SPECIAL FOCUS

The Changing of the Guard: Shifts in Industrial Commodity Demand

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Over the past 20 years, demand for commodities has surged driven primarily by rapid growth from China, resulting in a fundamental shift in the structure of global commodity markets. As China's economy matures and shifts towards less commodity-intensive activities, its demand for commodities is likely to plateau, and other EMDEs are unlikely to fill this gap, suggesting growth in commodity demand may slow. 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 prices underwent an exceptionally strong and sustained increase in the late 1990s. Between 1998 and 2008, real energy prices rose five-fold, metals prices increased 140 percent, and food prices rose 40 percent (Figure SF.1). Although commodity prices fell sharply in 2014, driven by the collapse in the price of crude oil, they have since partly recovered in tandem with the cyclical global economic recovery. Unlike a typical price cycle, this episode has been characterized as a "super cycle", i.e., a demand-driven surge in commodity prices lasting possibly decades rather than years (Jacks 2013; Radetzki at al., 2006; Cuddington and Jerrett 2008; Erten and Ocampo 2013).

The price boom has been supported by rapid demand growth and lags in supply. The industrialization of large emerging market economies, particularly China, led to a substantial, sustained increase in demand for all commodities (World Bank 2015b; 2018a). This was particularly pronounced for metals demand, which grew faster than both GDP and population between 1997 and 2017. Over the same period, energy consumption also rose, albeit less rapidly, while the demand for grains (a subset of agricultural commodities) grew roughly in line with population.[1]

Against this backdrop, this Special Focus answers the following questions:[2]

i. How has the structure of global demand for commodities changed over the past 20 years?

ii. What role has per capita income growth played in driving commodity demand?

iii. What are the implications of these factors for commodity exporters in the future?

Changes in the composition of commodity demand

Over the past 20 years, the structure of global commodity demand has fundamentally changed. In 1997, advanced economies accounted for the majority of commodity demand, consuming just over 50 percent of global energy and around 70 percent of global metals. However, by 2017 their share of energy consumption had fallen to 40 percent, and their share of metals had more than halved to 30 percent, with the reduction consistent across most metals.

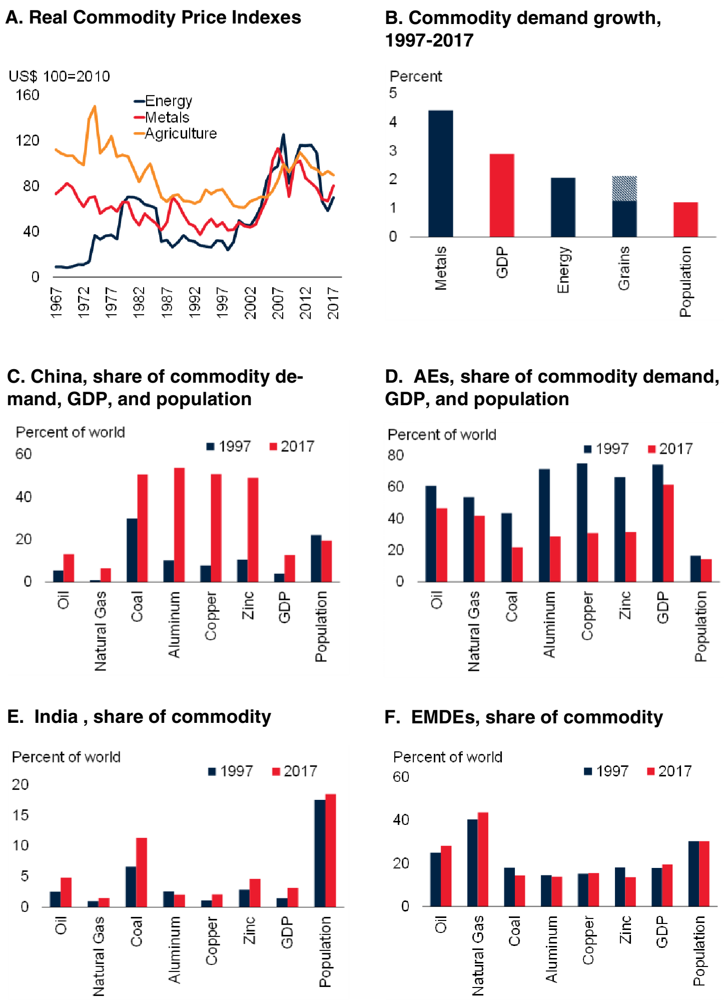
Meanwhile, China's share of energy consumption more than doubled, from 11 percent to 23 percent, while its share of metals consumption rose five-fold, from 10 percent to 50 percent. China accounted for four-fifths of the increase in global metals demand and half of the increase in

[1] An exception was demand for corn, which rose much faster than other grains, primarily because of its increasing use in the production of biofuels and animal feed.

