SPECIAL FOCUS 1

The Role of Major Emerging Markets in Global Commodity Demand

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Rapid growth among the major emerging markets over the past 20 years has boosted global demand for commodities. The seven largest emerging markets (EM7) accounted for almost all the increase in global consumption of metals, and two-thirds of the increase in energy consumption over this period. As these economies mature and shift towards less commodity-intensive activities, their demand for most commodities may plateau. While global energy consumption growth may remain broadly steady, growth in global demand for metals and food could slow by one-third over the next decade. This would dampen global commodity prices. China would likely remain the single largest consumer of many commodities, although consumption growth in other EM7 countries might accelerate. For the two-thirds of emerging market and developing economies that depend on raw materials for government and export revenues, these prospects reinforce the need for economic diversification and the strengthening of policy frameworks.

Introduction

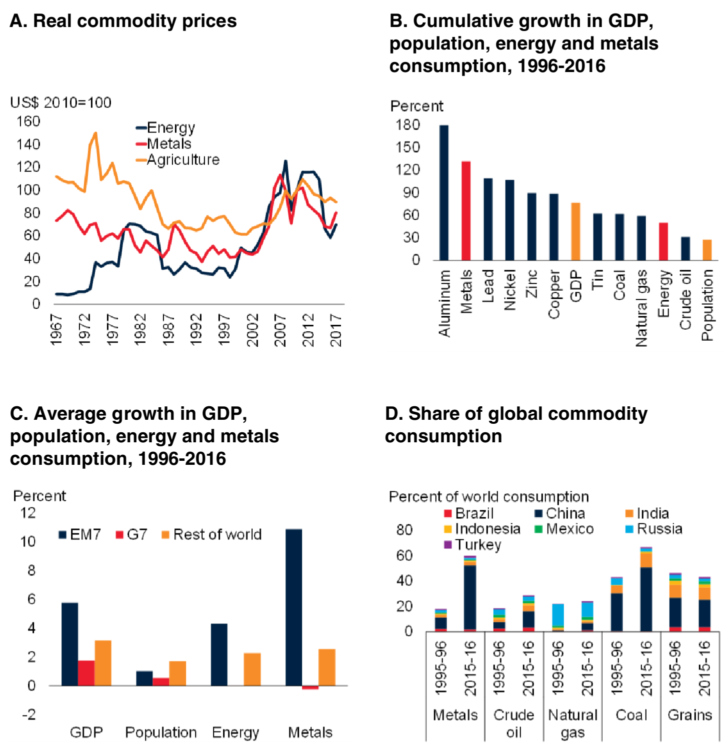
Global commodity demand surged in 2000-08, driven by rapid growth in large emerging market and developing economies (EMDEs), especially China. Over this period, real energy prices rose 154 percent, metals prices increased 107 percent, and food prices rose 62 percent (Figure SF1.1). Commodity prices peaked in 2011, and fell sharply in 2014, driven by the collapse in the price of crude oil. While commodity prices have since recovered as a result of the cyclical global economic recovery, over the longer term, economic developments in major EMDEs will be a critical factor for the path of demand.

This Special Focus explores the role of the seven largest EMDEs, the EM7 (Brazil, China, India, Indonesia, Mexico, the Russian Federation, and Turkey). Together, these economies account for about 25 percent of global GDP and 50 percent of the world's population. In commodity markets, this group about for around 60 percent of the consumption of metals and 40 percent of the consumption of energy and food. The EM7 have also driven much of the increase in industrial materials demand over the past two decades, with China alone accounting for 83 percent of the global increase in metals consumption and 48 percent of the increase in energy consumption.

Note: This Special Focus was prepared by John Baffes, Alain Kabundi, Peter Nagle, and Franziska Ohnsorge. Research assistance was provided by Xinghao Gong.

FIGURE SF1.1 Developments in commodity markets

Consumption of commodities has surged over the past 20 years. Growth in consumption of metals, particularly aluminum, has been much faster than GDP and population growth, while energy consumption growth has been slower than GDP growth.



Sources: BP Statistical Review, U.S. Department of Agriculture, World Bank, World Bureau of Metals Statistics.

A. Deflated using the manufacturing unit value index from the January 2018 edition of the *Global Economic Prospects* report.

B.-D. Metals aggregate includes aluminum, copper, lead, nickel, tin, and zinc. Energy aggregate includes coal, crude oil, natural gas, nuclear, and renewables.

C. G7 includes Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States. EM7 includes Brazil, China, India, Indonesia, Mexico, Russia, and Turkey.

D. Grains includes maize, rice, and wheat.

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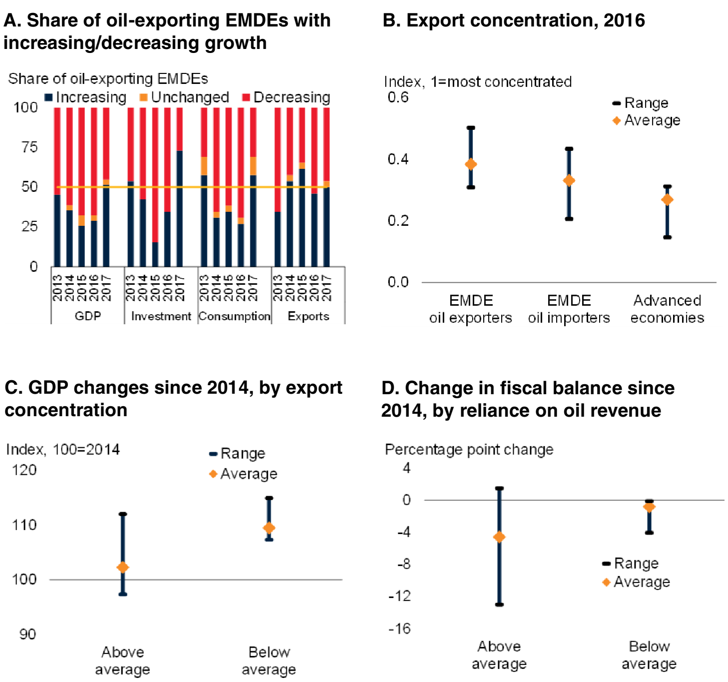
FIGURE SF1.2 Vulnerabilities to oil price fluctuations

The oil price collapse in 2014 severely set back economic activity and worsened fiscal positions in oil-exporting countries. Oil-exporting countries tend to have an above-average export concentration compared with other EMDEs. Activity in oil exporters with lower levels of export concentration recovered more quickly than in those with high export concentrations. The deterioration in fiscal deficits was greater in oil-exporting EMDEs with higher reliance on oil-related revenues.



Sources: International Monetary Fund, United Nations Conference on Trade and Development (UNCTAD), World Bank.

A. Aggregate growth rates calculated using constant 2010 U.S. dollar GDP weights. Increasing/decreasing growth are changes of at least 0.1 percentage point from the previous year. Countries with a slower pace of contraction from one year to the next are included in the increasing growth category.

B.-D. Figure shows average and interquartile range for the separate categories. Sample includes 31 oil-exporting EMDEs as defined in World Bank 2018a.

B.C. Export concentration is measured by a Herfindahl-Hirschmann Index, where values closer to 1 indicate a country's exports are highly concentrated on a few products.

C. "Above average" and "below average" groups are defined by countries above or below the sample average for export concentration in 2014.

D. Change in overall fiscal balance is measured from 2014-17. Above average and below average oil revenue groups are defined by countries above or below the sample average of oil revenues as a share of GDP based on 2014 data.

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EMDEs are likely to remain important drivers of commodity market developments, although the importance of individual countries will change. While China has been the main driver of growth in industrial materials, its expected growth slowdown and shift towards less commodity-intensive activities such as services could herald softer commodity consumption in the future. Global growth is expected to be increasingly driven by economies that are, at present, much less commodity intensive than China. Weaker commodity consumption growth is a key factor behind the World Bank's forecast of modest price growth over the medium-term (World Bank 2018a).

Slowing commodity demand and modest price increases will have important consequences for growth and poverty alleviation among other EMDEs. Two-thirds of EMDEs depend significantly on agriculture and mining and quarrying for government and export revenues, and more than half of the world's poor live in commodity-exporting EMDEs (World Bank 2016a). This exposes these economies to commodity price shocks (Didier et al. 2016; Baffes et al. 2015). For example, the crude oil price collapse in mid-2014 resulted in a growth slowdown in 70 percent of EMDE oil exporters, with the largest impact in countries with higher levels of export concentration (Figure SF1.2; World Bank 2017a, 2018b). The fall in prices weakened fiscal positions and led to sharp cuts in government spending. The prospect of weaker commodity prices intensifies the need for reforms to encourage economic diversification in commodity exporters, and to strengthen monetary and fiscal policy frameworks (World Bank 2018a).

This Special Focus addresses the following questions:

- What impact have the EM7 had on consumption of major commodities?
- What is the role of per capita income growth in rising commodity consumption?
- What are the prospects for global commodity consumption?
- What policy measures can commodity exporters implement to boost resilience?

This Special Focus presents a comprehensive and detailed analysis of the role of major emerging markets in global consumption of a wide range of commodities. It also presents estimates for the income elasticities of consumption for a range of energy, metals, and food products. In doing so, it expands on previous research looking at the impact of China and India on commodity consumption (World Bank 2015b; Pesaran et al. 1998, 1999; Sturmer 2017). Finally, it develops a set of stylized scenarios of consumption growth prospects based on estimated income elasticities, together with long-term population and GDP projections.

The role of the EM7 in commodity consumption

EM7 in the global economy. The share of the EM7 in the global economy has grown rapidly. Since 2010, the EM7 accounted for more than half of global growth, 19 percent of global trade and 18 percent of global FDI flows (Figure SF1.3). They now account for 25 percent of global GDP (at market exchange rates) and 50 percent of the global population.

Given their size and international integration, the EM7 economies can produce significant cross-border spillovers: estimates suggest that a 1 percentage point increase in EM7 growth is associated with a 0.9 percentage point increase in growth in other emerging market and developing economies and a 0.6 percentage point increase in global growth at the end of two years (Huidrom, Kose, and Ohnsorge 2017; World Bank 2016b). Individual EM7 countries can also have global and regional impacts:

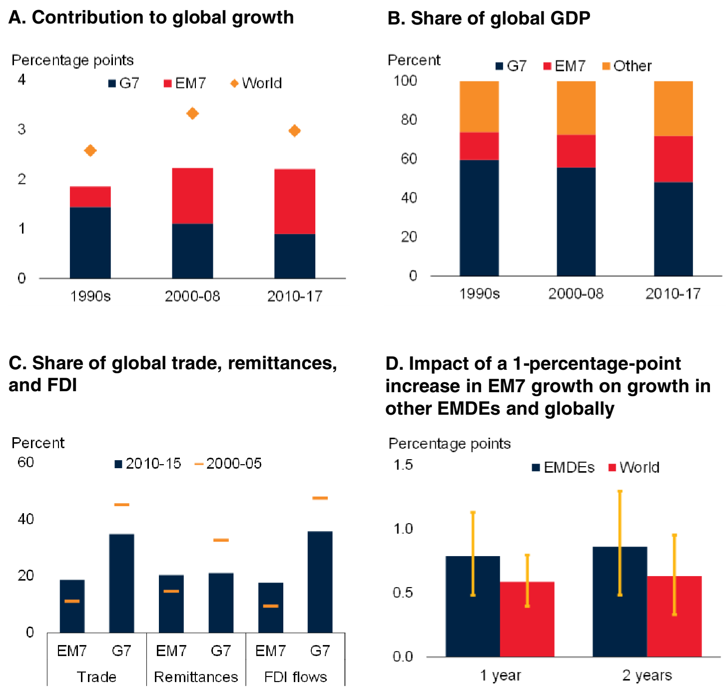
- *China* plays a uniquely important role among the EM7. Growth spillovers from China have a global reach, while those of other EM7 are largely regional (World Bank 2016a). China has almost as large a share of global GDP (12 percent) as the other EM7 combined (13 percent).

- *Brazil* and *Mexico* are the largest economies in Latin America and the Caribbean (LAC), accounting for 60 percent of regional GDP. Shocks to growth in Brazil, in particular, have a statistically significant impact on neighboring EMDEs (World Bank 2016b).

- *Russia* accounts for 46 percent of GDP in Europe and Central Asia (ECA). It has important spillovers to Central Asia and Eastern Europe through long-established trade, investment, and migration links.

