Special Feature: Commodity Market Developments and Forecasts

Primary commodity prices rose 16.6 percent between February and August 2021. The sharp, broad-based increase, led by metals and energy commodities, was buoyed by a strong recovery in commodity demand, loose financial conditions, and supply-side and weather disruptions. A resurgence of COVID-19 is the major risk factor. This special feature also analyzes how the soaring demand for metals may delay the energy transition.

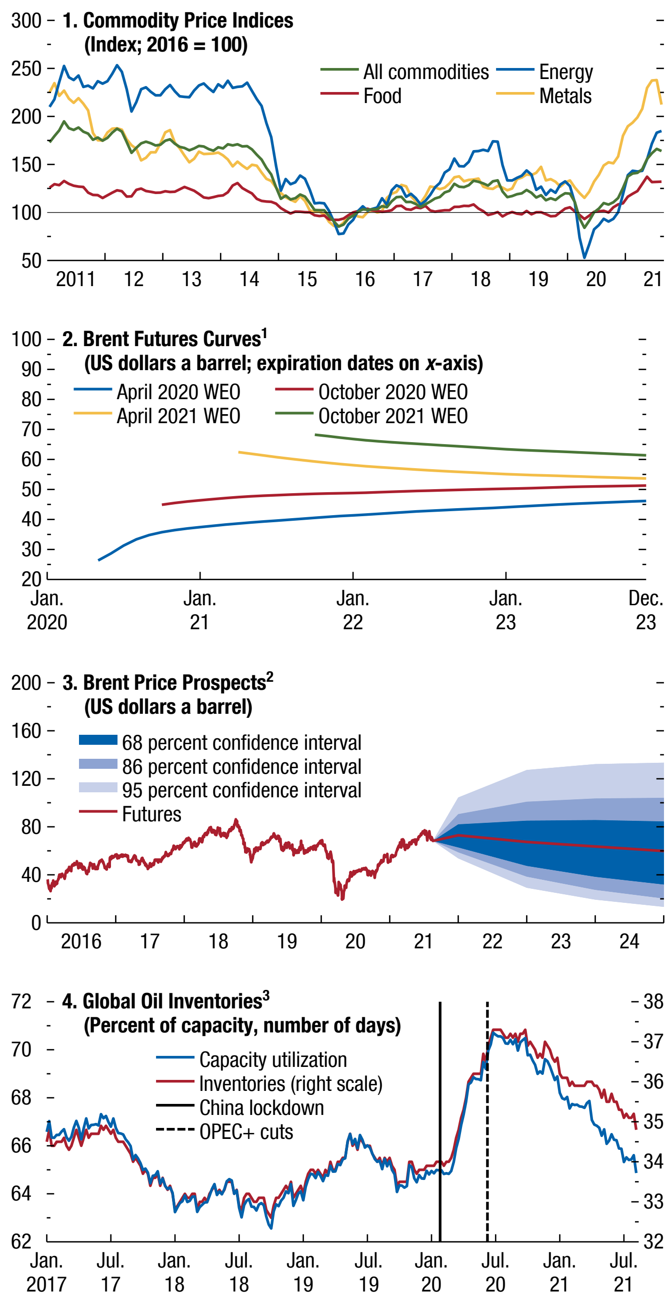
Market Developments

Oil prices rose 13.9 percent between February and August 2021 on the rapid economic recovery in advanced economies. In light of falling global inventories (Figure 1.SF.1, panel 4), OPEC+ (Organization of the Petroleum Exporting Countries, plus Russia and other non-OPEC oil exporters) agreed in July to gradually phase out their remaining 5.8 million barrel per day production curbs by September 2022.

Futures prices point to *backwardation* (a downward sloping curve), with oil prices at $65.7 per barrel in 2021—59 percent higher than the 2020 average—falling to $56.3 in 2026. Market tightness is expected to continue—in line with the International Energy Agency's (IEA) oil demand recovery projections. Risks to oil prices are balanced in the near term. Upside risks include lower global production capacity (because investment has fallen over the past year) and prolonged price support by OPEC+. The rise of the Delta variant of SARS-CoV-2 and higher output from uncommitted OPEC+ members (Iran, Libya, Venezuela) and US shale oil producers are the major downside risks to oil prices in the near term (Figure 1.SF.1, panels 2 and 3).

