crude oil is used for producing other commodities, crude oil supply disruptions can increase the cost of production for other commodities. Thus, a commodity market-specific supply disruption through this channel can result in a joint surge in commodity prices. In our framework, this effect would be captured as a commodity market-specific shock.

Similar models employing sign restrictions have been widely used in related studies. Charnavoki and Dolado (2014) use a similar model but with a smaller group of commodities. Ha et al. (2019) replace commodity prices with oil prices. Gambetti, Pappa, and Canova (2005) and Melolinna (2015) replace commodity prices with domestic interest rates. Baumeister and Peersman (2013) and Kilian and Murphy (2014) replace inflation with oil production and commodity prices with oil prices.

Estimation

The global commodity factor is estimated using equations (A3.3.1)–(A3.3.3) based on a state-space system where equation (A3.3.1) corresponds to an observation equation and equations (A3.3.2) and (A3.3.3) correspond to the transition equation. The estimation of this system follows the Bayesian state-space approach of Kim and Nelson (1998).[23] The estimation objective is to infer from the observed data: (1) the path of common factor, f_t, and (2) all unknown parameters of the model. The Bayesian approach views these as two vectors of random variables. Inference in the Bayesian framework is based on obtaining the joint and marginal distribution of these given the historical data on commodity prices, that is, obtaining the joint and marginal posterior distributions of the common factor and model parameters. However, since the joint posterior distribution of these vectors is not analytically obtainable, Gibbs sampling is used to sample from the posterior.

The observed data series are represented by the vector y_t. The Gibbs sampling proceeds by taking a drawing from the conditional distribution of the model parameters given the data y_t and the factor f_t , and then drawing from the conditional distribution of the factor f_t given data y_t and the prior drawing of the model parameters. The estimation of the model parameters given the factor, f_t, is straightforward. Note that by treating f_t as a set of data, generating the unknown parameters of the observation and state transition equations is a standard application of Bayesian linear regression. However, sampling from the posterior of the autoregressive (AR) coefficients is not simple since the conditional distributions of $\rho(L)$ and $\phi(L)$ are unknown. Therefore, the AR coefficients are sampled using a Metropolis-Hastings algorithm (see Chib and Greenberg 1994; Otrok and Whiteman 1998). The latter step involving the generation of the vector, f_t, is based on the multimove Gibbs-sampling (or the forward-backward) algorithm as described by Carter and Kohn (1994). This procedure allows generating f_t from the joint distribution.[24]

Using the Markov property of the state equation, the joint posterior of f_t can be factorized into $p(f_T\,|\,y_t)$ and $p(f_s\,|\,f_{s+1}, y_t)$ for all s =1 …, T–1. Since these two components are normally distributed given that error terms in the observation and state transition equations are normally distributed, we can draw from distributions by computing their mean and variance. The Kalman filter is used to compute the mean and variance of $p\,(f_T\,|\,y_t)$ and a backward recursion provides the mean and variance of $p(f_s\,|\,f_{s+1}, y_t)$. Thus, the Carter and Kohn (1994) forward-backward algorithm delivers a draw of f_t.[25]

[23] The classical approach to state-space modeling, which is based on maximizing the likelihood function with respect to all the parameters, can be computationally inefficient in large scale models. The Bayesian approach based on Gibbs sampling works with smaller components of the model by drawing from conditional distributions of the parameters (Blake and Mumtaz 2012). Another approach is the nonparametric Principal Component Analysis (PCA), which is computationally faster and commonly used. However, the parametric state-space approach to estimating factor models gives more accurate variance decomposition estimates compared to PCA-based methods. Jackson et al. (2015) provide a comparison of the different estimation methods.

[24] Note that single move Gibbs sampling generates elements of f_t one at a time from the conditional distribution. The multi-move Gibbs sampling procedure is computationally faster and more efficient (Kim and Nelson 1999).

[25] For a detailed exposition, see Blake and Mumtaz (2012), Jackson et al. (2015), and Kim and Nelson (1999).