FIGURE SF1.3 EM7 in the global economy

The role of the EM7 in the global economy has grown rapidly and they now account for 25 percent of global GDP, although they remain smaller than the G7. Since 2010, EM7 have accounted for more than half of global growth, 19 percent of global trade, and 18 percent of global FDI flows. Shocks to growth in EM7 countries can have sizeable spillovers at the global level, as well as to other EMDEs.



Sources: United Nations Conference on Trade and Development (UNCTAD), World Bank.
A.-C. EM7 includes Brazil, China, India, Indonesia, Mexico, Russia, and Turkey. G7 includes Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States.
A.B. Aggregate growth rates and GDP shares calculated using constant 2010 U.S. dollar weights.
C. World shares of EM7 and G7 countries of trade (exports and imports of goods and services), remittances (both paid and received), and FDI flows (inward plus outward) over respective periods.
D. Results are derived from a Bayesian vector autoregression using the methodology outlined in Huidrom, Kose and Ohnsorge (2017). The model includes, in this order, G7 growth, the U.S. interest rate, J.P. Morgan's Emerging Market Bond Index (EMBI), EM7 growth, oil prices, and growth in other EMDEs. Other EMDEs consists of 15 countries. Cumulative impulse responses of a 1-percentage point increase in EM7 growth on growth in other EMDEs (blue) and global growth (red), at the 1-year and 2-year horizons. Solid bars represent medians, and error bars represent 16-84 percent confidence intervals.
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EM7 in commodity markets. The EM7 are important participants in commodity markets, both as consumers and producers (Box SF1.1, Annex Tables SF1.1, and SF1.2).[1] The group accounts for a larger share of global consumption than the G7 in coal, all base metals, precious metals, and most foods (rice, wheat, soybeans; Figure SF1.4).

[1] "Consumption" includes the use of commodities for final consumption, as well as intermediate inputs into the manufacture of other products, including for export. To the extent that these other products are exported, the source country of final demand may not coincide with the source country of commodity demand.

BOX SF1.1 The role of the EM7 in commodity production

After decades of rapid growth, the EM7 have become major commodity producers. China is the world's single-largest producer of coal, several base metals, and fertilizers, while other EM7 are also key suppliers of several commodities. As a result, policies that affect EM7 commodity production—such as recent trade- and security-related measures—can move global markets.

Following several decades of rapid growth in commodity production, in part in response to rising domestic demand, the EM7 have become major commodity producers. For many commodities, their production exceeds that of the G7 economies by a wide margin. China in particular is now a major commodity producer, although its consumption of most commodities has outpaced its production.

This box analyzes the following questions:

- What is the role of EM7 in today's commodity production?
- How has this role evolved over time?

EM7's current role in commodity production

Major producers of many commodities. The EM7 account for more than half of global production in coal, rice, and most base metals (aluminum, copper, lead, tin, and zinc). In some energy commodities (oil and natural gas), they account for more than one-fifth of global production. EM7 production dwarfs G7 production in coal, metals, rice and maize, while it almost matches G7 production in crude oil, natural gas, and wheat. The EM7 produce about 20 times as much rice as G7 economies, almost eight times as much aluminum, and three to five times as much copper, coal, and zinc.

Individual EM7 countries. Individual EM7 countries, especially China, dominate global production of several commodities (Table SF1.2):

- *China* is the world's largest producer of coal, several metals (aluminum, refined copper, lead and gold), rice, and fertilizers.
- *India* is the largest producer of cotton and the second-largest producer of fertilizers.
- *Russia* is the second-largest producer of aluminum and natural gas, and third largest producer of oil.
- *Brazil* is the largest producer of coffee and sugar, the second-largest producer of soybeans, and the third-largest producer of bauxite.
- *Indonesia* is the largest producer of tin and palm oil and the second largest producer of rubber.
- *Mexico* is the largest producer of silver.

China's production of rice and wheat is almost as large as that of all other EM7 combined, while its production of most base metals (aluminum, copper, lead, zinc, and tin) is a multiple of that of all other EM7 combined.

Evolution of the EM7's role over time

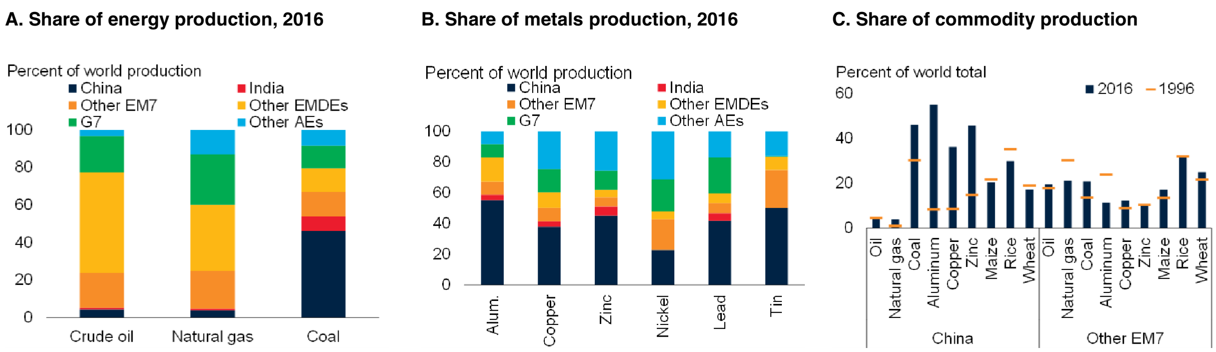
Role of the EM7 in energy and metals markets. Between 1996 and 2016, the EM7 share of global metals production more than doubled to 60 percent and their share of global energy production increased to 39 percent (Figure SF1.1.1). Over this period, the EM7 accounted for almost 90 percent of the increase in metals production and over half of the increase in global energy production.

Role of China in energy and metals markets. The growing role of the EM7 in global commodity production largely reflects expansion in China. China's share of global metals production increased to 48 percent between 1996 and 2016 (driven by aluminum), and its share of global energy production nearly doubled, to 18 percent in 2016. Growing domestic production dampened the impact of the increase in China's demand on global commodity markets, with domestic supply accounting for nine-tenths of the increase in China's metals consumption. China's consumption of copper and nickel was more dependent on imports than consumption of other metals. While production of metals rose in the other EM7, they lost global market share (from 16 percent to 12 percent) to China. The EM7 share of energy production rose slightly, driven by oil in Brazil and Russia, and coal in India and Indonesia.

BOX SF1.1 The role of the EM7 in commodity production (*continued*)

FIGURE SF1.1.1 EM7 in commodity production

The EM7 are some of the largest commodity producers in the world. Their share of global production of commodities has increased rapidly over the past 20 years, and they now account for around 60 percent of metals production, and 40 percent of energy and agricultural production.



Sources: BP Statistical Review, U.S. Department of Agriculture, World Bank, World Bureau of Metals Statistics.
A.B. "AEs" stands for advanced economies. "Other EM7" includes Brazil, Indonesia, Mexico, Russia, and Turkey (and excludes China and India).
A. Other AEs contains five countries. Other EMDEs is calculated as the residual of the global total.
B. Alum. refers to the metal aluminum. Other AEs contains 10 countries. Other EMDEs contains 25 countries.
C. Other EM7 includes Brazil, India, Indonesia, Mexico, Russia, and Turkey.
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Role of EM7 in agricultural commodities. In contrast to energy and metals, the role of the EM7 in agricultural production has been fairly constant over the last two decades, similar to the evolution of their consumption. The EM7 share of the three main grains (maize, rice, and wheat) has stayed broadly flat at about 44 percent since 1996.

Role of the EM7 in other EMDEs. Some of the EM7 are increasingly involved in production in other EMDEs through investments, or partnerships and subsidiaries. Sub-Saharan Africa has been one of the main beneficiaries of investment, which has been prevalent in agriculture and metals, notably rare earths (Deininger et al. 2011; Dollar 2016). Again, China has been the most prominent country, although Russia has also been a key player, particularly in aluminum.

Conclusion

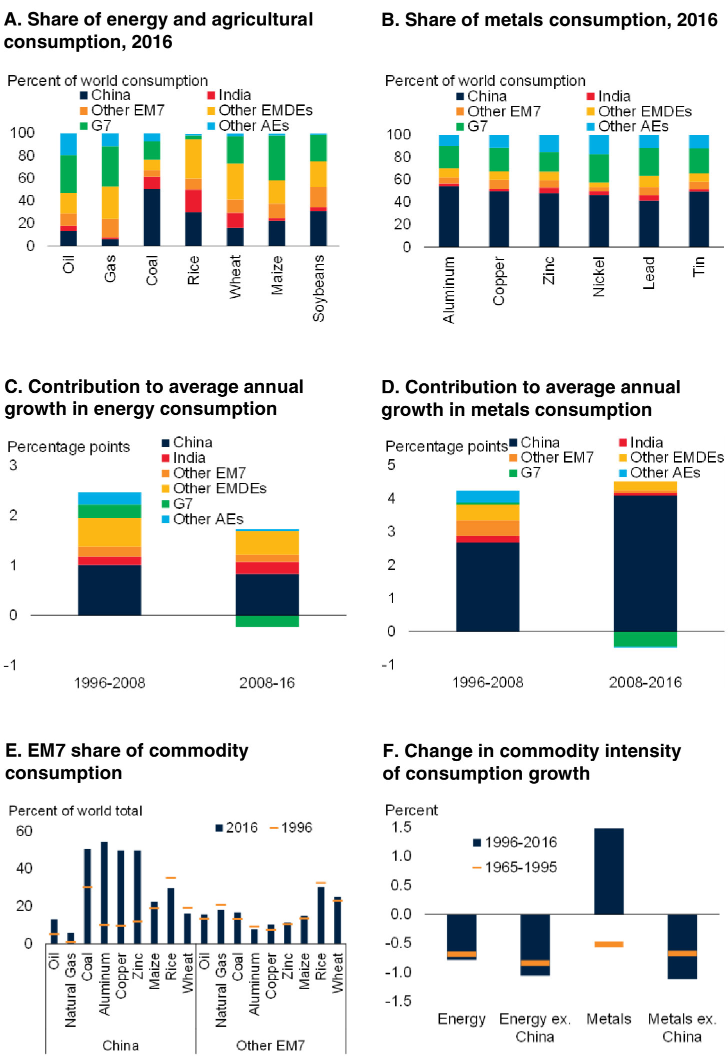
The EM7 have become some of the world's largest commodity producers after a period of rapid production growth. As a result, policies that affect their production or ability to export commodities—such as environmental policies to reduce pollution, or trade-related measures—can move global commodity markets and have spillovers to other regions.

China and India are particularly prominent consumers. China is the world's largest consumer of coal, several industrial metals (aluminum, refined copper, and lead) and fertilizers. India is the world's largest consumer of palm oil, and its second-largest consumer of coal (about one-quarter of China's consumption) and gold (for fabrication, about two-thirds of Chinese consumption). India is also the third-largest consumer of crude oil and natural rubber.

Combined, China's and India's use of commodities is a multiple of the remaining five EM7. For example, consumption in the two countries is more than ten times the remaining EM7 in coal, aluminum, and nickel, and more than six times in

FIGURE SF1.4 EM7 in commodity markets

China's share of global metals and coal consumption rose to around 50 percent in 2016, while the share of the other EM7 is smaller, but still significant. Over the last 20 years, the EM7 account for the majority of the increase in metals consumption, two-thirds of the increase in energy consumption, and more than one-third of the increase in agricultural commodity consumption. While the global commodity intensity of GDP has generally declined, it increased from the mid-2000s for metals, mainly due to growth in consumption in China, and is now back at its 1965 level.



Sources: BP Statistical Review, U.S. Department of Agriculture, World Bank, World Bureau of Metals Statistics.

A.-D. "AEs" stands for advanced economies. Other EM7 includes Brazil, Indonesia, Mexico, Russia, and Turkey.

A.C. "Other AEs" contains 18 advanced economies. Other EMDEs contains 32 countries.

B.D. "Other AEs" contains 17 advanced economies. Other EMDEs contains 31 countries.

F. Commodity intensity calculated as global energy and metals use (in volumes) relative to global GDP (in 2010 U.S. dollars), including and excluding China.