[2] This Special Focus considers three energy products (crude oil, coal, and natural gas) and three metals (aluminum, copper, and zinc). These commodities account for 85 percent of energy and base metals consumption, respectively. Agricultural commodities were examined in the Special Focus of the July 2015 edition of *Commodity Markets Outlook.*

FIGURE SF.1 Developments in commodity markets

Global commodity prices underwent a super-cycle starting in the late 1990s, with particularly rapid price increases for metals and energy. Consumption of commodities surged, driven by China, whose share of oil consumption doubled, and whose share of metals consumption rose five-fold to 50 percent. Advanced economies' share of metals consumption fell by half. Most other emerging markets saw little change in their shares of commodity demand.



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

A. Deflated using the World Bank's manufacturing unit value index.

B. Average annual growth rates over the period 1996-2017. Metals includes aluminum, copper, and zinc. Energy includes oil, coal, and natural gas. Grains includes barley, millet, oats, rice, rye, sorghum, and wheat. Shaded area for grains indicates contribution from corn, which is heavily used in the production of biofuels.

C.F. Share of country or country group in world total. Sample of countries included in this figure collectively accounted for 97 percent of global GDP and 83 percent of global population in 2017.

D. AEs stands for advanced economies.

F. EMDEs excluding China and India.

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global energy demand over this period (Baffes et al. 2018; World Bank 2018b). The steep increase in China's consumption of energy and metals appears to reflect factors beyond population growth, since China's share of global population declined over this period, from 22 percent to 19 percent.

Notably, the pace of China's commodity demand growth was much stronger than that of other fast-growing, large emerging markets. Although India's share of consumption of oil and coal doubled, this was in line with the increase in its share of global GDP, while its share of consumption of copper and zinc rose only modestly, and its share of aluminum fell slightly. Other EMDEs collectively saw little change in their share of global commodity demand, except for a modest increase in consumption shares of oil and natural gas.

Intensity of commodity demand

Population growth and economic development, as reflected by rising GDP per capita, have historically been key drivers of global demand for commodities. While population growth tends to be stable, economic growth can undergo more rapid developments, and the impact of economic development on demand for commodities can change substantially at different stages of development. These trends can be observed in commodity consumption patterns at the country and global level. Over the past 50 years, global per capita consumption of energy and metals (excluding China) has been strikingly constant (Figure SF.2; Figure SF.3). However, the global aggregate hides significant changes at the country level, with per capita energy and metals consumption in emerging market and developing economies (EMDEs) rising, and that of advanced economies, such as Japan and the United States, peaking and then declining.[3] Moreover, the "intensity" of use of energy and metals—defined as the consumption per unit of GDP—has steadily declined over the past 50 years. These trends reflect efficiency improvements (especially for energy), the increasing importance of the service sector in the global economy (which is much less

[3] Global per capita consumption (excluding China) of natural gas has risen while that of oil and coal has fallen, reflecting preference for natural gas as a less polluting fuel. For metals, use of aluminum per capita has risen at the expense of other metals reflecting its use as a superior replacement of some metals such as tin and lead.

