Special Feature: Commodity Market Developments and Forecasts

Energy prices—especially for coal and natural gas—have seen a broad-based decline since the release of the April 2019 World Economic Outlook *(WEO). After a temporary rebound in April led by positive market momentum and supply cuts, oil prices have retrenched following record-high US production growth and weaker economic growth prospects, especially in emerging markets. In response to declining oil prices, Organization for the Petroleum Exporting Countries (OPEC) and non-OPEC oil exporters (including Russia) agreed to extend their production cuts until March 2020. While supply concerns caused iron ore and nickel prices to rally, most base metal prices declined following continued trade tensions and fears of a global economic slowdown. Agricultural prices decreased slightly as an increase in meat prices caused by disease outbreaks was more than offset by price declines of other foods. This special feature includes an in-depth analysis of precious metals.*

The IMF's primary commodity price index declined by 5.5 percent between February 2019 and August 2019, the reference periods for the April 2019 and current WEO, respectively (Figure 1.SF.1, panel 1). Energy prices drove that decline, falling by 13.1 percent; food prices decreased by 1.2 percent, and base metal prices decreased by 0.9 percent, driven by continued trade tensions and fears of a global economic slowdown only partially offset by the supply-driven price rally in the iron ore and nickel markets. Oil prices rebounded sharply at the beginning of the year, surpassing $71 a barrel in April,[1] driven by positive momentum in financial markets, supply cuts, and declining US crude oil stockpiles. Since then, however, oil prices have retrenched substantially due to record-high production growth in the United States and subdued global economic growth (especially in emerging markets). In response to the price decline, OPEC and non-OPEC oil exporters (including Russia) in July agreed to extend their December 2018 production cuts to the end of the first quarter of 2020. Coal and natural gas prices decreased amid a decline in industrial activity and power generation across regions.

Oil Prices in a Narrow Range amid Energy Prices' Decline and Heightened Uncertainty

Oil prices have been relatively stable, trading within a narrow range this year despite heightened geopolitical uncertainty. In April, they surpassed $71, their highest for 2019, and hit their recent bottom of $55 in August before rebounding back above $60 in September. Initially, prices were pushed higher by the recovery of financial conditions as well as outages in Venezuela and US tensions with Iran. But in late spring a weaker global economy raised concern about the strength of global oil demand, which was amplified by a buildup of US crude oil stockpiles.

Supply outages and geopolitical tensions, however, masked the oil demand weakness and, so, temporarily supported prices. Venezuela suffered production loss after a power outage in March, and Russian oil exports were partially halted in May because of pipeline contamination. Although these outages were temporary, they helped balance the market, resulting in lower US inventories in early spring. In addition, in May, previously issued US waivers to eight major importers of Iranian crude oil were not extended. Moreover, geopolitical tensions in the Middle East rose because of several attacks on Saudi oil infrastructures and oil tankers near the Strait of Hormuz; given that about 20 percent of global crude oil trade passes through the Strait, the fear of a conflict in that area drives up precautionary oil demand and insurance costs. On September 14, an attack on two key oil facilities in Saudi Arabia knocked out 5.7 million barrels per day of production for a few days (that is, about half of Saudi Arabia's total production, or 5 percent of global oil production), raising initially the fear of disruptions in the physical crude oil market and further escalating tensions. Further support for oil prices came from OPEC and non-OPEC oil exporters (including Russia), which, on July 1, 2019, agreed to extend their crude oil production cuts beyond their initial six-month period for an additional nine months until March 2020, by 0.8 million barrels a day (mbd) and 0.4 mbd, respectively.

On the demand side, weaker global economic fundamentals have contributed to lower prices.

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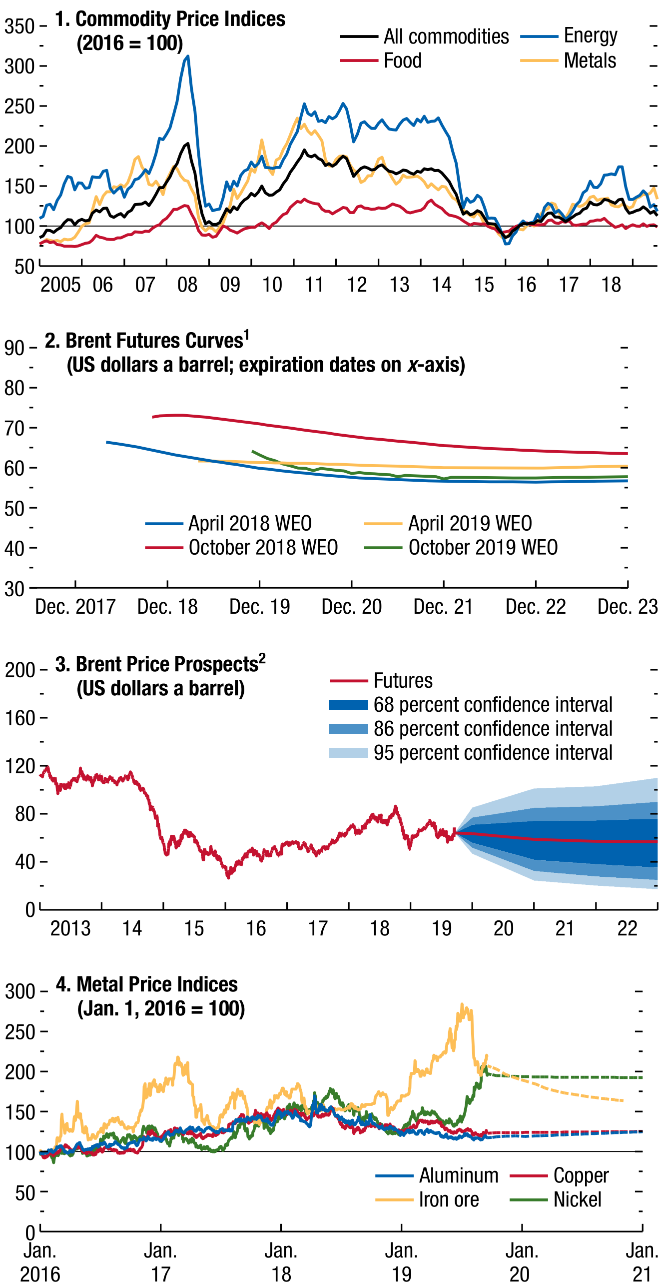
[1]Oil price in this document refers to the IMF average petroleum spot price, which is based on UK Brent, Dubai Fateh, and West Texas Intermediate, equally weighted, unless specified otherwise.