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copper, zinc, lead, and tin. China and India consume 50 percent more crude oil than the other five EM7, while their maize and wheat consumption is twice as high and their rice consumption five times as high. In turn, the EM7 account for four times the consumption of other EMDEs in coal and metals, and a similar amount of crude oil and grains.

Evolution of the EM7 share in commodity consumption. Over the past two decades, EM7 countries have driven the growth in global demand, especially for energy and metals. The EM7 accounted for 92 percent of the increase in metals consumption, 67 percent of the increase in energy consumption, and 39 percent of the increase in global food consumption between 1996 and 2016. The increase in demand for metals was such that the ratio of global metals consumption to GDP—which had been declining prior to the 1990s—reversed trend and started to rise rapidly by the turn of the century. This reversal largely reflected developments in China, which accounted for 83 percent of the increase in global consumption between 1996 and 2016, and occurred despite rising global demand for services, which are much less materials-intensive than goods (Tilton 1990, Radetzki et al. 2008). In contrast, the energy intensity of global GDP continued to decline, in line with its prior trend, supported by efficiency improvements as well as the shift of global demand toward services.

Drivers of commodities consumption

Several factors have supported the growing role of the EM7 in global commodity markets. This section takes a quantitative look at the role of per capita income growth and slowing population growth, as well as prices, in driving global demand for key commodities. The rest of the Special Focus, considers three energy products (crude oil, coal, and natural gas) and three metals (aluminum, copper, and zinc). These make up 85 percent of energy and base metals consumption. It also considers four foods (rice, wheat, maize, and soybeans), which collectively cover 70 percent of arable land.[2]

[2] This Special Focus does not consider iron ore or non-food agricultural commodities. The use of iron ore is more complex than the other metals considered here since it is an input into the production of steel. Competitive price benchmarks for iron ore are only available from 2005.

Per capita incomes and consumption. Per capita consumption of most commodities generally plateaus as per capita income rises, and may even decline at higher levels of income (crude oil, coal, copper, zinc, and rice; Figures SF1.5 and SF1.6). Natural gas shows less sign of plateauing than other commodities, which may reflect a shift in consumer demand to cleaner fuels as incomes rise. China has seen a much faster increase than other countries in its per capita use of aluminum and coal during 1965-2016, with higher consumption for a given level of per capita income.

The increase in coal and aluminum consumption relative to per capita income in China over the period 1965-2016 has also been faster than that of the Republic of Korea, a country which underwent rapid industrialization in the 1960s to 80s. Growth in China's copper and zinc per capita consumption relative to per capita income has been broadly in line with Korea's, while that of crude oil has been weaker. Per capita commodity consumption remains significantly higher than other EM7 across all categories except natural gas, due to high per capita consumption in Russia.

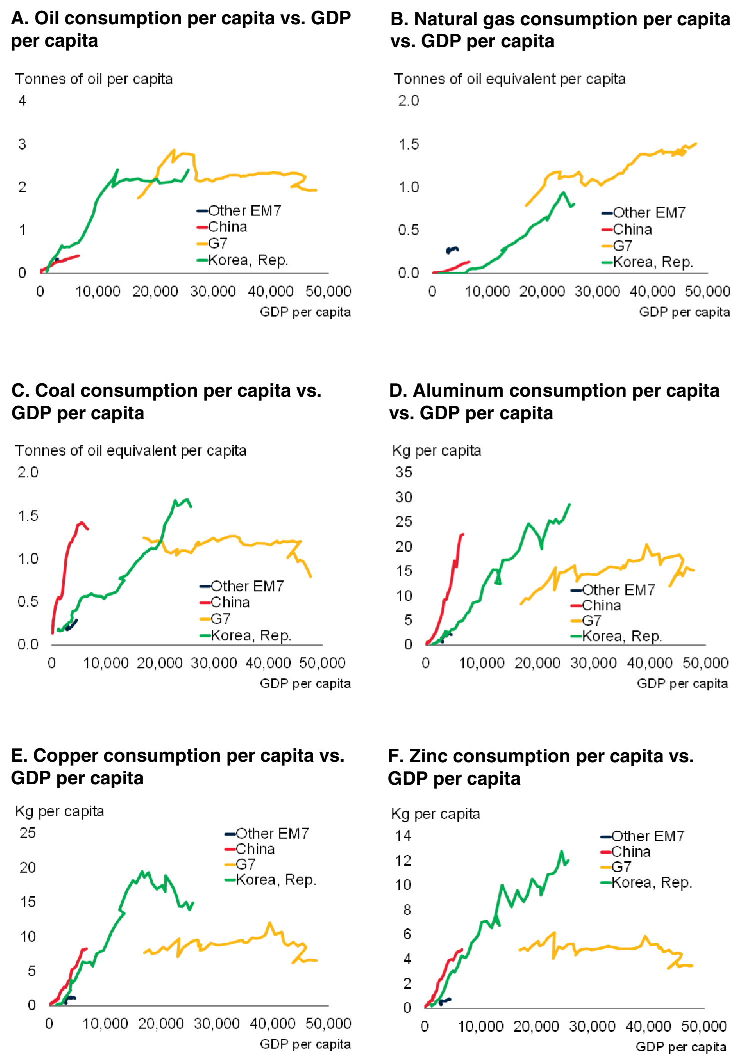
Income elasticity of consumption. The relationship between consumption and income is captured by the income elasticity of demand: the percent increase in commodity consumption associated with a 1 percent increase in income. Elasticities vary significantly between the long and short run, but tend to be larger in the long run as adjustment of consumption to higher incomes takes time.[3] The long-run elasticity is more relevant to the multi-decade trends described in this Special Focus.

Income elasticities can vary as per capita incomes rise and as economies mature. With rising incomes, consumer demand tends to shift towards less resource-intensive goods and services, which results in a fall in income elasticities (Tilton 1990; Radetzki et al. 2008). Consumer demand also tends to shift toward cleaner forms of energy such as natural gas, from more polluting and inefficient sources such as firewood and coal (Burke and Csereklyei 2016). Food consumption also tends to switch away from grains to products with higher protein and fat content such as meat (Salois et al. 2012). In addition, demand for industrial materials slows as economies mature and infrastructure needs are increasingly met.

[3] Dahl and Roman (2004) find a short-run income elasticity for crude oil of 0.47 and a long-run income elasticity of 0.84.

FIGURE SF1.5 Consumption of industrial commodities and income

The relationship between per capita income and industrial commodity consumption per capita shows signs of plateauing for most commodities as income rises. A notable exception is natural gas, which likely reflects preferences for cleaner fuels over more polluting fuels such as coal.



Sources: BP Statistical Review, World Bank, World Bureau of Metal Statistics.
A.-F. GDP per capita in constant 2010 U.S. dollars. Lines show the evolution of income and commodity consumption per capita over the period 1965-2016. Each data point represents one country or group for one year. Data for other EM7 are available from 1985-2016 for crude oil, natural gas, and coal, and 1992-2016 for aluminum, copper, and zinc.
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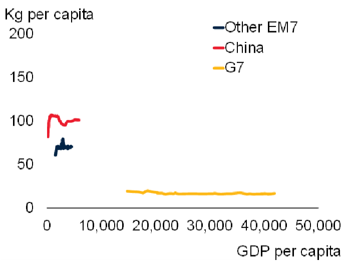
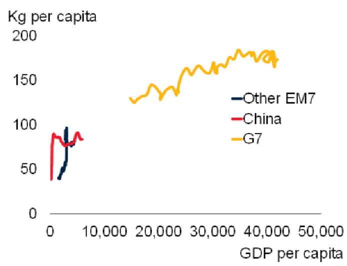
FIGURE SF1.6 Food consumption and income

The relationship between income per capita and food consumption per capita is more varied than that of income per capita and industrial commodities per capita. For rice, the relationship is heterogenous between countries, which may reflect domestic preferences or availability. Maize and soybeans exhibit a broadly linear relationship, reflecting their use in animal feed and biofuels, which have a relatively high income elasticity.

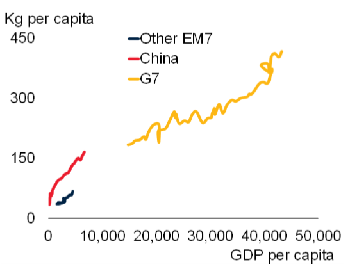
A. Rice consumption per capita vs. GDP per capita



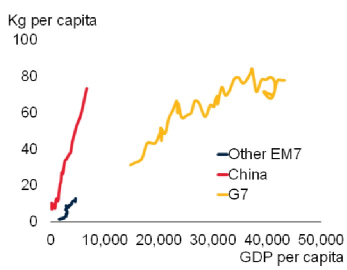
B. Wheat consumption per capita vs. GDP per capita



C. Maize consumption per capita vs. GDP per capita



D. Soybean consumption per capita vs. GDP per capita



Sources: U.S. Department of Agriculture, World Bank.
A.-D. GDP per capita in constant 2010 U.S. dollars. Lines show the evolution of income and grains consumption per capita over the period 1965-2016. Due to data restrictions "G7" includes the United States, Japan, Canada and all EU28 countries.
Click here to download data and charts.

Estimates of long-run income elasticities. Estimates of long-run income elasticities of demand vary by commodity, between countries, and over time, as incomes rise (Annex Table SF1.3).

- *Energy.* For energy, most studies have found an income elasticity of demand of less than unity (Burke and Csereklyei 2016; Csereklyei and Stern 2015; Jakob et al. 2011). That implies per capita energy consumption grows more slowly than per capita real GDP, consistent with a declining energy intensity of demand. Several papers find that income elasticities of demand fall as income rises (Dahl 2012; Foquet 2014; Jakob et al. 2012).[4]

- *Metals.* For metals, the elasticity of income depends on the availability of substitutes and the range of uses. Because of its wide applicability, demand for aluminum has been found to grow more than proportionately with rising output, i.e. with an above-unitary elasticity, while tin and lead, because of environmental concerns, grow less than proportionately, i.e., with a below-unitary elasticity (Stuermer 2017).

- *Food commodities.* Elasticities of food products vary widely. Elasticities for grains are generally below unity, with demand driven by population, rather than income, beyond a subsistence income threshold (Engel 1857; Baffes and Etienne 2016; World Bank 2015b). Valin et al. (2014) find a median income elasticity of demand of close to 0.1 for rice and wheat. Elasticities are generally higher for foods with higher fat and protein contents, such as animal products, suggesting that consumers switch to these types of foods as incomes rise (Salois, Tiffin, and Balcombe 2012; Valin et al. 2014, World Bank 2015b). The use of maize and soybeans as animal feed means that their elasticities are driven more by demand for meat than demand for direct consumption, resulting in higher elasticities.[5]

Estimates of price elasticities. Demand for commodities tends to be price inelastic. Within energy, price elasticities for crude oil range from zero to -0.4 (Huntington, Barrios, and Arora 2017; Dahl and Roman 2004). For metals, Stuermer (2017) finds the largest price elasticity for aluminum (-0.7), but smaller elasticities for copper (-0.4), tin, and zinc (less than or equal to -0.2). As with income elasticities, price elasticities of demand tend to be larger in the long-run than the short-run, as consumers have more

[4] An exception is Burke and Csereklyei (2016), who find the long-run income elasticity of demand increases as per capita real GDP rises. This finding likely reflects their country sample which includes a number of low income countries whose long-run income elasticity of demand tends to be very low, as a result of their reliance on non-commercial fuels (i.e., biomass). Elasticities in low income countries may also be kept artificially low by policies such as energy subsidies (Joyeux and Ripple 2011).

[5] For example, 70 percent of soybeans in the United States are used for animal feed (USDA 2015).

time to respond to changes in prices by finding substitutes, or efficiency gains.[6]

Estimation of long-run income elasticities. The remainder of this section reports estimates for the long-run income elasticities of the energy, metals, and agricultural commodities shown in Figures SF1.5 and SF1.6.

An autoregressive distributed lag model is used to estimate the logarithm of per capita commodity consumption (in physical units) as a function of per capita real GDP in U.S. dollars (Annex SF1.1).[7] The sample covers up to 33 countries (21 advanced economies and 12 EMDEs) for energy and metals, with annual data from 1965-2016 (Annex Table SF1.4). A different dataset, with predominantly EMDE representation and fewer advanced economies, is available for food, with 55 countries for rice, 35 countries for wheat, 47 countries for maize, and 32 countries for soybeans. A quadratic term for per capita real GDP is included to account for non-linearities in the relationship between per capita commodity consumption and per capita income (Meier, Jamasb, and Orea 2013). The regression controls for real commodity prices.[8]

Estimation results. The estimated long-run elasticities differ widely across commodities and across income levels (Table SF1.1; Figure SF1.7). As expected, for most commodities long-run elasticities decline with rising per capita income (indicated by a negative coefficient on squared per capita income in Table SF1.1 and Annex Table SF1.5). In general, long-run income elasticities for metals tend to be above those of energy and food.