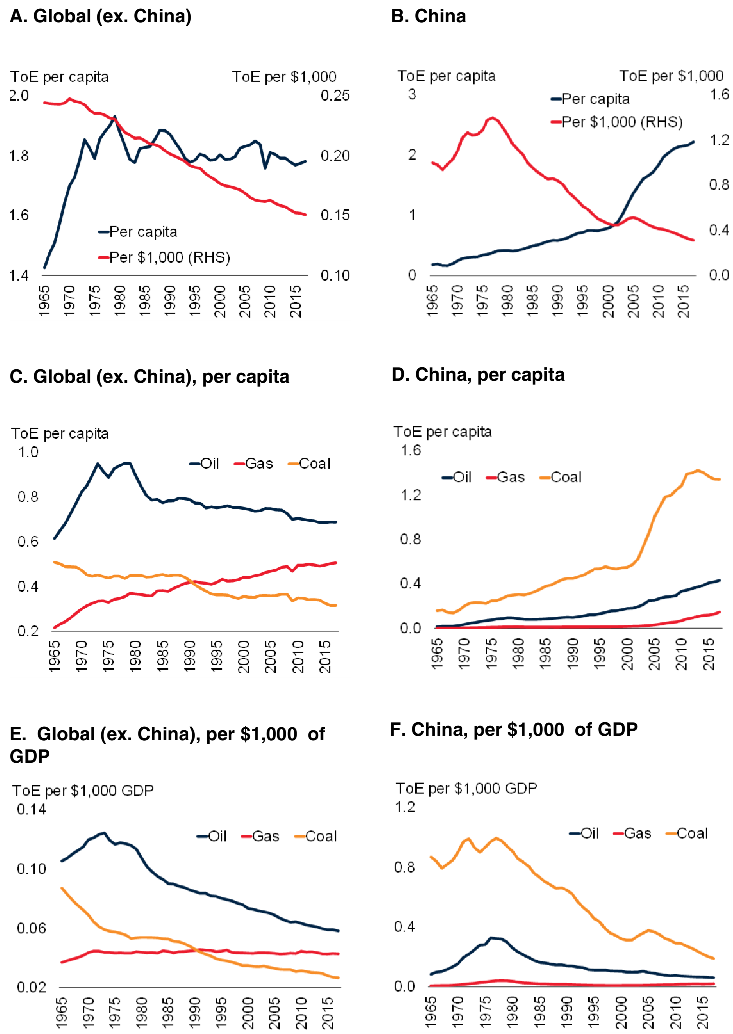
commodity intensive than manufacturing), and the reduced need for major infrastructure investment in mature economies (Tilton 1990; Radetzki et al. 2008). Consumption of all energy and metal commodities relative to GDP has been on a declining trend (although only marginally for natural gas), as the pace of growth in their consumption has been slower than that of GDP.

Developments in China have been substantially different from the rest of the world. Between 1965 and 2000, China's energy and metals use per capita grew steadily, while intensity fell, helped by efficiency improvements. From 2000 to 2017 however, growth in energy and metals use per capita accelerated sharply. Energy use per capita tripled, driven by coal (use of natural gas rose more quickly but from a lower base), while metals consumption per capita rose seven-fold, driven by rising consumption of aluminum. The increase in China's use of coal may have been amplified by the increase in aluminum consumption. China produces almost all of the aluminum it consumes, and the process of smelting aluminum is extremely energy intensive, and 90 percent of the electricity used in Chinese aluminum production is generated from coal (Arezki and Matsumoto 2017; International Aluminum Institute 2018).

Over this period China's energy intensity—consumption relative to GDP—continued its longer-term decline, similar to the rest of the world. However, China's metals intensity almost doubled. In part, this may have been a result of China's growing role in the global economy, and its manufacturing and export-driven growth model. Total demand for metals in China will be greater than total domestic consumption, as many of the commodities that China uses are intermediate inputs for exported goods. This also likely explains why the share of advanced economies' metals demand fell over this period, as manufacturing shifted overseas. While these shifts may affect country-level intensities, they should net out at the global level. But this has not occurred. The overall global metals intensity of demand, considering both China and the rest of the world, had been steadily declining from 1965-2000, but from 2000-17, the trend reversed and it

FIGURE SF.2 Energy consumption

Over the past 50 years, global consumption (excluding China) of energy per capita has been fairly constant, while the intensity of energy use—defined as energy used per unit of GDP—has steadily declined. The downward trend in intensity is a result of economic activity shifting to less commodity intensive-activities, as well as efficiency improvements. While energy intensity in China has also fallen, energy use per capita has tripled since 2000, driven by coal. Developments have varied by individual commodity reflecting changing preference for fuels.

