CHAPTER 1

The Evolution of Commodity Markets Over the Past Century

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Commodity markets have evolved dramatically over the past century. Consumption has soared, particularly for energy and metals, with a shift toward emerging market and developing economies. Significant technological developments, combined with the opening of new sources of raw materials, have led to a large expansion of supply. This chapter discusses the evolution of three commodity sectors: energy, metals, and agriculture. The composition of demand has evolved under the impetus of technical innovation, relative prices, and government policies. While commodity prices often move together in the short run, in real, inflation-adjusted terms, energy prices have trended upward and agriculture prices downward in the long run. A variety of policies have been used to stabilize commodity markets at the national level, and agreements have been signed with the same objective at the international level. These agreements have tended to break down, however, under the pressure of competition from new sources. In the years ahead, climate change poses a risk to agricultural output and rural communities. The ongoing energy transition from fossil fuels to zero-carbon energy sources has major implications for the composition of commodity demand, and new technological innovations will likely be required.

Introduction

Commodity markets have undergone seismic changes over the past century. Dramatic increases in productivity have resulted in a declining trend in prices relative to manufactured goods and services. Technical innovations have affected patterns of consumption and production. Innovations in transportation have reduced costs and widened the opportunities for international trade in commodities. The growing role of emerging market and developing economies (EMDEs) in the global economy has dramatically shifted the composition of demand for commodities, especially for energy and metals.

The post-World War II (WWII) economic expansion, and more recently the emergence of EMDEs as important players in the global economy, has increased commodity demand, especially for energy commodities and metals and minerals. Even though the world's population rose from 2 billion in 1920 to 8 billion in 2020, the production of commodities to feed, clothe, and support the rising population has more than kept pace. Expanding production was possible because of technological innovations, the discovery of new reserves of commodities, and more intensive agricultural production.

On the energy front, crude oil became the most important commodity, replacing coal. Known reserves of crude oil and natural gas have increased substantially even as production has risen. For example, the development of shale technology during the early

21st century enabled producers to exploit deposits that had previously been considered unprofitable, resulting in the United States once again becoming the largest producer of crude oil. Mineral resource development expanded due to advances in technology and new discoveries.

Metal production has become more efficient as innovations and productivity improvements became widespread in mining, smelting, and refining. Improved fabrication and new alloys have allowed less metal to be used without loss of strength. Despite radical changes in supply and consumption, metals prices, in real terms, have seen cycles around a quite flat trend over the past century. The major price fluctuations of metals have been mainly driven by global demand shocks (perhaps more so than other commodities), such as wars, the Great Depression of the 1930s, and the rapid industrialization of China in the 2000s.

Food production has increased faster than population, and most of the world's consumers have access to adequate food supplies today than they did one century ago. This is due to technological advances in the 20th century, especially the Green Revolution.[1] In large part because of increasing productivity, prices of agricultural commodities have experienced a downward trend over the past 100 years. During the Great Depression, however, weak demand and falling prices caused widespread hardship in rural communities. This led to numerous efforts by governments to protect domestic farmers and stabilize prices at a level that would allow agricultural workers to earn incomes in line with those of urban workers. More generally, large fluctuations in prices for a range of commodities have resulted in periodic efforts to reduce their volatility. At the international level, governments have negotiated agreements to stabilize prices for various products, but these have caused distortions in world markets and have usually broken down.

The objective of this chapter is to review historical developments for three commodity groups: energy, metals (including precious metals), and agriculture. Demand trends, technological progress, price fluctuations, and policy interventions are discussed.

Several themes emerge:

- *Changes in demand:* Commodity demand has increased substantially over the past century. The largest increases have been for energy and metals—as population and per capita income has grown, and technical change has leaned toward the use of metal inputs. The location of demand growth has changed, with a shift from Advanced Economies (AEs) toward EMDEs. There has been significant cross-commodity evolution. For example: in ocean shipping, oil replaced coal; and more

[1] The Green Revolution was initiated by Norman Ernest Borlaug, an American agronomist and recipient of the 1970 Nobel Peace Prize. He developed and promoted the use of new wheat varieties with short sturdy stems, high tilling ability, drought resistance, and responsiveness to fertilizers. The early maturity of these varieties allowed two (and sometimes three) crops to be grown each year.

recently, biofuels (an agricultural product) have been used as a substitute for fossil fuel-derived gasoline.

- *Technology:* Technological advances have encouraged consumption of some commodities via the creation of new products and new uses of commodities. They have also reduced the use of some raw materials by improving efficiency in consumption and production. In addition, technological advances have facilitated the discovery and development of new reserves and new commodities. Spectacular advances in agriculture production took place after the development of hybrid varieties in the 1930s and the Green Revolution of the 1960s-70s. The development of communications and information technology has had major impacts on the structure of commodity markets. A notable feature of the increased technical sophistication has been the expansion of futures and options markets and related hedging techniques.

- *Induced innovation:* Innovation in commodity markets has often occurred in response to periods of high prices. For crude oil, episodes of production restraint by the Organization of Petroleum Exporting Countries (OPEC) have stimulated the development of new sources of oil. The oil price shocks of the 1970s encouraged the development of off-shore oil in the North Sea and the Gulf of Mexico. High oil prices in the 2000s likewise spurred the development of shale oil production technology.

- *Policies:* Both domestic and international policies have been used to mitigate commodity price volatility. Intervention has taken varied forms at national levels, including subsidies, production quotas, trade controls as well as commodity agreements at an international level. Interventions have been most prominent in agriculture. Efforts to support prices, however, while they may have worked in the short term, often have unintended consequences: higher prices dampen demand and attract new suppliers. Downward pressure on prices often follows.

This chapter proceeds as follows. Section 2 covers energy markets, notably crude oil, coal, natural gas, nuclear, and renewable energy. Section 3 examines the markets of iron ore, aluminum, copper, other base metals, and precious metals. Section 4 assesses the evolution of agriculture through the lenses of technology and demand, with a further section covering agricultural policies. Section 6 concludes.

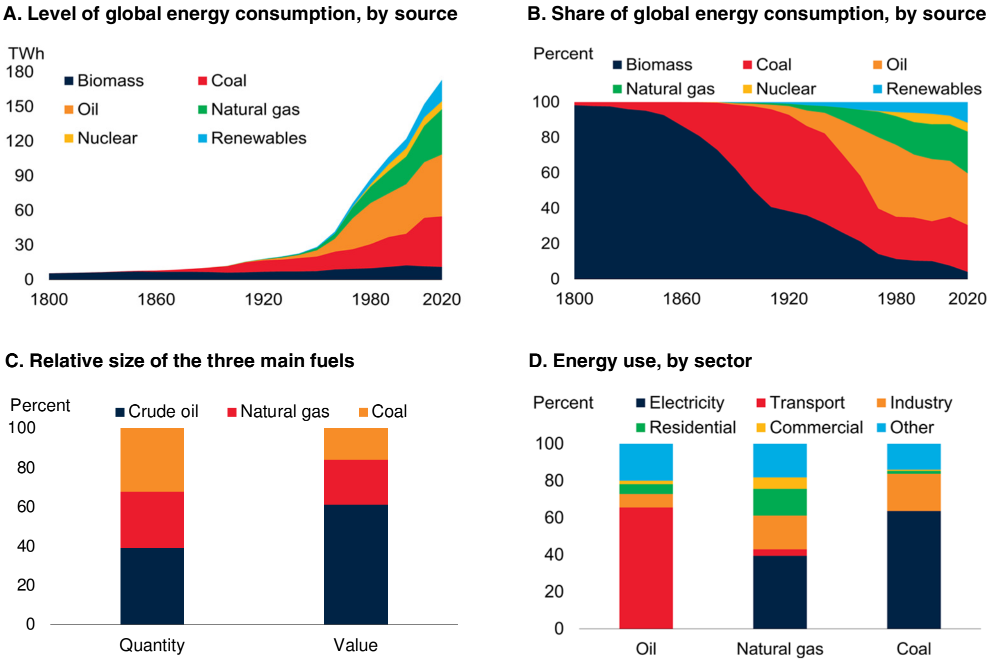
Energy

Overview

Although the demand for energy has long tracked economic growth, its consumption accelerated after WWII (figure 1.1). At the start of the 20th century, coal was the dominant fuel, but by 1920 oil was already making inroads—for road and sea transport, and for heating. Global crude oil production increased from just over 1 million barrels per day (mb/d) in 1920 to nearly 100 mb/d in 2019. Crude oil's share of global energy

FIGURE 1.1 Energy markets

The structure of energy markets has changed significantly over the past two centuries, with gradual transitions as new fuels have emerged. Crude oil is the largest of the energy commodities in terms of value. It is mainly used for transport. Natural gas and coal are used for electricity generation, heating, and industrial uses such as fertilizers (gas) and metal smelting (coal).



Sources: BP Statistical Review; International Energy Agency; OurWorldinData; UN Comtrade; World Bank.

A. TWh stands for terra-watt hour.

A.B. Renewables includes hydro-electric, solar, wind, geothermal, wave, and tidal.

C. Quantity refers to total consumption of the three fuels measured in exajoules. Value of consumption estimated as the sum of total consumption (quantity) and prices of crude oil, natural gas, and coal, using average nominal prices from the World Bank's *Pink Sheet* database. Data for 2019.

D. Use of oil shows total final consumption of oil products, derived from crude oil. Natural gas and coal show total consumption, including use in electricity production. Electricity also includes use in heating. Data are for 2019.

rose from less than 5 percent in 1920 to a peak of 43 percent in 1973, when price shocks dented demand. Consumption of natural gas began to rise alongside crude oil in the 1900s, but initially at a much slower pace. However, the increasing use of natural gas in electricity generation, as well as heating and cooking, resulted in natural gas rising from 1 percent of global energy consumption in 1920 to 22 percent in 2019.

Among the non-fossil fuel sources of energy, nuclear power emerged as an important source of electricity in the 1970s, peaking in 2000 at around 6 percent of total energy consumption. The share of renewable energy gradually increased over the 20th century before accelerating in the 2010s, reaching 10 percent of energy consumption in 2019.

Because of the ever-expanding demand for energy, new sources of energy have not replaced existing sources. Consumption of coal, for example, has risen in every decade, even though its share of total energy demand has fallen since 1920.

Today, the three main fossil fuels—oil, coal, and natural gas—account for 83 percent of total energy consumption, down from 94 percent in 1970. Crude oil accounts for around two-thirds of the global value of fossil fuel consumption and 40 percent of global energy consumption. The larger share of crude oil reflects its wide range of uses, limited substitutes for air and sea transport, readily available reserves, low cost of production, and ease of transport. For an equivalent energy output, coal is the cheapest of the three fuels, in part due to lower costs and plentiful reserves—estimated at about 140 years of current production compared to less than 60 years for crude oil and 50 years for natural gas.

Of the main uses of the three primary fuels, around two-thirds of crude oil is used for transport, with the remainder primarily used for petrochemicals. There are currently few substitutes for crude oil in transport. In contrast, the primary use of natural gas and coal is in electricity generation, accounting for about 40 percent and 60 percent of their consumption, respectively. Numerous substitute fuels can be used to generate electricity, although adoption can take time. Some plants are equipped to switch quickly between oil and gas, depending on relative costs. In the United States, for example, about 13 percent of electric generating capacity is switchable (EIA 2020). Substitution between coal and natural gas is more complicated, as it requires refitting or construction of new plants. Retrofitting, however, has become increasingly common, especially in the United States. Nuclear and renewable energy are also substitutes for electricity generation.

Crude oil

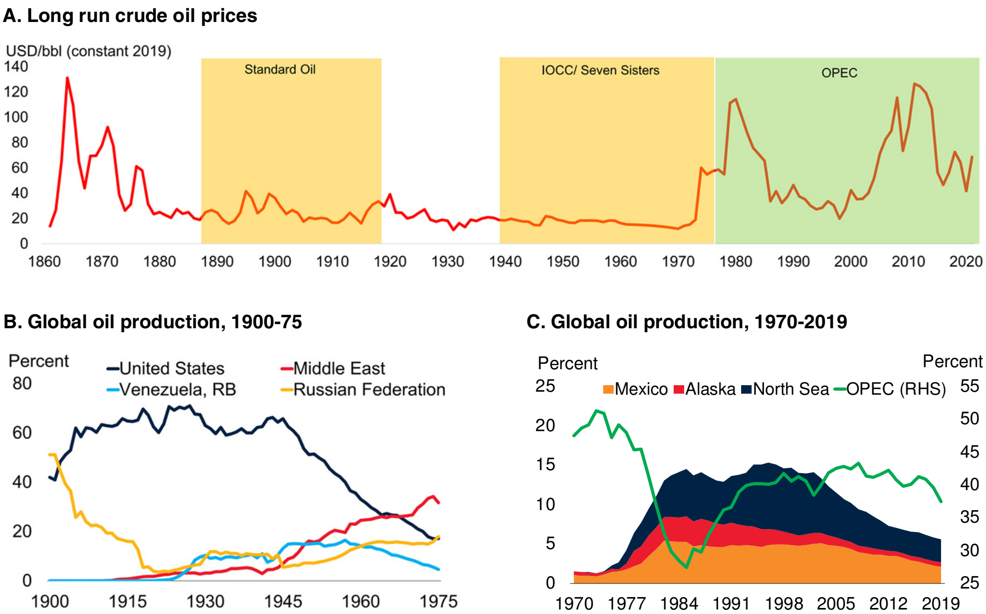
The global oil market has experienced many price booms and busts. It has also been subject to supply management and price-fixing, most notably Standard Oil from 1879 to 1910, the Interstate Oil Compact Commission (IOCC) and Seven Sisters between 1935 and the 1970s, OPEC since 1960, and OPEC+ since 2017 (figure 1.2; McNally 2017).

In the years following the breakup of the Standard Oil monopoly in 1910, the U.S. oil market experienced episodes of price booms and busts. After unsuccessful attempts to coordinate voluntary output reductions in the face of an oil glut, a group of U.S. states accounting for 80 percent of U.S. production combined to form the IOCC in 1935. The IOCC set enforceable quotas and could order reductions in production to keep prices stable. As Texas was the largest producer, and effectively acted as a swing producer, the Texas Railroad Commission came to have a major role in setting prices.

Global oil production was dominated by a group of the seven largest oil companies (five of which were U.S. companies), later nicknamed the "Seven Sisters." These companies obtained concessions in key oil-producing countries, primarily in the Middle East, giving them wide-ranging control of production in exchange for royalty payments. As a result, the Seven Sisters controlled the majority of global production in the mid-20th century, despite substantial oil discoveries during this period. They chose to benchmark oil prices relative to the U.S. price, therefore translating U.S. oil price stability to global oil price stability (McNally 2017). The group did not use its monopoly to push

FIGURE 1.2 Crude oil—historical developments

Crude oil prices were low and stable between 1930 and 1970, in large part due to the federal government-administered IOCC in the United States, and the Seven Sisters international cartel. Prices have since undergone sharp cycles since the rise of OPEC. Periods of high prices have periodically led to the emergence of new producers, often via new discoveries or new technologies, such as the Middle East after the Second World War, and the North Sea, Mexico, and Alaska in the 1970s.



Sources: BP Statistical Review; International Energy Agency; OurWorldinData; World Bank.
A. Oil price refers to the U.S. average between 1861-1944, Arabian Light between 1945-1983, and Dated Brent from 1984-2021. Real price series deflated using U.S. consumer price inflation (CPI).
B. Middle East includes Iran, Islamic Rep.; Iraq; Kuwait; Qatar; and Saudi Arabia.
C. North Sea includes Norway and the United Kingdom.

aggressively for higher prices because it wanted to avoid government intervention. This informal arrangement lasted for more than three decades but began to break down in the 1960s, in part because the United States had run out of excess capacity and was increasingly dependent on crude oil imports, but also because the oil-producing countries in the Middle East sought more control over their production and prices (Baumeister and Kilian 2016; Stern and Imsirovic 2020).

OPEC, formed in 1960, accounted for about half of world output by 1970. After raising prices several times in the early 1970s, OPEC generated a global oil price shock by quadrupling the price in 1973-74. A second price shock occurred in 1979-80 when the Iranian Revolution and war between Iraq and Iran resulted in a significant loss of global oil production and a sharp increase in prices.

While oil producers benefited from increased oil revenue, the high prices reduced oil demand and encouraged the development of non-OPEC oil production. Between 1979 and 1983, global oil demand fell by 10 percent, or 6 mb/d, with demand in AEs countries declining by 18 percent. Oil-importing countries mandated increases in fuel efficiency standards, and encouraged the use of substitutes, for example, by prohibiting the construction of oil-powered electricity power stations.[2] At the same time, high oil prices resulted in a sharp increase in non-OPEC supply, particularly from high-cost sources (Gately 1986). Output from Alaska, the North Sea, and the Gulf of Mexico rose from 2.2 percent of global production in 1975 to 14 percent in 1985, with market share taken at the expense of OPEC.

Because of these developments, oil prices declined every year between 1980 and 1985. To offset the sustained declines in prices, OPEC set production quotas for the first time in March 1982. Quotas were successively lowered, and Saudi Arabia accepted the role of a swing producer, absorbing the brunt of production cuts. However, non-compliance by other OPEC members was widespread, and by mid-1985, Saudi Arabia's oil production had fallen by more than three-quarters (Hamilton 2010). In 1985, Saudi Arabia changed its strategy and announced that it would cease its role as swing supplier and increase production, causing oil prices to collapse. In addition to raising Saudi Arabia's market share, the price war was meant to invoke production discipline among all OPEC members. OPEC again set quotas in 1987, along with a price target. However, apart from a spike at the onset of the Gulf War in 1990, prices continued to slide, reaching a low of $10/bbl in 1999.

The 1970s oil crisis and nationalization of company assets helped trigger the broader development of the oil market, including the emergence of market pricing mechanisms. The New York Mercantile Exchange introduced the WTI (West Texas Intermediate) oil futures contract in 1983, and the Brent contract was launched shortly thereafter. Today, there are three main oil price benchmarks—Brent, WTI, and Dubai—as well as many regional price benchmarks.[3] Oil futures are widely traded on futures exchanges, with WTI the most active. Of all commodity markets, oil futures have the longest horizon, although liquidity declines rapidly as the contract term lengthens.

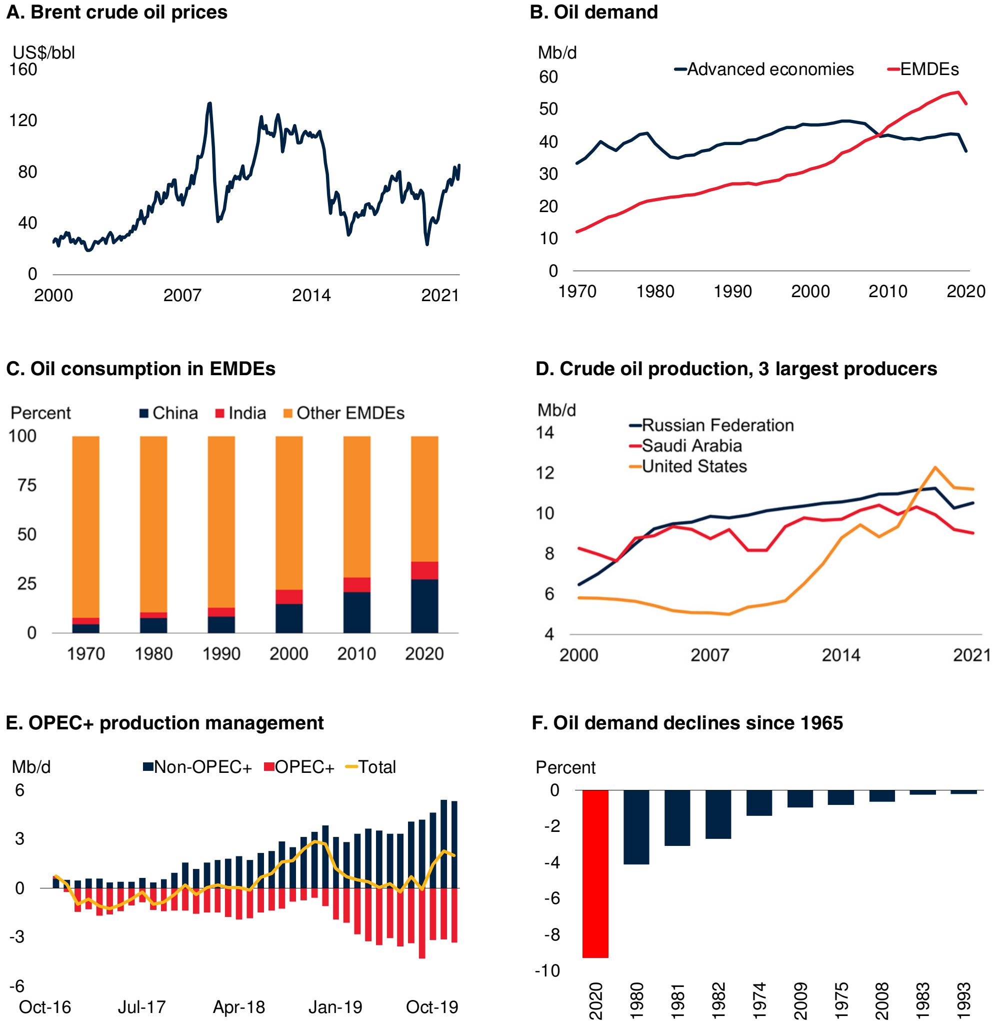
The 2000s saw a surge in oil prices, mainly reflecting larger-than-expected demand among EMDEs (figure 1.3; World Bank 2018). Oil consumption in China rose by nearly 70 percent during 2000-08, and in India by 40 percent. In contrast, oil demand among AEs was broadly unchanged over this period. In addition to increases in demand, only modest increases in supply from OPEC contributed to rising prices (Baumeister and Peersman 2013; Kilian 2009; Kilian and Murphy 2014). At the peak in 2008, oil

[2] Oil demand was also depressed by a steep rise in interest rates caused by the Federal Reserve's policy of reducing inflation, and by a global economic recession.

[3] Brent refers to crude oil produced in the North Sea. It is used to price two-thirds of the world's trade in crude oil, including that produced in Africa, Europe, and some parts of the Middle East (ICE 2021). WTI is the U.S. benchmark, while Dubai is generally used to price crude oil exports from the Persian Gulf to Asia. Differences between types of crude oil are primarily based on their sulfur content and their density. This determines if they are "sweet" or "sour" and "light" or "heavy" (EIA 2012). Brent and WTI are light, sweet crude oils, while Dubai is at the opposite end of the scale as a heavy, sour oil. In general, crude oil grades that are lighter and sweeter are more valuable than heavy, sour oils, because it is easier to produce gasoline and diesel from them.

FIGURE 1.3 Crude oil—Developments since 2000

After surging through the 2000s, oil prices averaged over $100/bbl between 2011-2014 before collapsing. The price surge was driven by a sharp increase in demand among EMDEs, while demand among advanced economies has declined. U.S. oil production has risen sharply as a result of the shale oil revolution. Amid surging global output, OPEC has attempted to manage oil markets by reducing its own production, and expanding its influence with the OPEC+ grouping. The COVID-19 pandemic presented a unique shock to oil markets, triggering a fall in oil demand more than twice as large as any previous decline.



Sources: BP Statistical Review; International Energy Agency; OurWorldinData; World Bank. C.

EMDE stands for emerging market and developing economies.

E. Figure shows change in production relative to October 2016. Last observation is December 2019. OPEC+ includes OPEC members and 10 non-OPEC countries which have agreed to collectively agree to production quotas.

F. Figure shows the top 10 declines in annual oil demand.

prices reached well over $100/bbl. The boom ended abruptly during the global financial crisis, but oil prices recovered rapidly due to robust growth in China and production cuts among OPEC countries.

Between January 2011 and mid-2014, oil prices plateaued at just over $100/bbl. In contrast, most other commodity prices gradually declined over this period because of weak global demand and rising supplies. Through 2013, the impact of soft global demand on oil prices was offset by geopolitical factors on the supply side. These included a collapse in exports from Libya due to internal conflict, as well as reduced exports from Iran following the imposition of sanctions by the United States and the European Union (Baumeister and Kilian 2016).

Oil prices began to drop in mid-2014 and continued to decline until a trough of $40/bbl was reached at the start of 2016—a decline of more than 70 percent from the highs earlier in the decade. Several factors were at play. High and stable prices prior to 2014 facilitated the development of other forms of crude oil, most notably U.S. shale oil, as well as Canadian tar sand production and biofuels. U.S. crude oil production increased by 55 percent between 2011-14, and its share of global oil production rose from 7.6 percent to 11.2 percent. In addition, oil supply disruptions arising from geopolitical events—including conflict in Libya, the impact of sanctions on the Islamic Republic of Iran, and fears of supply outages in Iraq—had less of an impact on production than expected, and while oil demand continued to grow, it consistently came out below market expectations (Baffes et al. 2015).

The drop in prices was exacerbated by a change in OPEC strategy. At its meeting in November 2014, OPEC opted to maintain a production level of 30 million bbl/d instead of anticipated production cuts (OPEC 2014). This signaled that OPEC would no longer act as the swing oil producer and would let prices be set by the marginal producer, U.S. shale. Shale oil projects differ from conventional drilling projects in that they have a shorter lifecycle and relatively low capital costs, and production tends to respond more rapidly to price changes (Kilian 2020; McCracken 2015).

The sharp fall in prices was expected to have a substantial negative impact on U.S. shale production. However, the U.S. shale industry adapted to lower prices and sharply reduced production costs via efficiency gains and innovation. As a result, U.S. production declined only modestly in 2016 before recovering rapidly as prices rebounded. In 2018, U.S. crude oil production rose by a record 1.5 million bbl/day. With this, the United States overtook Russia and Saudi Arabia to become the world's largest oil producer, accounting for nearly 15 percent of global production (EIA 2018).

As in the previous period, the increase in the U.S. share of oil production came at the expense of OPEC. In response to the rapid increase in U.S. production and relatively low prices, in December 2016 OPEC reached an agreement with 10 non-OPEC countries to cut oil production by a collective 1.2 million bbl/day.[4] The group became

[4] The 10 non-OPEC countries are Azerbaijan, Bahrain, Brunei, Kazakhstan, Malaysia, Mexico, Oman, Russia, Sudan, and South Sudan.

known as OPEC+ and continues to collectively set production targets. Between 2017 and 2019, OPEC+ had some success in maintaining prices, although this came at the expense of market share, and may have served to benefit the U.S. shale industry.

In 2020, the COVID-19 pandemic had a large impact on oil markets (Kabundi and Ohnsorge 2020). The one-month decline in oil prices in April 2020 was the largest on record, with the WTI price briefly turning negative (World Bank 2020). Oil consumption fell sharply because of government restrictions to stem the spread of the pandemic, with demand declining by almost 10 percent in 2020, more than twice as large as any previous decline (World Bank 2020). Amid plummeting prices, OPEC and its partners agreed in April 2020 to cut production by a record 9.7 million bbl/day.[5] Prices rose during the remainder of the year and accelerated in 2021 as the global economy recovered. While production rose, some producers struggled to increase output, hindered by various factors, including shortages of labor, transport bottlenecks, and bad weather (World Bank 2021).

Oil markets were once again disrupted by the war in Ukraine. In response to the invasion, several countries, including Canada, the United Kingdom, and the United States announced they would ban or phase out imports of oil from Russia. The International Energy Agency estimated about 3 mb/d of Russia's production was disrupted as a result. The longer-term implications of the war in Ukraine are examined in box 1.1.