- *Metals*. Elasticities of metals decline with rising incomes, but remain elevated (0.4) even at the top quartile of 2017 per capita incomes. Aluminum and copper have the highest long-run income elasticities (0.8 and 0.7, respectively; Figure SF1.7), while zinc is considerably lower at 0.3.[9]

- *Energy*. Long-run income elasticities for crude oil and coal also decline as per capita incomes rise. At the median per capita income in 2017, the income elasticity of crude oil is 0.5, while that of coal is 0.6.[10] The elasticity for coal, however, drops rapidly with rising per capita incomes as users switch from biomass, such as wood, to more efficient coal at low incomes, and subsequently from coal toward cleaner energy sources at high incomes. At the highest quartile of per capita incomes in 2017, the estimated income elasticity of coal is negative. For natural gas, in contrast, a significant non-linear relationship between income and consumption was not found, but rather a linear relationship was noted, with an elasticitiy of 0.4. Natural gas' use as fuel for electricity generation has grown rapidly, so few countries have reached the "plateau stage" within the sample.

- *Food commodities*. The estimated elasticity of rice consumption declines sharply as incomes rise, turning negative at the first income quartile in 2017. For wheat, the decline in elasticities as incomes rise is less pronounced, with the elasticity remaining positive, albeit low, for all income levels.[11] In contrast, for maize and soybeans the relationship between income and consumption appears to be linear, and elasticities are much higher than rice and

[6] For example, Dahl and Roman (2004) find a short-run price elasticity of crude oil of -0.11, and a long-run price elasticity of -0.43.

[7] This methodology allows for cross-country heterogeneity in short-term coefficient estimates but imposes homogeneity in long-term coefficient estimates. The Hausman test (Annex Table SF1.5) suggests that this assumption is appropriate.

[8] To account for potential endogeneity, a Generalized Methods of Moments (GMM) model is also estimated. The results are robust (Annex Table SF1.6). They are also qualitatively robust to including a time trend to account for potential long-term productivity growth (Annex Table SF1.7).

[9] The estimates for the metals commodities are weaker than Stuermer (2017), which found an elasticity of 1.5 for aluminum, 0.9 for copper, and 0.7 for zinc. The differences likely arise from the use of manufacturing output, rather than GDP, as the explanatory variable. Using manufacturing output controls for changes in the composition of growth in the economy over time, which is caused by the share of manufacturing output declining in favor of services over time.

[10] Huntington, Barrios, and Arora (2017) also find an elasticity of crude oil of 0.5.

[11] The elasticity at median incomes in 2017 for wheat was a little higher, and for rice a little lower, than found by Vanin et al. (2014).

TABLE SF1.1 Estimation results

Commodity	Log per capita income	Squared log per capita income	Income elasticity at 2017 median income
Aluminum	3.50	-0.15	0.8
Zinc	2.60	-0.12	0.3
Copper	2.95	-0.12	0.7
Crude oil	2.31	-0.10	0.5
Coal	6.04	-0.31	0.6
Natural gas[1]	0.38	...	0.4
Rice	1.39	-0.09	-0.3
Wheat	1.05	-0.04	0.3
Maize[1]	0.85	...	0.8
Soybeans[1]	0.84	...	0.8

Note: Results shown are a sub-set of the estimations obtained using the pooled mean group model (see Annex SF1.1). Values for log and log squared per capita income are the coefficients for these variables as estimated by the model. Income elasticities are calculated using these coefficients, together with median global per capita income in 2017. Annex Table SF1.5 displays the full set of results from the estimation, including both short-run and long-run coefficients.
[1] indicates linear regression results for commodities which do not appear to have a non-linear relationship with income.

wheat at 0.8.[12] These commodities are heavily used as animal feed (and also biofuels), so their use is closely linked to demand for meat which tends to have a higher income elasticity of demand than grains.

For most commodities, the estimated long-run income elasticities for the EM7 countries are much higher than for the G7. While the focus here is on long-run trends, it is worth noting that consumption adjusts quite slowly: the regressions imply adjustment periods to the long-run equilibrium of three to eight years for grains, four to seven years for metals, and six to fourteen years for energy.[13]

EM7 consumption growth in 2010-16. This section compares in-sample fitted growth rates generated by the model with actual growth rates over 2010-16 (these years are at the end of the sample period). The regressions capture well EM7 consumption growth for metals (6.9 percent) and energy (3.3 percent) during these years. That said, across metals, actual consumption growth of zinc somewhat exceeds the model estimates, while that of aluminum falls short (Figure SF1.7). Across energy, actual growth of crude oil and natural gas was somewhat stronger than the fitted values and that of coal much less. The over-prediction of coal and underprediction of natural gas may reflect active policy measures to rein in pollution in China over this period. The model somewhat over-estimates growth of rice and wheat consumption, and slightly under-estimates growth of maize and soybeans consumption.

The role of structural growth differences. One source of a nonlinear relationship between GDP and commodity use is the changing composition of output. The sectoral components of GDP differ in their use of energy, metals, and agricultural inputs. The GTAP (Global Trade Analysis Project) database allows the intensity of use of agricultural goods, energy, and metals by different sectors of the economy to be calculated (Figure SF1.7).[14]

- *Metals intensity*. The metals intensity of global manufacturing was about twenty times that of global services in 2011. Similarly, the metals intensity of global investment and exports was about seven times that of household consumption.

- *Energy*. Differences in energy intensities between sectors are smaller, but still pronounced; the energy intensity of manufacturing is two-and-a half times that of services. The energy intensity of global investment is much lower than that for household consumption and exports.

[12] Figure SF1.6 suggests that the relationship for soybeans and maize is linear. The initial regressions for these foods generated significant coefficients for the quadratic term but not for the linear term. The regression cannot distinguish well between a linear and a quadratic relationship, so the quadratic term was dropped.

[13] In line with the literature, the model also generates modest price elasticities, but the emphasis here is on income elasticities.

[14] The GTAP Data Base contains complete bilateral trade in goods and services, intermediate inputs among sectors, as well as taxes and subsidies imposed by governments for 140 regions and for 57 sectors. The latest reference year is 2011. See Aguiar, Narayanan, and McDougall (2016).

- *Agricultural commodities*. Agricultural intensities tend to be slightly lower than energy and metals intensities across all sectors, with the highest intensity in household consumption.

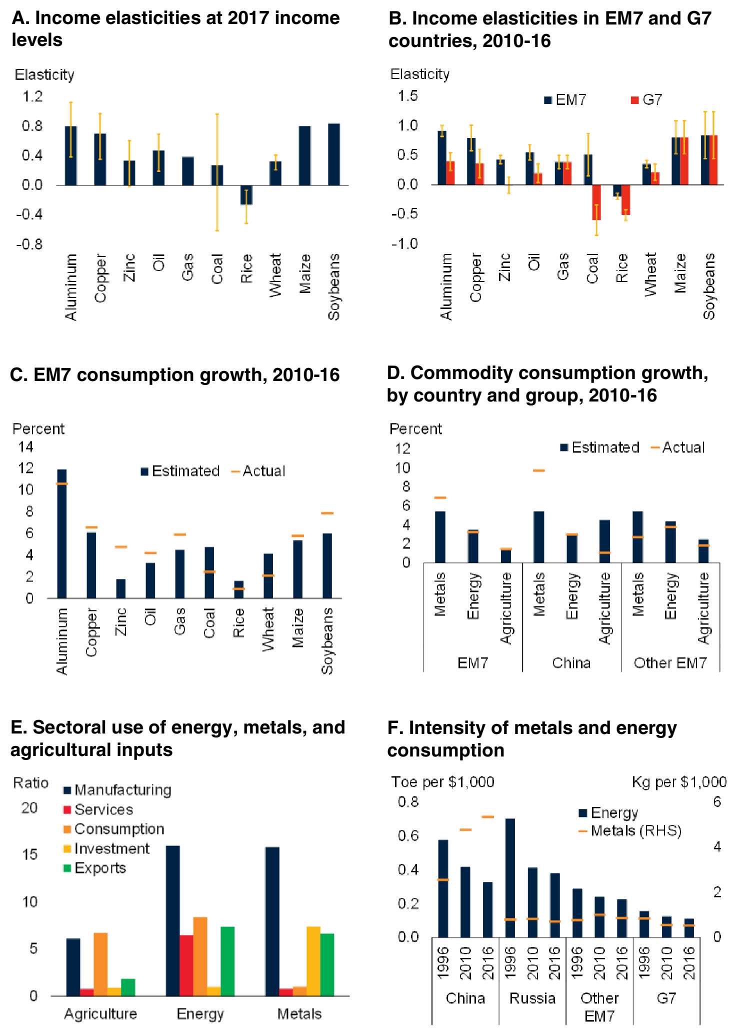
This suggests that countries with manufacturing-driven growth may experience a greater increase in energy and metals consumption for a given increase in output than economies driven more by services. Likewise, countries with investment-driven or exports-driven growth will see a greater increase in metals consumption than economies driven by household consumption.

Different engines of growth may have accounted for some of the under-estimation of metals consumption growth in China, and over-estimation in other EM7. For example, investment accounted for half of cumulative growth during 2010-16 in China, compared to one-quarter of cumulative growth in India, the second-largest EM7 economy, despite both countries growing at similar average rates (7.5-8 percent) during this period. In addition, manufacturing has been a more important driver of growth in China, growing twice as fast as in India on average over the past 10 years. This also helps explain the higher metals intensity of GDP in China than in its peers (World Bank 2015b).

The role of policies. Policies that favor energy-intensive and industrial sectors can significantly change the commodity intensity of demand. In the 1980s, in Russia and the former Soviet Union countries, the energy intensity of output (measured as energy use relative to GDP per capita) was much higher than in their free-market peers, particularly for energy. Countries that industrialized under central planning tended to exhibit high energy intensity because resource allocation was not determined by market mechanisms such as price or competition (Urge-Vorsatz et al. 2006, Ruhl et al. 2012). Following the collapse of the Soviet Union, and coinciding with rapid per capita income growth, the energy intensity of GDP in these countries fell steadily, although it remains elevated. China has a similar profile, with extremely high energy intensity in the 1980s, but this has steadily declined as per capita incomes rose.

FIGURE SF1.7 Estimated commodity consumption growth

Income elasticities of consumption decline with rising per capita incomes, but they differ widely across commodities and across income levels. Estimated elasticities for EM7 countries were considerably higher than for G7 countries throughout the sample. For 2010-16, the regressions capture well EM7 commodities consumption growth at the aggregate level, but their performance differs for individual metals, energy, and foods. Greater reliance on industrial production instead of services may account for faster metals consumption growth in China than in other EM7.



Sources: Aguiar et al. (2016), BP Statistical Review, U.S. Department of Agriculture, World Bank, World Bureau of Metals Statistics.
A.B. Income elasticity is defined as percent change in commodity consumption for each 1 percent increase in commodity prices. Estimated based on regression coefficients in Annex Table SF1.5.
A. Blue bars indicate elasticities at median real global per capita income in 2017; vertical bars indicate elasticities at upper and lower income quartiles. Gas, maize and soybeans have a linear elasticity and therefore do not have vertical bars.
B. Elasticities at median incomes over 2010-16, Vertical bars are 95 percent confidence intervals.
C.D. Estimated in-sample fitted values based on regression coefficients in Annex Table 1.5.
E. Use of energy, metals, and agricultural inputs by different sectors of the economy. Calculations show the gross value added of an input (e.g., energy) used by a sector (e.g., manufacturing) as a share of total gross value added of that sector. Values capture both direct and indirect use. Of the 57 sectors included in the Global Trade Analysis Project (GTAP) database, manufacturing contains sectors 19 to 42 and services contains sectors 47 to 57. For the inputs, agriculture includes sectors 1 to 12, energy includes sectors 15 to 17, 32, 43, and 44, and metals includes sectors 18, 35, and 36. The inclusion of sector 32, petroleum and coke, in manufacturing significantly increases its energy use; excluding this sector would reduce the energy use of manufacturing from 16 to 8.7.
F. Toe stands for tons of oil equivalent. Intensity of consumption calculated as consumption of energy or metals (in volumes) relative to output in constant 2010 U.S. dollars. Other EM7 includes Brazil, India, Indonesia, Mexico, Russia, and Turkey.
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Prospects for commodities demand

A hypothetical scenario is developed for the period 2018-27, and compared to the estimated values over 2010-16 as calculated by the model. This enables an assessment of the impact of changes in population and income growth, shifts between countries with different commodity intensities of demand, and within-country shifts as their incomes rise. The scenario is calculated separately for all countries in the estimation sample, and then summed to produce a global estimate. The sample includes advanced economies, the EM7, and other EMDEs. Data limitations exclude many smaller emerging markets and frontier markets, with sub-Saharan Africa (SSA) and the Middle East and North Africa (MENA) particularly under-represented in energy and metals.