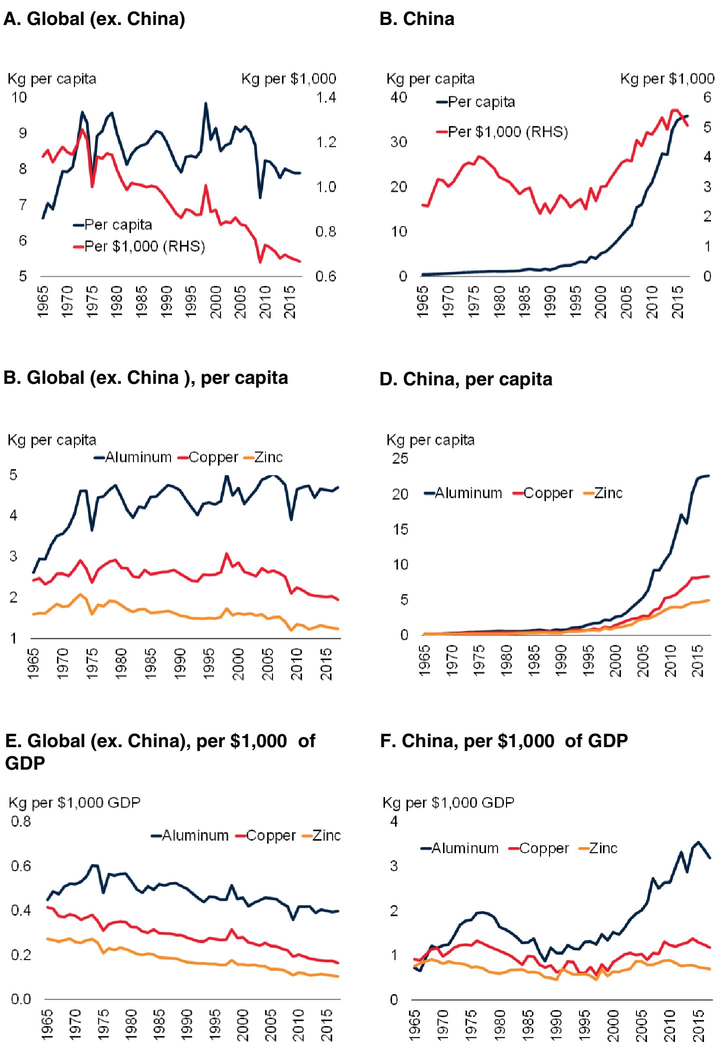


Sources: BP Statistical Review, World Bank.
A. B. Energy includes coal, natural gas and oil.
A.-F. ToE stands for tonnes of oil equivalent.
A. B. E. F. GDP in constant 2010 U.S. dollars.
Download data and charts.

began to increase. This suggests China-specific developments were a key driver, such as the very high share of investment, particularly in infrastructure and housing. Investment is much more metals-intensive than other sectors of the economy, such as consumption.

FIGURE SF.3 Intensity of metals consumption

The metals intensity of the world excluding China has steadily fallen, while per capita consumption has been relatively flat. In contrast, China's metals use per capita grew steadily between 1965 and 2000, while the intensity of consumption fell as GDP outpaced commodity demand. From 2000 onward metals use accelerated, with metals consumption per capita rising seven-fold, driven by aluminum. Although Chinese per capita consumption of commodities is now broadly in line with that of advanced economies, the intensity of metals use relative to GDP is unprecedented.



Sources: World Bank, World Bureau of Metals Statistics.
A. B. Metals includes aluminum, copper, and zinc.
A. B. E. F. GDP in constant 2010 U.S. dollars.
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The impact of income on commodity demand

The tendency for industrial commodity demand to plateau as economies develop was first suggested by Malenbaum (1978) who theorized the existence of an inverted U-shape relationship between income and commodity use, defined as the "intensity of use" hypothesis. The hypothesis has some support from the literature, although other economic factors also play an important role in determining demand (Foquet 2014; Fernandez 2018; Crowson 2017). Looking at the data, consumption of most commodities appears to plateau as per capita income rises, reflecting the tendency for consumption to shift to less resource-intensive goods and services (Figure SF.4).

Among advanced economies, demand of some commodities has begun to decline, particularly for coal as countries shift toward cleaner and more efficient forms of energy such as natural gas (Burke and Csereklyei 2016). Per capita demand for metals has also started to decline, driven to some extent by the outsourcing of manufacturing to EMDE countries including China.