Figure 1.SF.1. Commodity Market Developments



Sources: Bloomberg Finance L.P.; IMF, Primary Commodity Price System; Thomson Reuters Datastream; and IMF staff estimates.
Note: WEO = *World Economic Outlook.*
[1]WEO futures prices are baseline assumptions for each WEO and are derived from futures prices. October 2019 WEO prices are based on September 17, 2019, closing.
[2]Derived from prices of futures options on September 17, 2019.

The IMF's October downward revision of the global growth forecast—by 0.3 percent to 3.0 percent and by 0.2 percent to 3.4 percent for 2019 and 2020, respectively, from its April forecast—illustrates a slowdown in global activity, driven in particular by emerging markets and the euro area. In line with this slowdown, the International Energy Agency revised its oil demand growth forecast as of September for this year down to 1.1 mbd from 1.4 mbd in February.

In the natural gas market, spot prices have been declining in recent months amid increased production and higher stock levels due to lower global power demand. Coal prices have decreased in tandem because of declining power generation. Further downward pressure followed last year's record retirement of US coal-fired power capacity. Its replacement by cheaper gas-fired power plants, as part of a global trend, has lowered the share of coal in US power generation. Despite the ongoing decarbonization of the power sector in the United States and the rest of the world, however, global greenhouse gas emissions increased again in 2018 following strong global growth (see Box 1.SF.1).

As of late September 2019, oil futures contracts indicate that Brent prices will gradually decline to $55 over the next five years (Figure 1.SF.1, panel 2). Baseline assumptions, also based on futures prices, suggest average annual prices of $61.8 a barrel in 2019—a decrease of 9.6 percent from the 2018 average—and $57.9 a barrel in 2020 for the IMF's average petroleum spot prices. Despite the weaker demand outlook, risks are tilted to the upside in the near term but balanced in the medium term (Figure 1.SF.1, panel 3). Upside risks to prices in the short term include ongoing geopolitical events in the Middle East disrupting oil supply and contributing to rising insurance and shipping costs of oil cargoes. Downside risks include higher US production and exports thanks to new Permian pipelines coming online, noncompliance among OPEC and non-OPEC members, and a downturn in petrochemical demand. Further, a rise in trade tensions and other risks to global growth could decelerate global activity and reduce oil demand in the medium term.

Metal Prices Mixed

Base metal prices declined slightly by 0.9 percent between February 2019 and August 2019 as continued trade policy uncertainty and fears of a global economic slowdown—especially in China—were only partially offset by supply-driven price increases in iron ore and nickel. Precious metal prices rose, reflecting in part increased expectations of monetary easing in the United States and a flight to safety amid trade tensions.

Iron ore prices increased 6.7 percent between February 2019 and August 2019. Widespread disruptions—including the Vale dam collapse in Brazil and tropical cyclone Veronica in Australia—coupled with record-high steel output in China pushed iron ore prices to five-year highs during the first half of 2019. However, the normalization of previously disrupted operations and escalating trade tensions between the United States and China triggered a sharp correction in August, partially offsetting the gains since the beginning of the year. The price of nickel, a key input for stainless steel and batteries in electric vehicles, gained 24.1 percent between February 2019 and August 2019 on supply concerns as Indonesia, the world's largest nickel producer, introduced a complete ban on exports of raw nickel ore beginning in January 2020.

Other base metal prices suffered from a weaker global economy, however. Copper prices declined 9.4 percent on global trade uncertainty despite recent production cuts in the Republic of Congo, a labor dispute in Chuquicamata (Chile), and increasing extraction costs in Indonesia's Grasberg mine. The price of aluminum fell by 6.6 percent because of overcapacity in China and weakening demand from the vehicle market there. The price of zinc, which is used mainly to galvanize steel, decreased 16 percent from February to August 2019 as steel demand prospects deteriorated. The price of cobalt continued its downward trend and declined by 6.1 percent, reflecting a supply glut after production was ramped up in the Democratic Republic of the Congo.

The IMF annual base metals price index is projected to increase by 4.3 percent in 2019 (relative to its average in 2018) and decrease by 6.2 percent in 2020. Major downside risks to the outlook include prolonged trade negotiations and a further slowdown of industrial activity globally. Upside risks are supply disruptions and more stringent environmental regulations in major metal producing countries.

Meat Prices Higher Following Animal Disease Outbreaks

The IMF's food and beverage price index has decreased slightly, by 1.3 percent, as price declines of cereals, vegetables, vegetable oils, and sugar overwhelmed a large, 13.2 percent increase in the meat index.

Following the rapid spread of African swine fever across China (the world's largest producer and consumer of pork) and other parts of Southeast Asia, prices of pork jumped by 42.8 percent. News of disease outbreaks and animal culling have raised uncertainty regarding Chinese pork supplies in the near future. The outbreak has also led to tighter supplies and higher prices in Europe and the United States as domestic producers increased exports to China. In the wake of the crisis, prices of some other animal proteins surged too, with beef, for example, rising by 8.3 percent.

Record rainfall in the Midwest of the United States delayed corn and soybean-planting in May and June, introducing a high weather premium into grain markets. This premium then left the markets between late July and end of August, however, as US corn acreage and yields surpassed expectations. Strong global production also weighed on corn prices, which ultimately decreased by 3.6 percent between February and August. Soybeans experienced a net loss of 5.9 percent as trade tensions and the African swine fever outbreak in China continued to depress animal feed demand.

Cocoa prices decreased by 2.7 percent following favorable weather conditions in west Africa during July and August. Palm oil prices declined, by 2.6 percent, given that inventories are expected to increase and global demand in 2019–20 may shrink for the first time in two decades, following environmental concerns in some importing countries and rising competition from other vegetable oils.

Food prices are projected to decrease by 3.4 percent a year in 2019, mainly because of higher prices in the first half of 2018, and then increase by 2.8 percent in 2020. Weather conditions have been unusual in recent months and additional weather disruptions remain an upside risk to the forecast. On August 9, 2019, the US National Oceanic and Atmospheric Administration announced that El Niño climate conditions that started last September are now officially over. A resolution of the trade conflict between the United States—the world's largest food exporter—and China remains the largest source of upside potential for prices.

Precious Metals

What determines fluctuations in the prices of precious metals? What are they used for primarily? Are gold and other precious metals the ultimate haven and hedging instruments against the loss of monetary discipline, or is their role as a store of value overstated? This section tries to answer these questions by offering a brief historical overview, then investigating the basic characteristics of precious metals, including the geographical distribution of their production, and, finally, through an econometric analysis to test some possible answers to these questions.