Baseline scenario. The baseline assumptions for 2018-27 use existing estimates:

- *UN projections for population growth*. Slowing population growth is expected to dampen commodity consumption growth. The United Nations (2017) project that global population growth will slow slightly from 1.2 percent on average during 2010-16, to a 1 percent on average during 2018-27 (Figure SF1.8). The slowdown is most pronounced in the EM7.

- *Real output growth matches potential growth as estimated in World Bank (2018a)*. Real per capita income growth is expected to be broadly constant on average but slow by 0.2 percentage point in the EM7 countries.

- *Income elasticities are as in Annex Table SF1.5*. With continued per capita income growth, the elasticities of consumption of the EM7 economies are expected to decline (except for natural gas, maize and soybeans), by as much as one-third for coal.

- *Real commodity prices are assumed to be constant at current levels*. This assumption mitigates concerns about potential endogeneity arising from using World Bank price forecasts.

The assumed scenario for these fundamental drivers would mean slower global and EM7 demand growth in 2018-27 relative to the post-global-crisis period 2010-16 for virtually all commodities considered here. The slowdowns would be particularly pronounced for metals, especially in China. Even so, the country would remain the single largest consumer of energy and metals (Figure SF1.8). While per capita incomes in some of the other EMDEs would grow faster than in China, their current levels of commodity consumption are so much lower that their contribution to aggregate consumption growth would remain relatively modest.

- *Metals consumption*. Global metals consumption growth would slow by 1.4 percentage points to just under 3 percent on average during 2018-27. Because of still-high EM7 income elasticities and robust growth, the slowdown in EM7 consumption would be milder, by 0.4 percentage point to 4.9 percent. Growth in aluminum and copper would remain high, reflecting their high income elasticity of demand, while growth in zinc would remain modest, reflecting a near-zero G7 income elasticity.

- *Energy consumption*. Energy consumption growth would remain broadly steady at 2.3 percent globally but would slow by 0.4 percentage point to 3.1 percent in EM7 economies.[15] Rapid output growth in other EMDEs would shift the composition of global energy consumption toward more energy-intensive economies. Global crude oil consumption growth would remain broadly steady.

- *Food commodities*. Consumption growth of the foodstuffs included here would slow by 1 percentage point to 1.8 percent over 2018-27.[16] Rice and wheat would drive the slowdown because of their low-income

[15] BP (2018) expects energy growth to remain broadly steady between 2010-16 and 2017-25, while EIA (2017) expects growth to slow over this period.

[16] OECD (2017) expect a slowing in growth of consumption of cereals of about 1 percentage point.

elasticities and slowing population growth. In contrast, consumption growth of maize and soybeans would strengthen slightly.

Alternative growth paths. The baseline scenario described in the previous section depends critically on per capita income growth. The implications of upside and downside risks to the income growth path are discussed in two alternative model-based scenarios. Finally, policy measures—including those unrelated to commodity demand—could also lead to different paths of commodity consumption (Box SF1.2).

The first is a faster-growth scenario. Kilic Celik, Kose, and Ohnsorge (forthcoming) estimate the impact on potential growth if countries implemented reforms to fill investment gaps, expand labor force participation by women and older workers, and improve life expectancy and educational outcomes. Each country is assumed to repeat its best ten-year improvement on record in each of these dimensions over the next decade. For EMDEs, this would imply raising investment by almost 3 percent of GDP, life expectancy by 2.5 years, enrolment and secondary school completion rates by 5-7 percentage points, and female labor force participation by 10 percentage points. Such a concerted reform push could lift average annual global potential growth by 0.7 percentage point for the next ten years.

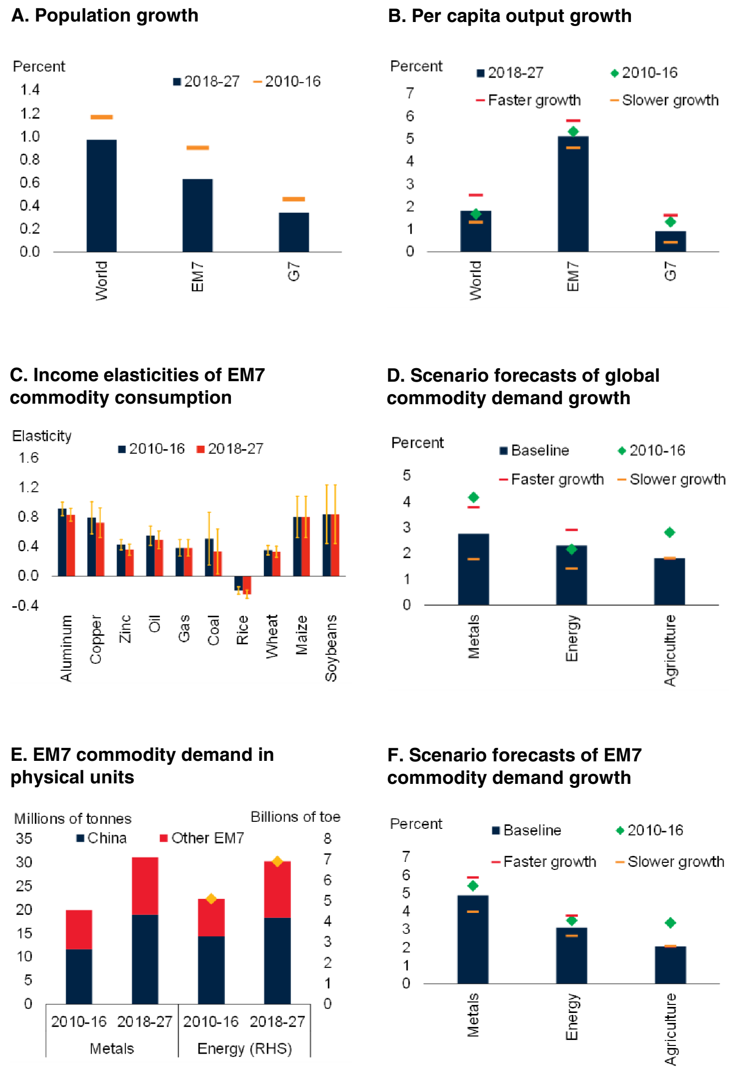
The second is a slower-growth scenario. This could, for example, be triggered by a financial crisis that is followed by a deep recession. Deep recessions leave lasting damage to output, as a result of hysteresis effects. The latter include the loss of human capital (job skills) associated with long-term unemployment, and the loss of embodied technical progress implied by lower investment. World Bank (2018b) estimates that deep recessions have, on average, reduced potential growth in the following five years by 1 percentage points.

These alternative growth paths make a significant difference to the projections, especially for the most income-elastic products (Figure SF1.8).

- *Faster-growth scenario.* In a faster-growth scenario, global metals consumption growth

FIGURE SF1.8 Commodity consumption scenarios

The baseline scenario suggests that fundamental drivers would slow global and EM7 commodity consumption growth between 2010-16 and 2018-27. The deepest slowdowns would occur in metals consumption. Despite China's expected output and commodity consumption growth slowdown, it would remain the largest consumer of energy and metal commodities among the EM7.



Sources: BP Statistical Review, United Nations, U.S. Department of Agriculture, World Bank, World Bureau of Metals Statistics.

Note: All growth rates are averaged over the period.

A. 2018-27 are based on UN Population Projections (2017).

B. 2018-27 data are forecasts of per capita potential growth based on World Bank (2018b) and UN Population Projections (2017).

C. Predicted values based on regression coefficients in Annex Table SF1.5. Vertical lines are 95 percent confidence intervals.

D.-F. To ensure comparability, 2010-16 is model-predicted commodity demand growth. The faster growth "reform" scenario assumes 0.7 percentage point higher output growth through 2018-27, while the slower growth "recession" scenario assumes 1 percentage point lower output growth for the first five years of 2018-27, based on World Bank (2018b).

E. Toe stands for tonnes of oil equivalent. Projected average annual commodity demand in billion tons of oil equivalent for energy and in millions of tonnes for metals.

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BOX SF1.2 Commodity consumption: Implications of government policies

Government policies—with respect to infrastructure investment, pollution control, energy use, and international trade—can have a major impact on commodity consumption.

Infrastructure investment. Significant infrastructure investment gaps exist at the global level, and closing these would provide both direct and indirect boosts to commodities consumption (World Bank 2016b, 2017a). The difference between expected investment needs and current actual investment in EMDEs is estimated at $1–$2 trillion per year (1.25 to 2.5 percent of global GDP).[1] By sector, the investment requirements are largest in electricity generation, followed by construction and transportation. Fiscal and structural policies such as increased public investment, structural governance reforms, and improved access to finance could boost investment directly and through the crowding-in of complementary private sector investment (World Bank 2017a).

China's Belt and Road Initiative (BRI) aims to promote economic development and integration across countries in Asia, Europe and Africa (State Council 2015). Outward foreign direct investment (FDI) from China increased substantially after the launch of the BRI from $28.6 billion in 2003 to $183 billion in 2016, with most of the increase going to countries on the BRI. The majority of FDI deals have been in manufacturing, while the construction and infrastructure sector has seen more rapid growth (Figure SF1.2.1).

Because of the high metal-intensity of investment, such policies could boost metals consumption. In addition, investment in electricity generation in EMDEs could result in energy demand shifting away from the decentralized use of biomass, toward centralized generation of electricity from fossil fuels and renewable sources of energy.

Pollution control. Environmental concerns are also likely to shape consumption patterns in commodity markets. For example, in energy markets, pollution or climate-change considerations, as embodied by the 2015 Paris Agreement, could accelerate the use of policy tools, such as carbon pricing, which favor the use of renewable energy and discourage the use of highly polluting fossil fuels (World Bank 2018a). During the past five years, global consumption of natural gas has increased nearly 10 percent while coal consumption has declined 2 percent.

Subsidies. Although aimed at protecting consumers, the use of energy subsidies can encourage energy consumption, discourage investment in energy efficiency and renewables, and impose large fiscal costs. The use of energy subsidies globally was equal to around 6.5 percent of global GDP in 2013. They are particularly prevalent in EMDEs (13-18 percent of GDP; IMF 2015; Rentschler 2018). The use of energy subsidies is high in the Middle East and North Africa (MENA), which accounts for half of all energy subsidies (World Bank 2014). The energy price collapse in 2014 provided impetus for subsidy reform, with more than half of commodity-exporting EMDEs doing so during 2014-2016 (World Bank 2018b). Additional subsidy reforms could further reduce energy consumption.