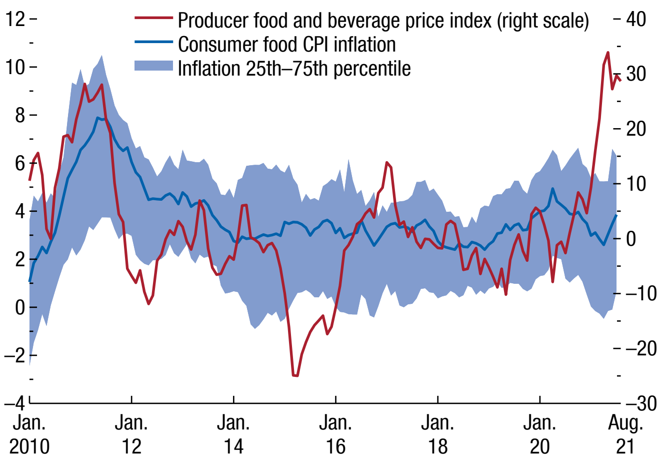
Natural gas prices spiked globally. Asian liquefied natural gas prices rose 132.2 percent to $16.6 a million British thermal units between February and August 2021, spilling over to European and US prices. The price spike was driven mainly by depleted natural gas stocks after a harsh winter, coupled with hot summer weather in the Northern Hemisphere, rebounding industrial activity, and idiosyncratic factors, such as low hydropower output in Brazil. High natural gas prices sustained the power sector's demand for coal, although surging coal prices—caused in part by supply disruptions and China's restrictions on Australian coal imports—and higher carbon prices narrowed coal's

Figure 1.SF.1. Commodity Market Developments



Sources: Bloomberg Finance L.P.; IMF, Primary Commodity Price System; Kpler; Refinitiv Datastream; and IMF staff estimates.
Note: OPEC+ = Organization of the Petroleum Exporting Countries, including Russia and other non-OPEC oil exporters; WEO = *World Economic Outlook*.
[1]Baseline assumptions for each WEO and are derived from futures prices. October 2021 WEO prices are based on August 18, 2021, closing.
[2]Derived from prices of futures and options on August 18, 2021.
[3]Inventories are expressed in days of 2019 oil consumption.

Figure 1.SF.2. Rising Pressure on Consumer Food Prices
(Percent)



Sources: Haver Analytics; and IMF staff calculations.
Note: Global food inflation represents the average level of consumer food price inflation in 91 countries. CPI = consumer price index.

cost advantage. Over the long term, phaseout plans and rising emission costs may negatively weigh on the demand outlook for coal, possibly benefiting natural gas demand in the coming years as the capacity for renewables ramps up.

The IMF base metal price index rose 9.7 percent between February and August 2021, while precious metal prices decreased by 1.8 percent. Base metals reached a 10-year high in July but have retreated somewhat since then. Prices were buoyed by the recovery in global manufacturing, improved prospects for infrastructure investment in advanced economies, and supply disruptions due to COVID-19. Expectations of higher metal demand during the energy transition supported prices for copper, cobalt, and other metals. Loose financial conditions provided additional price support.

The base metal price index in 2021 is projected to be 57.7 percent higher than the previous year average and to decrease 1.5 percent in 2022. Risks to the outlook are balanced, but the rise of the Delta variant is a major source of uncertainty as the resurgence of the virus may suppress demand for metals as well as disrupt supply. The pace of the energy transition adds uncertainty to the demand for some metals (see below). Precious metal prices are expected to rise 5.1 percent in 2021 and 0.2 percent in 2022.

Food prices: During the first half of 2021 prices of many staple crops surged, continuing the trend noted in the April 2021 *World Economic Outlook*. The IMF's food and beverage price index rose 11.1 percent between February and August, peaking in May 2021 at the highest price in real terms since the 2010–11 world food price crisis—led by meat (up 30.1 percent), coffee (29.1 percent), and cereals (5.4 percent).