Coal

Coal has been used extensively as a fuel throughout history and was instrumental in the Industrial Revolution. Thermal (or steam) coal, which accounts for more than 80 percent of global coal consumption, is chiefly used for electricity generation. The remainder is coking or metallurgical coal and is used to smelt iron ore for steel production. China is the largest consumer of coal, accounting for more than half of the world's consumption. China also accounts for half of global production, followed by India (10 percent), Indonesia (7 percent), and the United States and Australia (about 6 percent each).

Prior to the 1960s, international trade of coal was limited, mostly land-based, and regional, reflecting the high cost of transportation—even today, transport costs can make up half of total costs of coal supply (Paulus 2012). Former West Germany, for example, exported coal to other countries in Western Europe while Poland and the Soviet Union supplied Eastern European countries. There was also some land-based trade between the United States and Canada. The only seaborne coal trade was from the United States (the world's largest producer at that time) to Western Europe and Japan.

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[5] The group had previously failed to reach an agreement at their meeting in March 2020, which triggered the end of the existing cuts. Saudi Arabia announced it would increase oil production by more than 2 million bbl/day, to 12 million bbl/day, exacerbating the fall in prices.

An international market for coal began forming after the oil price shocks of the 1970s, which made coal competitive with crude oil for power generation despite higher transport costs. The increasing use of coal for electricity generation was facilitated by the International Energy Agency's (IEA) decision to ban its member countries from building new oil-fired electricity plants (IEA 1979). As a result, global coal consumption rose more than one-fifth between 1970 and 1980, leading to large increases in coal prices (figure 1.4). In addition, several countries developed their coal reserves and became coal exporters, including Australia, Canada, and South Africa. The result was a doubling of the quantity of coal traded between 1970 and 1990 (Wårell 2005).

Coal prices began to decline in the 1980s and plateaued in the 1990s despite continued growth in coal consumption. The decline was driven by supply-side factors, including the emergence of additional coal exporters in the 1980s, including China, Colombia, and Indonesia, as well as technological developments, particularly in the United States, where the cost of producing coal fell sharply (Ellerman 1995). Between 1985 and 1995, the labor productivity of coal miners in the United States doubled, from 2.7 tons per employee per hour to 5.4 tons (EIA 2021). The 1980s saw the first international coal price benchmark, which was the outcome of negotiations between a leading Australian coal supplier, BHP Billiton, and Japanese power and steel companies.[6]

The coal market changed significantly from 2000 onward as rapid growth in EMDEs, notably China, led to a surge in demand (Baffes, Kabundi, and Nagle 2022; World Bank 2018). Global coal consumption rose by almost 50 percent during 2000-08, with China accounting for more than two-thirds of the increase. Although China rapidly increased domestic production of coal, the increase was insufficient to meet the rise in domestic demand. As a result, the country became a significant importer of coal, driving up global prices (which peaked in mid-2008). The global financial crisis caused prices to fall sharply as the global economy contracted, but prices bounced back rapidly as the economy recovered, with China once again driving the increase in demand.

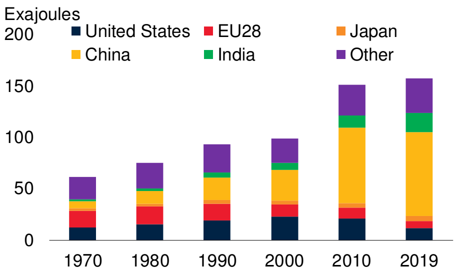
Demand for coal peaked in 2014 and has slightly declined since, as China's growth has slowed and shifted away from manufacturing and investment toward consumption and services (World Bank 2019a). Coal demand has been further affected by the U.S. shale revolution, which led to plentiful supplies of low-cost natural gas, enabling gas-to-coal switching in electricity generation (EIA 2020). Concerns about climate change and pressures to reduce carbon emissions alongside a fall in the cost of solar- and wind-powered electricity have further suppressed demand, especially in AEs, resulting in a fall in coal-powered electricity. Reflecting these developments, coal-fired electricity capacity has declined in Europe and the United States in recent years, even as it has increased in China and India. However, coal still accounts for 30 percent of primary energy consumption and generates 40 percent of the world's electricity.

[6] Today there are three widely used international coal price benchmarks: (i) fob spot at Richards Bay, representing thermal coal exports from South Africa, (ii) fob spot at Newcastle, representing thermal coal exports from Australia, and (iii) fob spot at Bolivar, representing thermal coal exports from Colombia, although numerous other prices are also used. Coal is also traded on several futures exchanges.

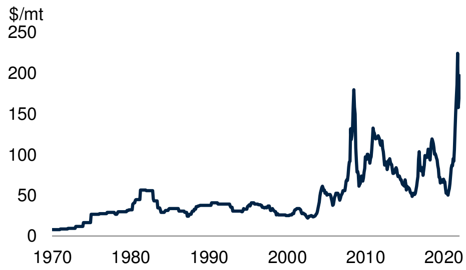
FIGURE 1.4 Coal

After a period of stability during the 1970s-2000s, coal prices surged in the 2000s, driven by rising demand from China and other EMDEs. The United States' share of coal production has fallen, while China, India, and Indonesia have seen increases, despite the United States having the world's largest coal reserves. Coal consumption in advanced economies has been flat or declining since 2010 due to a decline in coal use in electricity generation. Coal-fired power plants are being retired in the United States and Europe, but China and India have installed additional capacity.

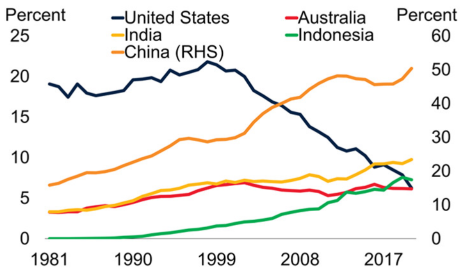
A. Global coal consumption



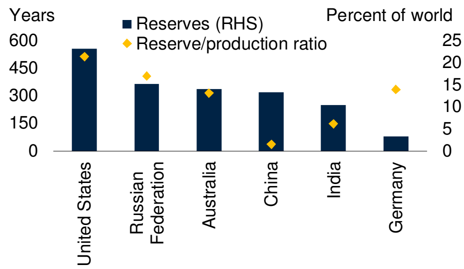
B. Monthly coal prices



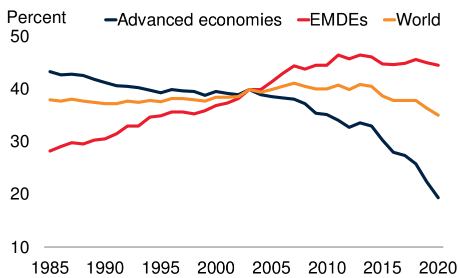
C. Shares of global coal production



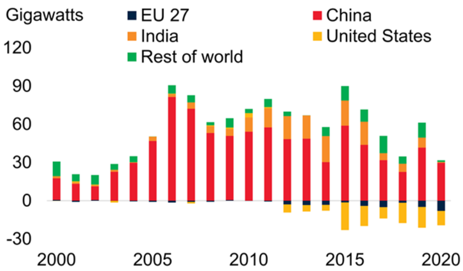
D. Global coal reserves



E. Use of coal in electricity generation



F. New coal capacity installation



Sources: BP Statistical Review; Energy Information Administration; Global Energy Monitor; International Energy Agency; World Bank.
B. Australian coal prices.
D. Reserve/production ratio refers to a country's known reserves relative to its production. Data for 2020.
F. Chart shows the net change in global coal-powered electricity generation capacity (additions of new capacity less retirement of existing capacity). A negative value indicates more coal generation capacity is being retired than is being added.

In 2020, the COVID-19 pandemic and the associated global recession caused a drop in demand for coal, and its price fell by nearly 30 percent between January and August. However, prices soared through 2021 and reached a new all-time high toward the end of 2021, as demand for imported coal rebounded in response to the economic recovery. Coal prices were further boosted by shortfalls in other sources of energy, including lower hydroelectric output, due to heatwaves and droughts in North and South America as well as China (World Bank 2021). Amid worries about energy shortfalls, China's policy makers announced several initiatives to increase production, resulting in China's coal production reaching a new all-time high by end-2021. In 2022, the war in Ukraine also disrupted coal markets, with several countries banning imports of Russian coal, leading to significant trade diversion (World Bank 2022).

Natural gas

Historically, natural gas markets have tended to be regional both in terms of production and consumption, as well as pricing. In North America, natural gas has typically been transported through pipelines between Canada, the United States, and Mexico. Similarly, in Europe, most natural gas has, until recently, been transported by pipeline from major producers, such as Norway and Russia, to consuming countries across the continent.[7] In Asia, by contrast, a larger proportion of natural gas has been transported as liquefied natural gas (LNG), with Japan and the Republic of Korea being the two largest consumers.

Pricing structures vary significantly by market. For gas transported by pipeline, prices can be set by open-market mechanisms similar to those used in oil markets, or they may be set by direct negotiations between buyers and sellers. Prices are regulated in some markets. In contrast, LNG contracts are typically longer-term, and indexed to the cost of feed gas, the floating price in the destination market, or indexed to oil or other commodities (Chandra 2020). In the United States and the European Union, gas supply and demand conditions help set prices at hubs, such as Henry Hub in the United States, and TTF (Title Transfer Facility) in the Netherlands (IEA 2013).[8] In Central and Southern Europe and Asia, natural gas prices are typically indexed to oil prices (and occasionally to other energy prices, such as coal).

Over the past two decades, the natural gas market has changed substantially. On the production side, the shale boom in the United States has helped lift U.S. natural gas production by more than 5 percent per year (on average) since 2010. The United States is now the largest producer of natural gas in the world (figure 1.5). This development came as a surprise to markets. From 2000 to 2007, U.S. production was flat, as existing fields matured. The United States was preparing to become a natural gas importer, with

[7] Natural gas is very capital-intensive, with substantial upfront costs in building pipelines, storage, and liquefaction and regasification facilities.

[8] The European Union gas market has undergone significant liberalization following the adoption of the "Third Energy Package" in 2009. This initiative contained several reforms to achieve a fully open market (European Commission 2009).

BOX 1.1 Comparing the effects of the war in Ukraine on commodity markets with earlier shocks

The Russian invasion of Ukraine has been a major shock to commodity markets and is causing significant disruptions to the production and trade of commodities. Earlier large commodity price shocks triggered policy and market responses that led to increased sources of supply and, for oil, substitution away from oil and greater consumption efficiency. Over time, the spike in prices following the war in Ukraine will likely once again spur more efficient energy consumption and a faster transition away from fossil fuels, particularly if supported by appropriate policy responses.

Introduction

The Russian invasion of Ukraine has caused major shocks to commodity markets. The war has led to significant disruptions to the production and trade of commodities for which Russia and Ukraine are key exporters, especially energy and food. The shocks exacerbated existing pandemic-related stresses in commodity markets, which had arisen as a result of rebounding global demand and constrained supplies. Together, the total changes in nominal prices resulting from the post-COVID-19 rebound and the war in Ukraine resulted in the largest increase in energy prices since the 1973 oil price spike (figure B.1.1.1; World Bank 2022). For food and fertilizers, the increase was the third-largest (after 1974 and 2008).

The invasion affected commodity markets in the short term through two main channels: the physical impact of blockades and the destruction of productive capacity, and the impact on trade and production following sanctions. Ukrainian wheat production and trade were severely disrupted, which especially impacted countries that rely heavily on Ukraine for wheat imports. In addition, many countries including Canada, the European Union, and the United States, chose to ban or phase out imports of Russian energy. This led to a costly diversion of trade in energy, as countries sought out alternative suppliers to Russia.

In addition to their short-term effects, shocks such as the war in Ukraine have longer-term consequences. They can trigger shifts in government policies and changes in the behavior of consumers and producers, leading to lasting changes in patterns of consumption and production. This box draws lessons from major shocks to commodity markets over the past 50 years. These include the 1970s oil and food price spikes and the broad-based rise in commodity prices during the 2000s. These price shocks induced policy and market responses that led to new supply sources, consumption efficiencies, and substitution among commodities.

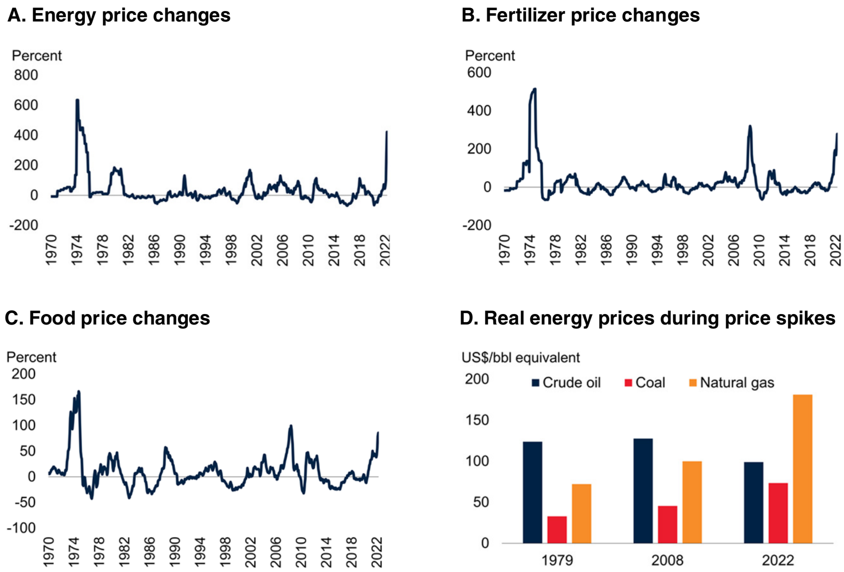
This box addresses the following questions:

- What were the main policy and market responses during earlier commodity shocks?

BOX 1.1 Comparing the effects of the war in Ukraine on commodity markets with earlier shocks *(continued)*

FIGURE B1.1.1 Market responses to price shocks

Commodity prices (in nominal terms) rose sharply following the start of the war in Ukraine, particularly for commodities for which Russia and Ukraine are key exporters. Price increases from April 2020-April 2022 were the largest for any equivalent two-year period since 1973 for energy and 2008 for fertilizers and food.



Sources: Bloomberg; World Bank.
A.-C. All prices in nominal U.S. dollar terms. Charts show the percent change in monthly price indexes over a two-year period. The last observation is based on April 2022 data. Due to data limitations, prior to 1979 the energy price change is proxied by the price of oil.
D. Chart shows the annual price of coal, Brent crude oil, and European natural gas, deflated using U.S. CPI. Data for 2022 reflect forecasts from World Bank (2022).

- How does the war in Ukraine compare with past episodes?

Policy responses during previous shocks

Energy

The global oil market has experienced three major price increases during the past 50 years. The first occurred in 1973 when several Gulf OPEC members imposed an oil embargo on exports to the United States and its allies following the Yom Kippur War. The second occurred in 1979 as a result of the Iranian revolution and was intensified by the Iran-Iraq war leading to a tripling in oil prices within a year. The third took place during the 2000s in a more gradual fashion as a result

BOX 1.1 Comparing the effects of the war in Ukraine on commodity markets with earlier shocks *(continued)*

of strong EMDE demand, especially in China and India, with a spike in prices in 2008 and again in 2011-14 (Baffes et al. 2018).

The oil price spikes of the 1970s triggered a number of policy responses, and these, alongside market forces, became the catalyst for demand reduction, substitution to other fuels, and the development of new sources of energy. After the first oil price shock, several OECD members set up the International Energy Agency in 1974 to safeguard oil supplies under a binding oil emergency sharing system, and to promote common policy making and data collection and analysis. Key policy decisions included the requirement to create national oil reserves equal to 60 days of imports (later expanded to 90 days) and a ban on building new oil-fired electricity plants, which included a directive to switch to coal (enacted in 1977; Scott 1994). Additional policies were adopted after the second oil price shock, with member countries agreeing to reduce oil demand by 5 percent.

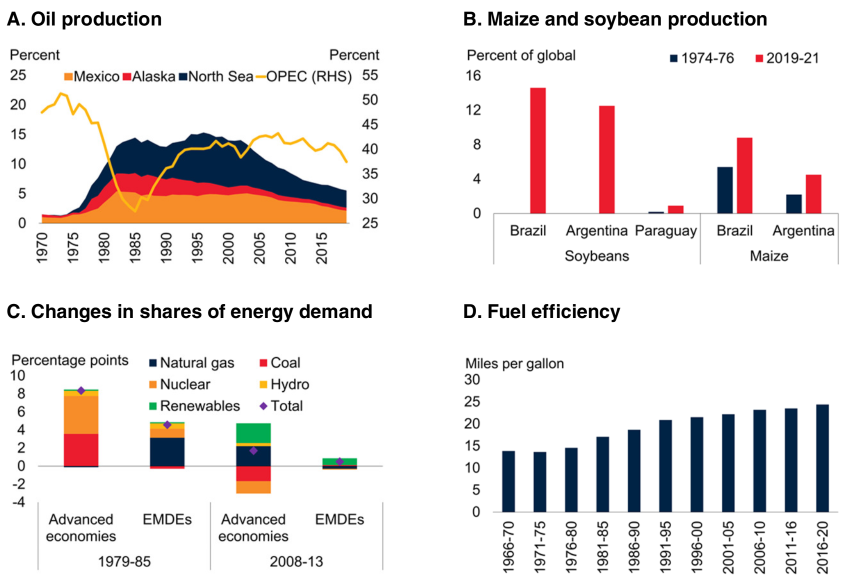
Policies varied at the country level. The United States initially responded to high prices with a complex array of price controls for different types of oil. These policies were generally deemed to have impeded the normal functioning of markets and led to significant distortions (McNally 2017). The country subsequently implemented numerous policy measures to address the underlying demand and supply imbalance with the Energy Policy and Conservation Act of 1975 (U.S. Congress 1975). On the demand side, these included energy conservation programs as well as regulations such as the prohibition of the use of crude oil in electricity generation, and improved fuel efficiency standards for new automobiles and consumer appliances. The average fuel efficiency of U.S. autos rose from 13 miles per gallon (mpg) in 1973 to 20 mpg by 1990 (figure B.1.1.2). On the supply side, measures included price incentives and production requirements to increase the supply of fossil fuels, including loan guarantees for new coal mines. The Act also mandated the creation of the Strategic Petroleum Reserve and measures to improve data, which led to the formation of the Energy Information Administration. In addition, in 1979, the United States announced it would remove price controls for oil (eliminated in January 1981), allowing market forces to address imbalances in supply and demand (Ilkenberry 1988).

In Japan, policies focused on measures to reduce energy use, develop alternative sources of energy to oil (notably nuclear power), and stabilize the supply of oil to Japan, for example through joint ventures with other countries (Shibata 1982). The Japanese government also phased out energy-intensive industries such as aluminum and petrochemicals. European countries implemented some similar domestic policies (Ilkenberry 1988).

BOX 1.1 Comparing the effects of the war in Ukraine on commodity markets with earlier shocks *(continued)*

FIGURE B1.1.2 Effects of price shocks on production and consumption

Rising oil prices led to increased production from alternative sources of oil such as the North Sea and Alaska in the 1970s-80s. The food price spikes of the 1970s encouraged the emergence of South American countries as major food exporters. The share of non-oil energy sources rose sharply after the 1979 oil price spike, notably nuclear and coal in advanced economies, while increases were smaller during the 2008 oil price spike. Higher prices also saw policies implemented to improve energy efficiency, including for vehicles in the United States.



Sources: BP Statistical Review; Energy Information Administration; U.S. Department of Agriculture; World Bank.

A. North Sea refers to production from Norway and the United Kingdom.

C. Chart shows the change in energy consumption in AEs and EMDEs in the five years after the oil price shocks of 1979 and 2008. The total change reflects the equivalent decrease in oil consumption.

D. Figure shows the fuel efficiency of U.S. vehicles in miles driven per gallon of gasoline consumed.

Steadily increasing oil prices in the 2000s again led to policies to address concerns about energy shortfalls. In the United States, the Energy Policy Act of 2005 and the Energy Independence and Security Act of 2007 included numerous provisions to reduce demand and boost production (EPA 2007). These included improving fuel efficiency in vehicles, tax breaks for the purchase of hybrid vehicles, as well as tax breaks and incentives for investing in energy-efficient buildings, both for commercial use and housing. On the supply side, the Act mandated a sharp increase in the use of biofuels, established renewable fuel standards, provided

BOX 1.1 Comparing the effects of the war in Ukraine on commodity markets with earlier shocks *(continued)*

energy-related tax incentives for fossil fuels and renewable energy sources, and provided loan guarantees. Other countries adopted similar policies. For example, the European Union introduced the Renewable Energy Directive in 2009 which mandated that 20 percent of all energy usage in the EU, including at least 10 percent of all road transport fuels, be produced from renewable sources by 2020, alongside measures to increase energy efficiency (European Parliament 2009). These directives were further expanded by the European Green Deal of 2019. Biofuel policies were also introduced in some EMDEs, including Brazil and India.

Food

Food commodity markets have experienced two major price increases over the past half-century, both during similar time periods to the oil price shocks. The first occurred during the 1972-74 oil crisis, and the second took place during the 2000s as part of the broader commodity price boom. As in the case of oil, food prices spiked in 2008 and again in 2011.

The 1970s food price spike was beneficial for food-exporting countries. In the United States, the government was able to reduce expensive support programs that it had previously implemented. Among commodity importers such as Japan, the price boom of the 1970s (as well as an embargo on soybean exports by the United States) reinforced the desire for self-sufficiency in food commodities. Japan promoted international cooperation to stabilize agricultural commodity prices and guarantee reliable supplies for importers (Honma and Hayami 1988). Other East Asian countries, including the Republic of Korea, increased protection of domestic agriculture and expanded the scope of state trading agencies.

During the 2008 price increase, governments in several EMDEs were confronted with difficult policy choices. Allowing domestic prices to adjust to world food price changes would have led to higher food price inflation, thereby causing a decline in real incomes of poor households that were net food buyers (Laborde, Lakatos, and Martin 2018). Instead, many countries attempted to reduce the transmission of international food price shocks to domestic markets. During the 2007-08 food price spike, close to three-quarters of EMDEs undertook policy actions to insulate their economies from the sharp increase in international food prices, especially for rice (World Bank 2019b). Similar policy actions were undertaken during the spike of 2010-11 (Chapoto and Jayne 2009; Ivanic and Martin 2008, 2014). Several studies have shown that the use of such trade policy interventions compounded the volatility of world prices and also increased poverty (Laborde, Lakatos, and Martin 2019).

BOX 1.1 Comparing the effects of the war in Ukraine on commodity markets with earlier shocks *(continued)*

Market responses during previous shocks

Market mechanisms respond to price shocks and associated policies through three main channels: demand reduction, substitution, and supply response. This section discusses how these channels apply to energy and food commodities. While substitution and supply responses are applicable across most commodities, the demand reduction channel is less applicable for food.

Energy

Demand reduction. Between 1979 and 1983, global oil demand fell by 11 percent, or 6 mb/d, with demand in advanced economies shrinking by almost 20 percent. While the drop in oil demand was partly a result of the global recession in 1982, energy efficiency and substitution policies implemented by oil-importing countries caused a permanent reduction in underlying demand growth. Changes in consumer preferences in response to higher prices also played a role. For example, in the United States, preferences shifted away from domestically-produced and less fuel-efficient vehicles in favor of more efficient Japanese-made cars—the share of Japanese cars in U.S. auto purchases rose from 9 percent in 1976 to 21 percent in 1980 (Cole 1981).

In the 2000s, high oil prices and policy changes once again induced efficiency improvements in the use of oil, but there was less substitution to other fuels as much less crude oil was being used in electricity generation. After peaking in 2005, oil consumption in advanced economies steadily declined such that by 2014 it had fallen 14 percent from its peak. Once again, consumer preferences played a role. For example, in the United States, there was a shift toward fuel-efficient hybrid cars (supported by government policies) away from sport utility vehicles (SUVs). Indeed, in 2008, sales of SUVs began to plunge, and by mid-2008 they were down more than 25 percent from the same period a year earlier (Hamilton 2009).

Substitution. In the five years after the 1979 oil price shock, the share of crude oil in the energy mix in advanced economies fell by more than 7 percent. This shift was chiefly due to the prohibition on the construction of oil-powered electricity power stations—which were replaced by nuclear and coal-powered stations. The shift to nuclear power, which had started in the late 1960s, was particularly pronounced in France and Japan, where its share in total energy consumption reached 23 and 8 percent, respectively, by 1984. Among EMDEs, the share of oil fell by 4 percent and was largely replaced by natural gas.

In the years following the 2008 oil price rise, the share of natural gas and renewables in the energy mix rose, reflecting the U.S. shale boom for natural gas,

BOX 1.1 Comparing the effects of the war in Ukraine on commodity markets with earlier shocks *(continued)*

and mandates and technological improvements for renewables. However, since oil was no longer used widely in electricity generation, the decline in its share was of marginal significance. Moreover, substituting other energy commodities for oil in its main uses—transport and petrochemicals—is much harder. As a result of mandates, the share of biofuels—ethanol and biodiesel—rose from about 0.15 percent of total oil consumption in 2005 to 1.7 percent in 2020, a large overall increase although still a very small share of overall oil consumption.

New sources of production. High oil prices in the 1970s induced investment in oil production facilities by non-OPEC countries, including Prudhoe Bay in Alaska, the North Sea offshore fields of the United Kingdom and Norway, the Cantarell offshore field of Mexico, and oil sands in Canada. High and stable prices in the 2000s also facilitated the development of alternative sources of crude oil. The most notable of these was the development of U.S. shale oil deposits, output from which rose from 5 mb/d in 2008 to 9 mb/d in 2014. In addition, Canadian oil sand production and Brazilian deep-water production rose rapidly.

Food

Substitution. In contrast to energy commodities, most of the substitution in food commodities takes place on the input side since different crops can be grown with much the same inputs of land, labor, machinery, and fertilizers. This flexibility allows shifts in crop patterns from one season to another, in turn preventing sustained price gaps among commodities. For example, the price spikes of the 1970s and 2000s were mostly focused in one commodity and subsequently spread to the prices of other crops. Indeed, despite the large increase in maize and edible oil demand due to biofuels and for animal feed over the past two decades, the prices of these commodities moved in tandem with other grains and oilseeds.[a]

Substitution on the consumption side does occur, but only for some agricultural commodities. For example, edible oils (including palm, soybean, and rapeseed oil) can be substituted for each other, which explains the high degree of comovement in edible oil prices. Substitutability also takes place in animal feed, especially between maize and soybean meal. Other food commodities, however, are less substitutable as consumption patterns depend on cultural factors (for example, Asia is mostly a rice-consuming region while Europe and the Americas are mostly wheat-consuming regions).

New sources of supply. The food price increases in the 1970s induced a supply response from some South American countries, including Argentina and Brazil.

a. For example, global demand for maize doubled during 2000-20, compared to the 26-28 percent increase in global demand for rice and wheat (in line with world's population growth of 27 percent over this period).

BOX 1.1 Comparing the effects of the war in Ukraine on commodity markets with earlier shocks *(continued)*

Today, these two countries account for 17 and 50 percent of global soybean production, respectively, whereas they produced virtually no soybeans in the 1970s. Over the same period, their share of global maize production almost doubled to about 8 and 4 percent, respectively. High food commodity prices in 2008 and 2011, however, did not bring any major new producers into the global food markets. Indeed, some of the factors behind the spikes reversed—for example, high energy prices started to decline, and restrictive trade policies were eased—thus replenishing stocks of most grains and oilseeds.