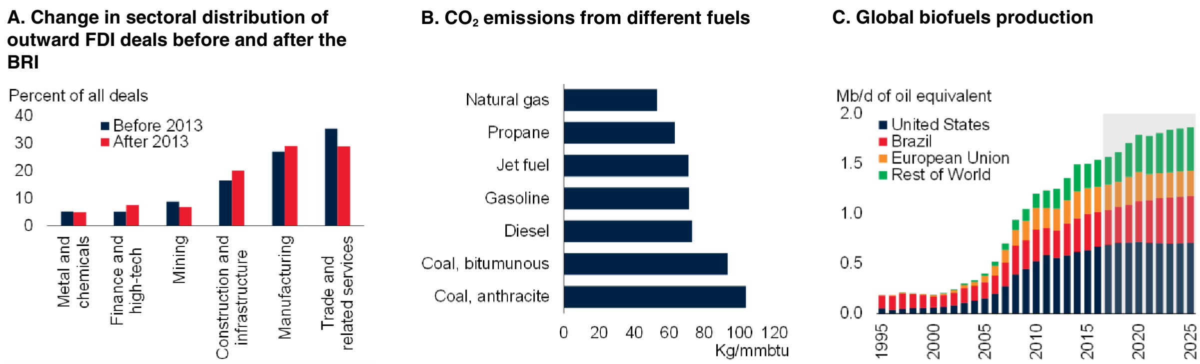
Biofuels. The diversion of food commodities to the production of biofuels will also affect demand for food commodities. Biofuels currently account for just over 1.5mb/d, or 1.6 percent, of global liquid energy consumption. Most biofuel production is not profitable at current energy and agricultural prices but is supported through various forms of mandates and trade measures (De Gorter, Drabik, and Just 2015). Biofuels come principally in the form of maize-based ethanol from the United States, sugar-based ethanol from Brazil, and plant oil-based biodiesel from Europe. Other smaller producers include China, Indonesia, and Thailand. The policy-driven diversion of food commodities to biofuels was motivated by energy security concerns and, especially, environmental benefits (Hill et al. 2006). However, interest has waned recently and biofuel production growth has slowed amid evidence of the

[1] Bhattacharya et al. (2012); McKinsey Global Institute (2013).

BOX SF1.2 Commodity consumption: Implications of government policies (*continued*)

FIGURE SF1.2.1 Developments in commodity markets

A number of policy actions could have unintended spillovers to commodity consumption. A renewed infrastructure push, for example to fill infrastructure investment gaps or in the context of China's "Belt and Road Initiative" could raise manufacturing and construction activity and, hence, metal demand. Environmental policies to control pollution could reduce and shift energy demand towards cleaner fuels, including natural gas and renewables. Biofuel production is likely to slow, however, as policy makers gradually acknowledge the limited environmental benefits of biofuel policies.



Sources: BP Statistical Review, Energy Information Administration, International Energy Agency, Organisation for Economic Co-operation and Development, Ministry of Commerce People's Republic of China, World Bank.

A. BRI stands for Belt and Road Initiative. Change in the average annual number of outward foreign direct investment (FDI) deals received by EMDEs before and after 2013. The sample covers EMDEs.

B. CO2 emissions in kilograms (kg) per million British thermal units (mmbtu) of fuel consumed.

C. Shaded area represents OECD (2017) projections. Units are million barrels of oil equivalent per day.

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limited environmental and energy independence benefits of biofuel policies (Searchinger et al. 2008; German et al. 2010). For example, biofuel production growth exceeded 20 percent per annum during 2001-10 but slipped to about 4 percent during the past five years. Current projections by the Organisation for Economic Cooperation and Development and the Food and Agriculture Organization of the United Nations (OECD/FAO) point to even lower biofuels production growth in the next decade (Figure SF1.2.1).

Food wastage. Although difficult to measure, by some accounts food waste may account for a quarter of global food production, amounting to roughly $680 billion in high income countries and $310 billion in developing countries, according to the Food and Agriculture Organization of the United Nations (FAO 2018). Policy interventions and technological improvements could significantly reduce food waste, which in turn would reduce demand for food commodities (Bellemare et al 2017; Delgado, Schuster, and Torero, 2017).

Trade policies and sanctions. Trade-restricting measures could have direct and indirect effects on commodity consumption and prices. A broad-based increase in tariffs would have major adverse consequences for global trade and activity (Ossa 2014; Nicita, Olarreaga, and Silva, forthcoming). An escalation of tariffs up to legally allowed bound rates could translate into a decline in global trade flows amounting to 9 percent (Kutlina-Dimitorva and Lakatos 2017). Such a fall in trade volumes would have a direct negative impact on oil consumption, given its use in transport fuel. A 5 percent drop in global trade could reduce international fuel oil bunker demand by at least 180 kb/d, or roughly 5 percent (IEA 2018). A reduction in global activity arising from trade-restricting measures would also reduce commodity demand. Finally, the imposition of sanctions could affect prices if they disrupt operations by major commodity-producing nations or companies (Box SF1.1).

could be one-third higher than under the baseline scenario and remain virtually at its post-crisis rates. Global and EM7 energy consumption growth might also be 0.6-0.7 percentage point stronger than under the baseline scenario and could rise above post-crisis rates. Aggregate food consumption would be little changed from baseline, but there would be further substitution away from rice and wheat (with low income elasticities) toward maize and soybeans (with higher elasticities).

- *Slower-growth scenario.* A slower-growth scenario would set back global metals consumption growth, relative to baseline, by one-third (1 percentage point) and global energy consumption growth by almost one-half (0.9 percentage point). Food consumption growth would, again, weaken only marginally with offsetting changes to rice and wheat compared to maize and soybeans.

The scenarios described above are stylized, and only show the impact of the baseline projections for income and population changes in the sample of countries. Prospects may differ considerably from these projections, depending on trajectories for variables not included in the model. For example, population growth in SSA is expected to be much higher than for advanced economies and the EM7, although it is not captured in this scenario. As such, these estimates could be biased downwards. The estimates also do not allow for the endogeneity of prices. Endogenous relative price changes would moderate the changes, in either direction, from the baseline paths.

Despite implying a slowdown in growth, all the model-based projections show that consumption of energy and other commodities expands significantly from current levels. This, however, would in itself likely stimulate innovation and the adoption of new technologies, including efficiency improvements that further reduce consumption (Arezki and Matsumoto 2017). An accelerated uptake of more fuel-efficient technologies (e.g., electric vehicles and natural gas-powered commercial trucks) could also reduce crude oil consumption prospects (Cherif, Hasanov, and Pande 2017; International Energy Agency 2017). The uptake of more climate-friendly technologies will also lead to shifts in demand for the metals and minerals that are required to manufacture new technologies. Countries that are key suppliers of these elements could benefit from these developments. Low-carbon energy systems are likely to be more metal intensive than high-carbon systems, although the use of commodities varies greatly between different low-carbon technologies (World Bank 2017b).

Policy implications

The baseline scenario outlined above suggests consumption growth of metals and staple foods will likely slow over the next decade, and that of energy will remain well below pre-crisis rates. More modest commodity consumption growth, all else equal, would dampen pressures on prices.

Many EMDEs, especially smaller ones, are heavily exposed to commodity markets. In four-fifths of EMDEs, commodities account for 30 percent of goods exports or more, or an individual commodity accounts for 20 percent of goods exports. On average, export concentrations are largest among crude oil exporters. Oil exporters also tend to be heavily reliant on fiscal revenues from the sector. For example, prior to the oil price collapse in 2014, hydrocarbon revenues accounted for more than half of fiscal revenues in eight EMDEs, including Nigeria and Saudi Arabia, and more than one-quarter of revenues in four EMDEs, including Mexico and Russia (World Bank 2017a).

The prospect of persistently lower demand heightens the need for commodity exporters to diversify. Over the medium term, diversification away from resource-based production would help raise GDP per capita and improve growth prospects for commodity-exporting EMDEs. Cross-country studies underscore that greater diversification of exports and government revenues bolsters long-term growth prospects and resilience to external shocks (Lederman and Maloney 2007; Hesse 2008; IMF 2016a). The successful diversification experience of some energy producers (e.g., Malaysia, Mexico) highlights the benefits of both vertical diversification (e.g., in crude oil, natural gas, and petrochemical sectors) as well as horizontal diversification. These involve reforms to improve the business environment, education, and skills acquisition (Callen et al. 2014).

In a majority of commodity-exporting EMDEs fiscal reforms are necessary to establish a firmer foundation for long-term fiscal sustainability (Mendes and Pennings 2017). The establishment of well-managed strategic investment funds with resource revenues can help in this regard (e.g. Chile, Norway). These funds can create opportunities for attracting private investment, deepening domestic capital markets, and building the capacity of governments to act as professional long-term investors (Halland et al. 2016).

Reforms to fiscal and monetary policy frameworks could also help reduce procyclicality and foster resilience to commodity price fluctuations (Frankel 2017). However, such policies are insufficient to mitigate the challenge of weaker commodity consumption discussed here.

Conclusion

Based on current trends, metals and foods consumption growth could slow by one-third over the next decade. Energy consumption growth would remain broadly constant at post-crisis rates, and shift towards faster-growing EMDEs. Aluminum and copper consumption would continue to grow steadily. Rice and wheat consumption growth is expected to slow as population growth slows, while rising incomes would result in a shift to foods such as meat, which require growing inputs of maize and soybeans. Slowing GDP growth and industrial rebalancing notwithstanding, China will remain the single largest source of EM7 commodity consumption growth.

Advances in global technology, shifts in consumer preferences, and policies to encourage cleaner fuels could trigger much steeper slowdowns in global use of some commodities than current trends indicate. A rapid shift away from investment-driven and industrial production-driven growth in China could sharply lower its demand for metals. Similarly, a tightening of environmental regulations could reduce coal use more than in the baseline. Improved technologies (such as electric cars), lower costs of alternative fuels, and policies favoring cleaner fuels, could reduce the use of petroleum in transportation. However, they could also increase demand for raw materials used in the production of these technologies, such as rare earths.

Demand for most commodities may decelerate over the next decade as economies mature, infrastructure needs are met, and GDP and population growth slows. Much of future GDP growth will come in the services sector, which is not materials-intensive, while environmental and resource concerns and new technologies will reduce demand for traditional raw materials, as well as encouraging substitutions between them. These trends have already become evident in advanced economies, and a similar path could be expected for the major EMDEs.

ANNEX SF1.1 Modeling income elasticities

The empirical approach adopted in this focus is based on the pooled mean group (PMG) auto-regressive distributed lag (ARDL) (p,q,r) model developed by Pesaran et al. (1999), where p, q, and r are respectively the lag length of the dependent variable and the two explanatory variables. The model is of the following form:

$$c_{ij,t} = \Sigma_{k=1}^{p} \lambda_{ij,k} c_{ij,t-k} + \Sigma_{l=0}^{q} \delta_{ij,l} y_{ij,t-l} + \Sigma_{l=0}^{q} \varphi_{ij,l} y_{ij,t-l}^{2} + \Sigma_{m=0}^{r} \gamma_{ij,m} p_{ij,t-m} + \alpha_{ij} + \varepsilon_{ij,t} \quad (1)$$

where $c_{ij,t}$ is the logarithm of real per capita consumption (in millions of tonnes for metals and food commodities and in tonnes of oil equivalent for energy commodities) of commodity i for country j at year t; $y_{ij,t}$ is real per capita income for country j at year t; $p_{ij,t}$ denotes the local currency-denominated world price of commodity i relative to the local currency-denominated GDP deflator, α_{ij} represents country fixed effects, and $\varepsilon_{ij,t}$ is the stochastic error term which has zero mean and constant variance. The quadratic term, $y_{ij,t}^2$, in equation (1) accounts for nonlinearities inherent in most demand function which, in this case, represents the level at which income plateaus.

The error correction form of equation (1) is:

$$\begin{aligned}\Delta c_{ij,t} &= \rho_i (c_{i,t-1} - \theta_{i,1} y_t - \theta_{i,2} y_t^2 - \theta_{i,3} p_t) \\ &+ \Sigma_{k=1}^{p-1} \lambda_{ij,k}^{*} \Delta c_{ij,t-k} + \Sigma_{l=0}^{q-1} \delta_{ij,l}^{*} \Delta y_{ij,t-l} \\ &+ \Sigma_{l=0}^{q-1} \varphi_{ij,l}^{*} \Delta y_{ij,t-l}^{2} + \Sigma_{m=0}^{r-1} \gamma_{ij,m}^{*} \Delta p_{ij,t-m} \\ &+ \alpha_{ij} + \varepsilon_{ij,t}\end{aligned} \quad (2)$$

where $\theta_{i,1}$, $\theta_{i,2}$, and $\theta_{i,3}$ represent the long-run dynamics of the demand function, such that:

$$\theta_{i,1} = \Sigma_{l=0}^{q} \delta_{ij,l} / (1 - \Sigma_{k=1}^{p} \lambda_{ij,k}),$$

$$\theta_{i,2} = \Sigma_{l=0}^{q} \varphi_{ij,l} / (1 - \Sigma_{k=1}^{p} \lambda_{ij,k}), \text{ and}$$

$$\theta_{i,3} = \Sigma_{m=0}^{r} \gamma_{ij,m} / (1 - \Sigma_{k=1}^{p} \lambda_{ij,k})$$

and λ^*, δ^*, φ^*, and γ^* capture the short-run relationship, where:

$$\lambda^* = -\Sigma_{n=k+1}^{p} \lambda_{ij,n},$$

$$\delta^* = -\Sigma_{n=l+1}^{q} \delta_{ij,n},$$

$$\varphi^* = -\Sigma_{n=l+1}^{q} \varphi_{ij,n}, \text{ and}$$

$$\gamma^* = -\Sigma_{n=m+1}^{r} \gamma_{ij,n}$$

Specifically, $\theta_{i,1}$ and $\theta_{i,2}$ are the long-term elasticities of demand with respect to a rise in per capita income, whereas $\theta_{i,3}$ is the long-run elasticity of demand with respect to real price. $\rho_i = -(1 - \Sigma_{k=1}^{p} \lambda_{ij,k})$ denotes the speed of adjustment towards the long-term equilibrium relationship.