Continued increases in international food producer prices pose upside risks to consumer food price inflation (Figure 1.SF.2), especially in emerging markets, where the pass-through from producer to consumer prices is higher than in advanced economies (26 percent versus 14 percent). The lag and magnitude of the pass-through vary according to regional factors, such as dependence of food imports and the strength of the local currency against the US dollar.

Clean Energy Transition and Metals: Blessing or Bottleneck?

To limit global temperature increases from climate change to 1.5 degrees Celsius, countries and firms increasingly pledge to reduce carbon dioxide emissions to net zero by 2050. Reaching this goal requires a transformation of the energy system that could substantially raise the demand for metals. Low-greenhouse-gas technologies—including renewable energy, electric vehicles, hydrogen, and carbon capture—require more metals than their fossil-fuel-based counterparts.

If metal demand ramps up and supply is slow to react, a multiyear price rally may follow—possibly derailing or delaying the energy transition. To shed light on the issue, this Special Feature introduces "energy transition" metals, estimates price elasticity of supply, and presents price scenarios for major metals. It also provides estimates for revenues and identifies which countries may benefit.

Critical Metals for Green Technologies

The metals required for clean energy transition are quite diverse (Table 1.SF.1). Some, such as copper and nickel (major *established* metals), have been traded for more than a century on metal exchanges. Others, such as lithium and cobalt (minor but *rising* metals), are thinly or not yet traded on metal exchanges but have gained popularity because they are used in energy transition technologies. In addition, the demand for some metals would increase with more certainty because they are used across a range of low-carbon technologies (copper, nickel, and manganese, for example) while

Table 1.SF.1. Key Indicators for Energy Transition Metals

Metal	Exchange Traded	Energy Transition Usage				Production (2020, $ billion)
		Renewable	Network	Battery	Hydrogen	
Copper	✓	✓	✓	✓		123.0
Aluminum	✓	✓	✓	✓	✓	107.0
Nickel	✓	✓		✓	✓	28.0
Zinc	✓	✓				28.0
Lead	✓	✓		✓	✓	26.0
Silver	✓	✓				13.0
Manganese	No	✓		✓	✓	25.0
Chromium	Recent	✓				19.0
Silicon	No	✓				14.0
Molybdenum	Recent	✓			✓	5.0
Cobalt	Recent			✓		4.1
Lithium	Recent			✓		1.8
Vanadium	No			✓		1.3
Graphite	No			✓		1.3

Sources: IEA (2021); World Bank (2020b); and IMF staff calculations.
Note: The column "Production" is the value of refined and unrefined mining production.

the use of others, such as cobalt and lithium, is limited to batteries.

The four representative metals chosen for in-depth analysis are copper, nickel, cobalt, and lithium. Copper and nickel are well-established metals. Cobalt and lithium are probably the most promising *rising* metals.

In the IEA's *Net Zero by 2050* emissions scenario, total consumption of lithium and cobalt rises by a factor of more than six, driven by clean energy demand, while copper shows a twofold and nickel a fourfold increase in total consumption (see Figure 1.SF.3).[1] The scenario also implies that the growth in metal demand would initially be very high between now and 2030 and slow down over time because the switch from fossil fuels to renewables requires large initial investments (Figure 1.SF.4). The increase in demand for metals is more modest in the IEA's *Stated Policies Scenario*.

Where Will Energy Transition Metals Be Produced? Who Will Benefit?