The estimation procedure can be summarized in the following four steps:

1. Conditional on f_t, sample b and Ω from their posterior distributions (where $E(\zeta_t\zeta_t') = \Omega$).

2. Conditional on f_t, sample $\phi(L)$ from its posterior distribution.

3. Conditional on the parameters of the state space, b, Ω, and $\phi(L)$, sample f_t from its posterior distribution as described above.

4. Repeat steps 1 to 3 until convergence.

The prior distribution for each model parameter is specified by the mean and the standard deviation. However, the priors are weak except that stationarity is imposed on the AR coefficients in equations (A3.3.2) and (A3.3.3). The priors for the AR coefficients in equations (A3.3.2) and (A3.3.3) are $N(0, 10)$ and $N(0, 10)$. The prior is specified over the roots of the polynomial for the variance terms and then translated into priors for the coefficients. The prior on all factor loading coefficients in equation (A3.3.1) is $N(0, 1)$, where the zero restrictions are appropriately applied. For the prior on the innovation variances in equation (A3.3.1), $IG(8, 0.25^2)$ is used, where $IG()$ denotes the inverse-gamma distribution.[26] The AR parameters for equations (A3.3.2) and (A3.3.3) are constrained to be stationary. The model is estimated for each commodity over 10,000 draws after a burn-in of 5000 draws.

To generate the structural impulse response functions from the FAVAR model, the procedure of Rubio-Ramírez, Waggoner, and Zha (2010) is followed. This is done by first drawing a $K \times K$ matrix, X, of independent $N(0, 1)$ values. Then the QR decomposition of X is generated such that $X = QR$ and $QQ' = 1$. The candidate solution, $\tilde{B}$, can be obtained as PQ, where P is the Cholesky decomposition of the reduced form residuals. The candidate solution is used to construct impulse responses that are checked against the maintained sign restrictions. These steps are repeated many times (1.5 million times here) and the results are recorded accordingly.[27]

Data

The commodity price data is obtained from the World Bank Commodities Price Data (*The Pink Sheet*), which contains data on more than 70 commodity prices and indices. Series that either aggregates or close substitutes of other series are excluded to avoid introducing price comovement by construction.

For example, Malaysian logs are included but Malaysian sawn wood is excluded since the latter is produced by cutting the logs longitudinally. Since these two commodities are close substitutes, any changes in the price of sawn wood will closely follow the fluctuations in the price of logs. Similarly, soybeans prices are assumed to also represent soybean oil and meal prices; global sugar prices are assumed to also represent U.S. and European sugar prices. The consumption-weighted average of liquid natural gas prices in the United States, Europe, and Japan represents global LNG prices; the unweighted average of Dubai, West Texas Intermediate, and Brent oil prices represents global oil prices; and the unweighted average of tea at auctions in Colombo, Kolkata, and Mombasa represents global tea prices. Finally, for coffee, rice, rubber, only series with data available from 1970 are used (arabica coffee, Thai 5 percent rice, Singapore/Malaysia rubber).

This leaves 39 commodity prices (all in U.S. dollars): 3 energy (oil, liquid natural gas, coal), 7 metals and minerals (aluminum, copper, iron ore, lead, nickel, tin, zinc), 3 precious metals (gold, silver, platinum), 5 fertilizers (diammonium phosphate, phosphate rock, potassium chloride, triple superphosphate, urea), and 21 agricultural commodities (maize, rice, soybeans, coconut oil, palm oil, bananas, beef, chicken, orange, shrimp, sugar, cocoa, coffee, tea, cotton, logs from Cameroon and Malaysia, rubber, sawn wood, tobacco, wheat). The resulting common factor is a

[26] Note that the priors are loose and experimenting with tighter priors suggests that results are not sensitive to these changes.

[27] Since sign identified structural vector autoregressions are set identified, the median target method is followed for reporting the impulse responses (see Fry and Pagan 2011). The standard deviations of all three shocks are about 1 percent.

standardized (demeaned with unit standard deviation) representation of global commodity price growth.