Comparing shocks from the war in Ukraine with earlier shocks

The war in Ukraine shock has a number of similarities, but also some differences, with earlier shocks. In all three shocks, high energy prices pushed up fertilizer prices and other input costs, thereby causing food commodity prices to spike. Export bans were also used in all three shocks. The 1970s shocks and the war in Ukraine were associated with geopolitical tensions, ongoing stresses in commodity markets, and inflationary pressures.

Energy

Prices. All energy prices saw significant increases through 2021 and the start of 2022, particularly natural gas and coal. In contrast, in the earlier episodes, oil prices rose much more sharply than those for coal and gas. In March 2022, the price of oil in real terms averaged 35 percent below its 2008 peak, while the price of European natural gas reached a historical high. With all energy prices elevated, there is less opportunity to substitute for cheaper fuel. In fact, with oil being one of the cheapest fuels, there was some substitution for it from natural gas in electricity generation in 2021 and 2022 (World Bank 2021). In addition, high prices of some commodities (such as energy) pushed up the production cost of other commodities (such as fertilizers, foods, and metals). While renewables—mainly solar and wind power—offer an alternative source of energy, their cost also rose in 2022 as a result of sharply higher prices for the metals used in their construction, including aluminum and nickel.

Intensity. The amount of oil required to produce a unit of economic output (the "oil intensity of GDP" has fallen considerably since the 1970s. Similarly, consumer spending on energy as a share of total spending has also fallen, especially in advanced economies (although it increased significantly in 2022). As a result, consumers may respond less to energy price changes, at least in the short term, than in the 1970s. Industry, on the other hand, may be more vulnerable to price changes. There is some evidence that price elasticity of demand in energy-intensive industries may be higher than that of consumers. For example, in

BOX 1.1 Comparing the effects of the war in Ukraine on commodity markets with earlier shocks *(continued)*

Europe high natural gas and electricity prices led to lower production of fertilizer and aluminum in 2021.

Policies. Policy responses to high energy prices following the war in Ukraine often focused on reducing fuel taxes or introducing subsidies—a marked reversal of a broader trend of declining subsidies over previous years. These policies were also in contrast to policy announcements to combat climate change (such as during COP26 in 2021), which included promises to phase out fossil fuel subsidies. Although tax breaks and subsidies can somewhat alleviate the immediate impact of price spikes, they do not provide large benefits to vulnerable groups, and by increasing energy demand, they tend to prolong the imbalance of demand and supply.

Energy supply disruptions following the war in Ukraine also complicated the energy transition, with several countries announcing plans to increase production of fossil fuels. China, for example, announced it would increase its coal production by 300 million tons (an amount equal to its imports), and an increase of nearly 8 percent from its production during 2021. The EU also announced plans to increase imports of LNG to reduce its reliance on Russian natural gas. While increasing the supply of fossil fuels helps alleviate energy shortages, it makes achieving climate change goals more challenging. Although some countries announced intentions to boost energy production from renewable sources or to revive or extend nuclear power plants, such projects take time to materialize.

As in the earlier shocks, the war on Ukraine has prompted several countries to unveil plans to reduce energy demand. For example, the United States announced a faster increase in fuel efficiency requirement for car manufacturers, requiring fuel efficiency to increase to 49 mpg by 2026, an increase of about one-quarter relative to 2021. The EU announced plans to encourage the installation of heat pumps, which are a more energy-efficient method of heating homes.

Food

A key similarity between the Ukraine war and the earlier food price shocks is the role of high energy (and fertilizer) prices in driving food price increases. However, the extent and breadth of price increases differed markedly across the three spikes. Whereas the 1970s food price increases were among the largest of the past 100 years, the more recent increases have been much smaller in magnitude, reflecting, in part, the long-term downward path of agricultural prices (Baffes and Kabundi 2021). While the 1970s price boom was broad-based, in 2008-09 it was led by rice, while in 2022 it was led by wheat, followed by edible oils.

BOX 1.1 Comparing the effects of the war in Ukraine on commodity markets with earlier shocks *(continued)*

Substitution has also played an important role and explains differences in price changes following the Ukraine war. While prices of agricultural commodities where Ukraine is a major exporter rose, increases were smaller for sunflower oil compared with wheat. That is because sunflower oil can be substituted by soybean and palm oil (the prices of all edible oils have risen since the war began, reflecting this substitutability). The larger price spike for wheat reflects the fact that it is less easily substituted by other commodities. Substitution of wheat will instead come from land reallocation, which takes place from one season to the next.

On the policy front, export bans and other trade restrictions were less common during the 2022 price spike compared to the previous events. However, the food price rises accelerated domestic food price inflation and increased food insecurity in many LICs, which had already deteriorated during the pandemic.

Conclusions and policy implications

The war in Ukraine has dealt a major shock to commodity markets. In the past, policy responses were key to providing a long-term solution to shocks. The comparison with earlier shocks highlights how some policies have been highly effective and beneficial, while others have provided short-term fixes but at the expense of market distortions or new problems. Increased efficiency standards for automobiles, incentives for more efficient home appliances, and renewable energy mandates (except biofuels) have all generated long-term benefits. Similarly, the creation of institutions to improve market transparency, coordinate policy responses, improve data quality, and facilitate policy dialog, have also been beneficial. These include the International Energy Agency (set up by the OECD after the first oil price shock) and the Agricultural Marketing Information System (set up by the G-20 in response to the 2007-08 prices spike).

Some policies that provided short-term respite to higher prices exacerbated problems in the medium-term or led to new problems. For example, price controls in the United States after the first oil price shock in 1973 distorted markets and may have increased oil demand. The promotion of coal use for electricity generation in the late 1970s reduced reliance on oil; however, it created environmental problems, including air pollution and the acceleration of climate change. Similarly, the introduction of biofuels provided an alternative to crude oil and may have increased the share of renewable energy, but its overall effectiveness has been questioned because biofuel production requires large amounts of energy and fertilizers and leads to upward pressure on food prices. Export bans on food commodities during the 2007-08 and 2010-11 price increases, while temporarily softening the impact of food price inflation on poorer households, also induced high volatility in world prices and reciprocal policy responses by other countries.

BOX 1.1 Comparing the effects of the war in Ukraine on commodity markets with earlier shocks *(continued)*

The current shock, however, has three key features that could make addressing the energy shortfall more difficult. First, there is less room to substitute away from the most-affected energy commodities—gas and coal—as price increases have been broad-based across all fuels. In addition, higher prices of some commodities such as energy have also increased the production costs of other commodities. Second, the energy intensity of GDP is much lower compared to the 1970s, so consumers may be less sensitive to relative price changes, at least in the short term. It may also be more difficult for countries to reduce energy use (i.e., less "low hanging fruit" available, as efficiency has already improved significantly in many areas such as lighting). Third, while many governments have implemented fuel subsidies or tax cuts, fewer have implemented policies to tackle the underlying supply and demand imbalance, thus risking prolonging the crisis.

major investments in LNG terminals to accommodate LNG imports. These terminals have since been retrofitted to allow exports instead (EIA 2014). Gas production has risen rapidly elsewhere, especially in Qatar, Australia, and China. The United States became the world's largest exporter in late 2021, superseding Qatar and Australia.

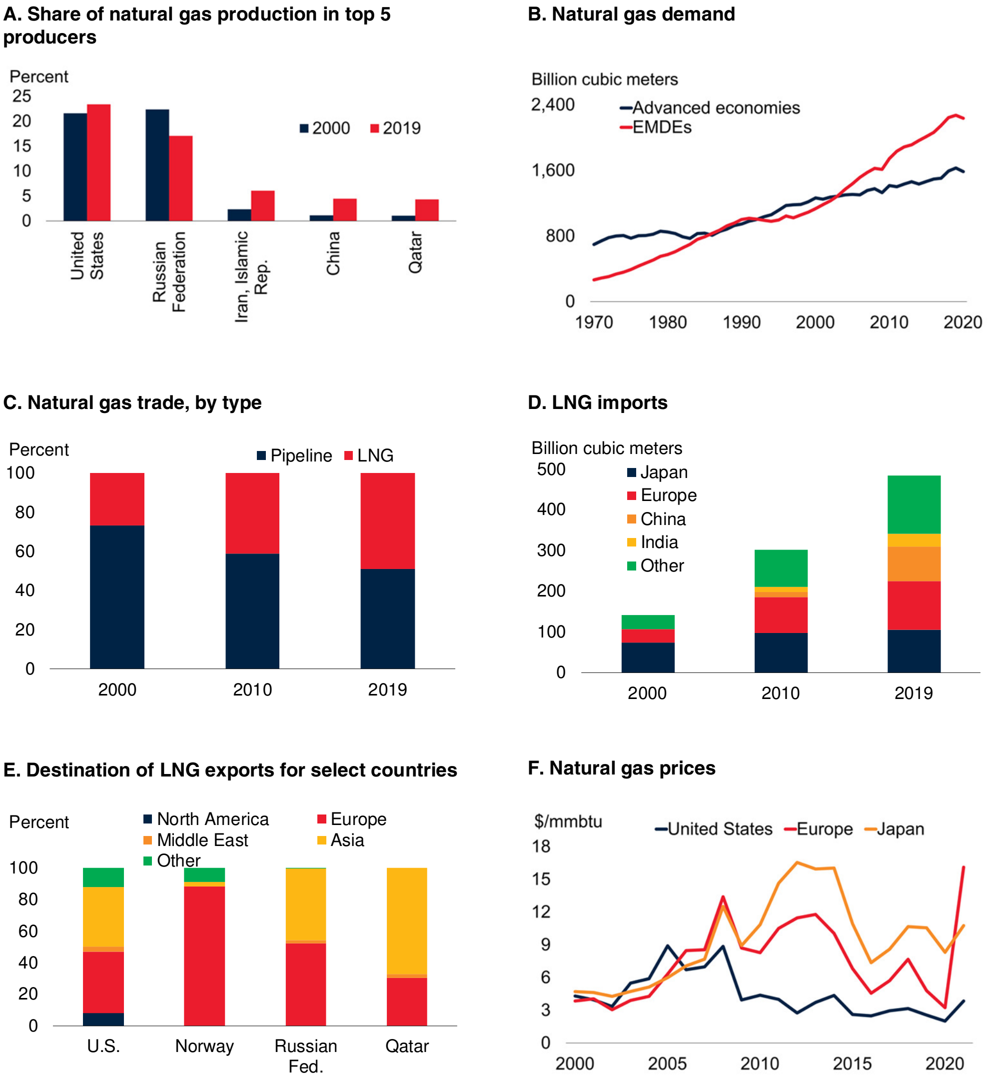
Demand for natural gas has grown rapidly, particularly among EMDEs, where growth has averaged nearly 4 percent per year since 2000. Consumption also rose in AEs, in notable contrast to oil and coal which have seen declines in AE demand over this period. The rise in demand for natural gas is due in part to superior properties as a fuel—far less polluting than coal, with half the carbon dioxide emissions, as well as fewer particulate emissions (IFC 2019). Coal-to-gas switching in power plants has become increasingly common, particularly in the United States and Europe (IEA 2019).

Historically, imports of LNG were concentrated in a few countries in Asia—Japan accounted for half of all LNG imports in 2000. Increasing availability of supply has encouraged a considerable broadening of trade, however. China and numerous countries in Europe now import much more LNG compared to two decades ago. LNG now accounts for roughly half of natural gas trade, up from one-quarter in 2000.

With increased numbers of suppliers and importers, and increased volumes of trade, the market structures for LNG have evolved. Pricing has become more responsive to changes in market conditions and the global market has become more unified. While the LNG market has traditionally relied on long-term contracts, short-term and spot-priced trades now account for more than one-third of all LNG trade. Exports from the United States account for much of this shift (IEA 2021a). That shift also helped increase the share of natural gas that is not indexed to other commodities, notably oil. Furthermore, LNG can be exported to a much wider range of countries than gas

FIGURE 1.5 Natural gas

Natural gas markets have undergone significant changes over the past two decades, including a sharp increase in production in the United States and elsewhere, rapid growth in consumption among EMDEs, and a shift in trade toward liquefied natural gas. These trends have caused varying divergences in natural gas prices across countries.



Sources: BP Statistical Review; World Bank.
C.-E. LNG stands for liquefied natural gas.

exported by pipeline (although it still requires infrastructure in the form of LNG terminals). As a result, cargos can be exported (or re-exported) to countries where prices are highest, which can contribute to a reduction in price differentials between regions.

In 2010, large and persistent differentials opened up between the three main price benchmarks—United States, Europe, and Japan. Unlike the United States, natural gas prices in Europe and Japan were formally linked to oil prices. When oil prices surged in 2010-14, prices rose sharply in the European Union and even more so in Japan. At the same time, natural gas prices fell in the United States (to levels last seen in the 1990s) because of a sharp rise in natural gas production. While European and Japanese prices eventually declined in 2015 alongside the fall in oil prices, differentials between the three benchmarks persisted. More recently, however, as LNG trade has expanded, the differentials between the prices have decreased. LNG from the United States is now transported to Europe or Asia, depending on where prices are highest (although the transport costs to Asia are higher than those to Europe).

The global economic fallout from the COVID-19 pandemic had large repercussions on natural gas markets. The recession in 2020 triggered a sharp fall in demand, and surplus gas in the United States resulted in a large increase in LNG exports, especially to Europe. This pushed European prices to an all-time low, and to parity with U.S. prices. However, the following year saw a reversal as demand for energy rebounded rapidly as the global economy recovered. A shortfall in coal in China, as well as reduced output of renewable energy more broadly, led to a sharp increase in natural gas prices in China and elsewhere. The price of European natural gas rose more than 400 percent over the course of 2021, as Europe was in direct competition with the rest of the world for LNG.

Natural gas markets were also severely disrupted by the invasion of Ukraine. The EU pledged to reduce its exports of natural gas from Russia by two-thirds by the end of 2022. As almost 70 percent of Russia's natural gas exports were by pipeline to Europe, there was less scope for diversion to other countries as there were few alternative means of transporting natural gas, and so a larger share of Russia's production was disrupted.

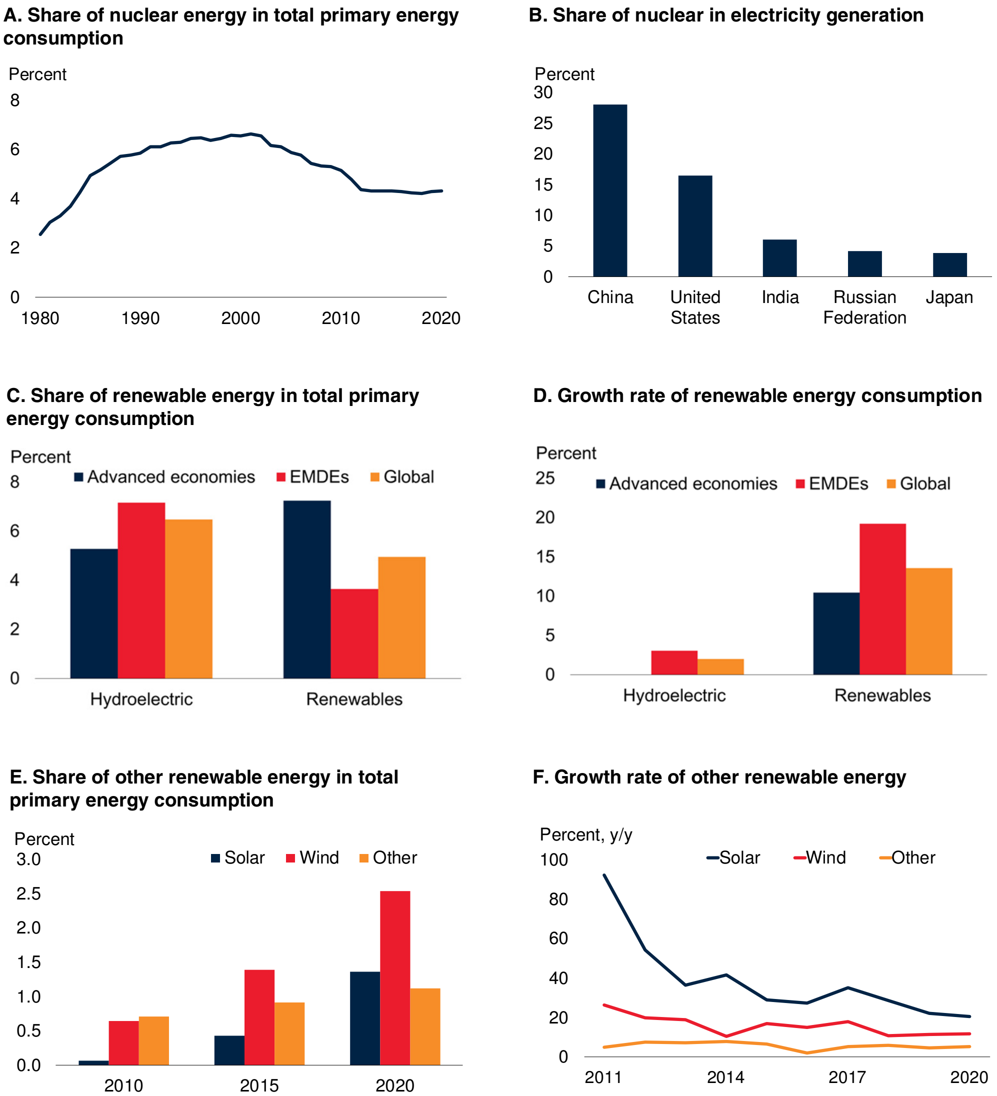
Nuclear energy

Commercial use of nuclear energy began in the mid-1950s and grew rapidly from the 1960s, with installed capacity increasing by about 20 percent per year between 1965 and 1988 (figure 1.6). The oil price shocks of the 1970s were a particular impetus for installation in several countries. For example, during 1970-1984, nuclear capacity in France rose from 6 terawatt-hours (TWh) to 191 TWh, such that nuclear energy accounted for about three-quarters of its total electricity production by 1985 (a share that has been fairly constant since then). The share of nuclear energy in total global energy consumption peaked at just under 7 percent in 2001, while its share of electricity generation was about twice as large. Currently, the United States is the world's largest producer of nuclear energy, accounting for about 30 percent of global generation.

The use of nuclear energy has been subject to opposition and restrictions, however, limiting its use (Gamson and Modigliani 1989). Opposition has focused on the

FIGURE 1.6 Nuclear and renewables

Collectively, low-carbon sources of energy (nuclear, hydroelectric, and other renewables) in 2020 account for about 16 percent of global energy consumption. While renewable energy and nuclear energy account for a larger share of total energy in advanced economies, consumption is growing much faster in EMDEs, particularly for renewables. Wind energy currently accounts for the majority of non-hydroelectric renewable energy and solar is the fastest growing source.



Sources: BP Statistical Review; World Bank.
Note: Renewables includes solar, wind, geothermal, biomass, and other non-hydro renewables.
B.C. Data for 2019.
D. Chart shows average annual growth rates over the period 2009-19
E.F. "Other" includes geothermal, biomass, and other non-hydro renewables.

potential dangers associated with nuclear energy, including the disposal of radioactive waste, nuclear accidents, and the risk of nuclear proliferation and terrorism. For example, nuclear installations declined sharply after the Chernobyl disaster in 1986. More recently, following the Fukushima nuclear accident in 2011, Japan temporarily shut down its nuclear power plants (although it has since restarted some of them). Germany decided to gradually phase out its use of nuclear power following the Fukushima accident, a process due to be finalized in 2022. This decision has resulted in contradictory policy objectives. As a decreasing share of electricity in Germany has been generated through nuclear sources, coal and natural gas have mostly filled the gap, despite the policy priority of reducing the use of fossil fuels in electricity production—and with major health and social costs (Jarvis, Deschenes, and Jha 2019).

Over the past decade, global nuclear energy production has risen because of growth in EMDEs, notably China. China's nuclear generation capacity grew by 17 percent per year, on average, between 2010-19. In contrast, nuclear generation in AEs has declined because of closures in several countries, including Germany and Japan. More recently, nuclear energy has been receiving renewed attention given the role it could play in aiding the energy transition as a reliable source of zero-carbon electricity (Birol and Malpass 2021). The International Energy Agency's net-zero emissions scenario envisions a 60 percent increase in nuclear energy over the next 30 years (IEA 2021b).

Renewable energy

Renewable sources of energy can be split into two main types—hydroelectricity and other renewables (such as solar, wind, geothermal, wave, tidal, and biomass). In contrast to fossil fuels, almost all energy from renewables is, at present, used to generate electricity. At present, renewables still account for a small share of global energy consumption: 11 percent in 2020, of which hydro accounted for more than half. However, installed capacity has been growing rapidly over the past decade, particularly non-hydro renewables. In general, the share of zero-carbon fuels in total energy consumption is larger in AEs than EMDEs, except for hydroelectricity (figure 1.6). This section focuses on hydroelectricity, solar, and wind.

Hydroelectricity

Hydropower is considered a more reliable base load source of electricity than solar and wind, since it is less intermittent, and output can also be varied to help with load balancing by redirecting water flow through dams.[9] However, since hydropower is dependent on plentiful water supplies, production faces increasing threats from climate change, in particular the heightened risk of droughts.[10] This occurred in 2021, when

[9] Hydropower can also be used to store energy in the form of "pumped" hydro. When there is excess electricity, water can be pumped from the bottom of a reservoir to the top, and when there is a need for electricity (including to meet large surges in demand) the dam can be used to generate electricity. Pumped hydro is one option to help address issues of storage associated with the use of other renewables.

[10] Hydroelectric dams also present the risk of dam failure, which can have very severe consequences.

hydropower in Brazil, China, and the United States was sharply reduced by drought, leading to increased demand for fossil fuels (World Bank 2021).

Hydroelectricity has been used as a source of electricity since the late 1800s. Capacity grew sharply throughout the 20th century, with its share of global energy rising from 1 percent of total energy in 1920 to 6 percent in the 1990s. Initial installations were primarily in AEs, but more recently new capacity has been concentrated in EMDEs. The largest producer of hydroelectricity is China, accounting for 31 percent of global production in 2020. In some countries, notably Brazil and Norway, hydropower is the primary source of electricity, accounting for more than 80 percent of total electricity.

Other renewables—solar and wind

The commercial use of wind and solar power to generate electricity began in the 1970s following the oil price shocks, although their adoption was initially relatively slow. By 2010, wind power accounted for just 0.6 percent of global energy consumption and solar power less than 0.1 percent. Over the past decade, however, their installation has accelerated, with solar capacity growing by almost 40 percent per year, since 2010, and wind power increasing by about 16 percent per year. Growth has been particularly rapid in EMDEs, with China currently accounting for the largest share of global renewables generation (more than one-quarter of total renewable generation capacity).

The increase in global renewable installation has been driven by a combination of improved technology and manufacturing processes, as well as government policies, which have collectively reduced the cost of solar generation by 90 percent since 2010 (IRENA 2020). Solar and wind power are now the lowest-cost sources of new electricity in most parts of the world. The ongoing energy transition is expected to lead to a large increase in the share of electricity generated by renewables, although this increase will require improvements in energy storage or backup generating capacity, since solar and wind power are more intermittent and seasonal than hydropower.

Metals

Overview

Metals have been used since prehistoric times to cast tools, weapons, and other objects. Copper was the first to find widespread use. In the Bronze Age (roughly 3000 BCE to 1200 BCE), copper was mixed with tin to form bronze, which produced stronger implements. Other metals were utilized in the period, such as gold, silver, mercury, and lead, as trade routes developed. The advent of the Iron Age (from 1200 BCE to 600 BCE) brought stronger iron-made weapons and tools, which included agricultural implements such as scythes and plows, boat rudders, and numerous other products.[11]

[11] The early adoption of copper (along with gold, silver, mercury, and lead) compared to iron ore reflected the lower melting temperatures of the former. Iron tools and weapons were also brittle. However, it was later discovered that heating wrought iron in a bed of charcoal, then quickly quenching in water or oil, would turn the outer layers into steel.

There was little fundamental change to iron and steel production technology until the Second Industrial Revolution in the late 19th and early 20th centuries. New technologies to mass-produce steel led to the displacement of cast iron; steel was lighter, stronger, and more cost-effective. Steel applications expanded and included railroads, bridges, buildings, factories, machinery, weapons, ships, and automobiles. Advances in mechanization—water pumps, drilling, loading, and hauling ores—also helped expand mining. For base metals, the use of copper expanded greatly from the late 19th century due to its use in electrical materials. Another major development was the mass production of aluminum by electrolysis.[12] Aluminum's strong and lightweight traits extended to many uses in transport, construction, packaging, electrical, and consumer goods. Aluminum demand grew rapidly, overtaking copper by volume in the 1960s, and today the volume of aluminum consumed is about two-and-a-half times that of copper.

Metal prices broadly declined during the 20th century due to advances in technology, efficiency improvements in processing and mineral extraction, and the discovery and development of large, low-cost mines (figure 1.7). Metal markets have experienced several boom-bust price cycles, with three longer-term cycles (Radetzki 2006). Strong post-WWII demand for the reconstruction of Western Europe and Japan and economic expansion in North America drove prices higher during the 1950s and early 1960s. A second cycle began in the 1970s, partly due to cost pressures following energy price shocks and the era of stagflation. A third cycle began in the 2000s, with the industrialization of China spurring enormous demand for metals—at a faster rate than previous industrial expansions—leading to higher prices. In all cases, prices eventually contracted because of recession, financial crises, or because high prices themselves generated additional supply. Apart from demand growth, a key reason for metal price cycles is the long lead times for discovery, exploration, and development. The average time from discovery to production for copper mines, for example, is 17 years (Khan et al. 2016). Consequently, at times of accelerated demand, a significant supply lag can occur and cause prices to rise. In contrast, softening demand is often met with lagged supply, causing prices to fall.

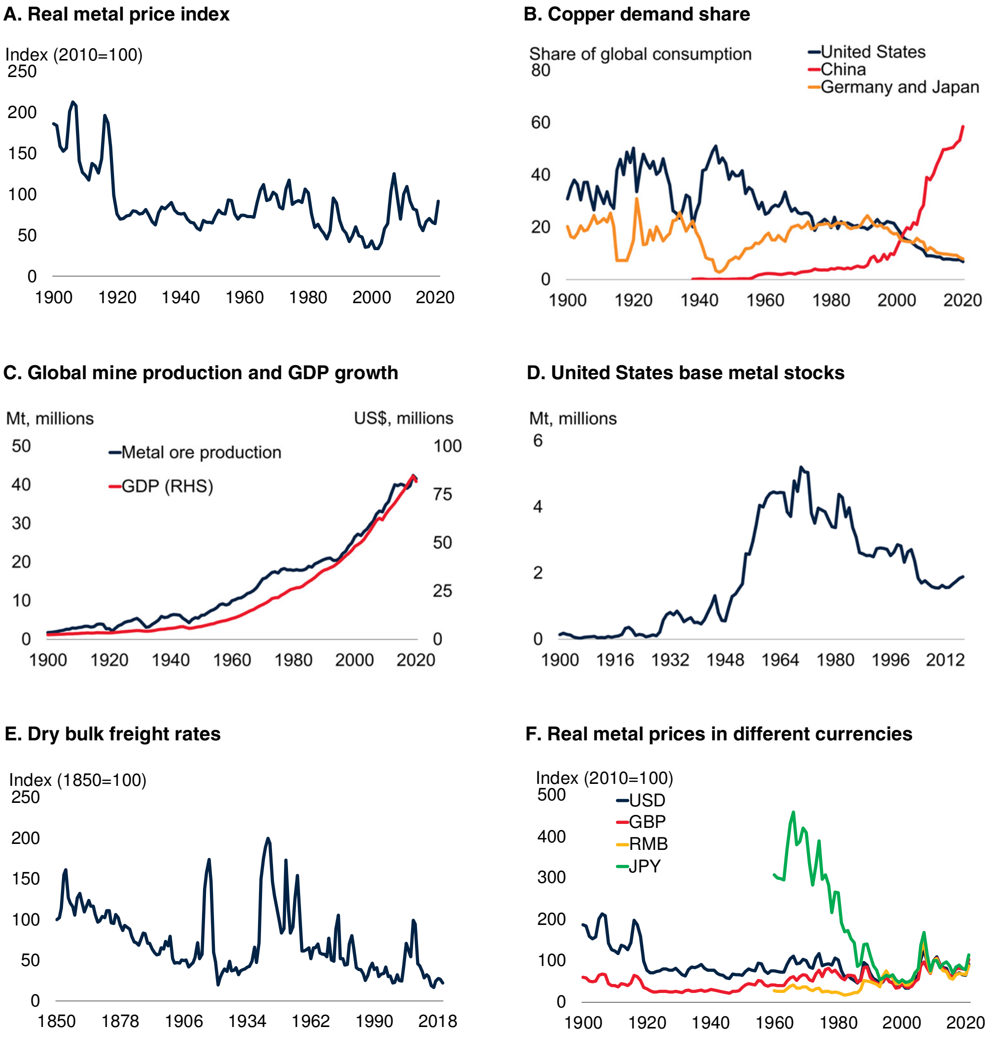
Since 2000, prices have rebounded largely due to surging import demand in China, which now produces and consumes over half the major base metals, iron ore, and steel, up from 10 percent two decades earlier. Yet metal prices have not moved in a uniform fashion. A striking example is the price differential between copper and aluminum. In 2001, copper and aluminum were trading at similar price levels. While the real price of copper rose nearly four-fold during the past two decades, the real price of aluminum was little changed, as China continued to build capacity in excess of domestic needs.