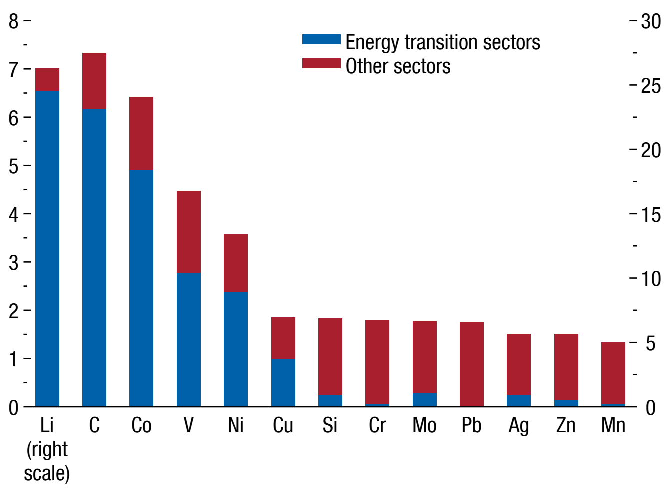
The supply of metals is quite concentrated, implying that a few top producers may stand to benefit. In most cases, countries that have the largest production have the highest level of reserves and, thus, are likely prospective producers. The Democratic Republic of the Congo, for example, accounts for about 70 percent of global cobalt output and 50 percent of reserves (Figure 1.SF.5).

[1]The IEA's *Net Zero by 2050* scenario assumes that policies and behavioral changes bring carbon emissions to net zero by 2050. The IEA's *Stated Policies Scenario* assumes a more gradual energy transition, resulting in insufficient action on climate change (IEA 2021).

Other countries that stand out in production and reserves include Australia (for lithium, cobalt, and nickel); Chile (for copper and lithium); and, to lesser extent, Peru, Russia, Indonesia, and South Africa.

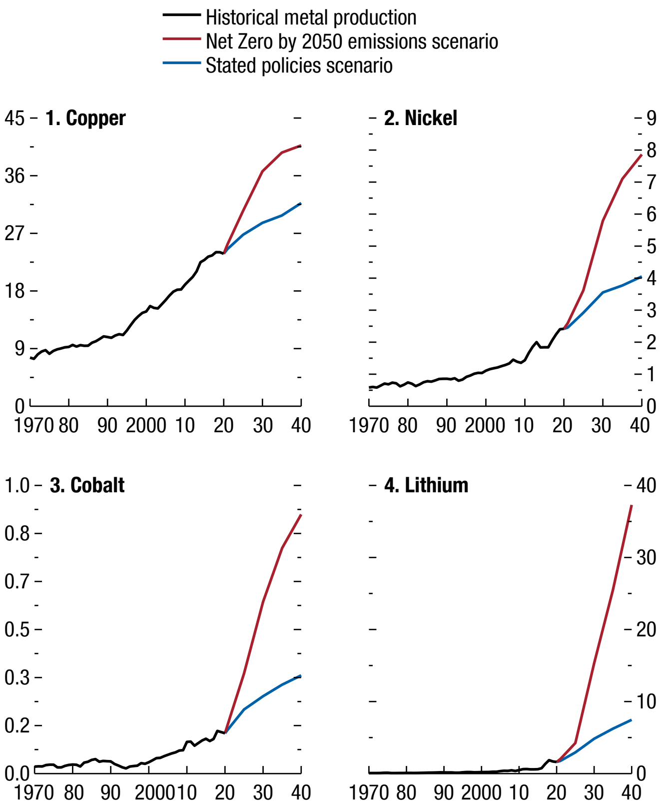
The economic benefits of higher prices for metal exporters could be substantial. Econometric analysis identifies the impact of price shocks, exploiting the different responses of GDP and government balances

Figure 1.SF.3. Demand for Critical Energy Transition Metals May Increase Sharply in the Next Two Decades
(Ratios, 2030s average consumption relative to 2010s average)



Sources: International Energy Agency (IEA); Schwerhoff and Stuermer (2020); and IMF staff estimates.
Note: The bars represent decade ratios: consumption of each metal in the 2030s divided by consumption in the 2010s, under the IEA's *Net Zero by 2050* emissions scenario. See Online Annex 1.SF.1 for the selection of metals and abbreviations.

Figure 1.SF.4. Historical Metal Production and IEA Energy Transition Scenarios
(Million metric ton)



Sources: International Energy Agency (IEA); Schwerhoff and Stuermer (2020); US Geological Survey; and IMF staff calculations.
Note: Copper and nickel refer to refined production, while cobalt and lithium refer to mine production.