Coinage, Money, and Precious Metals: A Brief Historical Overview

Since ancient times, luster, ductility, rarity, and remarkable chemical stability have conferred high value on precious metals (that is, gold and silver and, later, platinum and palladium, which share similar physical properties).[2] The first use of gold and silver for ornaments, rituals, and to signal social status dates to prehistoric times and was widespread across cultures and civilizations (Green 2007). The combination of these unique characteristics made precious metals excellent *stores of value* and probably was crucial in fostering the introduction of *coins*—a fundamental innovation in the history of money and a transition in the development of civilization itself (Mundell 2002). Coinage, in turn, inextricably connected precious metals to money and currencies for centuries.[3]

Thanks also to their density, gold and silver coins were strongly favored as medium of exchange relative to other metals (such as copper), especially for (sizable) international transactions. As a result, some gold and silver coins minted by reliable entities gained wide international acceptance (for example, gold florins and ducats in the Middle Ages and silver pesos in modern times)—facilitating and stimulating trade across kingdoms and civilizations (Vilar 1976).[4]

Mixed metallic standards, in which government or central bank notes are convertible into metal coins at a fixed price, were a natural evolution to overcome some of the obvious limitations of pure coin standards (Officer 2008). After centuries of widespread bimetallism, in which the gold–silver ratio is given by the mint price, in the third quarter of the 19th century, following the lead of Britain, monometallic gold standards prevailed across the major economic powers of that time—possibly stimulating global trade.[5] As silver was demonetized across the world, silver prices declined substantially, especially after the 1873 Coinage Act (also known as the "Crime of '73"; Friedman 1990). Hence, after thousands of years of relative stability, the silver–gold price ratio became volatile and shot up from 16:1 in the mid-1800s to almost 100:1 in subsequent decades (Figure 1.SF.2, panel 2).[6]

The stability of gold purchasing power was quite remarkable—with the exception of the world wars and the Great Depression—until the suspension of dollar-gold convertibility in 1971, which two years

[2]Gold and silver belong to the seven metals of antiquity (with copper, tin, lead, iron, and mercury). Today 86 metals are known. The first European reference to platinum appears in 1557 in the writings of the Italian humanist Giulio Cesare della Scala. Only at the end of 18th century, however, did platinum gain appreciation as a precious metal. Palladium was discovered by William Hyde Wollaston in 1802 (curiously named after the asteroid 2 Pallas) and has been used as a precious metal in jewelry since 1939 as an alternative to platinum in alloys called "white gold." (The naturally white color of palladium does not require rhodium plating.) Other precious metals, in addition to those analyzed, include the platinum group metals: ruthenium, rhodium, osmium, and iridium, which are, however, not widely traded.

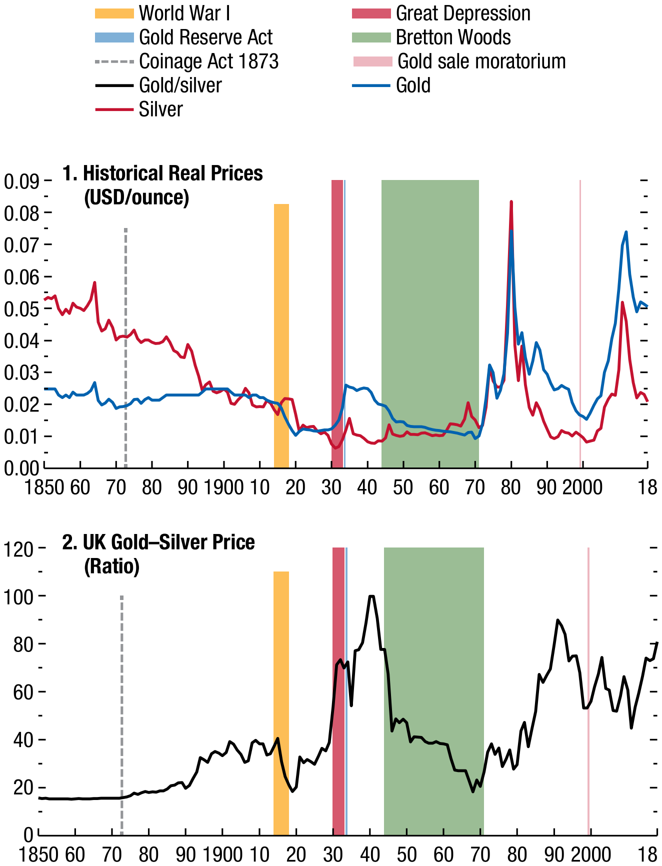
[3]The introduction of coinage is still shrouded in mystery, but it seems likely that the first coin (the *electrum*, a mix of gold and silver) was minted in Lydia around 600 BCE, and it rapidly spread throughout the Mediterranean area. The Lydian electrum coins were overvalued, yielding profit or seigniorage to the issuer. This overvaluation indicates that the issuing state must have been strong enough to enforce a monopoly of coinage, inhibiting entry by means of drastic prohibitions (Mundell 2002).

[4]By 500 BCE, after Darius conquered Lydia, Persia embraced coinage (opting for a bimetallic monetary standard) and struck massive quantities of Persian *sigloi* (a silver coin), which became the international currency of its time, along with two other Anatolian coins (that is, the gold coins of Lampsacus and the electrum coins of Cyzicus) (Mundell 2002). After the Roman *aureum*, in the middle ages, the gold Florentine florins and Venetian ducats became accepted across Europe, while the silver peso (also known as the "piece of eight"), minted in the Spanish Empire, was the international currency of modern times, the antecedent of the US dollar, and was legal tender in the United States until the Coinage Act of 1857 (Vilar 1976).

[5]Some studies have found that the rise of the classical gold standard, between 1870 and 1913, could account for 20 percent of the increase in global trade between 1880 and 1910—strongly supporting the idea that commodity money regime coordination and currency unions were an important catalyst for 19th century globalization (Lopez-Cordova and Meissner 2003).

[6]Silver was demonetized first in the United Kingdom in 1819, later during the 1870s in Germany, France, the Scandinavian Union, the Netherlands, Austria, Russia, and in the Latin Monetary Union (Belgium, Italy, and Switzerland), and in the United States with the 1973 Coinage Act. By the late 1870s, China and India were the only major countries effectively on a silver standard.