Robustness tests

The robustness check consists of using the global composite purchasing managers' index (PMI) as a measure of economic activity in place of the Baumeister and Hamilton's global industrial production index. This is done to capture the increasing importance of the service sector in the global economy, accounting for more than two-thirds of global economic activity. The global composite PMI obtained from J.P.Morgan covers the period July 1998 to September 2021, based on data availability. Overall, the results are qualitatively similar. Commodity market shocks remain the underlying driver of dynamics in global commodity prices, followed by supply shocks. The forecast error variance decomposition (FEVD) depicts a slight decline in the contribution of the commodity price shock, from 63 percent to 55 percent. In contrast, the contribution of demand shocks rises by 7 percentage points, to 28 percent of the variation in commodity prices. Finally, the contribution of supply shocks remains unchanged at 17 percent of the variation of commodity prices.

The results remain unchanged when the Baumeister and Hamilton (2019) global industrial production index and median headline CPI inflation are replaced, respectively, by the common factors of industrial production covering 72 countries, and headline CPI inflation for 143 countries. In the FEVD, the contributions of demand and commodity-market shocks to commodity price variations decrease only marginally, from 21 and 63 percent to 19 and 60 percent of commodity price variations, respectively. The contribution of supply shocks increases from 17 to 21 percent of commodity price variations.

ANNEX 3.4 Additional tables

TABLE A3.4.1 Characteristics of commodity price cycles

Commodity	Number of cycles	Average duration (months)		Average amplitude (percent)		Slope	
		Booms	Slumps	Booms	Slumps	Booms	Slumps
Energy							
Crude oil, Brent*	7	29	34	169	-59	5.8	-1.8
Crude oil, Dubai	8	33	32	253	-58	7.8	-1.8
Crude oil, WTI*	6	30	26	154	-57	5.1	-2.2
Crude oil, Average	9	28	31	219	-52	7.8	-1.7
Coal, Australian	6	34	48	136	-51	4.1	-1.1
Coal, South African*	6	23	41	118	-46	5.2	-1.1
Natural gas, Europe	6	32	51	139	-51	4.5	-1.0
Liquefied natural gas, Japan*	5	38	44	87	-46	2.4	-1.1
Natural gas, U.S.	6	41	41	243	-65	6.0	-1.6
Natural gas index	6	47	34	185	-59	4.0	-1.7
Metals and minerals							
Aluminum	8	27	35	89	-46	3.4	-1.3
Iron ore, cfr spot	7	27	41	112	-35	4.1	-0.9
Lead	11	24	24	127	-45	5.5	-1.9
Nickel	6	37	44	248	-65	6.9	-1.5
Tin	8	30	34	104	-46	3.6	-1.4
Zinc	9	26	32	151	-50	5.9	-1.6
Copper	6	33	46	153	-54	4.7	-1.2