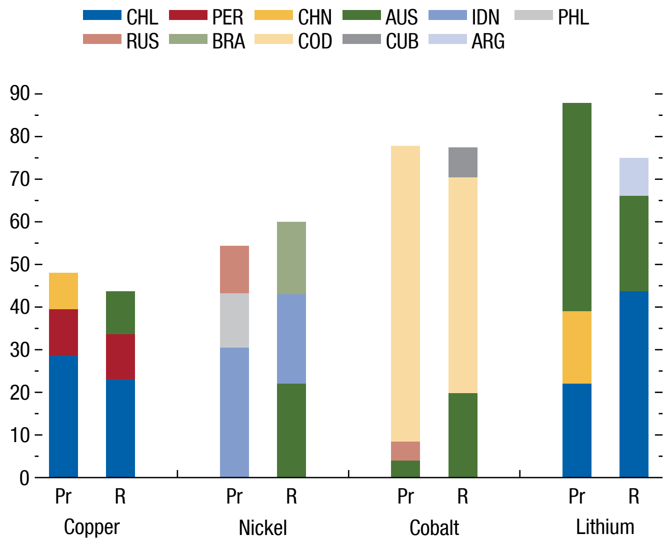
between the 15 largest metal exporters and importers. A 15 percent persistent increase in the IMF metal price index adds an extra 1 percentage point of real GDP growth (fiscal balance) for metal exporters compared with metal importers (Figure 1.SF.6).

Metal Prices and Supply Elasticities in a *Net Zero by 2050* Scenario[2]

Supply elasticities summarize how fast firms raise output in reaction to a price increase. In the short term, supply grows thanks to more recycling and higher utilization rates of mining capacity. In the long term, firms build new mines, innovate in extraction

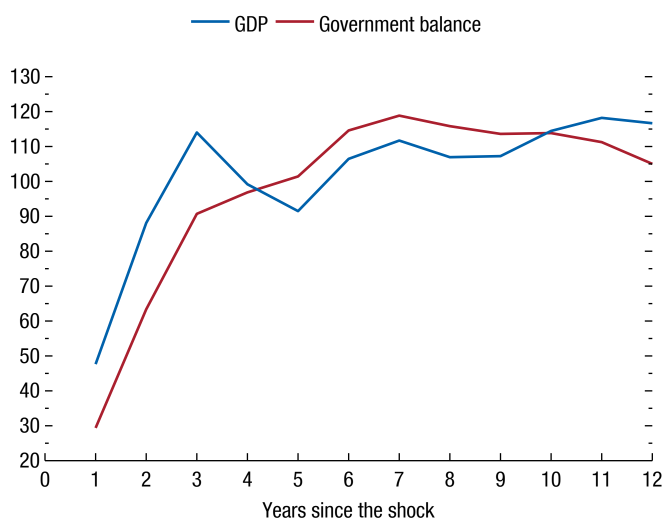
[2]The econometric analysis of this section and subsequent sections is based on Boer, Pescatori, and Stuermer (forthcoming).

Figure 1.SF.5. Top Three Countries, by Share of Global Production and Reserves for Selected Metals
(Percentage points)



Sources: United States Geological Survey; and IMF staff calculations.
Note: Data labels use International Organization for Standardization (ISO) country codes. Pr = Production; R = Reserves.

Figure 1.SF.6. Impact of Metal Price Shocks on Exporters
(Basis points)



Source: IMF staff calculations.
Note: The figure shows panel vector autoregression generalized impulse responses following Pesaran and Shin (1998) for the differences in GDP growth and the general government-balance-to-GDP ratio of the 15 largest metals exporters relative to the 15 largest importers for a 1-standard-deviation shock to metal prices (about 15 percent).