Figure 1.SF.2. Gold and Silver Prices



Sources: Measuringworth.com; Minneapolis Federal Reserve; and IMF staff calculations.
Note: USD = US dollars.

later led to the collapse of the system, inaugurating a new era of fluctuating gold prices and indefinitely severing the link between precious metals and currencies (Figure 1.SF.2).

Even today in a world of fiat currencies, the legacy of gold-currency convertibility is visible as official holdings of gold—mostly held by central banks and international institutions such as the IMF and the Bank for International Settlements—still represent a large share of the total stock of the precious metals of official reserves and, sometimes, even of a country's public debt (Table 1.SF.1).

The next section investigates the current role of precious metals in the global economy, looking at their production volumes and values (sizable for various countries) and their usage.

Basic Facts about Precious Metals

The Production of Precious Metals and Its Geographical Distribution

The production of precious metals, especially platinum and palladium, is concentrated in a few places. The global flow of production for gold was about 3,260 metric tons in 2018, equivalent to about $134 billion. The top five producers (China, Australia, Russia, United States, Canada) make up more than 40 percent of production. The value of gold production is bigger than copper and dwarfs other precious metals. Global production of silver, palladium, and platinum was $13 billion, $9 billion, and $4 billion in 2018, respectively. Their production, however, is much more concentrated; for example, the two largest silver producers (Mexico and Peru) represent almost 40 percent of global production. Similarly, Russia and South Africa account for three-quarters of global palladium production, while South Africa alone accounts for more than two-thirds of global platinum production (Table 1.SF.2).

Taken as a group, total production and reserves of precious metals represent a nonnegligible share of GDP (exports) for various countries (Figure 1.SF.3), especially for medium and small low-income countries (for example, Burkina Faso, Ghana, Mali, Suriname). Fluctuations in prices may, thus, induce significant income and wealth effects on a wide variety of countries.

The mining of precious metals is relatively inelastic to prices, as a price boom in the mid-2000s showed (Erb and Harvey 2013). Precious metal production ratios exhibit no clear trend over a long period, and the gold–silver ratio was, surprisingly, barely affected by the American silver production boom of the 16th and 17th centuries (Table 1.SF.3).[7] In addition, silver–gold production and price ratios have shown no obvious relationship in the past decade, suggesting that the relative supply of precious metals has not been a significant source of price fluctuations.

The Use of Precious Metals

Demand for precious metals can be classified as follows: industrial, jewelry, and investment and net official purchases by central banks and

[7]Interestingly, while the production volume of precious metals has increased about 500 times since 1500, global GDP and population have increased 50 and 15 times, respectively (Malanima 2009). Over the same period, the purchasing power of gold and silver has not declined (Erb and Harvey 2013).

Table 1.SF.1. Official Gold Reserves

	Tons						Value ($ billions)	Percent of Reserves	Percent of Public Debt
	1970	1980	1990	2000	2010	2019	2019		
United States	9,839	8,221	8,146	8,137	8,133	8,133	332	75	2
Germany	3,537	2,960	2,960	3,469	3,407	3,368	137	70	6
International Monetary Fund	3,856	3,217	3,217	3,217	2,934	2,814	115	–	#N/A
Italy	2,565	2,074	2,074	2,452	2,452	2,452	100	66	4
France	3,139	2,546	2,546	3,025	2,435	2,436	99	61	4
Russian Federation	–	–	–	343	710	2,183	88	19	39
China	–	398	395	395	1,054	1,900	77	2	1
Switzerland	2,427	2,590	2,590	2,538	1,040	1,040	42	5	15
Japan	473	754	754	754	765	765	31	2	0
India	216	267	333	358	558	613	25	65	5
Netherlands	1,588	1,367	1,367	912	612	612	25	6	1
European Central Bank	–	–	–	747	501	505	21	28	#N/A
Taiwan Province of China	73	98	421	421	424	424	17	4	8
Portugal	802	689	492	607	383	383	16	60	5
Kazakhstan	–	–	–	56	67	367	15	56	40
Uzbekistan	–	–	–	–	–	355	14	53	136
Saudi Arabia	106	142	143	143	323	323	13	3	9
United Kingdom	1,198	586	589	563	310	310	13	8	1
Turkey	113	117	127	–	–	296	12	14	5
Lebanon	255	287	287	287	287	287	12	23	14

Sources: IMF, *International Financial Statistics*; World Gold Council; and IMF staff calculations.
Note: 2019 values are as of March.

Table 1.SF.2. Precious Metals Production, 2016–18

Gold	Value ($ billions)	Cumulative World Share (Percent)	Silver	Value ($ billions)	Cumulative World Share (Percent)
China	13.1	11	Mexico	3.1	21
Australia	9.3	18	Peru	2.3	37
Russia	8.5	26	China	1.7	48
Kazakhstan	8.4	32	Chile	0.7	53
United States	7.4	39	Russia	0.7	58
Ghana	7.4	45	Poland	0.7	63
Peru	6.2	50	Australia	0.7	67
Canada	6.2	55	Bolivia	0.7	72
Brazil	5.6	59	Kazakhstan	0.6	76
Papua New Guinea	4.7	63	Argentina	0.6	80
South Africa	4.5	67	United States	0.5	84
Mexico	4.2	71	Other Countries	2.4	100
Other Countries	35.6	100	World	14.8	
World	121.3				
Palladium	**Value ($ billions)**	**Cumulative World Share (Percent)**	**Platinum**	**Value ($ billions)**	**Cumulative World Share (Percent)**
Russia	2.2	39	South Africa	3.9	70
South Africa	2.1	75	Russia	0.7	82
Canada	0.5	83	Zimbabwe	0.4	89
United States	0.4	90	Canada	0.3	95
Zimbabwe	0.3	95	United States	0.1	97
Other Countries	0.3	100	Other Countries	0.2	100
World	5.8		World	5.6	

Sources: IMF, Primary Commodity Price System; United States Geological Survey; and IMF staff calculations.
Note: Three-year average (2016–18) of both prices and production.

Figure 1.SF.3. Macro Relevance of Precious Metals
(Percent)

Sources: IMF, Primary Commodity Price System; S&P Global Market Intelligence; Thomson Reuters Datastream; UN, COMTRADE; United States Geological Survey; World Bank, World Development Indicators; and IMF staff calculations.
Note: Data labels use International Organization for Standardization (ISO) country codes.

international organizations. More than half of newly mined gold is used in jewelry (Figure 1.SF.4). Silver, instead, has various industrial applications, which account for half of silver consumption, while only 25 percent of silver demand is for jewelry. Investment demand for gold and silver (in the form of coins and bars or holdings in exchange-traded funds) varies significantly as it is more sensitive to prices.[8] Industrial use is more important for platinum and, especially, palladium—which are used in catalytic converters by the car industry.