Focusing on China, per capita consumption of coal and most metals is now comparable to that of advanced economies such as those in the group of seven countries (G7), or recently industrialized countries such as the Republic of Korea. By contrast, China's per capita consumption of oil and natural gas is much lower than that of Korea and the G7 economies, while that of coal and aluminum is at, or slightly above, current levels in these countries. Whereas per capita consumption levels are not particularly unusual by comparison with other countries, what has been remarkable is the speed at which China's consumption of commodities increased, and the level of per capita income at which it did so, especially for coal and aluminum.

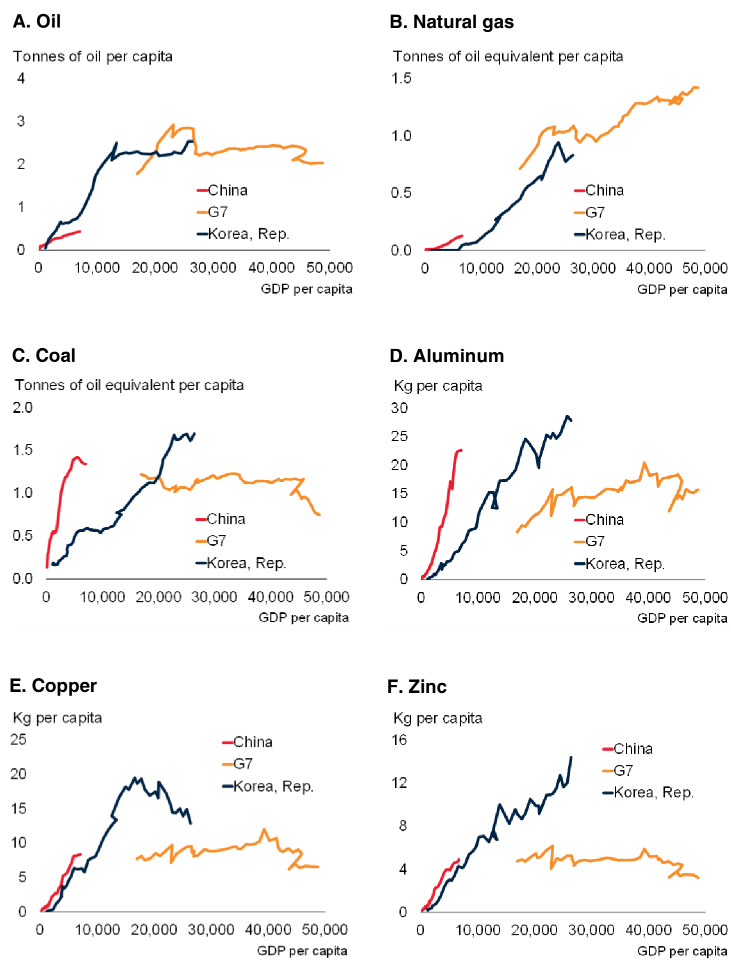
For example, China's intensity of demand for aluminum peaked in 2015 at 3.5 kg per $1,000 of GDP, much higher than the second highest country, the United Arab Emirates (2.5 kg/$1,000) and more than three times that of the United States (1.0 kg/$1,000). Based on current levels of consumption and expected growth rates, there do not appear to be any countries or groups of countries that are likely to experience an increase in commodity demand as fast as, or at the same magnitude of, China. For example, in India, a country with a similar population and growth rate as China but at an earlier stage of development, intensity of aluminum demand peaked in 2009 at 1.0 kg/$1,000 and has since fallen to 0.5 kg/$1,000.

These trends in demand intensity can be empirically examined by calculating the income elasticity of demand for different commodities: the percent increase in commodity consumption associated with a 1 percent increase in income. Estimates of income elasticities for three energy and three metal commodities were obtained using a dataset of 33 countries over the period 1965-2016 (see Annex). A number of results were obtained from this analysis.

- Long-run elasticities decline with rising per capita income for most commodities, which supports the intensity of use hypothesis and plateauing commodity demand. For example, the income elasticity of copper at the bottom income quartile in 2017 was 1.0, whereas it dropped to 0.4 at the upper income quartile.
- Long-run income elasticities for metals tend to be higher than those of energy, consistent with the observed increase in metals demand over the past 20 years being much faster than that of energy. For example, at the median income in 2017, the income elasticity of aluminum was estimated to be 0.8, while that of crude oil was 0.5.
- While income elasticities of metals are relatively homogenous, they vary substantially between energy commodities. For instance, while the elasticity of coal is high at low income levels, it falls rapidly and turns negative at higher income levels, whereas that of natural gas was found not to plateau. This likely reflects an increasing preference for natural gas over coal as incomes rise due to its properties as a cleaner-burning fuel.