Over time, technological advances in production, such as ore leaching, solvent extraction, electrowinning, and productivity improvements, led to significant reductions in production costs for all metals, and to the opening of new sources of reserves. In

[12] According to USGS, global iron reserves are 230 billion metric tons, bauxite reserves are estimated at 55 to 75 billion metric tons, and copper reserves are 3.5 billion metric tons.

FIGURE 1.7 Drivers of metal prices since 1900

Metal prices have generally declined over the past 120 years, with decades-long boom and bust cycles (supercycles) around the trend. Spurts of industrialization of major economies, and a sluggish supply response, underlay such supercycles. Efforts by producer groups and governments to control prices through output restrictions, export bans, and stock accumulations have had limited success.



Sources: British Geological Survey; Federal Reserve Bank of Minneapolis; Jacks and Stuermer (2021); Maddison Historical Statistics; Mitchell (1988); Schmitz (1979); U.S. Bureau of Labor Statistics; U.S. Geological Survey; World Bank; World Bureau of Metal Statistics.

A. Index is a weighted average of the prices of aluminum, copper, lead, nickel, tin, zinc, and iron ore. Weights used are from World Bank *Pink Sheet.* Prices are deflated using U.S. CPI. Last observation is 2021.

B. Data for China available from 1938. Last observation is 2020.

C. Mine production of copper, lead, nickel, tin, and zinc. Growth rates are 5-year moving averages. Last observation is 2020.

D. Base metals are aluminum, copper, lead, nickel, tin, and zinc. Stocks held by industry, government, and commodity exchange warehouses. Last observation is 2017.

F. USD = U.S. dollar, GBP = British pound, RMB = Chinese renminbi; JPY = Japanese yen. Last observation is 2020.

addition, improved transport technology has reduced freight rates. The application of steam power enabled the movement of goods on land by rail and across oceans by steamships in the latter half of the 19th century. At the same time, bulk carriers allowed economic transport of low-value products such as bauxite, coal, and iron ore (Lundgren 1996). Dry bulk freight rates declined almost 80 percent in real terms from 1850 to 2020, contributing to declining metal prices for importers.

Metal and mineral markets have been subjected to policy interventions at both international and country levels (Radetzki and Wårell 2016). At an international level, various efforts by producer groups and governments have sought to influence prices. Producer cartels operated in the aluminum, copper, lead, nickel, steel, and zinc industries during the first half of the 20th century, and an international commodity agreement operated in the tin market until its collapse in 1985.[13] The latter used buffer stocks to adjust imbalances in global supply and demand in an attempt to prevent excessive fluctuations in prices and export earnings. Motives for public intervention at the country level included support of industry during the Great Depression and restoring supply lines during WWII. During the 1960s and 1970s, a move toward state control of foreign-owned metal assets occurred in Latin America and Africa, similar to a trend toward state controls in the oil sector in these regions and the Middle East.

Further ahead, demand for some metals may soften as global growth slows and China continues to rebalance its economy away from investment toward domestic consumption (chapter 2). Moreover, the global shift toward net-zero carbon emissions is likely to spur unprecedented demand for critical metals (e.g., aluminum, copper, cobalt, lithium, and nickel) in low-carbon technologies. Prices for these metals could remain elevated for a prolonged period. This will depend on the speed and direction of the energy transition, the volume of mining capital investment, environmental constraints on these industries, and policy measures and incentives.

Iron ore

Iron ore is the key raw material used to make steel, which is mostly used in construction, infrastructure, and transport, but also in machinery and consumer goods. Iron ore deposits are abundant, yet mining operations are concentrated in a few countries (Australia, Brazil, China, India, and Russia account for more than 80 percent of global output) by virtue of transport infrastructure and low energy costs. China is a large producer of iron ore, but domestic production is insufficient to meet the considerable demand of the steel industry (China produces 57 percent of the world's steel). In addition, China's iron ore is low-grade, expensive to process, and mines are being depleted. For steelmakers located in its coastal regions, the cost of domestic ore can be

[13] The high degree of metal production concentration has led to concerns about market manipulation and collusion. Metal production is typically concentrated in a few countries, and multinational or state-owned corporations have large market shares in the production and refining of some metals. For instance, three countries in Southeast Asia—Indonesia, Malaysia, and Thailand—together accounted for more than half of global tin mine production in the 1970s.

higher than the price of imports. Iron ore exports are dominated by Australia and Brazil, and China imports three-quarters of global trade. China is by far the world's largest iron ore consumer, accounting for more than 70 percent of global demand in 2020.

Prices of iron ore historically have been set by producers or determined following negotiations between major mines and steel companies. After WWII, reference prices in Europe were set by producers in Sweden and European steelmakers, with Brazil's main producer Vale (also known as CVRD, Companhia Vale do Rio Doce) taking over the producer role in the mid-1970s. In Asia, the rising importance of Japan's steel industry resulted in an Asia price benchmark arising from negotiations between Japanese steel makers and iron ore producers.[14] In 2005, with the rising importance of China in the iron ore market, this negotiated price system began to shift toward a more market-based reference price, and by 2010 negotiated prices ended. The main price benchmark became a spot delivered price at Chinese ports.

Since 2005, iron ore prices have been subjected to three large price cycles. The first peak was reached in 2008 and quickly slumped during the financial crisis, in line with the boom/bust of other commodities. A second boom in 2011-14 was driven by a strong rebound in demand (also in conjunction with a recovery in other commodity prices), ended by a slowdown in China imports and expanding ore supply. Prices increased moderately in 2015 following the collapse of Vale's tailings dam in Brazil. A third spike occurred in 2021 when the extraordinary demand for goods in the wake of COVID-19 (partly due to fiscal stimulus) resulted in strong global steel demand.

Copper

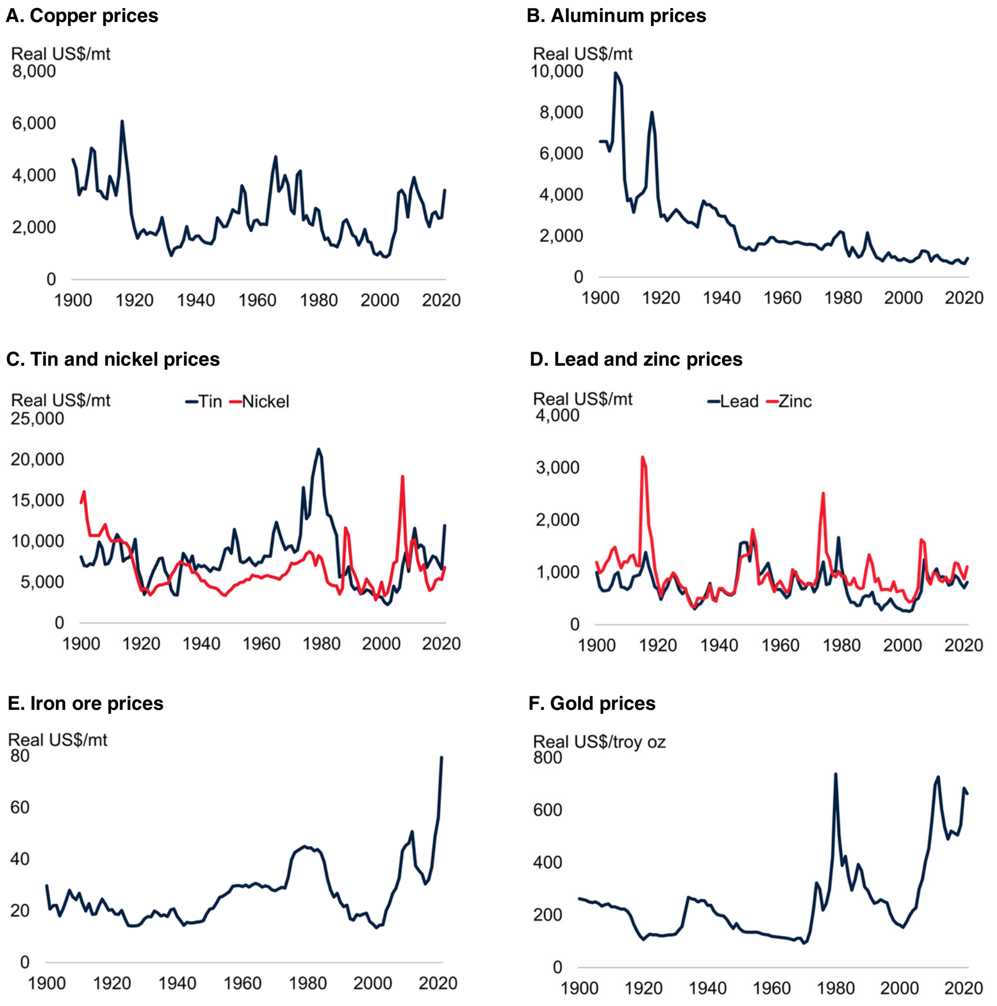
Copper is one of the oldest metals, along with gold and silver, and was historically used to mold utensils, jewelry, and weaponry. The discovery of smelting expanded the use of copper and allowed it to be alloyed with tin to yield a stronger product, bronze. The rise of iron and steel limited copper's expansion and was the first formidable competitor to copper (Radetzki 2009). In the late 18th century, the primary use of copper was to sheath the bottom of boats, but this use was later displaced by other alloys. In the late 19th century, copper use expanded due to its ability to conduct electricity and heat. The main uses of copper today are for construction, electric power infrastructure, industrial machinery, transportation, along with various consumer goods. Copper faces competition from plastics, fiberoptics, and aluminum, as well as efficiency improvements, particularly when prices are high.

Real copper prices declined during the 20th century amidst high volatility, with prices bottoming in 2001. The booms in copper prices coincided with major periods of industrialization that drove global demand for many metals (figure 1.8). Prices rose during most of the 2000s due to strong import growth in demand from China and lagging supply. Three price spikes have occurred since 2005: the financial crisis in 2008;

[14] Prior to 2005, iron ore prices changed infrequently, at most once a year, even during periods of inflation.

FIGURE 1.8 Real metal prices

Metal prices have always been volatile. There have been several periods of decades-long boom and bust cycles, particularly for copper, lead, and zinc. Aluminum prices have seen a long-run declining trend. Tin prices increased until 1985 when the international tin agreement collapsed. Iron ore and gold prices have increased substantially in the past few years.



Sources: Federal Reserve Bank of Minneapolis; Mitchell (1988); U.S. Bureau of Labor Statistics; World Bank.
A.-F. Prices are deflated using U.S. CPI (100 = 1982-84). Last observation is 2021.

the subsequent economic recovery in 2011; and the rebound from the pandemic in 2021. Looking ahead, while demand growth may mature and slow in some sectors, copper stands to benefit from the energy transition in wind turbines, solar panels, grid connections, electric vehicles, and battery charging infrastructure.

There have been numerous attempts to manage the market and influence prices. In 1887-89, the Secretan Syndicate led by the French fabricator Pierre Secrétan convinced bankers and investors to corner the market and lift prices on the London Metal Exchange (Slade 2020). It brought forth more supply than the syndicate could purchase, and the scheme collapsed. In 1899, the Amalgamated Copper Company was formed to consolidate the industry, resulting in a controlling stake in the Anaconda Copper Mining Company in Montana. The trust curtailed production and exports to Europe, causing prices to soar. This stimulated higher production by other producers. When Amalgamated released copper stocks in 1901, prices fell sharply (Herfindahl 1959). Several subsequent attempts at price manipulation have led to short-term price swings (Mueller and Gorin 1985). The first copper cartel, managed by the Copper Export Association, was formed in 1918 to liquidate large inventories accumulated during World War I (WWI), and was disbanded in 1924 after achieving its aim (Walters 1944). A second cartel, Copper Exporters Inc., was formed in 1926 to restrict output, but its power declined after the Great Depression. A third attempt to manage the copper market, the International Copper Cartel, did not have a major influence on prices, although it may have smoothed them somewhat (Guzmán 2018).

During the first half of the 20th century, copper production was dominated by a few U.S. multinational companies, notably Anaconda, Kennecott, and Phelps Dodge. Copper production grew slowly until WWII, but then expanded rapidly during the post-war industrial expansion. Nationalization of assets in the 1970s, notably in Chile and Peru, altered the structure of the local industries, although the adverse experience in Peru led to privatization in the 1990s (Lagos 2018). Subsequent improvements to the business climate and property rights in Latin America and Africa were an underlying factor encouraging the establishment of new mines (IMF 2015). Many new high-grade copper mines in Chile, such as Escondida, commenced production in the early 1990s. As a result, Chile accounted for about 35 percent of global copper supply in the 2000s. New greenfield copper mines in the Democratic Republic of Congo, Peru, and Zambia began production after 2010, reducing Chile's share to 27 percent by 2020. The growth in global mine supplies slowed after 2016 following a period of low prices. Growth was also negatively impacted by COVID-19-related disruptions.

Aluminum

Widespread use of aluminum is a relatively new development. When production began in the late 19th century, aluminum was used only in luxury items. However, significant improvements in the smelting process greatly reduced the cost of production.[15] Because of its light weight, strength, conductivity, and corrosion resistance properties, aluminum is now used in a wide range of industries, including construction, transportation, electrical, packaging, machinery, and consumer goods. It has taken market share from other metals, notably copper and tin. As with other metals, aluminum faces competition from other materials, namely carbon fiber, plastics, glass, and alloys.

[15] The Hall-Héroult process, developed in 1886, allowed large-scale commercial production, while the Bayer Process, developed in 1889, enabled bauxite to be refined to produce alumina (aluminum oxide), which is then refined to aluminum metal at a much lower cost.

Aluminum prices have declined significantly in real terms over the past 120 years. Unlike price spikes in the 2000s for other metals, aluminum prices have remained relatively flat—mostly in response to expansion of smelting capacity by China. However, steps by China to reduce emissions and energy consumption have led to a tightening in the aluminum market and, thus higher prices in 2021 (box 1.2 places China's industrialization and commodity demand in a historical context). The industry has also benefited from recycled aluminum, which has risen to one-third of global aluminum production and is much less energy-intensive than primary production.

Similar to other metals, aluminum prices have been affected by numerous policy interventions, both at the domestic and international level. The industry was marked by a continuous series of cartels until WWII (Bertilorenzi 2013). At the turn of the 20th century, five companies dominated the market—U.S. Alcoa, British Aluminum, Swiss AIAG, and two French companies. Three cartels were formed between 1901 and 1923 to set prices and allocate quotas; each ended because of competition from new entrants, recession, or war. In 1926, the European companies signed an agreement, but Alcoa stayed out because it was under antitrust scrutiny. The company spun off its non-U.S. holdings to its Canadian affiliate Aluminum Limited (later Alcan), and in 1931 Aluminum Limited joined the European companies to form a Swiss holding company, the Aluminum Alliance Company (Storli 2014). The aim was to allocate output during the Depression, which required the company to purchase excess stocks. Although the most successful aluminum cartel, it ended in 1939 with the start of WWII.

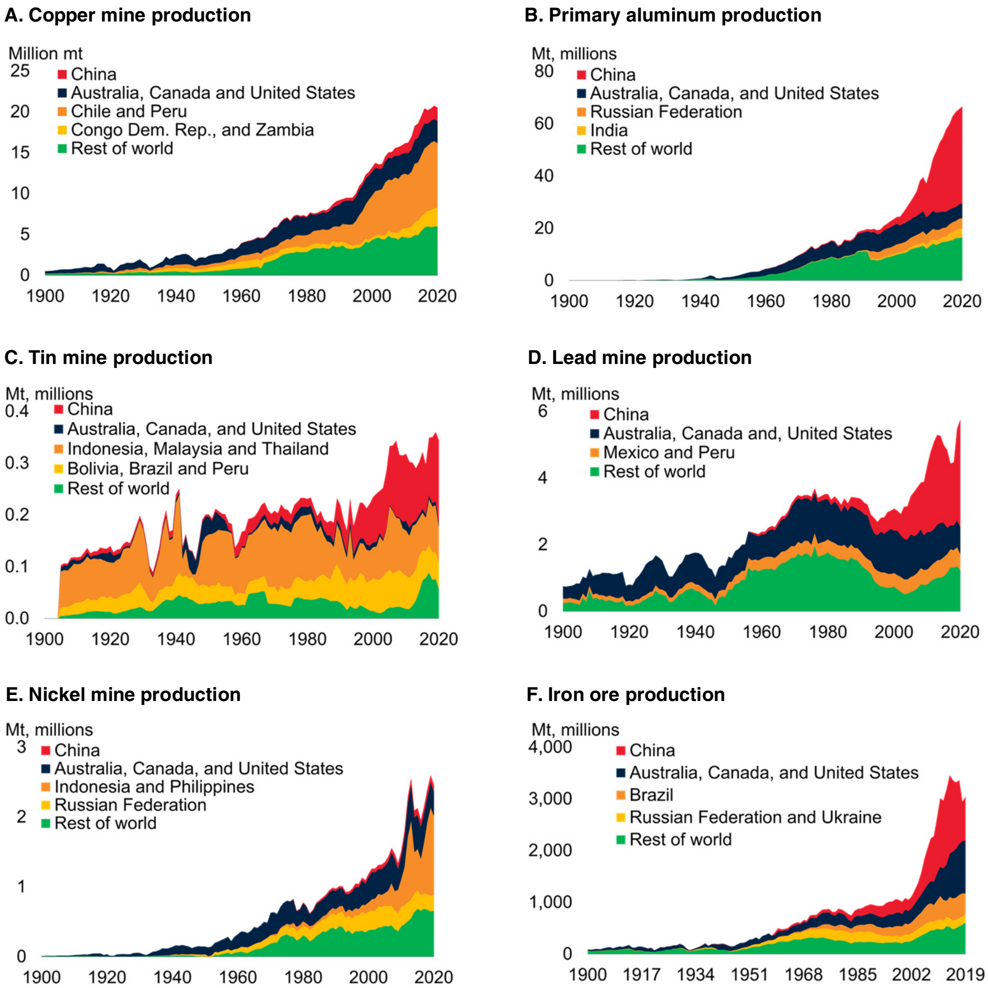
While official pre-war cartels stopped after 1945, cartel-like behavior continued, and an agreed price list was set (Bertilorenzi 2016). Anti-trust action was taken against Alcoa after World War II, but by the 1950s new entrants to the market dissuaded the government from breaking up the company. The European Commission also accused the industry of criminal cartel behavior in the 1970s. The era of cartelization ended in 1978, however, with the start of an aluminum futures contract on the London Metal Exchange (LME).

Since 1978, global production has increased five-fold in response to strong industrial demand and new applications (figure 1.9). China has accounted for 70 percent of the gain, partly owing to abundant coal-powered energy in the western and north-western regions. Outside China, given the energy-intensive nature of aluminum smelting, there has been a shift to concentrate production in countries with low-cost electricity, such as Canada, India, Norway, Russia, and United Arab Emirates. There have been significant changes in sources for the raw material bauxite and intermediate product alumina. Previously, bauxite and alumina production were concentrated in a few advanced economies, even though they were poorly endowed with bauxite reserves. The geographical location of alumina production has now shifted toward countries with access to abundant sources of bauxite (Nappi 2013). China is the largest alumina producer and imports more than two-thirds of its bauxite.

Looking ahead, aluminum is a critical raw material in the global energy transition, given its use in battery packaging, hydrogen fuel cells, and solar photovoltaics. However, the energy-intensive nature of the industry is also a significant source of greenhouse gas

FIGURE 1.9 Production of metals since 1900

Global metal production has shifted from advanced economies to EMDEs. In the early 20th century, production was dominated by a few industrialized countries such as the United States, Canada, and Australia. Today, Asia, Africa, and Latin America account for most of the world's metal supplies.



Sources: British Geological Survey; Schmitz (1979); U.S. Geological Survey; World Bank; World Bureau of Metal Statistics; WorldSteel.
A.-E. Last observation is 2020.
F. Last observation is 2019.

emissions. The ongoing strategy to site smelters near low-cost hydropower has the added benefit of constraining emissions.

Other base metals

Tin

Tin usage dates to antiquity when it was mixed with copper to produce bronze, tools, and weapons. Tin plating for cans began in Britain in the early 19th century and by the mid-20th century over half of tin use was for plating in cans for beverages and food. However, it was gradually displaced by aluminum and other materials, including plastic, recyclable glass, and more recently paper. Today over half of tin supplies are used in solder for electronics. Other applications include industrial chemicals, tin plating, and lead-acid batteries. Tin's use in small electronic components (used mainly in electric vehicles, solar panels, and battery storage) makes it critical to the low-carbon economy.

Unlike other base metals, tin prices rose in real terms throughout most of the 20th century. Prices increased sharply after World War II, driven mainly by rising demand from post-war reconstruction in Japan and Korea. Prices were also supported by policies, including the accumulation of inventories by the U.S. government in response to post-WWII supply concerns. Real prices peaked in 1979 but declined sharply in 1985 following the collapse of the Tin Agreement (discussed below). Tin prices boomed during the early 2000s in response to strong demand from China. Following a period of relative stability, prices surged again during COVID-19 in response to strong demand for tin-solder-contained electronics and household appliances.

During most of the 20th century, four countries—Bolivia, Indonesia, Malaysia, and Thailand—dominated global tin supplies. Today, China is the largest producer with almost half of the world's tin mine production (up from 5 percent in the 1980s), followed by Indonesia and Peru. Historical production trends for tin have been much more volatile than other metals due to interventions to manage supply and prices.

Policy intervention in the tin market began in the early 20th century, starting with the formation of the Bandoeng Pool in 1921, which attempted to stabilize prices through inventory management. The pool was dissolved in 1924 when its stocks were exhausted (Baldwin 1983; Thoburn 1994). In 1956, 24 consuming and producing countries began a series of agreements aimed at stabilizing prices through buffer stock management. Each agreement was modified to account for membership and policy changes (Chandrasekhar 1989). However, tensions mounted between producer and consumer interests, with price targets shifting from a mutually-agreed narrow band to one that favored producers. When global tin consumption fell in the early 1980s due to recession and substitution by aluminum, stocks began accumulating (Mallory 1990). The withdrawal of the United States (a member of only the fifth tin agreement) and Bolivia, along with mounting financial difficulties, led to the agreement's insolvency in October 1985 and the suspension of buffer stock activity. Tin prices plunged and financial burdens were absorbed by bank lenders, LME traders, and tin miners (Prest 1986).

Lead and zinc

Lead has been used since ancient times and was widely used in the Roman Empire, especially for water pipes.[16] Its corrosion-resistant properties and malleability, along with its low boiling-point temperature and easy extraction from ores, made it a popular metal

[16] Lead has been in use since at least 6500 BCE in Ancient Egypt. Lead was commonly used as roofing material in Europe during the Middle Ages, for instance, as well as in ammunition.

for ammunition, material for ships, underwater cables, and roofing. Lead was later used as an additive in various chemical applications, including paint and glass, and later as an additive to increase the octane rating of gasoline. The chemical uses, however, have been reduced or eliminated due to the metal's high toxicity and negative environmental impact. Today's primary use of lead is in lead-acid batteries, which account for four-fifths of global consumption.

Lead is often mined as a by-product of other metals—mainly zinc, but also copper and silver. Lead mine production grew during the post-WWll reconstruction. Most lead was produced in the Americas, followed by Europe and the Soviet Union. Production fell sharply after the collapse of the Soviet Union and reduced demand due to its health and environmental issues. Today, China is the world's dominant lead producer, accounting for more than half of global output. Mine supply accounts for only one-third of global consumption due to the high rate of recycling from the battery sector—lead can be recycled indefinitely without any decrease in quality.

Although lead prices have followed a downward path during the 20th century, they have been subjected to volatility in response to policies, environmental regulations, technological change, and, on some occasions, market manipulation.[17] For example, prices declined during the Great Depression, but they rose sharply after World War II following stockpiling policies by the United States in 1951. In the 1960s, prices were relatively stable, partly due to the lead and zinc mining stabilization program in the United States (Smith 1999). Prices increased in the 1970s amidst strong demand from centrally planned economies but fell sharply in the early 1980s due to the global recession. They remained low in the years that followed due to the gradual phaseout of lead from gasoline, paints, solders, and water systems. Prices, however, rebounded after 2000 amid surging demand for batteries (both for vehicles and backup storage of electricity) and supply restrictions stemming from environmental constraints associated with mining and processing. Given lead ore is a by-product of zinc production, the eventual phaseout of lead in batteries would affect the economics of zinc mining.

Zinc is the third most utilized non-ferrous metal, after aluminum and copper. Its traditional use (since antiquity) has been as an alloy with copper to form brass. More recently it has been used as an anti-corrosion material to galvanize steel. Zinc is also used as an alloy in the manufacturing of electrical components, and to produce zinc oxide, which is used for rubber manufacture and skin ointment. As with other metals, China accounts for half of global consumption owing to its vast steel production. Zinc is mined in many countries, and, like other metals, production has shifted from AEs to EMDEs. The expansion has been most notable in China in the 2000s. The country currently produces more than one-third of global mine output, with Australia and Peru the next largest producers (chapter 4).

[17] For example, in 1909 the Metallgesellschaft, a German company which controlled most of global output, withheld lead from the market to push prices up (Gibson-Jarvie 1983).

BOX 1.2 Industrialization of China and commodity demand in historical context

The structure of global industrial commodity demand has changed fundamentally over the past quarter-century. Advanced economies' share of energy and metals consumption has declined markedly. Meanwhile, China has emerged as the world's largest consumer, accounting for more than half of global demand for coal, metals, and iron ore. While China's industrialization draws many parallels with earlier industrializations, such as those of the United Kingdom and the United States, the speed of its ascent has been without precedent.

Introduction

Global metals consumption more than doubled during 1995-2020, with China accounting for 90 percent of the increase. Global energy demand rose 50 percent, with China contributing nearly three-fifths of the increase, mainly in the consumption of coal (Chapter 2). The unprecedented commodity demand surge has coincided with strong and sustained growth in emerging market and developing economies (EMDEs). During 1995-2020, economic growth in EMDEs was 5.5 percent per year, while in China it was 8.8 percent, increasing its per capita income from $540 to $10,550 (World Development Indicators).