Official sector gold holdings are large, accounting for about 30 percent of the global stock of gold. Their sale can disrupt the market and therefore has been limited to 400 metric tons a year.[9] The declining role of gold in the balance sheets of central banks in advanced economies, however, has been more than offset by a recent surge in emerging market gold reserves (Table 1.SF.1). The next section will take a financial investment perspective on precious metals by looking at them as an asset class, analyzing their major price determinants, and paying attention to their safe haven and hedging properties during market turmoil and against high inflation.

Price Properties of Precious Metals

Precious metals can be considered an asset class of their own. Their returns show a high correlation among themselves, especially gold, silver, and platinum, consistent with their respective ranking in industrial use (Figure 1.SF.5). At monthly frequencies, gold and silver have the highest correlation, 0.72, while palladium and gold have the lowest, at 0.33. At lower frequencies, palladium prices are more related to industrial metals (such as copper) than to gold, but the highest correlation for palladium is still with its close substitute, platinum. Movements in global industrial production have, however, minor implications for precious metal prices, even for palladium and platinum (Table 1.SF.5).

The relationship between precious metals and inflation throughout history has changed with the monetary system in place. In historical metallic regimes, in

[8]The exchange-traded fund GLD holds 20 percent of total stock scattered in warehouses across the world. Scrap metal is another significant, price-sensitive source of supply, which for gold is almost half of mining production.

[9]The central bank moratorium on gold sales, in September 1999, led the price of gold to rise by 25 percent within a month. There have since been three further agreements, in 2004, 2009, and 2014, limiting the amount of gold that signatories can sell in any one year.

Table 1.SF.3. Relative Rarity
(Production ratios of volume)

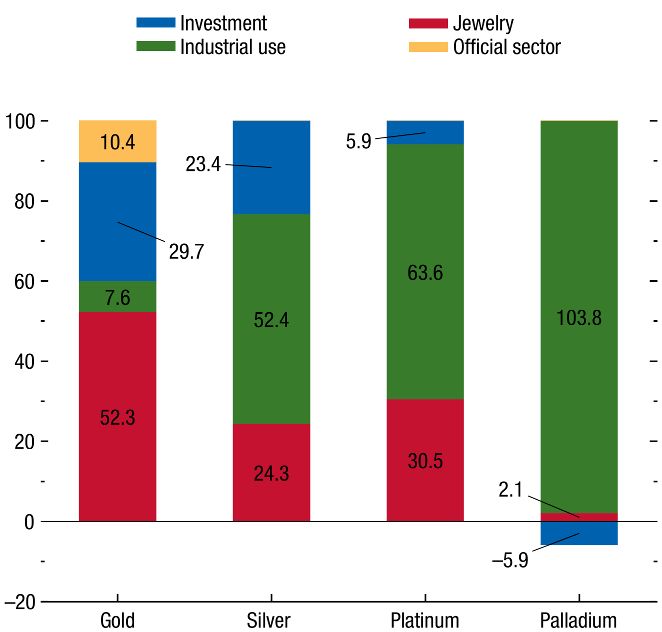
		American Silver Production Boom									
	Early 1500s	1500s	1600s	1700s	1800s	1900–10	1995–99	2000–04	2005–09	2010–14	2015–18
Silver (volume in metric tons)	47	233	373	570	2,223	5,655	16,260	19,280	21,120	24,920	26,775
Silver to Platinum							104	102	100	132	144
Silver to Palladium							119	105	104	126	124
Silver to Gold	8.1	32.7	40.8	30.0	11.9	10.2	7.0	7.6	8.8	9.1	8.5
Silver to Copper							0.0014	0.0014	0.0014	0.0015	0.0013
Gold–Silver Price Ratio	11.0	11.3	13.5	15.0	19.2	35.7	64.8	64.2	57.9	56.9	75.4

Sources: Broadberry and Gupta (2006); United States Geological Survey; Vilar (1976); and IMF staff calculations.
Note: Historical production ratios are century averages.

which a currency was pegged to metals, such as under the Bretton Woods system, an increase in price was associated with a decline in the real price of metals (Figure 1.SF.6). This result is, however, reversed in contemporary fiat currency regimes.

Bekaert and Wang (2010) proposes testing whether an asset is a good inflation hedge by simply regressing its nominal return on inflation, arguing that if the regression slope (inflation beta) is 1 then the asset is a good inflation hedge. Averages of precious metals' inflation betas calculated across a broad set of countries during 1978–2019[10] are below 1 at monthly frequencies but get close to 1 as the horizon increases, especially for gold and silver (Table 1.SF.4). However, the regression fit is usually modest, and betas vary substantially across countries (see Online Annex Table 1.SF.1), suggesting that precious metals, including gold and silver, are not a reliable and robust inflation hedge.[11] This result, however, is not that surprising, given that the volatility of precious metal prices increased substantially after the end of the Bretton Woods agreements, even for gold. It does, however, suggest that gold prices peaked in 1980 and 2012, two periods during which there was fear, justified or not, of a globally widespread wave of high inflation.[12] This observation would call

Figure 1.SF.4. Share of Total Demand
(Percent)