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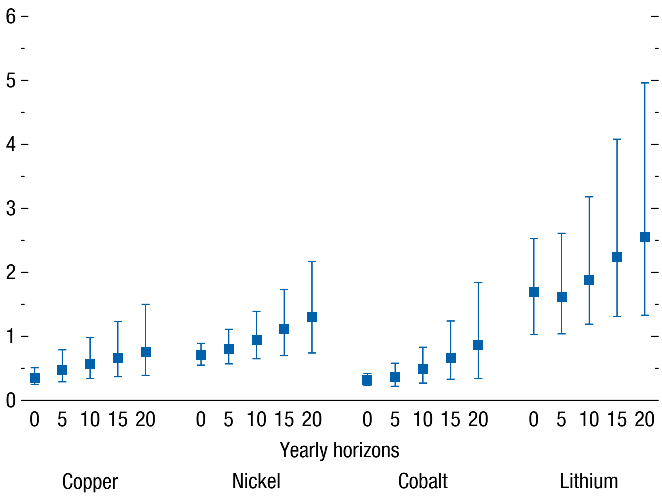
Figure 1.SF.7. Supply Elasticities for Selected Metals



Sources: Schwerhoff and Stuermer 2020; and IMF staff calculations.
Note: Supply elasticities are the ratio of the change in price and output from horizon 0 to 20 years, derived from metal-specific demand shocks. Lower and upper bounds are the 16th and 84th percentiles, respectively. See Online Annex 1.SF.1 for methodology.

technologies, and conduct exploration.[3] To estimate the elasticity at different horizons, data are used for global economic activity, output, and real prices from 1879 to 2020, where available.

Results show that supply is quite inelastic over the short term but more elastic over the long term (Figure 1.SF.7). A demand-induced positive price shock of 10 percent increases the same-year output of copper by 3.5 percent, nickel 7.1 percent, cobalt 3.2 percent, and lithium 16.9 percent. After 20 years, the same price shock raises the output of copper by 7.5 percent, nickel 13.0 percent, cobalt 8.6 percent, and lithium 25.5 percent.

The elasticities correspond to the four metals' different production methods. Copper, nickel, and cobalt are extracted in mines, which often require capital-intensive investment and take as long as 19 years to construct. In contrast, lithium is often extracted from mineral springs and brine as salty water is pumped from the earth. As such, lead times to open new production facilities—up to seven years—are shorter. Innovation in extraction technology, market concentration, and regulations also influence supply elasticities.

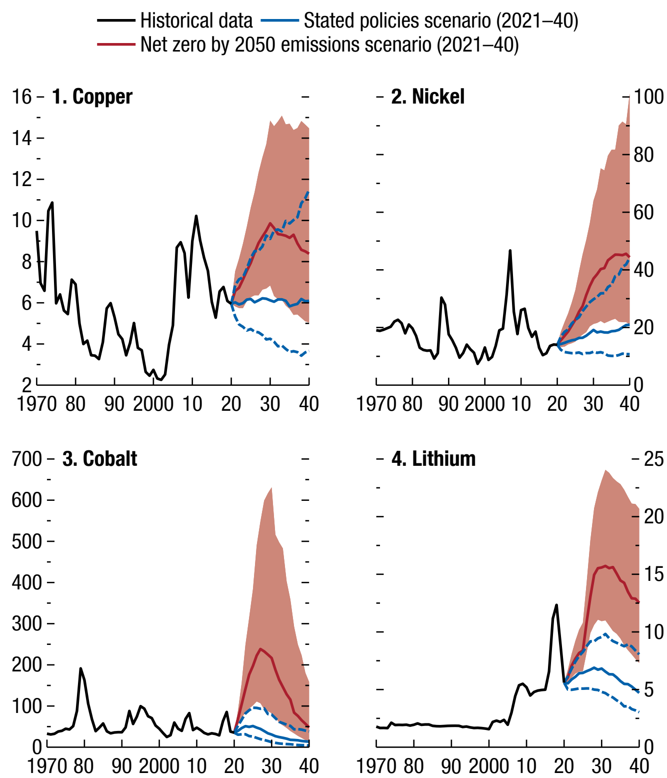
[3]Geological reserves are not fixed but dynamic. Firms can increase their reserves by investing in exploration and extraction technologies. The amount of metals in the Earth's crust is quite abundant compared to human extraction in any time frame relevant for economic considerations (see Schwerhoff and Stuermer 2020).