To better understand the structural shifts and their likely impact on future commodity demand, this box places the post-2000 industrial commodity demand boom into historical perspective by comparing it with three earlier surges in commodity demand: the Industrial Revolution in the United Kingdom from the late 18th century to the second half of the 19th century; the industrialization in the United States after the Civil War; and the post-WWII reconstruction and expansion in Europe and Japan. Specifically, this box examines the following two questions:[a]

- How has the structure of global industrial commodity demand changed over the past 25 years?
- How does China's structural shift in industrial commodity demand compare to major industrialization episodes since the 19th century?

Recent changes in the composition of industrial commodity demand

Over the past 25 years, the geographic location of global industrial commodity demand has undergone a fundamental change. In 1995, advanced economies accounted for one-half of global energy and nearly three-quarters of global metals

a. These demand surges have been studied in the context of price "super cycles" – that is, price cycles that are primarily demand-driven and which may last several decades from peak to peak (Cuddington and Jerrett 2008; Erten and Ocampo 2013; Heap 2005; Jacks 2013; Stuermer 2018). In contrast, the typical business cycle has a duration of just a few years (see Chapter 3).

BOX 1.2 Industrialization of China and commodity demand in historical context *(continued)*

consumption. By 2020, their share of energy consumption had declined to 34 percent, while their metals share fell to less than 25 percent.

Over the same period, demand from China increased enormously, underpinned by a rapid expansion of resource-intensive investment and manufacturing exports. Consumption of primary energy and, especially, metals is strongly correlated with industrial production (Chapter 2). During 1995-2000, China's share of energy consumption more than doubled while its share of metals consumption increased six-fold, from 9 percent to 57 percent.

The acceleration of China's industrial commodity demand has been much stronger than other fast-growing, large EMDEs. For instance, although India's share of consumption of oil and coal doubled, in line with the increase in its share of global GDP, its share of metals consumption increased only marginally. Other EMDEs collectively saw little change in their share of global commodity demand.

Coal contributed nearly 85 percent of the increase in China's energy consumption. Today, China consumes more than half of the world's coal, up from 30 percent in 1995 (figure B1.2.1). The country's dependence on coal reflects, in part, its large coal reserves (Chapter 4). Although China's share of global oil consumption more than doubled over the same period, at 17 percent it is in line with the country's share of global GDP.

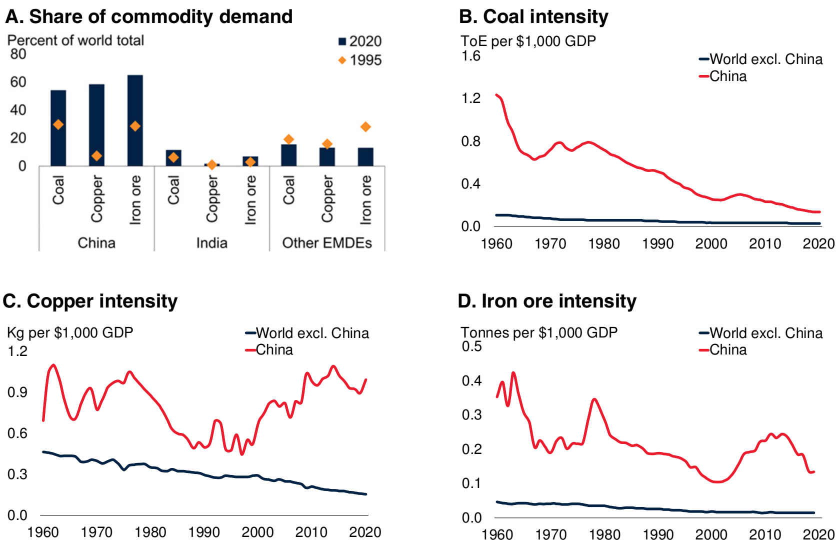
The increase in China's metal consumption has been even more remarkable. Its share of global copper consumption increased from 7 percent to 58 percent during 1995-2020. Consumption of other metals show similar trends. The sharp rise in coal and iron ore demand has been driven, in large part, by the growth in Chinese steel production. Both coal and iron ore are key inputs in steel production. Coal is heavily used in the production of aluminum—about 90 percent of the electricity used in Chinese aluminum production is generated from coal.

Commodity consumption relative to GDP—often termed intensity of consumption—reveals some important trends. China's coal intensity follows a downward trend, similar to the rest of the world, in part reflecting a shift away from fossil fuel use. Its copper intensity, however, which was declining until the late 1990s, reversed its trajectory. This is in sharp contrast to the steady downward trajectory in the rest of the world. Similarly, its iron ore intensity picked up after 2000, although it began to fall in 2014. These diverging trends in intensity attest to the importance of country-specific developments at work in China, notably the focus on investment for construction, infrastructure, and manufacturing for domestic use and export, which are much more metals intensive than for other consumption and services.

BOX 1.2 Industrialization of China and commodity demand in historical context *(continued)*

FIGURE B1.2.1 Changes in the composition and intensity of industrial commodity demand

Over the past 25 years, China's share of global energy consumption more than doubled, while its share of global metals consumption rose more than six-fold. The pace of China's commodity demand growth was much stronger than in India and other fast-growing, large emerging markets. Today, China accounts for more than half of the world's consumption of coal, metals, and iron ore. China's "energy intensity" has continued to decline, in line with the rest of the world. However, its metal intensity, which fell until the late 1990s, has since trended upward.



Sources: BP Statistical Review of World Energy; British Geological Survey; International Historical Statistics; U.S. Geological Survey; World Bank; World Bureau of Metal Statistics; World Steel Association.
Note: Commodity intensity is defined as the ratio of material used per unit of output.
A. Share of country or country group in world total. Latest data for iron ore is 2019.
B.-D. GDP in constant 2015 U.S. dollars.

Industrial commodity demand since the 19th century

To place China's structural shift of industrial commodity demand in a broader and longer-term context, this section compares its recent industrial ascent with three historical episodes of industrialization.

- *Industrial Revolution in the United Kingdom.* This began in the late 18th century and continued throughout the 19th century. Coal fueled the Industrial Revolution due to its use in factories, railway locomotives, and steamships. As an efficient fuel, it was essential for turning iron ore into the

BOX 1.2 Industrialization of China and commodity demand in historical context *(continued)*

iron, and later steel that was used to build ships and railways (Clark and Jacks 2007). The advent of electricity in the late 19th century heralded a vast increase in copper demand for electrical wiring. The smelters in Swansea, Wales, processed much of the world's copper ore due to Britain's superiority in smelting technology (Radetzki 2009; Evans and Saunders 2015).

- *Industrialization in the United States.* This began in the mid-1800s and accelerated in the 1870s, after the Civil War. Innovations in mining and smelting techniques developed in the United States resulted in a dramatic expansion of the global copper market. The first half of the 20th century featured electrification and mass production of steel, automobiles, telecommunications, chemicals, and mechanized agriculture.

- *Post-WWII reconstruction of Europe and Japan.* This began after WWII. The postwar reconstruction in Europe was assisted by financing through the U.S. Marshall Plan (Eichengreen and Uzan 1992). The recipient countries underwent similar rapid growth in construction, infrastructure, and manufacturing that the U.K. and the U.S. experienced earlier.

The remarkable trends in commodity consumption brought about by these industrializations are clearly evident in figure B1.2.2, which shows country shares of global demand dating back to the 1800s for coal, iron ore, and copper.

Copper. During the industrialization cycles described above, the share of global copper demand peaked in the United Kingdom at 60 percent (the late 1870s), the United States at 58 percent (1945), and the combined shares of Western Europe and Japan at 40 percent (early 1990s). While it took many decades to reach the peaks in the United Kingdom and the United States, the expansion in Europe/Japan was shorter. In contrast, China's share of global copper demand rose at unprecedented speed, from less than 10 percent in the 1990s to 58 percent in 2020. This is broadly similar to the peak shares in the United Kingdom and the United States, suggesting that China may also be near its peak. Its consumption, however, is showing no sign of plateauing.

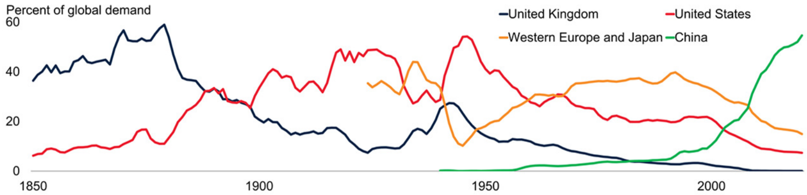
Coal. The United Kingdom's share of global coal demand exceeded 60 percent in 1850 and has since steadily declined toward zero. In the United States, its share peaked at 50 percent in 1918, while the combined shares of Western Europe and Japan hovered around 20 percent until 1970. Both have since declined, but coal remains a sizeable component of electricity generation in both areas. In contrast, China's share of global coal demand surpassed 50 percent in 2013, up from 20 percent in 1986. Its coal consumption has broadly plateaued in recent years, and the country intends to start phasing it out beginning in 2026.

BOX 1.2 Industrialization of China and commodity demand in historical context *(continued)*

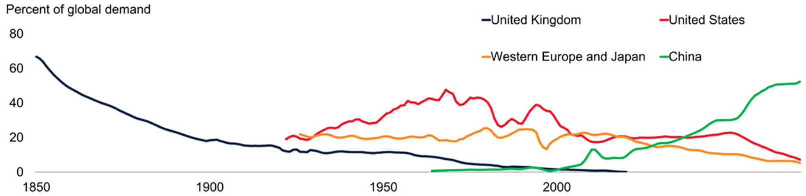
FIGURE B1.2.2 Commodity demand during major industrialization periods

Four major periods of industrialization have driven commodity demand growth since the beginning of the 19th century: the Industrial Revolution in the United Kingdom beginning in the late 1700s; industrialization in the United States after the Civil War; post-WWII expansion of Western Europe and Japan; and the industrial rise of China since the 1990s. China's strong and sustained commodity demand growth is consistent with the experiences of earlier industrializing countries, but its remarkable pace has been unprecedented.

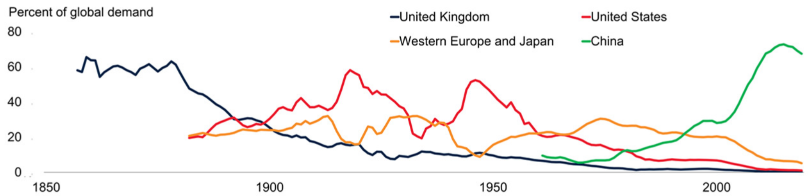
A. Copper demand



B. Coal demand



C. Iron ore demand



Sources: Abstract of British Historical Statistics; BP Statistical Review of World Energy; British Geological Survey; Bureau of Mines Minerals Yearbook; Historical Statistics of the United States; International Historical Statistics; Lemon (1838); Mineral Statistics of the British Empire and Foreign Countries; Statistical Summary of the Minerals Industry; Schmitz (1979); Smil (2017); Stuermer (2017); The Copper Handbook; U.K. Department for Business, Energy & Industrial Strategy; U.S. Energy Information Administration; U.S. Geological Survey; World Bank; World Bureau of Metal Statistics; World Steel Association.

A.-C. Share of country or country group in world total. Share of global consumption plotted as 3-year moving average to improve readability. Where consumption is not available, apparent consumption (production + imports - exports) is used. Where there is missing data, especially in the earlier years, linear interpolation is applied.

A. Data from 1850 to 2020.

B. Data from 1850 to 2020.

C. Data from 1857 to 2019. China's iron ore consumption based on gross weight.

BOX 1.2 Industrialization of China and commodity demand in historical context *(continued)*

Iron ore. The declines in advanced countries' shares of iron ore are similar to coal. However, the huge increase in China's demand for the metal is even more striking than that of coal. Its share of global iron ore demand reached 73 percent in 2013, up from 20 percent in 1991. The rate of increase and the current market share of China's consumption has no historical equivalent.

In terms of intensity of use, China's per capita consumption of copper and coal is now comparable to that of the advanced economies when they had similar per capita incomes (figure B1.2.3). Despite China's extensive use of coal, its peak per capita coal consumption is much lower than the United Kingdom and the United States, partly reflecting the broader range of fuels available today. For example, in 1860, nearly all primary energy consumption in the U.K. came from coal; similarly, in the United States, 80 percent of energy consumption in 1910 was from coal.

Iron ore, however, presents a vastly different picture. China's per capita consumption has reached levels far beyond those seen in earlier industrialization episodes. This is driven almost entirely by the growth in steel production for domestic and export markets. The primary domestic sources of demand for steel are for construction, infrastructure, and manufacturing. A large part of the increase in construction and infrastructure has been driven by the large growth in China's urban population, from 20 percent in 1980 to more than 60 percent in 2020.[b] Rising incomes and new housing have in turn led to increased demand for steel-using durable goods such as automobiles, machinery, and home appliances.

Conclusion

Global commodity demand has shifted significantly over the past 25 years from advanced economies toward EMDEs. The shift has been concentrated in China, which today accounts for more than half of the global demand for coal, metals, and iron ore. Many features of China's industrialization and commodity demand growth are broadly in line with the experiences of the United Kingdom and the United States in the 19th century and early 20th century, as well as in post-WWII Japan and Europe. However, the speed at which China's consumption of commodities has increased, especially iron ore, is unprecedented. This reflects China's rapid industrialization and export-led economy. In addition, a massive shift of population into urban areas has driven large-scale infrastructure projects and soaring residential investment, amplifying the demand for steel and iron ore.

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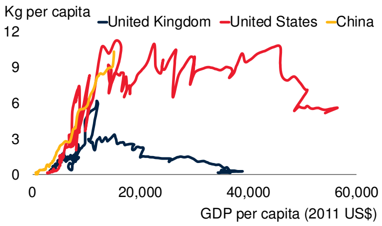
b. In contrast, it took the United States 80 years (1860-1940) to achieve a similar degree of urbanization (Boustan, Bunten and Hearey 2013).

BOX 1.2 Industrialization of China and commodity demand in historical context *(continued)*

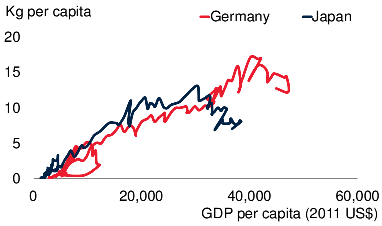
FIGURE B1.2.3 Consumption of industrial commodities per capita and income per capita

The growth in China's per capita consumption of copper and coal has been similar to the run-up in other industrializing nations. However, the pace and scale of China's per capita consumption of iron ore—a key raw material in steel production—has been unprecedented, reflecting China's rapid economic development, industrialization, and urbanization. The primary sources of demand for steel in China are residential property construction, public infrastructure, and manufacturing.

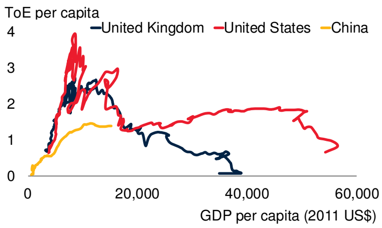
A. Copper in U.S, U.K. and China



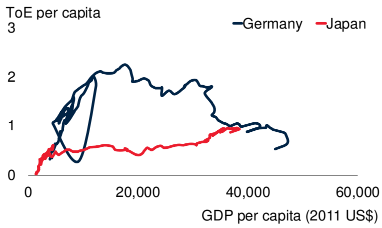
B. Copper in Germany and Japan



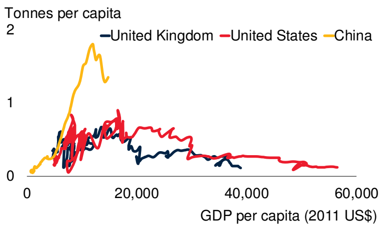
C. Coal in U.S, UK and China



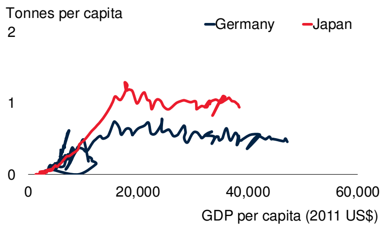
D. Coal in Germany and Japan



E. Iron ore in U.S, UK and China



F. Iron ore in Germany and Japan



Sources: Maddison Project Database; World Bank; and sources in figure B2.2.2.

A-C. GDP per capita in constant 2011 U.S. dollars. Lines show the evolution of income and commodity consumption per capita. Where consumption is not available, apparent consumption (production + imports - exports) is used. Where there is missing data, especially in the earlier years, linear interpolation is applied.

A.B. Data from 1820 (A) and 1850 (B) to 2020.

C.D. Data from 1820 (C) and 1872 (D) to 2020.

E.F. Data from 1855 to 2019. China's iron ore consumption based on gross weight.

The price dynamics of zinc are broadly similar to lead, although price peaks have been sharper. Previously cartel behavior influenced prices, and there were several attempts at cartel action since (Stuermer 2018). For example, some European producers in the 1960s attempted to form a cartel but ultimately failed to stabilize prices (Tolcin 2012).

Nickel

Nickel has been known since ancient times, but it wasn't available for use until technological improvements during the industrial revolution made its separation from other minerals possible. The first commercial nickel smelting facility was developed in Norway in 1848. Nickel's resistance to corrosion makes it an important alloy, especially in stainless steel, where about 70 percent of nickel demand resides. Nickel is also used as an alloy for nickel steels, nickel cast iron, brass, and bronze. Other uses include rechargeable batteries and lithium-ion batteries, used in electric and hybrid vehicles.

Real nickel prices experienced a broad decline during the 20th century. Post-WWII demand helped lift prices through the 1970s, but the recession of the early 1980s and the emergence of lower-cost suppliers drove prices lower. Following the breakup of the Soviet Union, large volumes of nickel were released into the global market. Combined with weak demand during the East Asian financial crisis, this pushed prices to historical lows in 1998. The demand boom in China (which today accounts for more than half of the world's nickel demand), alongside recent growth in use in batteries, reversed the downward price trend.

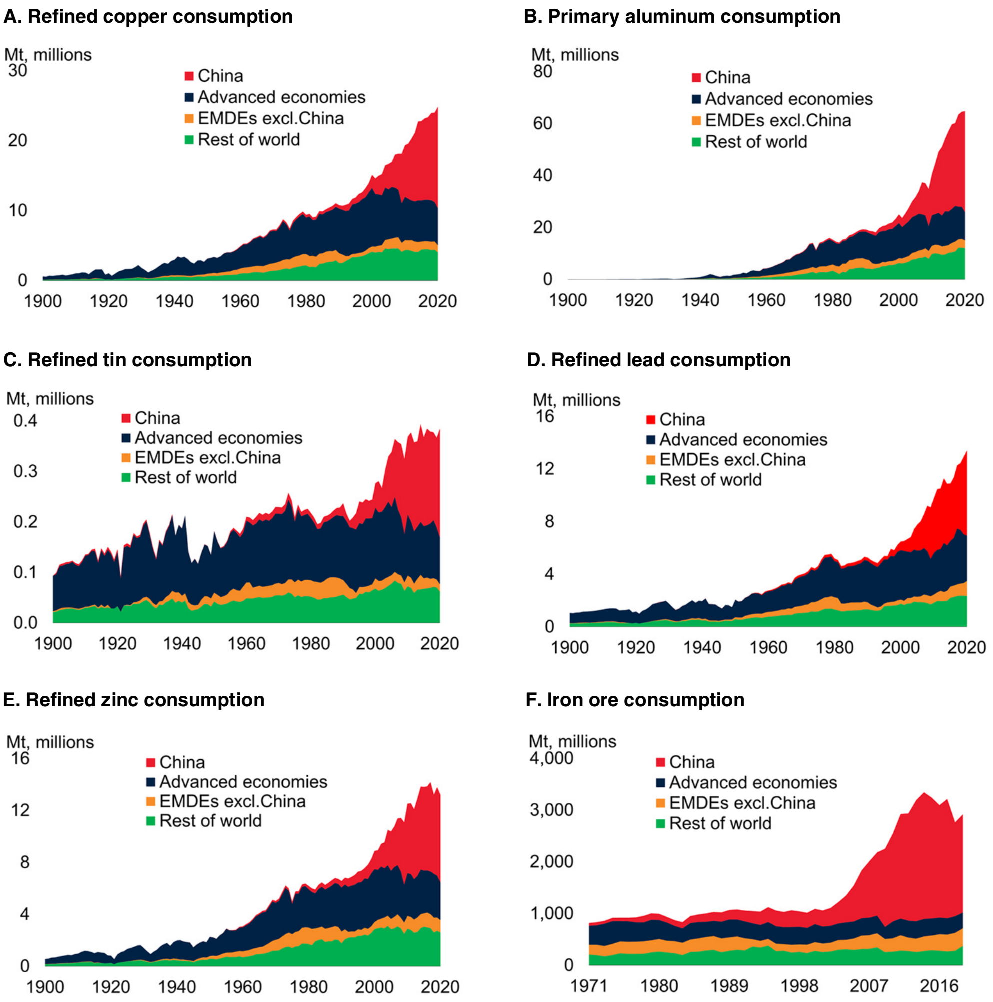
Nickel is found in two types of ores. First, from sulfide ores, which are typically found in underground rock formations, especially in Canada and Russia (figure 1.10). Second, from laterite ores, found near the surface of humid, tropical areas— such as Indonesia, the Philippines, and New Caledonia. Sulfide was the preferred ore due to its higher purity and less complex production process, but technological improvements in laterite ore (the majority of global reserves) made it profitable in the 1970s and it is used extensively today.

Historically, New Caledonia has been key nickel supplier, but Canada emerged as the dominant producer in the 1960s. Canadian International Nickel Company enjoyed a near monopoly outside the former Soviet Union, setting global prices and thereby extracting considerable resource rents (Kooroshy and Preston 2014). However, the emergence and subsequent profitability of laterite ore weakened the oligopoly structure of the industry (Erhlich 2018). Furthermore, the introduction of a futures contract in 1979 by the LME gave a further impetus to competitive pricing (Kuck 1999).

Trade flows and prices of nickel have been affected by trade policies as well, especially by Indonesia, the world's largest nickel producer. In 2014, Indonesia introduced an export ban on unprocessed ores in order to increase the country's share of the value added to its mineral resources (UNCTAD 2017). Following a sharp fall in exports, Indonesia relaxed the ban in 2017 but re-introduced it in 2020.

FIGURE 1.10 Consumption of metals since 1900

In 1900, Europe and the United States consumed almost all of the world's metal output. Today, China alone accounts for 50 to 60 percent of global consumption.



Sources: British Geological Survey; Schmitz (1979); Stuermer (2017); U.S. Geological Survey; World Bank; World Bureau of Metal Statistics; WorldSteel.

Note: EMDEs excluding China consists of India, Russian Federation, and Brazil.

A.-E. Last observation is 2020.

F. Last observation is 2017.

From an energy transition perspective, nickel is deemed a "winner" commodity due to the ongoing electrification of transport and growing demand for large-scale battery storage capacity for wind- and solar-generated electricity. However, further advancements in battery technology will determine which type of commodity will be in high demand, and ultimately which will gain a dominant position in global production.

Precious metals

Gold has been used by humans since ancient civilizations, first used for jewelry and later as a store of wealth and medium of exchange. Jewelry and transactions remained the most important uses of gold well into the 20th century. Britain was the first to adopt a gold standard for its currency in 1821 and had been on a de facto gold standard since 1717 (George 2012). The price of gold has been intricately linked with the gold standard, in use during 1871-1914, during the interwar period, and during the Bretton Woods (1944-71) period. This kept the price of gold stable for two hundred years until U.S. Gold Reserve Act of 1935 raised it from $20.67 per troy ounce (toz) to $35/toz (Cooper 1982). During the Bretton Woods period, the U.S. dollar was the principal reserve currency, with the price of gold set at $35/toz (Meltzer 1991).

Delinking gold from the U.S. dollar in 1971 set the stage for the flexible exchange rate regimes adopted by many countries. Real gold prices peaked in 1980 on safe-haven buying and hedging against inflation. Prices stayed relatively low in the 1980s and 1990s in part because of sales by European central banks, preferring to hold their foreign reserves in the form of interest-bearing assets in major currencies. Prices started to rise in 2001 in response to the terrorist attacks and a long period of low mine production (George 2012). During the past two decades, gold prices have responded to real interest rates and, to a lesser degree, inflation and geopolitical concerns (Barsky et al. 2021).

Gold production was long dominated by South Africa, but the country's share in global gold production has steadily declined. In 2020, South Africa accounted for just 3 percent of global mine production, compared to two-thirds in 1970. Production has risen, notably in Australia, Canada, China, Russia, and the United States. Recycled gold makes up about 30 percent of supply. A large proportion of gold demand comes from China and India, mostly associated with jewelry fabrication. Central bank buying in these and other EMDEs have added to physical demand. Gold exchange-traded funds have increased in popularity as investment vehicles, providing an easier and less costly way to own gold than had been done traditionally. Gold's use in industry is primarily in electronics because of its high electrical conductivity and resistance to tarnishing.

Other precious metals include silver and platinum-group metals. Silver prices are more aligned to economic cycles since more than half of silver's demand comes from industrial applications, such as in electronics, solar panels, batteries, and photographic equipment. It stands to benefit from the energy transition given some of these applications and multiple components in electric vehicles.

Platinum and palladium prices are heavily influenced by vehicle demand, as both metals are used in emissions-reducing catalytic converters in car exhaust systems. Mexico and Peru are the top producers of silver, whereas production of platinum and palladium is dominated by South Africa and Russia. Both metals are expected to benefit in the energy transition, mainly in fuel cells, and most aspects of the envisioned hydrogen economy.

Agriculture supply and demand

Introduction

Agricultural commodities have been traded for centuries, beginning with high-value products such as spices and coffee. As the cost of transport declined and communications improved at the start of the 20th century, trade became profitable for bulky commodities, such as grains, in turn allowing countries to make produce and trade agricultural commodities according to their comparative advantage. Tropical commodities, including cocoa, coffee, and tea, were exported from Africa and Asia, while grains and other temperate commodities were exported from Argentina, Russia, and the United States. Raw materials were exported from key producing countries to countries with large industries using those materials, such as the export of cotton produced in the United States to the textile industry in the United Kingdom. Specialization provided incentives for the adoption of new technologies and production practices to increase output and exports.

Technological improvements have been a key driver of agricultural production and trade. Early in the 20th century, the introduction of hybrid varieties changed the path of yields for most agricultural commodities. Prior to the 1930s, one hectare of land produced 1.6 metric tons (mt) of maize in the United States, with virtually no change from year to year. Today it produces more than 10 mt. Similar developments have taken place for many other commodities and, after the 1960s, in many other countries. Other improvements, such as transportation (including containerization), bulk storage, cold storage, and packaging have enabled most consumers to consume almost every agricultural commodity throughout the year. More recent productivity improvements, including biotechnology, precision farming, real-time information from satellites and weather stations, and controlled-release fertilizers, are expected to further boost productivity as they are adopted more widely. Productivity improvements along the supply chain, lower transportation costs, and better information technology have exerted a downward impact on most agricultural commodity prices over time (figure 1.11).