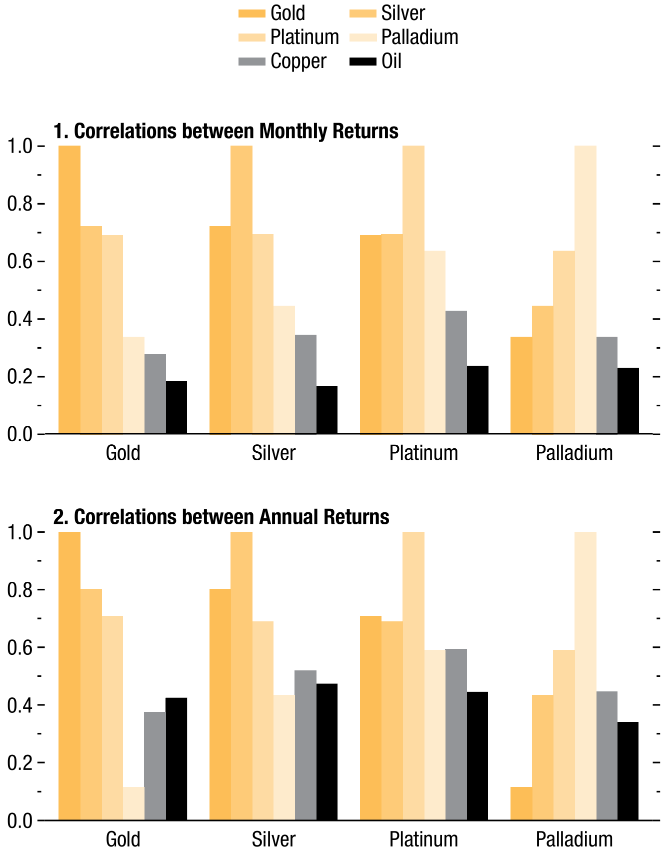
Sources: 2018 World Silver Survey; PGM Market Report; and World Gold Council.
Note: Investment includes coins, bars, and exchange traded funds' inventory changes; for silver, jewelry includes silverware; for platinum and palladium, industrial use includes autocatalysts; 2015–17 averages.

[10]Executive Order 6102, issued in 1933, prohibited hoarding of gold coins, gold bullion, and gold certificates in the continental United States. The limitation on gold private ownership in the United States was repealed in 1974, leading to a resumption of gold bullion trading in spot and futures markets in 1975.

[11]A similar conclusion is obtained when testing for the presence of a unit root in the real price of precious metals over a long time span. Most of the tests are inconclusive, suggesting that metal prices are not an obvious inflation hedge. In fact, even though long-term real returns are close to zero, fluctuations in the real price of precious metals can be very persistent, especially in local currency.

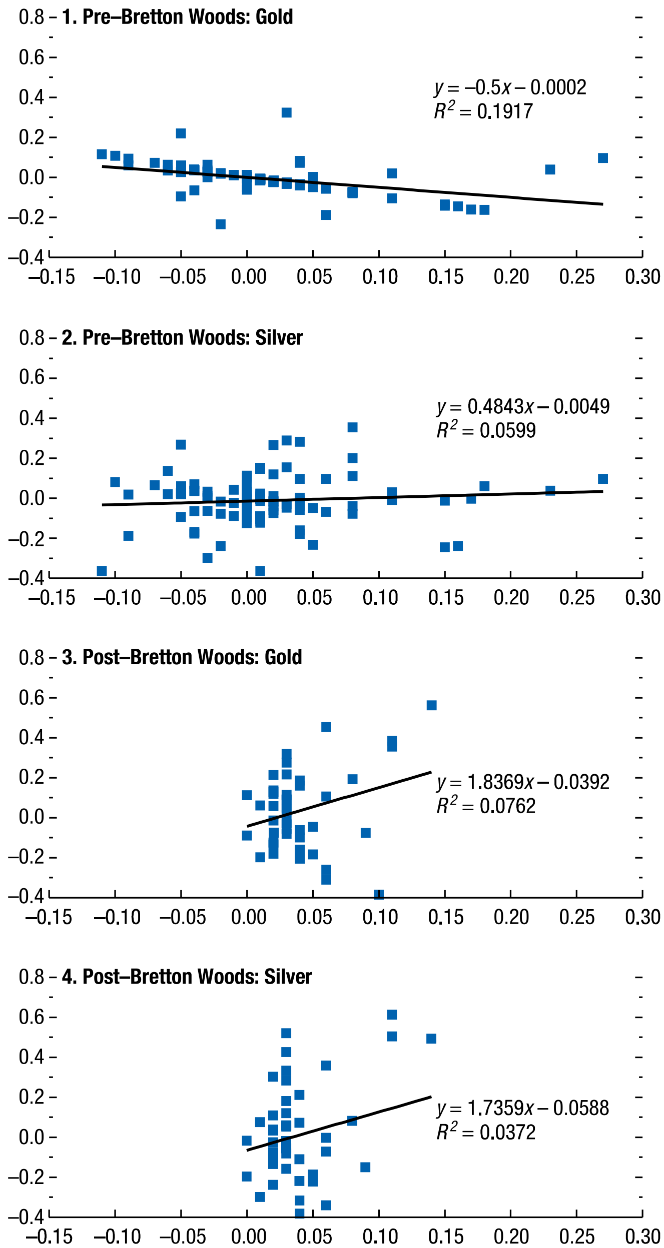
[12]In early 1980 US consumer price inflation peaked at almost 15 percent. By 2012 many central banks around the world had embarked on quantitative easing; the Federal Reserve balance sheet doubled in size while consumer price inflation in the United States had peaked at almost 4 percent in the previous year. Bekaert and Wang (2010) argues that the "recent crisis has made market observers and economists wonder whether inflation will rear its ugly head again in years to come. Central banks across the world have injected substantial amounts of liquidity in the financial system, and public debt has surged everywhere. It is not hard to imagine that inflationary pressures may resurface with a vengeance once the economy rebounds." In both episodes, however, concerns were probably overplayed given that inflation declined in the subsequent years (in most advanced economies).

Figure 1.SF.5. Correlation: Precious Metals, Copper, and Oil



Sources: IMF, Primary Commodity Price System; and IMF staff calculations.
Note: Sample period of gold, silver, copper, and oil is from 1970:M1 to 2019:M5; Platinum starts in 1976; Palladium starts in 1987.

Figure 1.SF.6. Precious Metals versus Consumer Price Index Inflation



Sources: Measuringworth.com; Minneapolis Federal Reserve; and IMF staff calculations.
Note: A regression of annual real gold price change (silver) on US consumer price index inflation shows a negative coefficient before 1973 but positive thereafter.

for testing precious metals' ability to hedge against tail events, such as the collapse of major fiat currency systems—a daunting task, however, given that that has never happened.

A more viable alternative is to regress precious metal prices on a measure of inflation risk (such as past inflation volatility or inflation forecast dispersion) and a set of control variables (Table 1.SF.5). Results of the analysis support the view that precious metal prices react to inflation concerns. The analysis uses monthly data starting in 1978 and controlling for the exchange rate (traditionally, an important determinant), Treasury yields (a proxy for carrying costs), mean reversion, and expected and surprise inflation. An increase in inflation uncertainty by one standard deviation tends, within a month, to raise the price of gold by 0.8 percent and silver by 1.6 percent. A decline in inflation uncertainty can explain half of the observed gold price decline of the 1990s and one-third of the price rise after 2008.