Metal Price Scenarios

Based on historical data and the estimated supply elasticities, the algorithm by Antolin-Diaz, Petrella, and Rubio-Ramirez (2021) pins down a series of exogenously- and demand-driven price shocks that incentivize the production path needed for the energy transition in the IEA scenarios (see Online Annex 1.SF.1, available at www.imf.org/en/Publications/WEO). A price path implied by these shocks is then derived. Compared with conditional forecasts, this methodology can distinguish between demand and supply shocks driving the price.

Results show that prices would reach historical peaks for an unprecedented, sustained period under the *Net Zero by 2050* emissions scenario. The prices of cobalt, lithium, and nickel would rise several hundred percent from 2020 levels and could delay the energy transition (Figure 1.SF.8). In contrast, copper is less in danger of a bottleneck as it faces

Figure 1.SF.8. Price Scenarios for the IEA's *Stated Policies Scenario* and the *Net Zero by 2050* Emissions Scenario
(Thousands of 2020 US dollars a metric ton)



Sources: International Energy Agency (IEA); Schwerhoff and Stuermer (2020); US Bureau of Labor Statistics; US Geological Survey; and IMF staff calculations.
Note: Prices are adjusted for inflation using the US consumer price inflation index. The scenarios are based on a metal-specific demand shock. See Online Annex 1.SF.1 for the data descriptions and methodology.

less steep demand increases. Estimated prices reach a peak, roughly such as the one in 2011, although for a longer period. Prices for all four metals would broadly stay in the current range in the *Stated Policies Scenario*. Results are subject to high uncertainty, reflected in the large bounds.

Prices peak mostly around 2030 for two reasons: first, the steep rises in demand are frontloaded in the *Net Zero by 2050* emissions scenario. Unlike fossil-fuel-based energy production, renewable energy production uses metals up front; for example, to build wind turbines or batteries. Second, the price boom induces a supply reaction, reducing market tightness after 2030.

Table 1.SF.2. Estimated Cumulated Real Revenue for the Global Production of Selected Energy Transition Metals: 2021–40
(Billions of 2020 US dollars)

	Historical (1999 to 2018)	Stated Policies Scenario	Net Zero Scenario
Selected Metals	**3,043**	**4,974**	**13,007**
Copper	2,382	3,456	6,135
Nickel	563	1,225	4,147
Cobalt	80	152	1,556
Lithium	18	141	1,170
Fossil Fuels	**70,090**	**. . .**	**19,101**
Oil	41,819	. . .	12,906
Natural Gas	17,587	. . .	3,297
Coal	10,684	. . .	2,898

Sources: International Energy Agency; and IMF staff calculations.
Note: For 2021–40, prices of $30 a barrel for oil, $1.50 a million British thermal unit for natural gas, and $40 a metric ton for coal are assumed.

Revenue and Policy Implications

In the *Net Zero by 2050* emissions scenario, the demand boom would lead to a sixfold increase in the value of metal production—totaling $12.9 trillion over the next two decades for the four energy transition metals alone, providing significant windfalls to producers. This would rival the potential value of global oil production in that scenario (see Table 1.SF.2).

High uncertainty surrounds the demand scenarios. First, technological change is hard to predict. Second, the speed and direction of the energy transition depend on policy decisions.

High policy uncertainty, in turn, may hinder mining investment and increase the chances that high metal prices will derail or delay the energy transition. A credible, globally coordinated climate policy; high environmental, social, labor, and governance standards; and reduced trade barriers and export restrictions would allow markets to operate efficiently, directing investment to sufficiently expand metal supply—thus avoiding unnecessarily increasing the cost of low-carbon technologies and supporting the clean energy transition.

Finally, a new international institution focused on metals—analogous to the IEA for energy and the Food and Agricultural Organization for agricultural goods—could play a pivotal role in data dissemination and analysis, industry standards, and international cooperation.

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