FIGURE SF.4 Consumption of industrial commodities per capita, and income per capita

The consumption of industrial commodities 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. The increase in China's consumption of coal and aluminum has been much faster, and occurred at much lower levels of income, than other countries.



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. Korea was chosen as an example of a country which underwent industrialization over the period shown: in 1965 its GDP per capita was equal to 7 percent of the level of GDP per capita in the G7 economies; by 2017 it had increased to 55 percent.
Download data and charts.

Conclusion and policy implications

Many EMDEs, especially smaller ones, are heavily exposed to commodity markets. Two-thirds of EMDEs depend significantly on natural resources for government and export revenues, and more than half of the world's poor live in commodity-exporting EMDEs (World Bank 2016a). Such dependency exposes these economies to commodity price shocks (Didier et al. 2016; Baffes et al. 2015).

The growing role of China in commodity markets has critical implications for commodity exporters.

In recent decades, the growth of demand from China has provided an important boost to the price of industrial materials. These prices are now much more sensitive to shocks to China's growth. For example, a 1 percentage point drop in China's growth has been estimated to lead to a decline in average commodity prices of about 6 percentage points after two years, with a larger price impact for commodities where China's demand is particularly important, such as metals (World Bank 2016b).

The intensity-of-use hypothesis implies commodity demand growth slows as economies mature, infrastructure needs are met, and GDP and population growth slows. These developments are expected to increasingly occur in China over the next decade, with a moderation in growth and a shift toward less commodity-intensive activities. Such a shift will result in more modest commodity demand, which in turn will provide less support to commodity prices. Based on current levels of consumption of commodities and expected growth rates elsewhere, there is no country or group of countries that is expected to come close to replicating China's growth in metals demand.

In addition, technological advances, shifts in consumer preferences, environmental concerns, and policies to encourage cleaner fuels could result in a more rapid slowing of global commodity demand. For example, efforts to meet the goals of the 2015 Paris Agreement could encourage greater use of carbon pricing and other tools to encourage a shift toward cleaner and/or renewable energy sources (World Bank 2018a).[4] Indeed, during the past five years, global consumption of natural gas has increased nearly 10 percent while coal consumption has declined 2 percent.

The prospect of persistently slower commodity demand growth only reinforces the need for commodity exporters to diversify their economic bases. Extensive cross-country analysis has already demonstrated that greater diversification of exports and government revenue sources bolsters long-term growth and resilience to external shocks (Lederman and Maloney 2007; Hesse 2008). 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. But achieving this diversification will require reforms, including those to improve the business environment, educational attainment, 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; World Bank 2015a). 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 shocks (Frankel 2017). However, such policies are insufficient to mitigate the challenge of weaker commodity consumption, since they deal with cyclical, rather than structural, developments.

[4] In contrast, more energy efficient and climate-friendly technologies may lead to increasing demand for some metals and minerals, as low-carbon energy systems are likely to be more metal intensive than high-carbon systems (World Bank 2017).

ANNEX Commodity Demand Model

Model specification

The empirical approach is based on the pooled mean group (PMG) auto-regressive distributed lag (ARDL) (*p,q,r*) model developed by Pesaran, Shin, and Smith (1999), where *p*, *q*, and *r* are respectively the lag length of the dependent variable and the two explanatory variables. The model is as follows:

$$c_t = \Sigma_{k=1}^{p} \lambda_k c_{t-k} + \Sigma_{l=0}^{q} \delta_l y_{t-l} + \Sigma_{l=0}^{q} \varphi_l y_{t-l}^2 + \Sigma_{m=0}^{r} \gamma_m p_{t-m} + \alpha + \varepsilon_t \quad (1)$$

where c_t is the logarithm of real per capita consumption of each commodity for each country at year *t*; y_t is real per capita income for each country at year *t*; p_t denotes the local currency-denominated world price of each commodity relative to the local currency-denominated GDP deflator, α represents country fixed effects, and ε_t is the stochastic error term which has zero mean and constant variance. The quadratic term, y_t^2, accounts for nonlinearities inherent in most demand function which, in this case, represents the level at which income plateaus.