The role of inflation uncertainty is, instead, positive but not significant for platinum and palladium, yet irrelevant for copper. Interestingly, because of dollar invoicing, an appreciation of the US dollar has a similar strong negative effect on all metals tested, including copper. What is more surprising is a coefficient above

Table 1.SF.4. World Average Inflation Betas

Horizon	Gold	Silver	Platinum	Palladium
1 Month	0.42	0.48	0.44	0.40
6 Months	0.77	0.81	0.77	0.66
12 Months	0.90	0.89	0.82	0.61
5 Years	1.05	1.05	0.89	0.72

Sources: IMF, *International Financial Statistics*; IMF, Primary Commodity Price System; Newey and West (1987); and IMF staff calculations.
Note: The betas reported are weighted averages across all countries (weight = the inverse of the Newey–West standard errors). For each country, betas come from regressions between log difference of 1-month, 6-month, 12-month, and 5-year nominal precious metal prices in local currency and inflation corresponding to the same horizon.

unity, suggesting that metal prices are excessively sensitive to the US dollar.[13]

In addition to tail events in the monetary sphere, precious metals have been considered safe assets during sharp movements in economic and policy uncertainty, as proxied by stock price changes. Table 1.SF.6 shows that gold and (to a lesser extent) silver returns do not correlate during days of high stock market swings: the top 30 stock market booms are associated with a stable gold price, on average, while the top 30 stock market declines are associated with an average slight increase in gold prices (there is still-sizable uncertainty around the average reaction). This safe haven property—which stands out for gold and, to a lesser extent, silver but is not present for platinum nor, especially, palladium—is shared by the US dollar and Treasury notes, typical safe haven assets. It is not shared by other base metals. Finally, cryptocurrencies, which have some similarities to gold

[13]Capie, Mills, and Wood (2005) and Sjaastad (2008) examine the hedge property of gold with respect to changes of the US dollar and show that dollar exchange rates and gold prices are inversely related. This result has also been found for oil prices (Kilian and Zhou 2019).

Table 1.SF.5. Determinants of One-Month Return on Precious Metals

	(1) Gold	(2) Silver	(3) Platinum	(4) Palladium	(5) Copper
Industrial Production	0.095	–0.018	0.487	1.049	1.993***
	(0.26)	(–0.03)	(0.94)	(1.43)	(3.79)
Inflation Surprise	2.583*	2.690	3.117*	0.407	1.297
	(2.24)	(1.32)	(2.41)	(0.22)	(1.06)
Lag of Inflation Expectation	0.406	–0.086	–0.128	–2.235**	–0.062
	(0.86)	(–0.10)	(–0.24)	(–3.29)	(–0.15)
Oil Price	–0.001	0.002	0.002	0.00292*	0.00371***
	(–0.74)	(1.14)	(1.59)	(2.01)	(3.98)
US Treasury Bill	–17.210	5.885	0.061	60.04*	–5.640
	(–1.87)	(0.31)	(0.01)	(2.15)	(–0.74)
Lag of US Treasury Bill	12.330	–10.760	–2.681	–53.170	4.101
	(1.34)	(–0.59)	(–0.32)	(–1.86)	(0.52)
Lag of Precious Metal Real Price	–0.0163**	–0.0341***	–0.0286**	–0.012	–0.013
	(–3.31)	(–3.43)	(–3.06)	(–1.24)	(–1.69)
Exchange Rate	–1.219***	–1.437***	–1.456***	–0.561	–1.365***
	(–6.93)	(–4.17)	(–6.19)	(–1.68)	(–4.99)
Inflation Volatility	0.909*	2.373**	0.821	1.327	0.254
	(2.34)	(2.8)	(1.55)	(1.62)	(0.57)
Constant	0.0293**	–0.0792**	0.0654**	0.0456*	0.049
	(2.62)	(–3.28)	(3.22)	(2.02)	(1.85)
Sample Start Date	1980m1	1980m1	1980m1	1987m2	1980m1
Sample End Date	2018m12	2018m12	2018m12	2018m12	2018m12
R^2	0.18	0.15	0.21	0.15	0.26

Sources: Consensus Economics Forecast; IMF, Primary Commodity Price System; Thomson Reuters Datastream; University of Michigan, Survey of Consumers; and IMF staff calculations.
Note: Variables are in logarithmic scale. Industrial Production and Oil Price are in log difference. Lag of Precious Metal Real Price = real price of dependent variable in US dollars. Exchange Rate = exchange rate constructed to be orthogonal to other independent variables using nominal effective exchange rate. Inflation Volatility = rolling standard deviation of inflation over 36-month window. t statistics in parentheses.
*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

Table 1.SF.6. Asset Returns Associated with Largest Single-Day Changes in the S&P 500 Index
(Percent change)

	S&P 500	Gold	Silver	Platinum	Palladium	US dollar	10Y Yield	Metals	Bitcoin
Top 30	5.3 (4.3,5.5)	0.0 (–1.1,1)	–0.2 (–2.5,0.9)	0.1 (–1.2,1.6)	0.7 (–1.2,3.7)	–0.3 (–0.8,0.3)	4.9 (–2.9,11.2)	0.5 (–1.7,2.3)	1.2 (–1.2,1.7)
Top 50	4.7 (3.8,4.9)	–0.4 (–1.3,0.7)	–0.6 (–2.5,0.6)	0.2 (–0.9,1.7)	0.3 (–1.5,2.2)	–0.2 (–0.6,0.5)	5.3 (–2.5,12.8)	0.4 (–1.4,2.1)	0.9 (–0.8,2.5)
Top 100	3.9 (3.1,4.2)	–0.3 (–0.7,0.5)	–0.4 (–1.6,0.7)	0.3 (–0.7,1.5)	0.3 (–0.8,1.4)	–0.1 (–0.6,0.5)	5.6 (–0.9,12.2)	0.6 (–0.4,1.8)	0.0 (–3.9,0.9)
Bottom 30	–6.0 (–6.9,–4.8)	0.6 (–0.8,1.8)	0.2 (–0.4,0.7)	–0.5 (–1.5,0.9)	–0.9 (–2,1.3)	0.3 (–0.2,0.8)	–9.2 (–17.7,–3)	–2.7 (–4,–1.8)	–0.3 (–2.5,4.1)
Bottom 50	–5.2 (–6,–3.9)	0.5 (–0.8,1.8)	0.1 (–0.6,0.6)	–0.4 (–1.6,1.1)	–1.0 (–2.2,0.9)	0.1 (–0.5,0.8)	–9.1 (–14.2,–3.4)	–2.0 (–3.8,–0.4)	–2.6 (–4.3,4.2)
Bottom 100	–4.2 (–4.6,–3.1)	0.3 (–0.6,1.2)	0.0 (–1,1.1)	–0.4 (–1.4,1.1)	–0.9 (–2.1,0.8)	0.1 (–0.5,0.7)	–7.5 (–11.7,–3.6)	–1.5 (–2.7,–0.1)	–1.4 (–4,3.7)