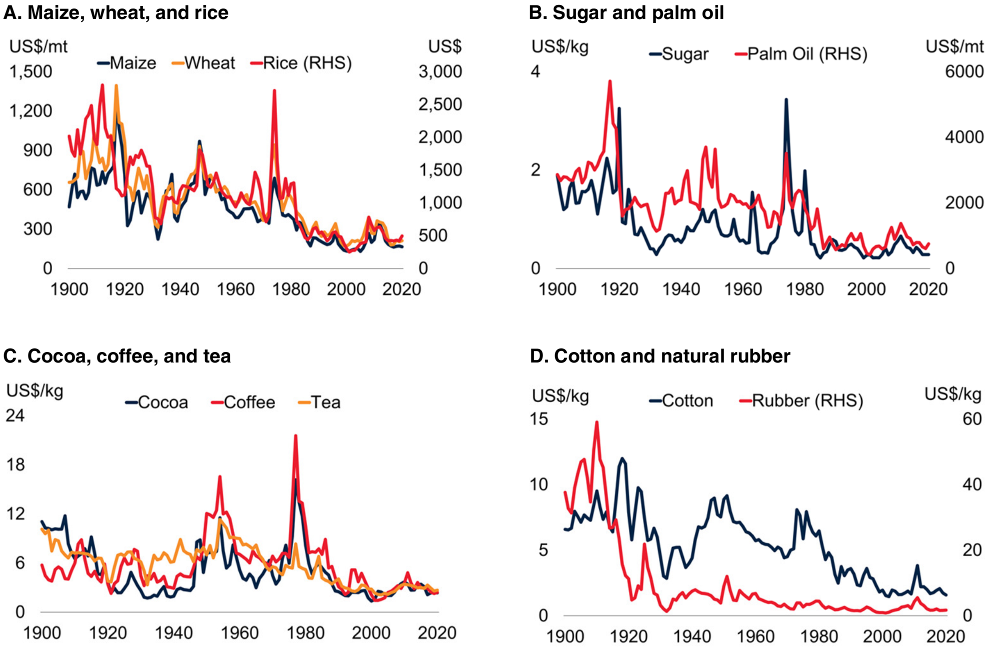
Technological change

Improvements in technology during the 20th and early 21st centuries have boosted the production and trade of agricultural commodities, essentially satisfying the basic caloric needs of the growing world population. Technology has fundamentally altered how agricultural commodities are produced, transported, stored, and consumed. Communications and information technology have encouraged the ongoing development of markets and the creation of sophisticated hedging facilities (box 1.3).

Production. The first major productivity improvement in agriculture was the development of hybrid maize in the United States. This has often been called the biggest agricultural miracle of the 20th century (Crow 1998). Hybrid seeds, formed by crossing four interbred lines, became commercially available during the 1920s and were widely adopted in the major maize growing areas of the United States by 1940. For example, in the U.S. state of Iowa, a key maize producing state, hybrid seeds accounted for nearly 97

FIGURE 1.11 Real agricultural commodity prices since 1900

Most agricultural commodity prices have followed a long-term downward path in real terms. Prices have also been volatile, especially during the first three decades of the 20th century. Volatility patterns differ among commodities, with the exception of grains (in part due to land substitutability). The price spike during the oil crises of the 1970s was similar to that of other commodities.



Source: World Bank.
Note: Prices deflated by Consumer Price Index (CPI).

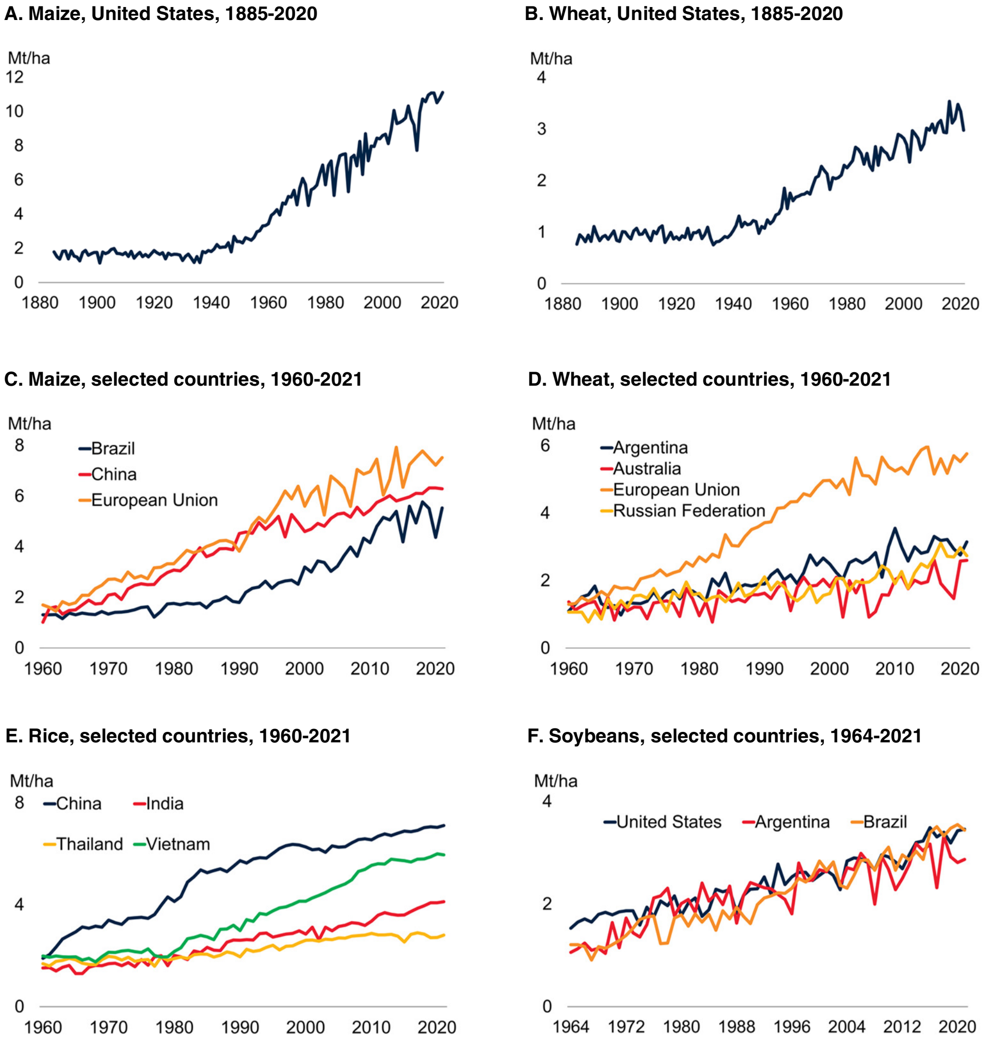
percent of the area allocated to maize by 1941, with yields reaching 3.20 mt/ha (metric tons per hectare), up from 1.95 mt/ha a decade earlier. Mechanization, improved production practices, fertilizer, and chemical use, and continued improvements in the genetic material resulted in further productivity gains. In 2016-21, maize yields in the United States exceeded 10 mt/ha, an eight-fold increase since the introduction of hybrid varieties (figure 1.12). Similar productivity improvements have occurred for most other agricultural commodities on a continuous basis.

Productivity improvements in grains attained in AEs during the 1940s and 1950s were replicated in EMDEs during the Green Revolution. The high-yielding varieties of rice and wheat now used in EMDEs were developed at the International Maize and Wheat Center (CIMMYT) in Mexico and the International Rice Research Institute (IRRI) in the Philippines and adapted to EMDE agroecological and climatic conditions.[18] The

[18] CIMMYT and IRRI are members of the Consultative Group for International Agricultural Research (CGIAR), an umbrella organization that unites 14 international agricultural research institutes. CGIAR's provides evidence, innovation, and new tools to "harness the economic, environmental, and nutritional power of agriculture" (CGIAR 2022).

FIGURE 1.12 Yield trends in AEs and EMDEs for selected food commodities

Innovations during the 1930s set the stage for productivity improvements for most food commodities. During 1930-2020, each hectare of land in the U.S. produced, on average, 108 kgs more maize and 23 kgs more wheat each year. After the Green Revolution got underway in the 1960s, EMDEs achieved similar productivity gains. More recent technological improvements, including biotechnology, precision farming, smart fertilizers, and extensive use of satellite and weather-station data, have sustained productivity gains in both advanced economies and EMDEs.



Sources: U.S. Department of Agriculture (2019); U.S. Department of Agriculture; World Bank.
Note: Data until 2021. Mt/ha refers to metric ton per hectare.

outcome included improved hybrid seeds, increased effectiveness of fertilizers and chemicals, and expanded irrigation and mechanization. The wheat yield increases achieved by the United States in the 1940s were achieved in India by the mid-1960s. Similarly, rice yields in China, India, and Vietnam quadrupled between 1960 and 2020, while wheat yields in Argentina doubled.

The location of production shifted as these changes occurred. Brazil became a major soybean producer and exporter during the second half of the 20th century, accounting for more than one-third of global production in 2020, from near zero in 1950 (figure 1.13). Indonesia and Malaysia became leaders in palm oil production. Vietnam now accounts for nearly one-fifth of global coffee supply, from zero in 1980. Cotton production shifted from the United States to China and India (figure 1.14).

A further increase in productivity began in the mid-1990s with the introduction of genetically modified crops in the United States.[19] Such crops can reduce costs because they reduce chemical applications. Biotechnology had a much larger positive impact on yields in EMDEs than in AEs because chemical applications in EMDEs had been relatively low, and thus suboptimal for conventional seed varieties (Baffes 2012; Qaim and Zilberman 2003). Not all countries, however, have adopted biotechnology. Among advanced economies, Australia, Canada, and the United States have used biotechnology extensively, while the EU has left it up to the member states to decide. Among EMDEs, Argentina, Brazil, Paraguay, and South Africa are adopters.

Transportation and marketing. In the first half of the 20th century, the combined effects of mature railroad networks, oil-fueled ships, and the motor vehicle reduced transport costs, increased trade, and brought greater integration in commodity markets. The pace of change accelerated after 1945. Investments in the shipping industry enabled the capacity of cargo ships to double in the three decades following 1950 (Levinson 2016). Increasing demand for bulk transportation spurred other technological improvements, including dry bulk, supertankers, and container ships, which allowed greater economies of scale (Jacks and Stuermer 2021).[20] The decline in transportation costs contributed to increased commodity trade and lower commodity prices as countries were able to exploit their comparative advantage. Ocean freight rates for bulk cargo, such as coal and grains, halved in real terms during the past 50 years.[21]

The ratio of transportation costs to grain prices has remained relatively constant during the past 70 years as the cost of ocean transport and grain prices have declined at similar rates. More efficient port handling facilities have contributed to the decline in shipping

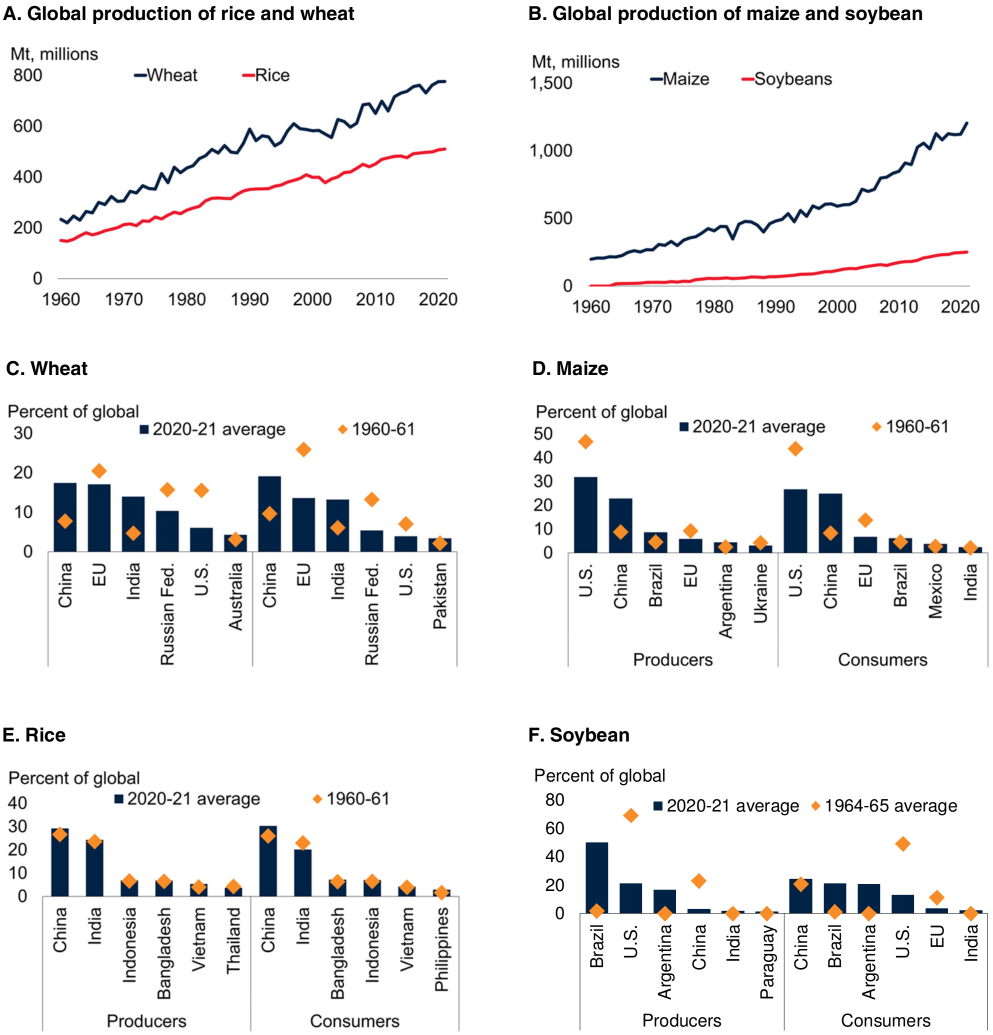
[19] A genetically modified crop is "a plant used for agricultural purposes into which one or several genes coding for desirable traits have been inserted through the process of genetic engineering. These genes may stem not only from the same or other plant species, but also from organisms totally unrelated to the recipient crop" (Qaim 2009, p. 665).

[20] Closures of the Suez Canal in 1956-57 and 1967-75 accelerated these innovations.

[21] This decline has not been smooth. There have been several spikes in ocean freight rates, including during WWII in the 1940s, the Korean War in the 1950s, the oil crises during the 1970s, and the commodity price boom during the 2000s.

FIGURE 1.13 Production and consumption shares: Food commodities

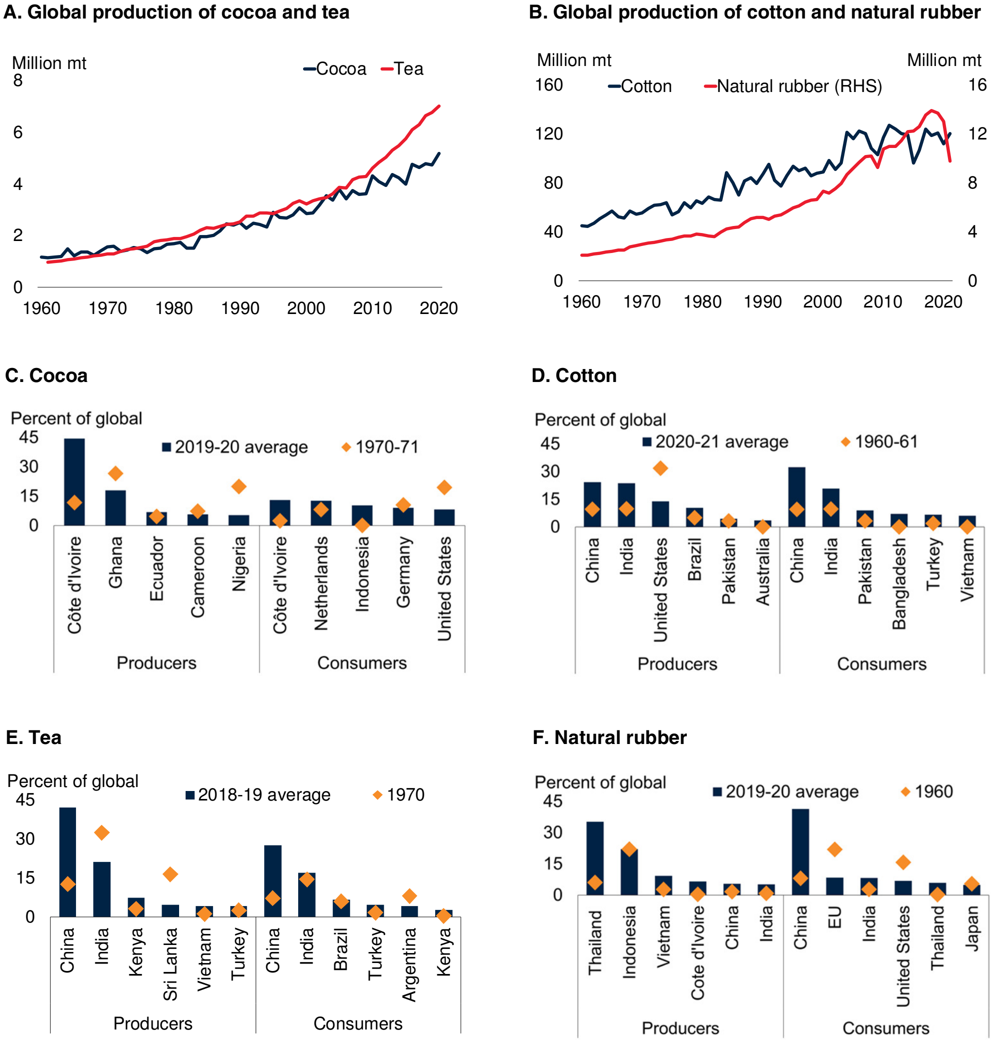
The past six decades have seen significant shifts in the production and consumption of food commodities. China has emerged as a key producer and consumer of maize (to feed the rapidly expanding number of livestock). The EU and Russia play an important role in the global wheat markets. China and India dominate global production and consumption of rice, and Thailand is a large exporter. Argentina and Brazil have become key players in the soybean market.



Sources: U.S. Department of Agriculture; World Bank.
A.B. Data until 2021.

FIGURE 1.14 Production and consumption shares: Export commodities

Production of export commodities has been dominated by EMDEs. Côte d'Ivoire and Ghana dominate the cocoa market. Cotton production and consumption has shifted to China and India at the expense of the U.S. China and India dominate global tea production and consumption, but Kenya is the biggest exporter. Thailand has emerged as the main global supplier of natural rubber, and China is the main buyer.



Sources: Food and Agriculture Organization (FAO); Grilli, Agostini, and Hooft-Welvaars (1980); International Cocoa Organization; International Coffee Organization; International Rubber Study Group; U.S. Department of Agriculture; World Bank.

A. Data until 2020.

B. Data until 2021.

BOX 1.3 The development of price benchmarking in commodity markets

Global commodity price benchmarks set a guideline for prices at which transactions in commodities take place. They are essential to the futures contracts used in organized exchanges. Benchmark pricing based on competitive commodity markets flourished since the late 1800s for commodities such as cotton and grains. However, further progress in the mid-20th century was hindered by protectionist trade policies and a proliferation of supply management schemes. The development of competitive markets and associated price benchmarks reemerged following rounds of trade liberalization in the 1950s and 1960s. The collapse of the Bretton Woods fixed exchange rate system gave impetus to futures markets for currencies, and to associated innovations in hedging techniques that have influenced organized markets generally. Today, the main commodity markets have mature global price benchmarking mechanisms, which assist in the efficient allocation of resources and the reduction of market risks for producers and consumers alike.

Introduction

A benchmark price is the price of a standard unit of a good (or financial asset) with a reputation for consistent quality and wide availability in its market. It sets a baseline for the pricing of other goods in the same category, which may have somewhat different qualities and characteristics. A product in the group with inferior qualities will trade at a discount to the benchmark, whereas one with superior qualities will trade at a premium. Benchmark prices for commodities are calculated and published daily from the trading on organized futures exchanges (e.g., the Brent crude futures on the Chicago Mercantile Exchange). Traders do not deal in physical commodities but in precisely defined contracts for which a standardized quality and delivery date are essential. Since only the price is negotiable, the benchmarks from futures exchanges provide a transparent and accurate guide for the pricing of the physical products that are actually delivered. As an integral part of the market mechanism, they help increase economic efficiency, and reduce risks, to the benefit of producers and consumers alike.

Global commodity price benchmarks, principally formed at commodity exchanges, encapsulate worldwide supply and demand conditions. For this reason, they influence the prices at which most transactions in primary commodities take place. Global price benchmarks were first formed in the mid-19th century when the speed of information transmission was decoupled from the speed at which commodities were transported. That, in turn, enabled market participants to incorporate information on demand and supply conditions that went beyond the geographic coverage of the transaction in question.

Price benchmarks for cotton and some grains were fully developed by the end of the 19th century. Benchmarks for industrial commodities emerged rather later.

BOX 1.3 The development of price benchmarking in commodity markets *(continued)*

For some commodities, such as iron ore, the formation of mechanisms for international price benchmarks is still a work in process, and in some cases, such as fertilizers and rare earth metals, the process is either at an early stage or has not yet begun. For natural gas, the high cost of trans-ocean transportation means that existing benchmarks apply only to regional markets—there have been wide differences between prices on futures exchanges in the United States and Europe.

Against this background, this box answers the following questions:

- How has price benchmarking evolved in commodity markets?
- What are the recent trends and impediments in price benchmarking?

The evolution of competitive pricing in commodity markets

The London Tea Auction began operation in 1679 and was the world's most important tea pricing center until it closed in 1998 (Pettigrew and Richardson 2013). Amsterdam also saw the emergence of commodity trading in the 17th century, and the use of a primitive futures contract (Goss and Yamey 1978; Stringham 2003). Price benchmarking as it is known today began during the mid -1800s on two parallel tracks. First, the global cotton market emerged from regional trading hubs in Alexandria (Egypt), Liverpool, New York, and New Orleans. Second, Chicago became the trade hub for grains produced in the Midwest United States. In both cases, price benchmarks began to emerge—a regional benchmark in grains, and a global benchmark in cotton.

Japan has been credited with the birth of futures trading, starting with trading at the Dōjima rice market in Osaka in 1730 (Markham 1987; Schaede 1989). Key characteristics of the Dōjima market, presaging the characteristics of modern futures trading, were the central clearing of contracts, contract standardization, mark-to-market accounting rules, and the concept of settlement price.

The origins of the global cotton market go back to cotton trading in Liverpool in the mid-18th century (Dumbell 1923). Liverpool was the port of entry to the textile industry in northern England for cotton from America, Egypt, and India. The Liverpool Cotton Exchange originated early versions of futures contracts in the 1840s, making it the first global cotton pricing center. Cotton futures contracts were traded in Alexandria as early as 1849, although the Alexandria Cotton Exchange was not formally established until 1861 (Baffes 2005).

Developments in transportation and information technology in the mid-19th century—first the steamship and later the telegraph—were instrumental in speeding and broadening the informational content of commodity prices. With

BOX 1.3 The development of price benchmarking in commodity markets *(continued)*

the introduction of steamships in the 1820s and their expanded use in the next two decades, the time taken to cross the Atlantic was reduced from two months to two weeks (Armstrong 1859). Early mail steamships were faster than cargo ships. This allowed information about cotton supply conditions in the United States, the principal cotton supplier to England at the time, along with cotton samples, to arrive much earlier than the cotton itself. Using the early arrival of information on supply conditions in the U.S., merchants in Liverpool were able to trade "to arrive" or "intransit" contracts more than one month prior to the physical arrival of the product. These contracts formed the basis for forward and futures contracts (Dumbell 1923). However, the defining moment that turned the cotton market into a global market was the installation of the first successful transatlantic cable in 1865. Information on market conditions in the United States could now be transmitted instantaneously to Europe and vice-versa. [a] By the end of the 1880s, five cotton futures exchanges were connected by cable (Alexandria, Le Havre, Liverpool, New York, and New Orleans), giving birth to the world's first global competitive pricing mechanism (Baffes and Kaltsas 2004).

In North America, the Chicago Board of Trade (CBOT) was founded in 1848 to facilitate cash transactions in grains. Forward ("to arrive") contracts began to be traded shortly thereafter (Williams 1986). [b] Grain traders in Kansas followed suit by establishing the Kansas City Board of Trade. In 1859, the Illinois legislature granted CBOT self-regulatory authority, thereby enabling it to facilitate the standardization of contracts. Shortly thereafter, formal trading rules were instituted regarding delivery procedures. In 1868, rules were adopted against certain manipulative activities, such as cornering the market, i.e., buying a good in a large enough quantity to be able to later push the price artificially high (CFTC 2017). Together, the adoption of trading rules and rules defining manipulation marked the beginning of grain (wheat, corn, and oats) futures trading in CBOT. The global cotton market in conjunction with the grain market in Chicago (and New York) set the stage for the golden era of competitive commodity pricing.

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a. The effects of the steamship and the transatlantic cable on cotton pricing are summarized by Dumbell (1923, p. 259): "So long as cotton and news travelled across the sea at the same pace there could be no volume of dealings except in cotton on the spot. But as soon as the mail steamer, carrying letters and samples, outstripped the sailing ship with its cargo of cotton, that cargo could be bought and sold while still at sea. The gradual extinction of the sailing ship would have eliminated the time interval which made that practice possible, but in the meantime the telegraph came to magnify and perpetuate the difference between the transmission of news and the shipment of cotton."

b. According to Williams (1982, p. 312): "Although the western ports did not get a telegraph until 1848, Buffalo and New York were connected in late 1846. Perhaps then, the flurry of trading in 1847 accompanied the introduction of the telegraph."

BOX 1.3 The development of price benchmarking in commodity markets *(continued)*

Further advances in competitive price benchmarking were hindered by policy developments in the inter-war period and after World War II. During the Great Depression, many countries adopted protectionist trade policies, beginning with the passage of the U.S. Tariff Act of 1930 (the Smoot-Hawley Tariff). Exchange rate movements that were deemed excessive encouraged further protectionist measures (Irwin 2012).

After World War II, recognition of the harmful effects of protectionist policies underlaid a more open approach to international trade policy, enshrined in the General Agreement on Tariffs and Trade (1947). As the recovery from the war gained momentum in the 1950s and 1960s, governments effected large reductions in tariffs on a vast range of goods in several rounds of international negotiations. However, the high tariffs and other trade restrictions in agriculture were largely left untouched.[c] And non-tariff interventions continued to obstruct competitive commodity pricing in various other areas. These included subsidies, discriminatory domestic taxes, and trade-distorting regulations on investment. Price benchmarks for many commodities were also influenced by international supply management schemes (see box 1.4). The Uruguay Round achieved some easing of non-tariff protectionist measures, but even so substantial barriers to trade in agriculture have remained (Tyers and Anderson 1992; Baffes and de Gorter 2005).

These interventions weakened global benchmarking mechanisms in agricultural commodities and halted progress toward the competitive pricing of industrial commodities. Many attempts to establish futures contracts on organized exchanges failed. Traders were reluctant to take positions because prices were either too stable to generate hedging interest or susceptible to abrupt changes resulting from political decisions they could not predict.[d]

Post-Bretton Woods developments in price benchmarking

A number of post-World War II developments facilitated the development of price benchmarking as we know it today. First, following the collapse of the Bretton Woods fixed exchange rate system, and the subsequent adoption of flexible exchange rates for major currencies, the Chicago Mercantile Exchange launched currency futures contracts (Clifton 1985). Second, agricultural policies

c. Prior to the Uruguay round, there were seven GATT rounds: Geneva (1947), Annecy (1949), Torquay (1950-51), Geneva (1955-56), Dillon (1961-62), Kennedy (1963-67), and Tokyo (1973-79).

d. The absence of competitive pricing, along with the public ownership of resources, created rent-seeking conditions (Krueger 1964). Hieronymus (1977) and Carlton (1984) cited commercial interests as a key reason for the frequent failure of commodity futures contracts after World War II.