The error correction form corresponding to (1) is:

$$\Delta c_t = \rho\,(c_{t-1} - \theta_1 y_t - \theta_2 y_t^2 - \theta_3 p_t) + \Sigma_{k=1}^{p-1} \lambda_k^* \Delta c_{t-k} + \Sigma_{l=0}^{q-1} \delta_l^* \Delta y_{t-l} + \Sigma_{l=0}^{q-1} \varphi_l^* \Delta y_{t-l}^2 + \Sigma_{m=0}^{r-1} \gamma_m^* \Delta p_{t-m} + \alpha + \varepsilon_t \quad (2)$$

where θ_1, θ_2, and θ_3 represent the long-run dynamics, such that:

$$\theta_1 = \Sigma_{l=0}^{q} \delta_l \,/\, (1 - \Sigma_{k=1}^{p} \lambda_k),$$

$$\theta_2 = \Sigma_{l=0}^{q} \varphi_l \,/\, (1 - \Sigma_{k=1}^{p} \lambda_k)\text{, and}$$

$$\theta_3 = \Sigma_{m=0}^{r} \gamma_m \,/\, (1 - \Sigma_{k=1}^{p} \lambda_k)$$

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

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

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

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

$$\gamma^* = -\Sigma_{n=m+1}^{r} \gamma_n$$

Specifically, θ_1 and θ_2 are the long-term elasticities of demand with respect to a rise in per capita income, whereas θ_3 is the long-run elasticity of demand with respect to real price. $\rho = -(1 - \Sigma_{k=1}^{p} \lambda_k)$ denotes the speed of adjustment towards the long-term equilibrium relationship.

Differentiating (2) with respect to income gives the time-varying income elasticities for each commodity and country:

$$\eta_t = \frac{\partial c_t}{\partial y_t} = \theta_1 + 2\theta_2 y_t \quad (3)$$

Data and estimation procedure

The model is applied to three energy commodities and three base metals. The three energy commodities account for the majority of global energy demand: crude oil (31 percent), coal (29 per-cent), and natural gas (21 percent). Of these energy sources, oil is primarily used for transport, accounting for 90 percent of the energy used in this sector. Coal and natural gas are heavily used in electricity generation, although coal's share of energy supply has fallen below 50 percent as coal-fired electricity generation is replaced with natural gas and renewable fuels. Coal and natural gas are also used extensively in industry.

The three base metals, aluminum, copper and zinc account for more than 80 percent of total base metal use by volume. Aluminum is widely used because of its light weight, strength, and anti-rust properties, which encourages substitution from other metals and materials. Aluminum's largest uses are in transport, followed by construction, packaging (foil, cans), elec-trical grids, among others. Copper's main application is in the electri-cal sector, including power cables, generators and motors, as well as in construction and electronics. Zinc is mostly used as an anti-corrosion agent to galvanize iron and steel. Zinc is also alloyed with other metals, e.g. to produce brass (with copper).

Annual data from 1965-2016 for 33 countries were used. Data on per capita income (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 Commodity Price Data and converted into real terms by using country-specific GDP deflators. Exchange rates were taken from the St. Louis Federal Reserve Bank's database.

The models were estimated using the PMG ARDL (1,1,1,1), the lag length indicated as optimal by the Bayesian information criterion (BIC). The Hausman test suggests that the PMG estimator is appropriate in nearly 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. Similarly, the results are robust to including a time trend.

Brief literature review

Estimates of income elasticities of demand vary by commodity, between countries, and over time (Table SF.1). For energy, most studies find an income elasticity of less than unity (Burke and Csereklyei 2016; Csereklyei and Stern 2015). That implies per capita energy consumption grows more slowly than per capita real GDP, consistent with a declining energy intensity of demand. Several studies have found that income elasticities decline as income rises (Dahl 2012; Fouquet 2014; Jakob, Haller, and Marschinski 2012).

For metals, the income elasticity depends on the availability of substitutes and the range of uses. Demand for aluminum has been found to grow faster than manufacturing output, i.e., with an income elasticity greater than one, while tin and lead have a below-unitary elasticity (Stuermer 2017). Fernandez (2018) also finds a higher income elasticity of demand for aluminum (and nickel and zinc), than for lead and tin.

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).