From equation (2), income elasticities for each commodity and country are calculated by taking the partial derivative of the long-run estimation with respect to income, as follows:

$$\eta_t = \frac{\partial c_t}{\partial y_t} = \theta_1 + 2\theta_2 y_t$$

The model is applied to three energy commodities (crude oil, coal, and natural gas) and three metal commodities (aluminum, copper, and zinc), which together make up 85 percent of energy and base metals consumption respectively. Annual data from 1965-2016 for 33 countries were used in the analysis. The model is also applied to four food commodities (rice, wheat, maize, and soybean) which, together, account for 70 percent of arable land. For lack of data, a different dataset was chosen for food commodities, with predominantly EMDE representation and few advanced economies (Annex Table SF1.4).

Data on per capita income (expressed in real 2005 terms) were obtained from the World Bank's World Development Indicators; commodity consumption was taken from the BP Statistical Review (energy) and World Bureau of Metal Statistics (metals); world commodity prices were taken from the World Bank's *Pink Sheet*, and were converted into real terms by using country-specific GDP deflators. Exchange rates were taken from the St. Louis Federal Reserve Bank's FRED database.

The models were estimated using the PMG ARDL (1,1,1,1), the lag length indicated as optimal by the BIC criterion. Results are reported in Annex Table SF1.5. The models for natural gas, maize and soybeans turned out to be linear whereas all other models were nonlinear, with statistically significant linear and quadratic terms. The Hausman test suggests that the PMG estimator is appropriate in virtually all instances.

The ARDL approach is appropriate when both the cross-sectional and the time dimension are moderate to large, with the time dimension being larger the cross-sectional dimension—as it is here. Alternatively, the fixed- or random-effects, or even the generalized methods of moments (GMM) of Arellano and Bond (1991), could be used. The results are broadly robust to the use of a GMM estimation which includes lagged (by 1 year) independent variables as instruments (Annex Table SF1.6). Similarly, the results are qualitatively robust to including a time trend (Annex Table SF1.7).

The backward-looking fitted values and the forward-looking scenarios are aggregated from country-level data, using country-specific per capita income and GDP deflators, and global commodity prices from World Bank (2018a). For each country, all regression coefficients (short- as well as long-run coefficients) are applied to country-specific per capita income and deflated commodity prices. The resulting fitted or predicted per capita consumption levels (in physical units) are multiplied by the size of the population, as provided by UN Population Statistics or UN Population Projections. Total world consumption is the sum of these country-level fitted or predicted consumption levels.

$$C_{(i,WORLD,t)} = \sum_{i=1}^{I} \hat{c}_{i,j,t} \times pop_{i,t}$$

where $\hat{c}_{i,j.t}$ is the fitted value of per capita consumption in country *i* of commodity *j* at time *t*, and $pop_{i,t}$ is the population of country *i* at time *t*.

The forward-looking scenarios assume that real per capita income grows at potential growth over the next decade, as estimated by the production function approach in World Bank (2018b), deflated by population growth as forecast by the UN Population Projections. For all scenarios, commodity prices are assumed to be constant, to mitigate potential endogeneity concerns.

ANNEX TABLE SF1.1.A Top 10 commodity consumers, 2016

	Aluminum		Copper		Zinc		Oil		Natural Gas	
1	China	54.4	China	49.7	China	48.2	United States	20.3	United States	22.0
2	United States	8.8	United States	7.7	United States	5.7	China	12.8	Russia	11.0
3	Germany	3.8	Germany	5.3	India	4.8	India	4.6	China	5.9
4	Japan	3.0	Japan	4.2	Korea, Rep.	4.5	Japan	4.2	Iran	5.7
5	Korea, Rep.	2.5	Korea, Rep.	3.2	Germany	3.5	Saudi Arabia	4.0	Japan	3.1
6	India	2.4	Italy	2.5	Japan	3.4	Russia	3.3	Saudi Arabia	3.1
7	Turkey	1.6	Brazil	2.2	Belgium	2.6	Brazil	3.1	Canada	2.8
8	Italy	1.6	Taiwan, China	2.2	Spain	1.9	Korea, Rep.	2.9	Mexico	2.5
9	United Arab Emirates	1.4	India	2.1	Italy	1.9	Germany	2.5	Germany	2.3
10	Brazil	1.3	Turkey	2.0	Turkey	1.7	Canada	2.4	United Kingdom	2.2
	Others	19.2	Others	18.9	Others	21.8	Others	39.8	Others	39.4

ANNEX TABLE SF1.1.B Top 10 commodity consumers, 2016

	Coal		Maize		Rice		Wheat	
1	China	50.6	United States	30.0	China	29.8	European Union	17.6
2	India	11.0	China	22.7	India	20.3	China	15.7
3	United States	9.6	European Union	7.1	Indonesia	7.8	India	13.1
4	Japan	3.2	Brazil	5.9	Bangladesh	7.3	Russia	6.1
5	Russia	2.3	Mexico	4.0	Vietnam	4.6	United States	4.0
6	South Africa	2.3	India	2.5	Philippines	2.7	Pakistan	3.4
7	Korea, Rep.	2.2	Egypt	1.5	Thailand	2.3	Egypt	2.7
8	Germany	2.0	Japan	1.4	Myanmar	2.1	Turkey	2.4
9	Indonesia	1.7	Canada	1.3	Japan	1.8	Iran	2.4
10	Poland	1.3	Vietnam	1.3	Brazil	1.7	Indonesia	1.6
	Others	13.8	Others	22.4	Others	19.6	Others	31.1

Sources: BP Statistical Review, Food and Agriculture Organization, U.S. Department of Agriculture, World Bureau of Metal Statistics.
Notes: Numbers indicate shares of global consumption. Refined consumption for aluminum, copper, and zinc.

ANNEX TABLE SF1.2.A Top 10 commodity producers, 2016

	Aluminum		Copper		Zinc		Oil		Natural Gas	
1	China	55.0	China	36.2	China	45.8	United States	13.4	United States	21.1
2	Russia	6.1	Chile	11.2	Korea, Rep.	7.4	Saudi Arabia	13.4	Russia	16.3
3	Canada	5.5	Japan	6.7	Canada	5.1	Russia	12.2	Iran	5.7
4	United Arab Emirates	4.3	United States	5.2	India	4.5	Iran	5.0	Qatar	5.1
5	India	3.3	Russia	3.7	Japan	3.9	Iraq	4.8	Canada	4.3
6	Australia	2.8	India	3.3	Spain	3.7	Canada	4.8	China	3.9
7	Norway	2.3	Congo, Dem. Rep.	3.0	Peru	2.5	United Arab Emirates	4.4	Norway	3.3
8	Bahrain	1.7	Germany	2.9	Kazakhstan	2.4	China	4.3	Saudi Arabia	3.1
9	Saudi Arabia	1.5	Korea, Rep.	2.6	Mexico	2.3	Kuwait	3.4	Algeria	2.6
10	United States	1.4	Poland	2.3	Finland	2.1	Brazil	2.8	Australia	2.6
	Others	16.0	Others	22.9	Others	20.3	Others	31.3	Others	32.1

ANNEX TABLE SF1.2.B Top 10 commodity producers, 2016

	Coal		Maize		Rice		Wheat	
1	China	46.1	United States	35.8	China	29.9	European Union	20.0
2	United States	10.0	China	20.8	India	22.6	China	17.1
3	Australia	8.2	Brazil	8.9	Indonesia	7.6	India	13.0
4	India	7.9	European Union	5.9	Bangladesh	6.7	Russia	11.2
5	Indonesia	7.0	Argentina	3.2	Vietnam	5.8	United States	6.2
6	Russia	5.3	India	2.6	Thailand	4.2	Canada	3.9
7	South Africa	3.9	Mexico	2.6	Myanmar	2.7	Ukraine	3.6
8	Colombia	1.7	Ukraine	2.3	Philippines	2.5	Pakistan	3.5
9	Poland	1.4	Canada	1.4	Brazil	1.7	Australia	2.8
10	Kazakhstan	1.2	Russia	1.3	Japan	1.6	Turkey	2.8
	Others	7.3	Others	15.2	Others	14.7	Others	16.0

Sources: BP Statistical Review, Food and Agriculture Organization, U.S. Department of Agriculture, World Bureau of Metal Statistics.
Notes: Numbers indicate shares of global production. Refined production for aluminum, copper, and zinc.

ANNEX TABLE SF1.3 Literature review of long-run income elasticities of demand for commodities

Authors and Publication Year	Data/sample	Methodology	Results
Stuermer (2017)	12 advanced economies and 3 EMDEs, annual data, 1840-2010	Auto-regressive distributive lag	Income elasticity of demand is estimated to be 1.5 for aluminum, 0.9 for copper, 0.7 for zinc, 0.6 for tin, and 0.4 for lead.
Burke and Csereklyei (2016)	132 countries, annual data, 1960-2010.	Ordinary least squares (OLS) with panel data, in levels and growth rates.	Aggregate income elasticity of energy demand is estimated to be 0.7. Income elasticity is found to rise with higher incomes, in contrast to other studies. This results from the inclusion of low income countries, which typically have a much lower income elasticity of demand for energy as they rely on non-commercial fuels (biomass). Controlling for this results in constant elasticities across income groups.
Csereklyei and Stern (2015)	93 countries, annual data, 1971-2010.	OLS in growth rates.	Average income elasticity of energy demand is estimated to be between 0.6 to 0.8. As income rises, the rate of growth of energy use per capita declines.
Huntington, Barrios, and Arora (2017)	Review of 38 papers providing 258 estimates of price and income elasticities of energy demand.	Review of existing studies.	Income elasticity of oil demand is found to be 0.5 on average, and 0.9 for natural gas.
Fouquet (2014)	UK energy use, annual data, 1700-2000.	Vector error correction model	Long run income elasticity for energy demand for transport peaks at 3 before declining to around 0.3 as income rises.
Joyeux and Ripple (2011)	30 OECD and 26 non-OECD countries, annual data, 1973-2007	Error correction model with pooled mean group estimators.	For OECD countries, income elasticity estimated to be 1.1, for non-OECD countries, income elasticity of energy demand estimated to be 0.9.
Jakob, Haller and Marschinski (2011)	30 EMDEs and 21 advanced economies, annual data, 1971-2005.	Difference-in-differences estimator on panel data.	Find income elasticity of primary energy demand of 0.63 for EMDEs and 0.18 for advanced economies (although statistically insignificant).
Vanin et al. (2014)	Review of 10 global economic models for agricultural commodities	Review of different modeling approaches	Find median income elasticities for rice and wheat close to 0.1. First and third quartile range of estimates range from 0 to 0.2.