TABLE A3.4.1 Characteristics of commodity price cycles *(continued)*

Commodity	Number of cycles	Average duration (months)		Average amplitude (percent)		Slope	
		Booms	Slumps	Booms	Slumps	Booms	Slumps
Precious metals							
Gold	5	53	49	201	-49	3.8	-1.0
Platinum	4	39	72	179	-54	4.7	-0.8
Silver	7	36	39	186	-49	5.2	-1.2
Agriculture							
Banana, Europe*	3	20	53	93	-55	4.5	-1.0
Banana, US	7	32	40	119	-51	4.1	-1.3
Barley*	8	31	36	102	-53	3.3	-1.5
Beef	8	28	36	54	-36	2.0	-1.0
Meat, chicken	9	31	27	27	-25	0.9	-0.9
Cocoa	8	31	35	96	-49	3.1	-1.4
Coconut oil	9	33	24	185	-61	5.7	-2.5
Coffee, Arabica	8	30	33	151	-54	5.1	-1.6
Coffee, Robusta	6	33	49	228	-63	7.1	-1.3
Groundnuts*	9	21	26	95	-49	4.5	-1.9
Groundnut oil*	9	24	33	97	-48	4.0	-1.5
Lamb*	7	29	46	56	-33	1.9	-0.7
Orange	9	21	38	109	-51	5.6	-1.3
Palm oil	8	28	35	130	-55	4.7	-1.6
Fish meal*	7	27	35	79	-40	3.0	-1.1
Rapeseed oil*	3	27	26	62	-32	2.4	-1.2
Rice, Thai 5%	7	31	45	140	-53	4.5	-1.2
Rice, Thai A.1*	6	37	24	115	-45	3.1	-1.9
Maize	7	26	45	90	-48	3.5	-1.1
Sorghum*	5	29	65	110	-54	3.9	-0.8
Soybeans	7	24	49	79	-52	3.4	-1.1
Soybean meal	9	30	35	123	-47	4.1	-1.3
Soybean oil	9	23	34	102	-48	4.6	-1.4
Sugar, EU	7	28	44	65	-36	2.4	-0.8
Sugar, US	5	36	60	147	-50	4.2	-0.8
Sugar, world	6	39	41	219	-68	5.7	-0.6
Tea, avg 3 auctions	8	28	36	71	-42	2.6	-0.9
Tea, Colombo	7	38	36	153	-51	4.1	-1.4
Tea, Kolkata	5	52	41	126	-62	2.5	-1.5
Tea, Mombasa	6	39	48	71	-46	1.8	-0.9
Shrimps, Mexican	8	25	40	52	-35	2.1	-0.9
Wheat, US HRW*	8	28	37	105	-50	3.8	-1.4
Wheat, US SRW*	8	29	31	87	-48	3.1	-1.5
Palm kernel oil*	4	29	23	139	-57	4.9	-2.5

TABLE A3.4.1 Characteristics of commodity price cycles *(continued)*

Commodity	Number of cycles	Average duration (months)		Average amplitude (percent)		Slope	
		Booms	Slumps	Booms	Slumps	Booms	Slumps
Agriculture: Raw materials							
Cotton, A Index	9	24	33	98	-50	3.0	-1.5
Logs, Cameroon	9	25	33	52	-28	2.1	-0.8
Logs, Malaysian	12	21	27	28	-37	3.5	-1.3
Rubber, SGP/MYS	5	37	55	263	-66	7.3	-1.2
Rubber, TSR20*	2	32	37	200	-50	6.3	-1.4
Tobacco, US import u.v.	7	30	43	30	-25	1.0	-0.6
Plywood*	9	23	30	42	-32	1.8	-1.1
Sawnwood, Malaysian	7	45	38	51	-35	1.3	-0.9
Fertilizers							
DAP	10	27	27	131	-45	3.9	-1.7
TSP	7	26	46	167	-46	6.4	-1.0
Urea	8	24	39	316	-60	13.2	-1.5
Potassium chloride	6	27	57	103	-42	3.8	-0.7
Phosphate rock	6	36	42	286	-55	8.0	-1.3

Source: World Bank.
Note: Cycles denotes the number of completed peak-to-peak cycles. Turning points are identified using the business cycle algorithm of Harding and Pagan (2002) with a phase of at least 12 months and a cycle of at least 24 months. Duration measures the average length (in months) of a phase (booms or slumps). Amplitude measures the average price change (in percentage terms) from trough to peak for booms and from peak to trough for slumps. Slope measures the average price increase per month (in percentage terms) during booms and the average price decline during slumps. Data from January 1970 to October 2021. No turning points are identified for four commodities in the sample (sunflower oil; two varieties of rice; and sawnwood – Africa) because of gaps in the data. * denotes missing observations at the beginning and/or at the end of the sample.

TABLE A3.4.2 Global recessions and downturns since 1970

Global episode	Time period	Associated peak in industrial production
Global recession	1974Q1-1975Q1	1973M11
Global recession	1981Q4-1982Q4	1981M9
Global recession	1990Q4-1991Q1	1990M8
Global downturn	1998	1997M12
Global downturn	2001	2000M12
Global recession	2008Q3-2009Q1	2008M1
Global downturn	2012	2012M12

Sources: Kose, Sugawara, and Terrones (2020); World Bank.

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