Main results

Long-run income elasticities of commodity consumption calculated from the coefficients are reported in Table SF.2. The income elasticities differ widely across commodities and income levels (Figure SF.5). For most commodities, long-run elasticities decline with rising per capita income, consistent with the intensity of use hypothesis. In general, long-run income elasticities for metals are higher than for energy. The income elasticities for EMDEs were also estimated to be much higher than for advanced economies.

Income elasticities of metals decline with rising incomes but remain elevated even at the top quartile of per capita incomes. Aluminum and copper have the highest income elasticities (0.8 and 0.7, respectively), while zinc is considerably lower at 0.3. Long-run income elasticities for crude oil and coal consumption 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, in line with Huntington, Barrios, and Arora (2017). The elasticity for coal, however, drops rapidly, as users switch toward cleaner energy sources at high incomes, and was negative at the highest quartile of per capita incomes in 2017. For natural gas, in contrast, a significant non-linear relationship between income and consumption was not found. This may be because natural gas' popularity as a fuel for electricity generation has increased rapidly, so few countries will have reached the "plateau stage" within the sample period. The model also generates modest price elasticities, which are broadly in line with the existing literature.

TABLE SF.1 Long-run income elasticities of demand for commodities in the literature

Study	Data	Methodology	Results
Jakob, Haller and Marschinski (2011)	30 EMDEs and 21 advanced economies, annual data, 1971-2005, energy	Difference-in-differences estimator on panel data	Income elasticity of primary energy demand of 0.63 for EMDEs and 0.18 for advanced economies (although statistically insignificant).
Joyeux and Ripple (2011)	30 OECD and 26 non-OECD countries, annual data, 1973-2007, energy	ECM 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.
Fouquet (2014)	UK, annual data, 1700-2000, energy	VECM	Long run income elasticity for energy demand for transport peaks at 3 before declining to around 0.3 as income rises.
Valin et al. (2014)	Review of 10 papers global economic models for agricultural commodities	Literature review	Median income elasticities for rice and wheat are close to 0.1. First and third quartile range of estimates range from 0 to 0.2.
Csereklyei and Stern (2015)	93 countries, annual data, 1971-2010, energy	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.
Burke and Csereklyei (2016)	132 countries, annual data, 1960-2010, energy	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, and results from the inclusion of low income countries which tend to have low income elasticities.
Huntington, Barrios, and Arora (2017)	Review of 38 papers providing 258 estimates of price and income elasticities of energy demand	Literature review	Income elasticity of oil demand is found to be 0.5 on average, and 0.9 for natural gas.
Stuermer (2017)	12 advanced economies and 3 EMDEs, annual data, 1840-2010, base metals	ARDL	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.

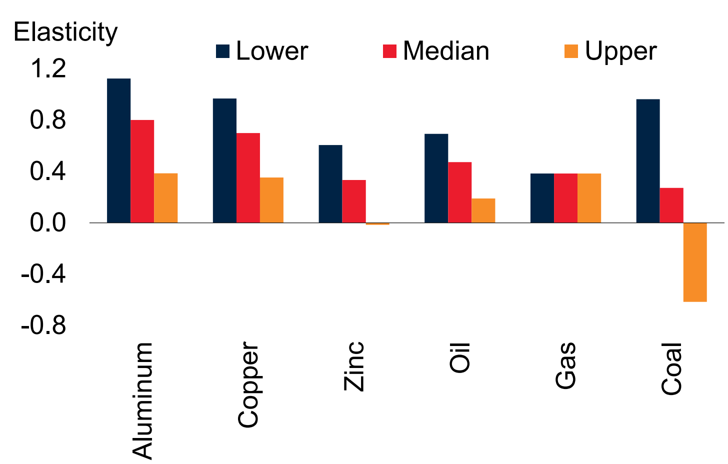
TABLE SF.2 Estimation results and income elasticities

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	0.3
Natural gas*	0.38	...	0.4

Notes: Results shown are a sub-set of the estimations obtained using the pooled mean group model. 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. * indicates linear regression results for commodities which do not appear to have a non-linear relationship with income.

FIGURE SF.5 Income elasticities of demand

Income elasticities of consumption decline with rising per capita incomes, but they differ widely across commodities and across income levels.



Source: World Bank.

A. Elasticities at lower, median and upper income quartiles in 2017.

Download data and charts.

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