ANNEX TABLE SF.1.4 Economy samples, by commodity modeled

Aluminum, zinc, oil, gas	Copper	Coal	Rice	Wheat	Maize	Soybeans
Australia[1 2]	Australia[1]	Australia[2]	Argentina[3]	Algeria	Algeria	Argentina[3]
Austria	Austria	Austria	Australia	Argentina[3]	Argentina[3]	Australia
Belgium	Belgium	Belgium	Bangladesh	Australia	Australia	Bolivia
Brazil	Brazil	Brazil	Benin[3]	Bangladesh	Bolivia	Brazil[3]
Canada[2]	Canada	Canada[2]	Bolivia	Bolivia	Brazil[3]	Canada
China	China	Denmark	Brazil[3]	Brazil[3]	Cameroon[3]	Chile[3]
Hong Kong SAR, China	Finland	Finland	Burkina Faso[3]	Canada	Canada	China
Denmark	France	France	Cameroon[3]	Chile[3]	Chile[3]	Colombia
Finland	Germany	Germany	Chad	China	China	Ecuador[3]
France	Greece	Greece[2]	Chile[3]	Colombia	Colombia	Egypt[3]
Germany	India	India	China	Ecuador[3]	Côte d'Ivoire[3]	Guatemala[3]
Greece[2]	Italy	Ireland	Colombia	Egypt.[3]	Cuba	India
India	Japan	Italy	Congo, Rep.	Guatemala[3]	Ecuador[3]	Indonesia[3]
Indonesia[2]	Mexico	Japan	Costa Rica[3]	India	Egypt[3]	Iran
Ireland	Netherlands	Mexico	Côte d'Ivoire[3]	Iran	Ghana[3]	Japan
Italy	Portugal	Netherlands	Cuba	Japan	Guatemala[3]	Korea, Rep.
Japan	South Africa[1]	New Zealand	Dominican Republic[3]	Kenya	Honduras[3]	Mexico
Mexico	Korea, Rep.	Norway[2]	Ecuador[3]	Lesotho	India	Morocco[3]
Netherlands	Spain	Portugal	Egypt[3]	Mexico	Indonesia[3]	Myanmar
New Zealand	Sweden	South Africa	El Salvador	Morocco[3]	Iran	Nigeria
Norway[2]	Switzerland	Korea, Rep.	Gambia, The[3]	Nepal[3]	Japan	Pakistan[3]
Portugal	Taiwan, China	Spain	Ghana[3]	New Zealand[3]	Kenya	Paraguay[3]
Singapore	Turkey	Sweden	Guatemala[3]	Nigeria	Korea, Rep.	Peru[3]
South Africa[1]	United Kingdom	Switzerland	Guyana[3]	Norway	Lesotho	South Africa
Korea, Rep.	United States	Taiwan, China	Honduras[3]	Pakistan[3]	Madagascar[3]	Switzerland
Spain		Turkey	India	Paraguay[3]	Malawi[3]	Taiwan, China
Sweden		United Kingdom	Indonesia[3]	Peru[3]	Mexico	Thailand
Switzerland		United States	Iran	South Africa	Morocco[3]	Turkey
Taiwan, China			Japan	Sudan[3]	Nepal[3]	United States
Thailand			Kenya	Taiwan, China	Nicaragua[3]	Uruguay[3]
Turkey			Korea, Rep.	Tunisia	Nigeria	Venezuela
United Kingdom			Liberia	Turkey	Pakistan[3]	Zambia
United States			Madagascar[3]	Uruguay[3]	Panama	Zimbabwe[3]
			Malawi[3]	Zambia	Paraguay[3]	
			Malaysia	Zimbabwe[3]	Peru[3]	
			Mali		Philippines	
			Mexico		Senegal[3]	
			Morocco[3]		South Africa	
			Nepal[3]		Taiwan, China	
			Nigeria		Thailand	
			Pakistan[3]		Turkey	
			Panama		United States	
			Paraguay[3]		Uruguay[3]	
			Peru[3]		Venezuela	
			Philippines		Vietnam	
			Senegal[3]		Zambia	
			Sierra Leone[3]		Zimbabwe[3]	
			Sri Lanka[3]			
			Taiwan, China			
			Thailand			
			Togo[3]			
			Turkey			
			United States			
			Uruguay[3]			
			Venezuela			

Source: World Bank.

Note: 1 indicates metals exporter; 2 indicates energy exporter, 3 indicates agricultural exporter. An economy is defined as an exporter if exports of the commodity account for 20 percent or more of their total exports. Greece, Portugal, and South Africa are not included in the estimation of gas consumption due to missing observations (for 17, 32, and 27 years, respectively).

ANNEX TABLE SF.1.5 Estimation results for pooled mean group estimation

	Aluminum	Zinc	Copper	Oil	Coal	Gas 1/	Gas	Rice	Wheat	Maize 1/	Maize	Soybeans 1/	Soybeans
Long run													
Log per capita income	3.50***	2.60***	2.95***	2.31***	6.04***	0.30	0.38***	1.39***	1.05***	0.28	0.85***	-0.65	0.84***
	(0.40)	(0.23)	(0.71)	(0.46)	(1.28)	(1.04)	(0.57)	(0.12)	(0.20)	(0.24)	(0.02)	(0.50)	(0.04)
Squared log per capita income	-0.15***	-0.12***	-0.12***	-0.10***	-0.31***	0.01		-0.09***	-0.04***	0.05***		0.10***	
	(0.02)	(0.01)	(0.04)	(0.02)	(0.06)	(0.05)		(0.01)	(0.01)	(0.02)		(0.03)	
Log real price	-0.31***	-0.17***	-0.36***	-0.47***	0.15**	-0.27***	-0.29***	0.03	0.01	-0.22***	-0.19***	-0.48***	-0.68***
	(0.04)	(0.03)	(0.06)	(0.05)	(0.07)	(0.03)	(0.03)	(0.02)	(0.02)	(0.03)	(0.03)	(0.11)	(0.09)
Short run													
Adjustment coefficient	-0.26***	-0.28***	-0.14***	-0.07***	-0.10***	-0.17***	-0.17***	-0.22***	-0.33***	-0.19***	-0.15***	-0.14***	-0.13***
	(0.03)	(0.03)	(0.03)	(0.01)	(0.01)	(0.03)	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)	(0.02)	(0.02)
Log change in per capita income	-19.06**	2.90	1.04	4.28*	-13.41***	31.60	0.63***	-2.28	-2.44	-1.61	0.49***	-13.54	0.89**
	(9.43)	(13.55)	(7.20)	(2.34)	(3.78)	(21.43)	(0.20)	(6.58)	(6.88)	(4.95)	(0.14)	(21.28)	(0.42)
Squared log change in per capita income	1.07**	-0.01	0.07	-0.17	0.70***	-1.51		0.08	0.07	0.15		1.33	
	(0.47)	(0.67)	(0.36)	(0.11)	(0.18)	(1.06)		(0.46)	(0.38)	(0.32)		(1.33)	
Log change in real price	0.09**	0.05	-0.03	-0.01*	-0.01	0.03*	0.03*	-0.02**	-0.01	0.02	0.01	-0.03	-0.02
	(0.04)	(0.03)	(0.03)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.15)	(0.02)	(0.10)	(0.10)
Constant	-4.56***	-3.50***	-2.10***	-0.90***	-2.85***	-0.86***	-0.78***	-0.40***	-0.53***	0.61***	0.29***	0.93***	0.36***
	(0.54)	(0.42)	(0.36)	(0.08)	(0.44)	(0.17)	(0.17)	(0.07)	(0.08)	(0.15)	(0.11)	(0.18)	(0.09)
Joint Hausman test-statistic	5.25	7.72	3.26	3.66	4.53	3.02	5.80	2.52	1.45	1.62	5.43	5.86	2.31
p-value	0.15	0.05	0.35	0.30	0.21	0.39	0.06	0.47	0.69	0.66	0.07	0.12	0.32
log likelihood	886.27	711.20	743.02	3065.46	1557.88	1134.57	1141.82	1647.65	1141.82	1534.65	1462.82	85.70	47.73
Observations	1,668	1,658	1,275	1,683	1,366	1,366	1,443	2,692	1,781	2,372	2,372	1,500	1,500
Number of countries	33	33	25	33	28	30	30	55	35	47	47	32	32
Memorandum item:													
Income elasticity at 2017 median income	0.8	0.3	0.7	0.5	0.6	...	0.4	-0.3	0.3	...	0.8	...	0.8

Note: *** *p*<0.01, ** *p*<0.05, * *p*<0.1. Standard errors in parentheses.

1/ Indicates robustness check but not baseline regression. All other regressions are baseline regressions.

ANNEX TABLE SF.1.6 Estimation results under generalized method of moments

	Aluminum	Zinc	Copper	Oil	Coal	Gas	Rice	Wheat	Maize	Soybeans
Log per capita income	3.99***	3.81***	2.57***	2.41***	4.19***	0.27***	1.49***	0.70***	0.47***	0.48***
	(0.21)	(0.18)	(0.36)	(0.12)	(0.25)	(0.09)	(0.13)	(0.12)	(0.03)	(0.05)
Squared log per capita income	-0.17***	-0.19***	-0.06***	-0.10***	-0.19***		-0.09***	-0.04***		
	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)		(0.00)	(0.01)		
Log real price	-0.45***	-0.18***	0.00	-0.05***	0.07	-0.47***	-0.33	-0.04	-0.48***	-1.33***
	(0.05)	(0.04)	(0.12)	(0.01)	(0.08)	(0.13)	(0.02)	(0.03)	(0.09)	(0.15)
Constant	-19.51***	-18.16***	-17.67***	-13.60***	-23.64***	-4.16***	-1.83***	-1.46***	6.29***	10.01***
	(0.83)	(0.77)	(0.73)	(0.63)	(1.13)	(0.87)	(0.50)	(0.47)	(0.51)	(0.97)
Adj. R^2	0.86	0.81	0.80	0.96	0.90	0.84	0.91	0.91	0.12	0.11
J-statistic	0	0	0	0	0	0	0	0	0	0
Observations	1,608	1,583	1,275	1,617	1,428	1,583	2,776	1,730	2,372	1,501
Number of countries	33	33	25	33	28	33	55	35	47	32

Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses.
One lag of independent variables is used as instruments. The J-statistics confirm their validity.

ANNEX TABLE SF.1.7 Estimation results including trend

	Aluminum	Zinc	Copper	Oil	Coal	Gas	Rice	Wheat	Maize	Soybeans
Long run										
Log per capita income	4.23***	2.20***	11.06***	1.90***	4.16***	0.71***	0.52***	3.42***	1.37***	1.03***
	(0.45)	(0.22)	(0.95)	(0.47)	(0.99)	(0.09)	(0.14)	(0.24)	(0.24)	(0.21)
Squared log per capita income	-0.19***	-0.08***	-0.57***	-0.06**	-0.23**			-0.21***		-0.03***
	(0.03)	(0.02)	(0.05)	(0.03)	(0.05)			(0.01)		(0.01)
Log real price	-0.21***	-0.16***	-0.26***	-0.01***	-0.02	-0.25***	0.00	-0.04	-0.03	-0.02
	(0.04)	(0.03)	(0.04)	(0.00)	(0.06)	(0.03)	(0.02)	(0.03)	(0.06)	(0.02)
Short run										
Adjustment coefficient	-0.27***	-0.28***	-0.16***	-0.07***	-0.06***	-0.17***	-0.24***	-0.27***	-0.12***	-0.33***
	(0.03)	(0.03)	(0.03)	(0.07)	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)	(0.04)
Log change in per capita income	-18.98*	11.17	2.13	3.69**	-1.78	0.60**	0.19***	11.32**	0.80*	-2.56
	(9.81)	(14.16)	(8.04)	(2.23)	(3.22)	(0.21)	(0.03)	(5.73)	(0.43)	(6.79)
Squared log change in per capita income	1.06**	-0.45	-0.04	-0.14	0.13			-0.76*		0.08
	(0.49)	(0.71)	(0.42)	(0.11)	(0.16)			(0.41)		(0.37)
Log change in real price	0.08*	0.05*	-0.03	-0.01*	0.00	0.03	-0.09	-0.02	-0.07	0.00
	(0.04)	(0.03)	(0.03)	(0.06)	(0.02)	(0.02)	(0.02)	(0.01)	(0.10)	(0.02)
Constant	-5.40***	-3.39***	-8.00***	-0.92***	-1.34***	-1.29***	1.41***	-2.94***	-0.71***	-0.55***
	(0.64)	(0.41)	(1.32)	(0.08)	(0.37)	(0.27)	(0.19)	(0.37)	(0.15)	(0.08)
Joint Hausman test-statistic	4.46	5.45	5.01	2.99	11.07	0.82	1.21	1.20	6.34	6.27
p-value	0.22	0.14	0.17	0.39	0.01	0.66	0.55	0.75	0.10	0.10
Log likelihood	889.59	694.75	755.16	3067.80	1546.83	1146.19	1529.00	1978.46	47.31	1696.66
Observations	1,668	1,680	1,275	1,683	1,428	2692	2,372	2,775	1,500	1,781
Number of countries	33	33	25	33	28	33	47	55	32	35

Note: *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Standard errors in parentheses.

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