Sources: Thomson Reuters Datastream; and IMF staff calculations.
Note: Numbers represent asset returns (percent change) associated with large changes in the S&P 500. For example, Top 30 and Bottom 30 refer to the average percent change of the 30 largest single-day increases and decreases, respectively, of the S&P 500. Data for all asset returns are sorted based on S&P 500. 10Y Yield is the daily basis point difference on 10-year US bond yields. For all other indicators, data are daily growth rates. For Bitcoin, the time period is August 18, 2011, to August 19, 2019. Metals is the IMF base metals index. For all other indicators, the time interval is January 1, 1998, to August 19, 2019. Bitcoin numbers are adjusted by multiplying by the ratio of the S&P 500 movements over the aforementioned time intervals. Data in the parenthesis are the interquartile range.

and silver, do not appear to be safe havens during stock market routs.[14,15] Moreover, unlike gold and silver, they do not have intrinsic value.

Conclusions

Precious metals are macrorelevant (more so for some low-income countries) and have relevant industrial use, especially platinum and palladium—even though their price is only mildly affected by global activity. Gold and silver can function as inflation hedges, but this property should not be overstated, especially when changes in inflation are modest. Instead, given their historical role in monetary systems and purchasing power stability, gold and silver seem to have been buoyed at times by the (possibly irrational) fear of a collapse of major fiat currency systems. The safe haven properties of precious metals have probably been more apparent during some (but not all) major economic and policy shocks, proxied by stock market swings, that triggered or reversed investor flight to safety—with gold standing out as a safe asset, much like US Treasury notes. Crypto assets do not seem to share this property, so far.

[14]Cryptocurrency prices, proxied by Bitcoin, are calculated for 2011–19.

[15]As is true of gold and silver, the supply of some cryptocurrencies is limited. Cryptocurrencies also appeal to users and investors because of their decentralized nature and anonymity.

Box 1.SF.1. What's Happening with Global Carbon Emissions?

To slow the pace of climate change, carbon emissions need to be reduced. But how have emissions changed over the past decade? And which countries are driving those changes? Although global carbon emissions were flat between 2014 and 2016, they alarmingly rebounded in 2017 and 2018 (Figure 1.SF.1.1).

China has been a key driver of emission growth since the turn of the century, but its impact has diminished in recent years as economic reforms have picked up pace. India and other emerging markets, instead, are partially filling the gap. In 2018 emissions decreased in all Group of Seven economies besides the United States, whose emissions increased because of a resurgence of industrial production and bad weather (see BP 2019).

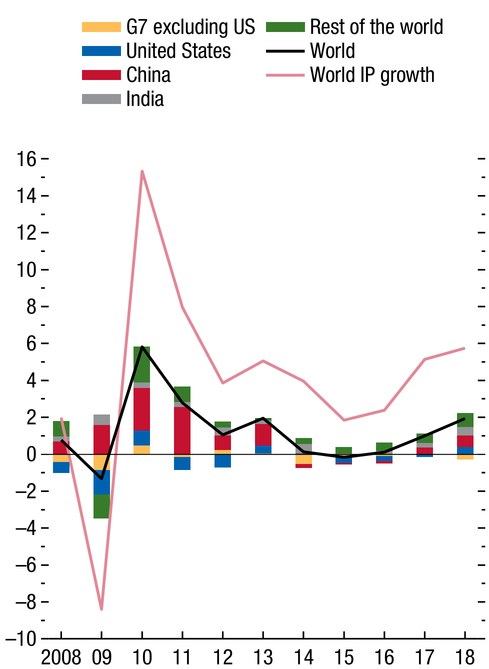
The authors of this box are Christian Bogmans, Akito Matsumoto, and Andrea Pescatori.

It is possible to decompose total emissions E as a product of carbon intensity c (carbon emissions per unit of energy), energy intensity e (energy per unit of GDP), GDP per capita y, and human population P (Kaya and Yokobori 1997):

$$E = \frac{E}{Energy} * \frac{Energy}{GDP} * \frac{GDP}{P} P = c * e * y * P.$$

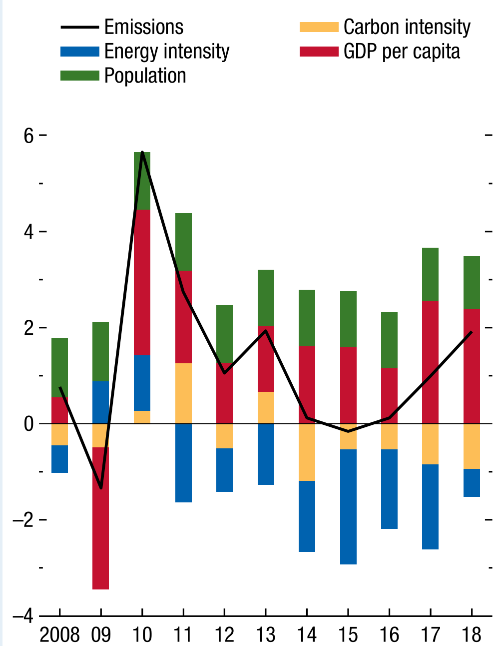
The contribution of income growth to the growth of carbon emissions is larger, on average, and more cyclical than that of population growth (Figure 1.SF.1.2). Declining energy intensity has consistently helped reduce emission growth, but in 2018 its contribution was lower, possibly because of a cyclical pickup in global industrial production. In 2018 decarbonization was the most important mitigation force as wind, solar, and natural gas slowly replaced coal as the energy source of choice in the power sectors of all major emitters.

Figure 1.SF.1.1. Contribution to World Emissions, by Location
(Percent change)



Sources: British Petroleum; International Energy Agency; and IMF staff calculations.
Note: G7 = Group of Seven; IP = industrial production.

Figure 1.SF.1.2. Contribution to World Emissions, by Source
(Percent change)



Sources: British Petroleum; International Energy Agency; World Bank, World Development Indicators; and IMF staff calculations.