BOX 1.3 The development of price benchmarking in commodity markets *(continued)*

in high-income countries gradually became more market-oriented, initially with the replacement of stock-holding mechanisms by price supports, and later by the introduction of direct support to farmers in place of price supports and government-organized supply management (Gardner 1987). Pivotal policy shifts in this respect were the 1985 US Farm Bill and the 1992 CAP reform in the European Union (Baffes and Meerman 1998). Third, the transition from central planning in Central and Eastern Europe and Central Asia, and later in China, expanded the geographical scope of international markets. Developing economies followed suit, with the dismantling of parastatals in charge of marketing and trading of commodities (Akiyama et al. 2003). Fourth, rapid advances in computer technology and in options pricing algorithms led to the increasing use of derivative instruments and sophisticated hedging strategies in futures markets, and to a large rise in trading volumes.

Today, most major commodity markets have benchmarking mechanisms in place. Yet, the transition to global benchmark pricing has not been the same across all commodity markets. Crude oil benchmarks, for example, emerged relatively quickly after the 1970s crises. The New York Mercantile Exchange introduced the WTI (West Texas Intermediate) oil futures contract in 1983, which became the price benchmark for the mid-continent United States. Shortly thereafter, the Brent contract developed into an alternative world price barometer. Numerous other futures oil contracts have been launched since then (Yang and Zhou 2020).

Futures markets for some commodities, however, have developed more slowly, as highlighted by three examples.

- *Coal.* The first international coal price benchmark was the outcome of negotiations between a key Australian supplier and a group of Japanese power and steel companies. This pricing system was replaced by a Reference Price System in the late 1990s. Spot markets emerged in the early 2000s, providing an alternative means of benchmark pricing. Today there are three widely used international coal price benchmarks —in South Africa, Australia, and Colombia. Coal futures are also traded on several exchanges, and began with NYMEX (now CME) in 2001, followed by the Intercontinental Exchange in Europe, and more recently exchanges including Amsterdam and Australia. Yet coal futures are not as liquid as other commodities, and studies have concluded that the international coal market continues to be weakly integrated (Liu and Geman 2017; Zaklan et al. 2012).

- *Natural gas.* In contrast to most other commodity markets, natural gas does not have a global price benchmark. Because of the costs of transport,

BOX 1.3 The development of price benchmarking in commodity markets *(continued)*

especially across oceans, there are several segmented markets whose prices can move quite independently of each other. Markets connected by pipeline have a much higher degree of integration, but can still show local differences (e.g., between Alberta in Canada and Texas). The U.S. natural gas market has a mature pricing mechanism, including a futures contract that was launched in the early 1980s. Prices of European natural gas and liquefied natural gas (LNG) have been traditionally benchmarked to crude oil. This has been changing, however, through the so-called "spotification" of the LNG market (Colombo, Harrak, and Sartori 2016).[e]

- *Iron ore.* As recently as 2005, international iron ore prices were set through negotiations between Vale, Brazil's largest iron ore producing company, and European steel manufacturers. During the 1980s and 1990s, Brazil was the world's top iron ore producer while Europe was one of the largest consumers, along with the United States and Japan (Vale 2014). The rapid expansion of China's steel consumption radically altered this nexus. The pricing of the iron ore market changed in 2005 from negotiated to spot pricing (Astier 2015).

Over the past 25 years, the strong economic expansion of EMDEs in Asia, especially China, has led to a corresponding rise of commodity trading activity in that region. Benchmark commodity prices in centers such as Dalian, Shanghai, and Singapore offer increasingly viable alternatives to those from established locations in Chicago, London, and New York (Tamvakis 2018).

Conclusion

Price benchmarking is instrumental in allocating resources efficiently among producers and consumers. The associated development of future markets and hedging instruments allows both sides to reduce exposures to risks. Organized price benchmarking goes back to the London Tea Auction (1679) and the Dōjima rice market in Osaka (1730). Defining moments for regional and global benchmarks came in the 19th century. The introduction of the mail steamship, and a few decades later, the transatlantic cable, accelerated the transmission of information well ahead of the physical movements of commodities. By the late 19th century, the cotton futures exchanges on both sides of the Atlantic had effectively coalesced into a well-integrated global market. Markets for other commodities were to follow a similar path into the 20th century.

e. LNG could act as "insurance" against geopolitically driven embargoes or, as Nakano (2016) put it, "democratization of LNG."

BOX 1.3 The development of price benchmarking in commodity markets *(continued)*

However, trade protectionism during the Great Depression, and economic disruptions from World War II, slowed the spread of this development. Global trade liberalization in the 1950s and 1960s allowed organized markets to progress once again. Price benchmarking as it exists today got underway after the collapse of the Bretton Woods fixed exchange rate system and the subsequent evolution of futures markets. Advances in computer technology led to the increasing use of sophisticated instruments and trading techniques, which depend on benchmark prices, and a large expansion of trading volumes.

Today, many important commodities are traded in organized futures exchanges. For some commodities, such as fertilizers and rare earth metals, global price benchmarking is still in the early stages of development. For others, geography will always pose barriers to global integration. For example, price benchmarking for natural gas is still segregated—and based on regional demand and supply conditions—because of the high cost of trans-ocean transportation.

costs, as has the weakening of shipping cartels and increased competition, advances in propulsion technology, and electronic navigation (Sjostrom 2004; World Bank 2000). Shipping of non-grain agricultural products, including meat and fresh produce, has benefitted greatly from the growing use of refrigerated storage and intermodal containers (which may be carried on ships, airplanes, trains, and trucks). As a result, temperate-climate countries have been able to import tropical and off-season produce year-round and on a large scale. Innovations in processing, packaging, and retailing continue to expand the food choices open to consumers.

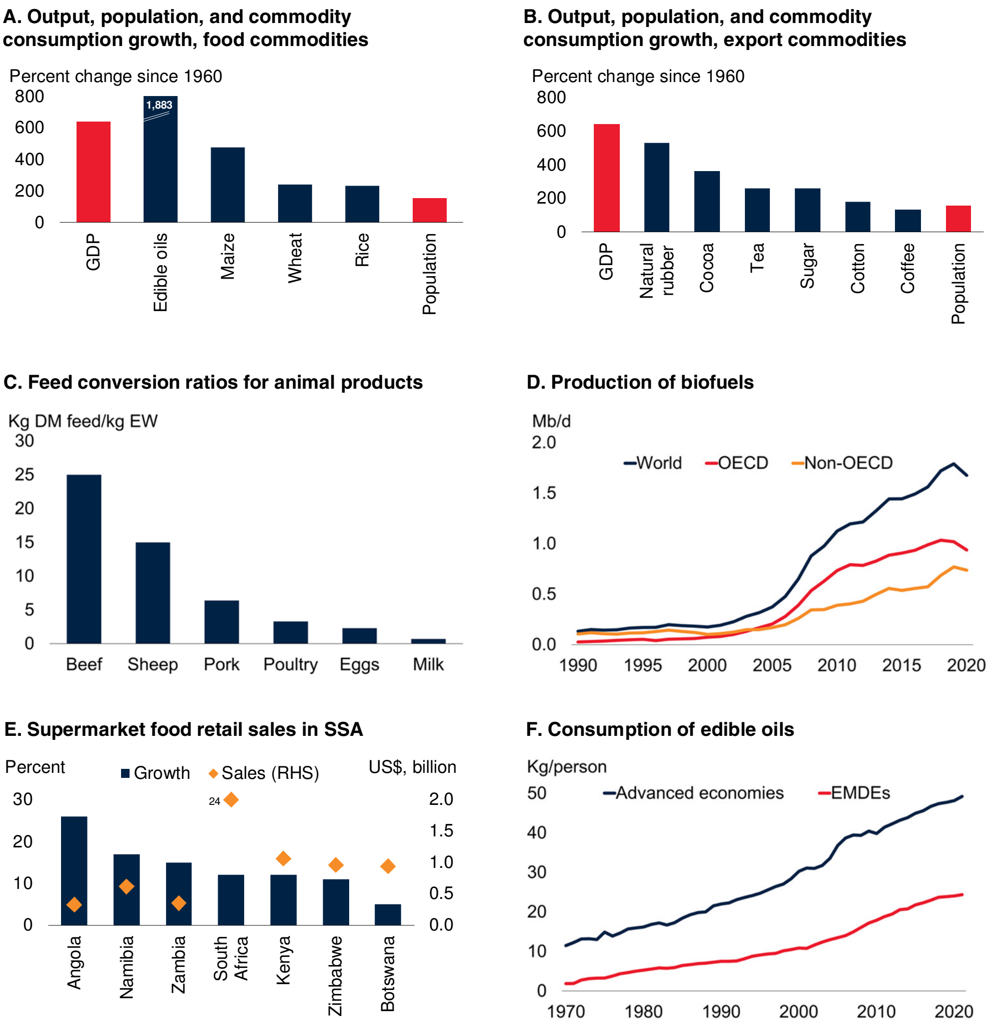
Evolution of food consumption

An important aspect of overall demand for food is that income elasticity declines as incomes rise beyond subsistence levels (chapter 2). Global per capita consumption over time has risen more slowly than per capita real income during the past 60 years, indicating an income elasticity of less than unity. Declining income elasticities have been more noticeable for basic foods. Total consumption of wheat and rice, for example, has grown at a rate similar to the population growth rate, implying a per capita income elasticity close to zero (figure 1.15; chapter 2). However, per capita consumption of other items, including protein-rich seeds and meats, beverages, and oils, has continued to increase as per capita incomes have risen.

Between 1965 and 2020, global edible oil consumption increased nearly 20-fold (Kearney 2010). Per capita consumption in EMDEs increased by a factor of 13, and in AEs by a factor of four. Three trends are behind this. First, as per capita income grows,

FIGURE 1.15 Demand for agricultural commodities

During the past six decades, rice and wheat consumption has grown similar to population growth. Edible oils (and less so) maize have grown much faster; the former due to its use in packaged foods and the latter due to biofuel demand. Among export commodities, consumption of natural rubber has grown the most as it responds to industrial activity; demand for other commodities grew more in line with population. Looking ahead, animal products (especially some meats which require considerable amount of feed) will continue to be key sources of demand growth. Biofuels could also play an important role, if the announced policy mandates (in response to energy transition) materialize.



Sources: Alexander et al. (2016); BP Statistical Review (2021); Grilli, Agostini, and Hooft-Welvaars (1980); International Cocoa Organization; Reardon et al. (2021); U.S. Department of Agriculture; World Bank.

A. “Edible oils” includes coconut, olive, palm, palm kernel, rapeseed, soybean, and sunflower seed oil. The base year corresponds to the 1964-65 average.

C. The “Sheep” category also includes goat and some other meats. Feed conversion ratios were adjusted to express feeding requirements per unit edible weight (EW) and also to account for the need to raise sire and dam animals (Smil 2002).

D. Biofuel volumes have been adjusted for energy content.

E. SSA = Sub-Saharan Africa.

F. “Edible oils” includes coconut, olive, palm, palm kernel, rapeseed, soybean, and sunflower seed oil.

people tend to consume more food in packaged form and to use restaurants and fast food more frequently—forms of food that are typically more oil-intensive. Second, for health reasons, consumers also reduce consumption of animal fats for cooking (in favor of edible oils) as incomes rise. Third, edible oils are used to produce biofuels.

The rapid growth in consumption of meats, dairy, and packaged foods was made possible by advances in transportation, refrigerated storage, and packing technology. Associated with these developments was the expansion of supermarkets, which made access to these products more convenient. While supermarkets have been common in advanced economies, their presence grew briskly in Asia and Latin America toward the end of the 20th century. Supermarkets have also made inroads in Africa during the past 20 years (figure 1.15). In a review of 66 studies, covering 48 African countries, Colen et al. (2018) reported average income elasticities of less than 0.4 for cereals, close to 0.8 for meats, and more than 1.2 for beverages. As income grows, especially in low-income countries (LICs), consumption of animal products and packaged foods is expected to continue to grow relatively strongly, in turn increasing the demand for animal feed, such as maize and soybean meal, and for cooking oil.[22]

Biofuels are a newer source of demand for agricultural products. Currently, Brazil, the European Union, and the United States account for nearly two-thirds of global biofuel production. The crops most commonly used to produce biofuels are sugarcane and maize (for ethanol) and edible oils (for biodiesel). Several countries have announced their intention to increase biofuel production as part of efforts to meet climate change targets. China, for example, is expected to more than double its ethanol production over the next five years. Other countries have set ambitious targets, including India, Indonesia, and Malaysia. According to some estimates, biofuel production could increase as much as 50 percent by the end of the 2020s.

Agricultural policies

Agricultural commodity markets have been influenced by government policies since the early 20th century. These policies continue to affect markets today, albeit in a less distortionary manner. Policies have different objectives and effects—some encourage higher production through price supports and trade measures, while others seek to nationalize production and trade. The latter leads to stagnation and often the collapse of commodity sectors. International policies (including schemes that managed supplies at an international level and various trade agreements) have also played a key role, especially during the 20th century (box 1.4 discusses the rise and collapse of international supply management schemes).

Policy intervention in agricultural commodity markets in advanced economies began in the United States shortly after WW I when the loss of export markets in Europe caused

[22] As shown in figure 1.15C, it takes about 25 kgs of feed to produce one kg of beef. The corresponding feed requirements for pork and chicken meat are 6.4 and 3.3 kgs of feed, respectively.

prices to fall. Policy interventions began in Western European countries shortly after the formation of what is now the European Union. Specifically, the creation of the Common Agricultural Policy (CAP) in the early 1960s aimed to keep farm incomes comparable to those of non-farm workers. At the time, Europe was a major importer of most agricultural commodities, but high and stable prices under CAP encouraged higher production and turned the EU into a commodity exporter. Similarly, Japan's agricultural policies were aimed at maintaining self-sufficiency and to keep farm incomes comparable to non-farm sectors. In EMDEs, high taxes on crop exports were introduced to promote food self-sufficiency and keep food prices low (a practice aligned with EMDE efforts to promote industrialization). Lastly, centrally planned economies aimed at self-sufficiency through public ownership of most aspects of production and trade.

United States

The loss of European markets after the end of WWI, together with depressed agriculture prices, resulted in pressure for government intervention. After initial attempts at price support failed, the Federal Farm Board was established in 1929 with the aim of stabilizing agricultural commodity prices through government-financed inventory building. The effort failed, however, due to inadequate financing and the overwhelming impact of the Great Depression. In 1930, the U.S. Congress passed the Smoot-Hawley Act, which raised tariffs sharply (Irwin 1998). These trade barriers against the backdrop of the depression led to a spiraling of trade restrictions around the world.

Widespread distress among agricultural communities during the Great Depression had a lasting impact on policies. With the aim of raising domestic prices, the United States initiated a wide array of measures to pay farmers for cutting their output, to finance the purchase and storage of crops, and to subsidize exports of products deemed to be hurt by foreign government intervention. The Agricultural Adjustment Act of 1933 introduced various policy instruments, in effect rendering the government buyer of last resort.[23] Price stabilization was to be achieved by loan and storage programs that removed supplies from the market while a system of nonrecourse loans was initiated. Under the program, a producer could receive a government loan on their crop at the price support level and repay the loan by delivering the crop to the government. Because it was often impossible to export commodities at the support price, a system of export subsidies had to be instituted. The system was buttressed by a high tariff and import quotas. All of this in effect isolated the United States from world markets.

Although strong commodity demand after WWII brought booming commodity markets, efforts to institute a more flexible agricultural support mechanism in the late 1940s failed. But in the mid-1950s, demand slowed, stocks rose sharply, and program costs began to escalate, despite large-scale land retirement programs and increased food

[23] Although the Supreme Court declared the Act unconstitutional, subsequent modifications kept most its key elements intact.

BOX 1.4 The rise and collapse of international supply management

Numerous efforts to manage commodity supplies at an international level throughout the 20th century have had initial success but ultimately ended in failure. Their main objective was usually a profitable and stable level of prices, to be achieved via limits and quotas on production. Attempts to reduce supplies following World War I included export quotas and planting restrictions for coffee, and export quotas for copper. Attempts to control the market through stockpiling include government purchases of wool and buffer stocks of tin. Falling prices during the Great Depression spurred numerous schemes, which included tea, natural rubber, sugar, coffee, and copper. Buyers as well as producers were involved in attempts to revive supply management schemes during the shortages and inflations after World War II, and the 1970s. Initially, some of these schemes achieved their stated objectives. However, attempts to set up longer-term supply arrangements laid the foundation for their eventual failure. The high prices that such arrangements may have created for a while induced investment and innovation, brought new suppliers to the market, and caused consumers to substitute alternative products. The Organization of Petroleum Exporting Countries may have been an exception in its longevity, but it has not succeeded in reducing the volatility of oil prices.

Introduction

Internationally coordinated supply management schemes have been applied to numerous commodity markets since the early 20th century. This box analyses such arrangements with respect to industrial commodities and perennial agriculture. [a] Sometimes these arrangements were managed by producer cartels, other times they were negotiated among commodity-exporting or importing countries. Objectives of these attempts included an orderly transition from periods of high stress (e.g., collapse of demand, or high levels of inventories), a general reduction of price volatility, and, in the case of cartels, price increases. Some of these arrangements fulfilled their objectives for a substantial period, while others failed outright. In several instances, the period of success laid the foundation for a later failure, as it facilitated the emergence of new entrants to the market, or induced the development of substitute products.

The box adds to the literature in two ways. First, it considers a full cohort of commodity agreements, thereby providing a greater breadth of historical evidence. Existing studies have analyzed either a single commodity such as oil

a. Perennial agriculture refers to tree-based products such as natural rubber, coffee, and tea. Unlike annual agriculture, production capacity cannot be switched from one use to another from year to year in response to changing market conditions. Domestic policies toward the management of agriculture in general are discussed in the main text of Chapter 2. Although these may have international ramifications, governments generally enact them independently. Trade agreements often impose constraints on the supply -management measures that a government might adopt, but these differ from the coordinated steps negotiated under an international supply management system.

BOX 1.4 The rise and collapse of international supply management (*continued*)

(Kaufmann et al. 2004; McNally 2017), coffee (Akiyama and Varangis 1990), tin (Chandrasekhar 1989), and natural rubber (Verico 2013), or a group of non-oil commodities (Davis 1946; Gilbert 2011; Roberts 1951). Second, it considers the policy implications of the experiences with such schemes. Whereas most studies have warned of the difficulties associated with international supply management, this box takes a more nuanced approach and considers circumstances where globally coordinated action may be appropriate. This is of particular relevance in the context of the post-2000 boom-bust price cycle, the COVID-19 pandemic, and the ongoing energy transition. To shed light on the issues facing commodity markets today, this box draws on historical experiences to examine two questions:

- What short- and long-run objectives have governed coordinated efforts to manage commodity supplies?
- What has been their impact on commodity markets?

Short- and long-term objectives of supply management mechanisms

Supply management arrangements have had both short- and long-term objectives. A common short-term objective has been to restore orderly markets after a crisis. A common long-term objective has been to maintain stable prices at a profitable level for producers.

The short-term objective has been paramount in the policy response to large destabilizing events, such as the Great Depression or the aftermath of war. Transition to an orderly market involves a reduction in price volatility and a restoration of viable conditions for both producers and consumers. Because the objective is essentially short-run, and limited in ambition, actions aiming at an orderly post-crisis transition have often been successful. It may involve no more than the temporary use of buffer stocks to increase or reduce supply on the market. For example, the coordinated liquidation of tin inventories during 1921-23, which had accumulated during World War I, is considered a success. OPEC responded to the sharp fall in oil demand in 2020 at the onset of the recession caused by the COVID-19 pandemic with large cuts in production, which were matched by some non-member producers (Norway and Indonesia).

Schemes with long-term objectives for the management of commodity markets have rarely survived in an operative form. They confront an economic dilemma which has usually led to their demise: any initial success in controlling output and raising prices encourages new entrants, and hence an expansion of supply. It also stimulates substitution by consumers into alternative products, reducing demand. Over time, these reactions in the market wear down the attempt at supply

BOX 1.4 The rise and collapse of international supply management (*continued*)

management. Their ultimate failure is evident empirically in the volatility and long-term downtrends of a range of real commodity prices subject to supply management (figure B.1.3.1.).

Attempts to lift and stabilize prices through supply management nevertheless occurred throughout the 20th century (see table 1.4.1 for a comprehensive list of non-oil supply management schemes). An early attempt at international supply management followed the 1902 International Coffee Conference in New York (Hutchinson 1909; Wickizer 1943). Brazil agreed to reduce coffee supplies, with other Latin American producers joining the effort shortly after (Hutchinson 1909; Krasner 1973; Wickizer 1943). To reduce post-WWI disruptions to international trade, agreements were reached for the orderly liquidation of tin and wool inventories accumulated during the war (Baranyai 1959; Blau 1946; Briggs 1947; Tsokhas 1993). Lifting prices was the objective for private cartels in copper (Walters 1944) and silver (Bratter 1938; Friedman 1992).

During and after the Great Depression, numerous agreements sought to address chronic surpluses and deflationary pressures—despite the fact that the collapse in aggregate demand was the cause, not overproduction. These covered the entire commodity spectrum, including agricultural raw materials, timber, food commodities, beverages, metals, and precious metals (Table 1; Davis 1946; Glesinger 1945). Examples are the agreements covering tea (Roberts 1951); sugar (Fakhri 2011; Hagelberg and Hannah 1994); and beef (Tsou and Black 1944). Some one-off interventions, such as those for wool, beef, and timber, had limited but well-defined objectives, and were deemed to have been successful.[b]

Supply management schemes put in place after World War II were inspired by the United Nations Conference on Food and Agriculture (1943) and the Havana Charter (1948). These schemes—targeting coffee, cocoa, natural rubber, tin, and sugar—had more ambitious goals and broader international membership, including both exporting and importing countries (Baranyai 1959; Swerling 1968). Their principal objective was price stabilization through export restrictions and inventory management (Gilbert 1996). These attempts at supply management broke down before long.[c]

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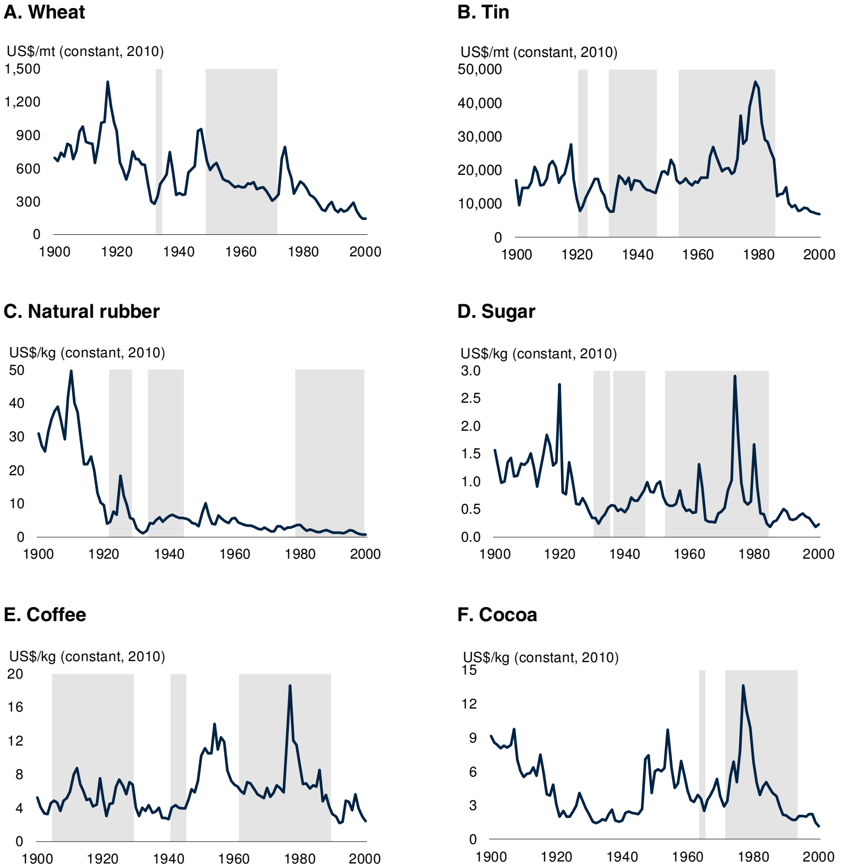
b. The silver cartel, however, did not succeed.

c. The mid-1970s was a period of inflation and high relative prices for commodities. Some governments attempted to limit further price increases through independent direct action. For example, the United States imposed price controls and drew down strategic stocks of metals (Cooper and Lawrence 1975). These measures had little success against the inflation and were soon abandoned.

BOX 1.4 The rise and collapse of international supply management (*continued*)

FIGURE B1.4.1 Prices of commodities subjected to supply management schemes after World War II

Five of the six commodities subjected to supply management after World War II were also subjected to supply management prior to the war, the exception being cocoa. Since then, the International Wheat Agreement ceased market operations in 1971, while coffee, sugar, and tin lasted until the late 1980s. The last cocoa agreement lasted until 1993, while the natural rubber agreement (the last non-oil agreement) collapsed after the 1997-98 Asian financial crisis.



Source: World Bank.
Note: The series has been deflated by the U.S. CPI. The shaded areas denote periods of supply management.

BOX 1.4 The rise and collapse of international supply management (*continued*)

The most durable international arrangement for supply management has been OPEC. It has attempted to set production quotas for its members, and thereby stabilizing the price of oil at a high level. Adherence to the quotas by members has, however, been mixed. And the periods of high prices that the organization has achieved have encouraged new sources of supply—e.g., North Sea oil and shale oil. Moreover, changes in strategy by leading members have caused occasional extreme volatility in oil prices.

Impact of supply management schemes

There is strong empirical evidence that international agreements have had an impact on commodity prices. However, measuring their exact impact is challenging as other things are continually shifting. For example, while the tin agreement in itself may have put upward pressure on tin prices, concurrent technological advances were making aluminum a superior substitute. The rest of this section summarizes the literature on the subject, discusses some summary statistics, and also gives some model-based results looking at all commodities.

Brazil's first coffee supply restriction in 1905 successfully raised and stabilized prices, and was renewed twice (Krasner 1973). Similarly, the 1921 agreement to limit the sale of tin inventories accumulated during World War I was successful in stabilizing prices (Baldwin 1983). Numerous studies have concluded that most post-World War II agreements had a substantial impact on prices. See, for example, Akiyama and Varangis (1990) for coffee, Chandrasekhar (1989) for tin, and Verico (2013) for natural rubber.

Figure B.1.3.2 reports price changes after the collapse of an agreement for six non-oil commodities. The change is gauged by the 3-year average of the inflation-adjusted price after the collapse minus the 3-year average before it. In four cases (sugar, Arabica coffee, Robusta coffee, and tin) prices dropped by about 50 percent after the collapse of the agreement. However, prices increased substantially after the cocoa and wheat agreements expired, while there was no change for natural rubber. These declines in prices suggests that the agreements, as long as they were in effect, helped lift prices. It is also important to note that the increase in the price of wheat coincided with the 1970s commodities price boom.

To further examine the relationship between commodity agreements and prices, we present summary results adopted from the price decomposition model reported in Chapter 3. The model, which looks at the behavior of 27 inflation-adjusted commodity prices from January 1970 to December 2019, decomposes real prices into cycles (up to 20 years) and trends. One can then examine the

BOX 1.4 The rise and collapse of international supply management (*continued*)

degree of non-linearity of the trends. The analysis finds that trends differ across most commodities. Six commodities subjected to agreements within the sample period—cocoa, coffee (Arabica and Robusta), crude oil, natural rubber, and tin—exhibit a much higher degree of non-linearity than the rest of the commodities. Indeed, the root mean square error—a measure of how much the long-term trends deviate from a linear trend—of the six commodities subjected to intervention is almost 11, compared to 4 for the remaining commodities. Subject to the caveats discussed earlier, this could suggest that interventions in commodity markets may be associated with deviations of real prices from their long-run trends.

While higher and more stable prices benefited participating countries in the short term, they often unleashed forces that led to their eventual collapse. First, higher prices reduce consumption by encouraging more efficient usage and a switch to alternative products. For example, the more than ten-fold increase in oil prices in the 1970s induced conservation and efficiency gains, as well as substitution to other fuels; this led to a four-year, 10 percent decline in global consumption. World oil demand growth never fully recovered from the price shocks, as improved efficiency reduced the energy-intensity of world output. In addition, as noted above, high tin prices maintained by the tin agreement accelerated the use of aluminum and other products in the canning industry.

Second, commodity agreements frequently suffered from low compliance. While constrained production by some members led to higher prices, it increased the rewards for cheating. Poor compliance was the main reason why oil agreements prior to the Second World War collapsed. (OPEC has often suffered from poor compliance with quotas.) The most successful agreements were those which had a legal mandate to enforce production restrictions.

Third, higher prices attract the entry of new producers that operate outside the agreement—"free riders" benefitting from the output constraints on members of the agreement. High coffee prices, along with a lack of access to the global coffee market, prompted Eastern European countries and the Soviet Union (who were not members of the coffee agreement) to seek new coffee supplies. They provided technical and financial assistance to Vietnam to develop its coffee industry outside the coffee agreement. High tin prices brought new tin suppliers into the market, such as Brazil. For oil, high prices have repeatedly stimulated the development of new high-cost supplies—offshore oil in Brazil and the North Sea, and non-conventional sources like U.S. shale.

d. These "new" organizations include the International Grains Council, the International Coffee Organization, and the International Cocoa Organization.

BOX 1.4 The rise and collapse of international supply management (*continued*)

Thus, the passage of time brings to bear market forces that eventually overwhelm supply management schemes. In some cases, organizations originally established to intervene in commodity markets have modified their objective to providing information, via market monitoring and the provision of statistics, thus improving market transparency through information-sharing, analysis, and consultation on market and policy developments. Such organizations serve a useful purpose by providing a public good.[d] Looking forward, ongoing efforts to substitute environmentally friendly energy sources for fossil fuels could benefit from the sharing of technical information among producers and consumers (see energy transition discussion in box 1.1).

Conclusion

Coordinated supply management efforts have been implemented in numerous commodity markets over the past century. They were implemented with various stated motives. For some, the objective was to facilitate an orderly transition in response to a large destabilizing event, such as the Great Depression or the aftermath of war. OPEC responded to the sharp fall in oil demand in 2020 at the onset of the recession caused by the COVID-19 pandemic with large cuts in production, which were matched by some non-member producers (Norway and Indonesia). The objective was limited and essentially short-run. For these reasons, actions aiming at an orderly post-crisis transition have often been successful.

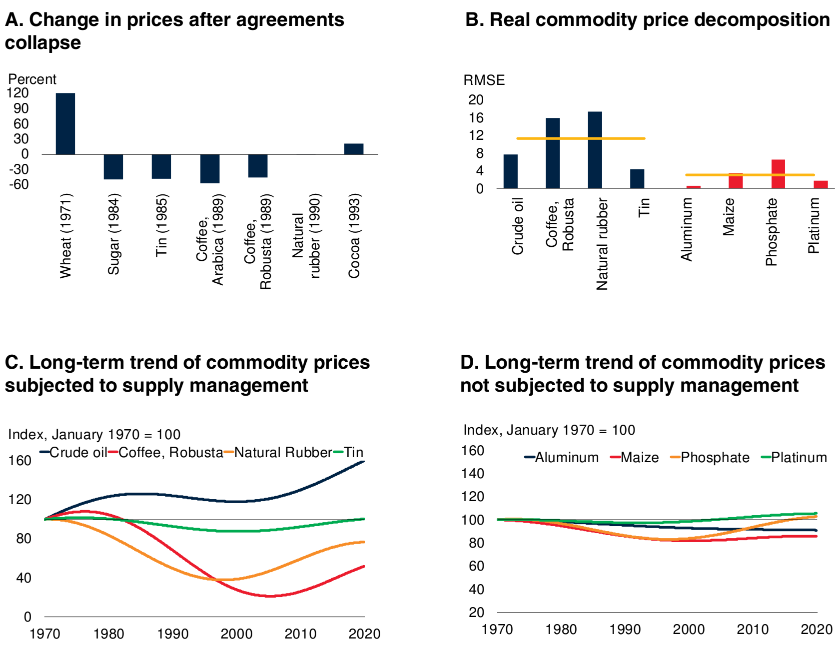
However, the original primary objective of most internationally negotiated supply management schemes has been more ambitious: to increase and stabilize prices over a longer term through agreed controls on production and exports or inventory management. Some of these schemes have been successful for a while, but they have often become victims of their own early success. High and stable prices have encouraged new producers to enter the market, and consumers to reduce their consumption. High oil prices, for example, have encouraged the expansion of non-OPEC supplies, the adoption of energy efficiency measures, and switching to substitute products. Moreover, enforcing quotas on members becomes more difficult as the benefits of adherence become more elusive. For these reasons, the passage of time tends to wear out supply management schemes.

From a policy perspective, the historical experience of supply management mechanisms with longer-run goals is not encouraging. While they can appear as an attractive tool to mitigate the adverse effects of the boom-bust cycles of commodity prices, they also distort markets by keeping prices stable or elevated and thereby cause their own collapse. At their worst, these mechanisms can exacerbate commodity price cycles and can harm producers of a given commodity

BOX 1.4 The rise and collapse of international supply management (*continued*)

FIGURE B1.4.2 Impact of collapse of supply management schemes on commodity prices

The collapse of supply management schemes most often led to declining prices. Prices of commodities subjected to supply management are characterized by high degree of non-linearity.



Source: World Bank.

A. The change is based on the 3-year nominal average before and after the year of the collapse of the agreement. The year of collapse is noted in the parenthesis and is excluded from the comparison.

B. RMSE refers to the root mean square error, which is a proxy for nonlinearity. Yellow line denotes group averages.

by encouraging consumers to switch to alternatives, which may lead to a permanent reduction in demand for the commodity.

Some international organizations that originated with the intention to manage supply, have shifted focus to become providers of market information, as a public good. Looking forward, ongoing efforts to substitute environmentally friendly energy sources for fossil fuels could benefit from the sharing of information among producers and consumers on technical research.

BOX 1.4 The rise and collapse of international supply management (*continued*)

TABLE 1.4.1 Non-oil Commodity Management Schemes

	Mechanism (membership), duration	Nature
	Pre-World War II	
Coffee	Export quotas and planting restrictions (State of São Paolo), 1905-29	Valorization schemes: They raised and stabilized prices and were profitable to the participating banks.
Wool	Government purchases (1 importer and 3 exporters), 1916-20	**Imperial Wool and Sheepskin Contract Scheme:** It maintained price stability and was terminated in 1920, as scheduled.
Copper	Export quotas (4 exporters), 1918-24	**Copper Export Association:** It succeeded in an orderly liquidation of copper inventories and was disbanded in 1924.
Tin	Buffer stocks (2 exporters), 1921-25	**Bandoeng Pool**: It was successful in liquidating inventories and led to the establishment of the International Tin Committee.
Tea	Production quotas (3 exporters), 1929-33	**Tea Restriction Scheme:** It raised prices of lower quality tea, but consumers preferences changed towards higher-priced teas.
Rubber	Export quotas and production restrictions (2 exporters), 1922-28	**Stevenson Plan**: It raised prices but led to output expansion by other exporters.
Copper	Export quotas (American and European mining companies), 1926-32	**Copper Exporters, Inc:** It raised prices but a strike by buyers and imposition of import tax the U.S. led to its dissolution in 1932.
Coffee	Prohibition of plantings and coffee destruction (Brazil), 1930-37	**Coffee Control Scheme**: It was a costly scheme; eventually the government allowed free competition.
Tin	Buffer stocks and export quotas (5 exporters), 1931-46	**International Tin Control Scheme**: It failed to stabilize prices due to rapid changes in demand during and after WWII.
Sugar	Export and production quotas (associations in 7 exporters), 1931-35	**The Chadbourne Agreement**: It failed to stabilize prices and collapsed a year before its termination date.
Silver	Government purchases (5 exporters and 3 importers), 1933-37	**London Silver Agreement**: It did not increase prices as expected but it benefited some exporting countries and companies.

BOX 1.4 The rise and collapse of international supply management (*continued*)

TABLE 1.4.1 Non-oil Commodity Management Schemes *(continued)*

	Mechanism (membership), duration	Nature
Pre-World War II		
Wheat	Export and import quotas (9 exporters 12 importers), 1933-34	**International Wheat Agreement**: It failed to stabilize prices and broke down after one year of operation.
Tea	Export quotas and planting restrictions (3 exporters), 1933-47	**Tea Regulation Scheme**: It stabilized prices initially but the agreement collapsed following increased demand after WWII.
Rubber	Export quotas and planting restrictions (5 exporters), 1934-44	**International Rubber Regulation Agreement**: Despite being extended for a second 5-year period, it was not successful in reducing price volatility.
Copper	Production quotas (mining companies from 7 exporting countries), 1935-39	**International Copper Cartel:** It stabilized prices but was terminated due to the outbreak of WWII.
Timber	Export quotas (9 exporters), 1935-39	**European Timber Exporters Convention**: It raised prices, but the scheme collapsed 1939 following the outbreak of WWII.
Beef	Export and import quotas (6 exporters), 1937-40	**Beef Agreement**: It operated successfully but was suspended during the outbreak of WWII.
Sugar	Export quotas and other restrictions (21 exporters and importers), 1937-46	**Regulation of Production and Marketing of Sugar**: It failed to address high-cost production among exporters.
Wool	Government purchases (1 importer and 3 exporters), 1940-46	**Imperial Wool Purchase Scheme**: It was successful in coordinating the allocation of wool and managing high wool inventories after WWII.
Coffee	Export quotas and import quotas (14 exporters and the U.S.), 1941-45	**Inter-American Coffee Agreement**: It raised prices but brought new producers, especially from Africa.
Post-World War II		
Wheat	Export and import quotas (5 exporters and 36 importers), 1949-71	**International Wheat Agreement**: It failed to stabilize prices and collapsed shortly before the 1970s commodity price boom.
Sugar	Export and import quotas (26 exporters and 18 importers), 1953-84	**International Sugar Agreement**: It did not achieve price stability despite being renewed three times (it was not implemented in between renewals).

BOX 1.4 The rise and collapse of international supply management (*continued*)

TABLE 1.4.1 Non-oil Commodity Management Schemes *(continued)*

	Mechanism (membership), duration	Nature
	Post-World War II	
Tin	Buffer stocks and export quotas (7 exporters and 18 importers), 1954-85	**International Tin Agreement**: It raised and stabilized prices but new entrants and substitution by aluminum led to the insolvency.
Coffee	Export quotas (42 exporters and 7 importers), 1962-89	**International Coffee Agreement**: It raised prices but disagreements among between resulted in the termination of the agreement.
Cocoa	Export quotas (6 exporters), 1964-65	**International Cocoa Agreement:** It lasted only one year due to a bumper crop.
Cocoa	Buffer stocks and export quotas (9 exporters and 35 importers), 1972-93	**International Cocoa Agreement**: Limited impact on prices despite being extended four times.
Rubber	Buffer stocks (13 exporters and 49 importers), 1979-99	**International Natural Rubber Agreement:** It did not stabilize prices and collapsed during the East Asian Financial crisis.

Source: Author's summary from references cited in the text.
Note: The schemes appear in chronological order.

aid to developing countries. A different support system, with deficiency payments when prices fell below a threshold level, was instituted in 1973.

In a sudden turnaround in world market conditions, surplus stocks soon disappeared as the Soviet Union became a large-scale grain importer. World grain production experienced a shortfall, and input costs increased sharply due to the oil price spike. Concerns about commodity surpluses and low prices were replaced by near panic over high prices and short supplies. This led to price controls for some meat products and a soybean export ban in 1974. High commodity prices during the late 1970s and early 1980s, along with strong exports, meant that little support from the U.S. government was required. However, the price collapse of the mid-1980s meant that the cost of the price support program spiraled again.

Policy revisions in 1985 and 1990 were aimed largely at controlling program costs. The boom in grain prices in the mid-1990s, which obviated the need for price deficiency payments, presented the opportunity for a thorough redesign of U.S. agricultural policy. The 1996 *Freedom to Farm Act* gave farmers fixed support payments, independent of current farm prices and production (Baffes and de Gorter 2005).

Over the past two decades, U.S. agricultural policies have shifted to reflect environmental and conservation concerns. These policies included a more flexible approach featuring counter-cyclical payments, subsidized insurance, and conservation programs (Glauber and Smith 2021). In a further shift, in 2019 the United States introduced cash compensation for farmers hurt by the escalation of tariffs in a trade dispute with China.

Western Europe

Prior to WWII, each Western European country had different agricultural structures and policies. France was a relatively low-cost producer with surplus capacity. The United Kingdom pursued a liberal trade policy with heavy dependence on imports. Germany's agriculture was heavily protected, with large, productive agricultural estates in the East, and small, less-efficient farms in the West. Holland had an efficient, export-oriented sector. During WWII and the years that followed, European countries experienced food shortages due to disruptions in production, distribution, and trade.

In recognition of the need for secure supplies of food for its population, and of the difficulties facing European farmers, a founding principle of the European Economic Community (EEC) in 1957 was the establishment of a Common Agricultural Policy (CAP). Its mandated objectives were multiple: to increase productivity through technological progress and the best use of resources; to ensure a fair standard of living for rural communities; to stabilize markets; to secure the availability of supplies, and to enforce fair prices. CAP began operating in the early 1960s, using common internal prices, tariffs, and financing as instruments to achieve the objectives. Measures included import levies to maintain price targets, export subsidies to gain global market share, and storage programs to keep excess supplies off the market.

When CAP was formulated, most member states were net importers of agricultural commodities. At first, it brought price stability in the internal market and posed no threat to external competitors. However, high and stable prices incentivized farmers to increase production, and within a decade the EEC went from being a major food importer to an exporter of grains, meats, sugar, and other food commodities.

Moreover, to maintain parity between farm incomes and rising urban incomes, the EEC had to repeatedly raise internal agricultural support prices (and hence widen the domestic-world price gaps). This imposed increasingly heavy costs on members for commodity purchases, storage, and export subsidies. To sustain CAP objectives, the EEC looked to international commodity agreements to achieve higher and more stable world prices. This became the EEC's main negotiating objective in the Tokyo Round of General Agreement on Tariffs and Trade (GATT) negotiations.

Declining world commodity prices during the 1980s, however, intensified the difficulties with the CAP. Stocks rose at unsustainably high rates, costs skyrocketed—the 1980s CAP accounted for around 60 percent of total EEC spending —and farm incomes still lagged those of non-farm sectors. Reforms to the CAP since then reduced the fiscal burden on the European Union (established in 1992) to 35 percent of the budget in 2020. Markets opened up, support prices were phased out, and EU storage spending was capped. The reforms marked a policy reorientation—from price support per se toward supporting incomes of farmers directly, improving food quality, and encouraging environmental sustainability. For example, the EU has measures to retire farmland in favor of afforestation. Policy reforms in Western Europe combined with reforms in the United States and other advanced economies have resulted in a decline in overall agricultural support to OECD countries by more than one-third during the past two decades (figure 1.16).

Japan and East Asia

Prior to WWII, Japan depended on imports from Korea, China, and elsewhere in the region to supplement domestic food production. Following WWII, the main government objective was a high degree of self-sufficiency in rice and maintaining farmer incomes. Key aspects of the policies included support of an extensive system of cooperatives for small farmers and the establishment of state trading agencies for imports. Marketing of basic commodities—including rice, wheat, beef, and dairy products, but excluding other commodities, such as soybeans and coarse grains—was another feature. Domestic prices were protected by import quotas.

The commodity price boom of the 1970s along with the soybean export embargo by the United States reinforced the desire for self-sufficiency in food commodities and fueled Japan's interest in international agreements to stabilize agricultural commodity prices and to guarantee reliable supplies of imports. Other East Asian countries, including Korea, also adopted policies that placed a heavy emphasis on high domestic protection and extensive use of state trading agencies.

Centrally planned economies

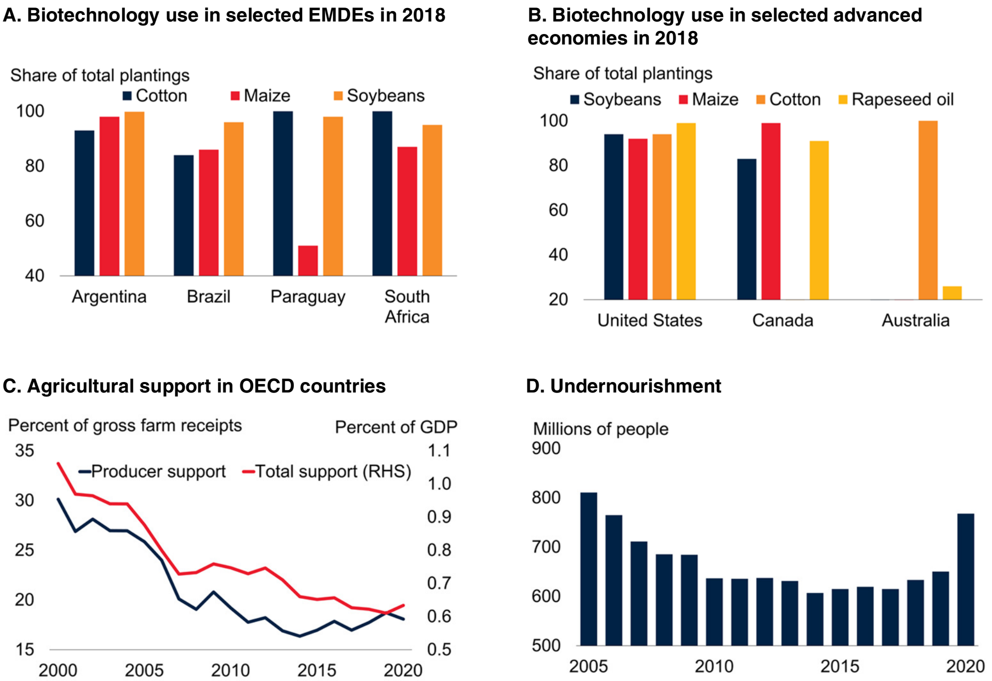
The Soviet Union nationalized agricultural production, marketing, and internal distribution in the 1930s. After WWII, it imposed a similar system on most Eastern European countries (with the exception of Poland, where small farmers retained control of their land). The two objectives of the centrally planned system were self-sufficiency and low costs of food for urban consumers. In sectors where self-sufficiency could not be achieved, trade was undertaken with other centrally planned economies, with crude oil often used in the barter exchange.

These policies were not successful. Inefficient production and marketing systems could not produce adequate supplies to meet consumer demand at artificially low prices. Consumption was rationed due to severe shortages, ultimately forcing the Soviet Union and several Eastern European countries to import grains and meats in the early 1970s.

Large and erratic Soviet imports had a destabilizing effect on international commodity markets during the 1970s and 1980s. In 1975, the United States signed an agreement with the Soviet Union under which the latter agreed to import at least 6 mmt of grains annually. The Soviet Union also agreed not to exceed a maximum amount, although

FIGURE 1.16 Developments since 2000

Despite high food commodity prices during 2020-22, world food markets are much better supplied compared to the early 2000s, according to the aggregate stocks-to-use ratio, a measure of demand relative to supply. Input costs, however, have risen, posing important risks if such increases become permanent. On the technology front, biotech commodities have been used by both advanced economies and EMDEs, with considerable productivity gains for the latter. Most of global cotton, maize, and soybean production comes from biotech varieties. Domestic support to agriculture by OECD countries has declined during the past two decades. On the demand side, food marketed through formal channels, such as supermarkets, has increased in most regions, including Sub-Saharan Africa countries. However, challenges regarding undernourishment remain, especially following COVID.



Sources: Brookes and Barfoot (2020); Food and Agriculture Organization of the United Nations; Oorganisation for Economic Co-operation and Development; U.S. Department of Agriculture (December 2021 update); World Bank (Commodity price database).
D. Data from FAO report *The State of Food Security and Nutrition in the World, 2021*. Data for 2020 are estimates.

domestic U.S. policies prevented any upper limit from being enforced. In the early 1980s, in response to the Soviet invasion of Afghanistan, the United States imposed an embargo on grain exports to the Soviet Union, triggering a collapse of grain prices in the global market.

Although the Soviet Union was producing large amounts of wheat prior to 1990, it was an inefficient producer. It relied on imports in the 1980s for grains to feed its livestock sector, which was growing rapidly under the incentive of heavy subsidies.[24] The breakup

[24] During 1970-90, meat production in the Soviet Union increased by two-thirds, and by the end of this period its per capita meat consumption was on par with that of advanced economies (Liefert 2002).

of the Soviet Union in 1991, and the transition to market economies, led to a major liberalization of agriculture, the removal of livestock subsidies, and substantial improvements in productivity. Russia, along with Ukraine and Kazakhstan, became key players in the global grain market.

Other centrally planned economies, notably China, began importing grains in the 1970s to offset domestic shortfalls. In the late 1970s, China began liberalizing its domestic commodity markets, albeit in a gradual manner. Initial reforms included the right to trade surplus production (Huang and Rozelle 2006). More reforms followed record production growth in the mid-1980s, including a reduction of production quotas (implying that farmers could sell more in open markets). New reforms were launched in the early 2000s, including the removal of all marketing restrictions and the elimination of government intervention in grain prices (Huang et al. 2004).

Agriculture policies of other EMDEs

Government intervention in agriculture in EMDEs has had multiple objectives. These include support for rural incomes, protection of domestic output (or self-sufficiency), maintenance of secure supplies, low prices of basic foods, and conservation of the environment. Managing the trade-offs between these objectives is a difficult task, fraught with political and social pitfalls. For reasons of economic efficiency, economists often advocate the replacement of distortionary subsidies and price controls with direct income supplements to farmers and low-income households. However, attempts to enact such proposals generally meet overwhelming opposition from interested parties (through regular political channels) and through street demonstrations. Another challenge is that governments often do not have the administrative capacity to deliver individualized support payments to targeted households in countries where a large proportion of the population works in the informal sector (Ohnsorge, Okawa, and Yu 2021). In these circumstances, government welfare payments may not be a feasible alternative to subsidized price-controlled food, e.g., bread or flour provided to poor people from a government outlet.

Some EMDEs had adopted policies aimed at shifting resources from raw materials and agriculture to processing and manufacturing. This industrialization-focused approach was based on the observation that rising incomes tend to boost demand for manufactured goods and services while having noticeably less impact on demand for primary products. That, in turn, would have a negative impact on primary commodity prices relative to manufacturing goods (Kindleberger 1943; Prebisch 1950; and Singer 1950; chapter 2). This view dominated the development agenda of the 1950s and 1960s and set the stage for the widespread industrialization policies pursued by LICs in the following decades. Import substitution, whereby domestic manufacturing is heavily protected from foreign competition, was a favored approach for promoting industrialization. At the same time, government parastatals assumed sole authority to manage all aspects of domestic commodity markets, including marketing, trade, provision of inputs, and exports—at considerable cost to these economies. Many EMDEs assumed large external debts to finance industrialization projects.

Numerous authors warned against such interventions from the outset. Johnson (1947) argued that the agricultural sector should not be subjected to interventions. Friedman (1954) disputed the benefits of managing income variability for agricultural producers. Johnston and Mellor (1961) criticized the pro-urban policies followed by many developing countries in pursuit of the industrialization agenda.

In the end, poor results undermined the arguments for industrialization and import-substitution policies. This was largely because programs were poorly conceived and managed. Government interventions in Africa have been found to amount to expropriation from agricultural producers for the benefit of urban populations (Bates 1981). More fundamentally, the strategic decisions of government planners were undone by the realities of world markets. Lal (1985) criticized the rigid approach to planning (where governments actively dictate economic decision-making) and advocated for more reliance on the price mechanism for allocating resources. The industrialization programs were ill-prepared to adapt to changes in technology and patterns of demand—or to the policy changes of foreign governments. Many authors highlighted the growing distortions associated with interventions in commodity markets (e.g., Krueger, Schiff, and Valdés 1992; World Bank 1986). Through the commodities price boom of the 1970s, rising revenues and heavy borrowing kept programs afloat, but the bust of the early 1980s, and the following EMDE debt crisis fully exposed their deficiencies.

On a practical level, international organizations pushed for market-oriented reforms as a condition of financial assistance. The World Bank introduced Structural Adjustment Loans in the early 1980s to assist EMDEs with debt issues caused by poor fiscal management. The associated conditions included reduced intervention by the state along with a reduction of subsidies and trade barriers. Some authors, however, have questioned the effectiveness of the adjustment programs (e.g., Harrigan and Mosley 2007). Reappraisal of conditionality in World Bank and IMF lending in the 2000s has led to less prescriptive programs, with more focus on results and the specific circumstances facing borrowing countries (Koeberle et al. 2005).

Conclusion

The chapter has reviewed developments in three commodity sectors—energy, metals, and agriculture—over the past century. It has looked at demand patterns, the impact of technology on supply, and the evolution of policy.

On the demand side, consumption of energy and metals has expanded more rapidly than the world population and per capita income in recent decades. For agricultural commodities, demand has expanded at about the same pace, especially that of basic foodstuffs. Over the past half-century, the location of demand growth for all commodities has shifted from AEs toward EMDEs, with a large shift in the consumption of primary products to China. Similarly, production of some commodities, especially refined metals, has also shifted to EMDEs. Technological improvements have taken place in all sectors, at varying rates, and with different effects both for consumption and production. The shale revolution, for example, upended oil and natural gas market dynamics in the 2010s. Among metals, innovation has led to wide-spread substitution (notably aluminum for other metals) and to the discovery and development of new reserves. In addition, the technology behind the energy transition will increasingly drive demand for metals. Spectacular increases in agricultural productivity followed the development of hybrid grains in the 1930s and the Green Revolution of the 1960s-70s. Advances in technology have also encouraged consumption via the creation of new products and hence new uses of commodities.

Commodity prices have always been volatile. Over the past half-century, oil prices have seen large fluctuations following shifts in strategy by OPEC, and the emergence of new sources of oil. Metals prices have seen prolonged cycles caused mainly by macroeconomic developments in the main consuming markets. Agricultural prices on the world market have followed a downward path in real terms, largely because of the large increases in agricultural productivity. Volatility around the downtrend has been caused by geopolitical factors (e.g., on-off grain purchases by the Soviet Union in the 1970s) and variations in harvests.

Policies at the national level have had multiple objectives, for example: stabilizing prices; protecting domestic industries; ensuring secure supplies; and raising rural incomes. Policy tools have included border policies (such as export subsidies, export/import bans, and tariffs) and internal policies (such as subsidies, taxes, and other types of support). Policies at the international level, such as international commodity agreements, have generally been directed toward stabilizing world markets and prices. They have included agreements to limit output, such as production quotas. However, in practice policies have had distortionary and, in the long run, destabilizing effects on commodity markets. For example, in the oil market, the changing strategies of OPEC have caused steep jumps and drops in prices. And the long-run outcome of agricultural support programs, despite their intention, has generally been excess supplies and stockpiling, and heightened downward pressure on prices.

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