The Role of Major Emerging Markets in Global Commodity Demand

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Abstract

Rapid growth among the major emerging markets over the past 20 years has boosted global demand for commodities. The seven largest emerging markets accounted for almost all the increase in global consumption of metals, and two-thirds of the increase in energy consumption over this period. As emerging market economies mature and shift towards less commodity-intensive activities, their demand for commodities may plateau. This paper estimates income elasticities of demand for a range of energy, metal and food commodities, and finds evidence of plateauing among several commodities. Looking ahead, as economies mature and GDP growth slows, growth in demand for commodities may also slow. Based on current population and GDP growth forecasts, this paper produces scenarios of potential growth in demand for commodities over the next decade. 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. Despite an expected slowdown in its growth rate, China would likely remain the single largest consumer of many commodities. 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.

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The Role of Major Emerging Markets in Global Commodity Demand*

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1. Introduction

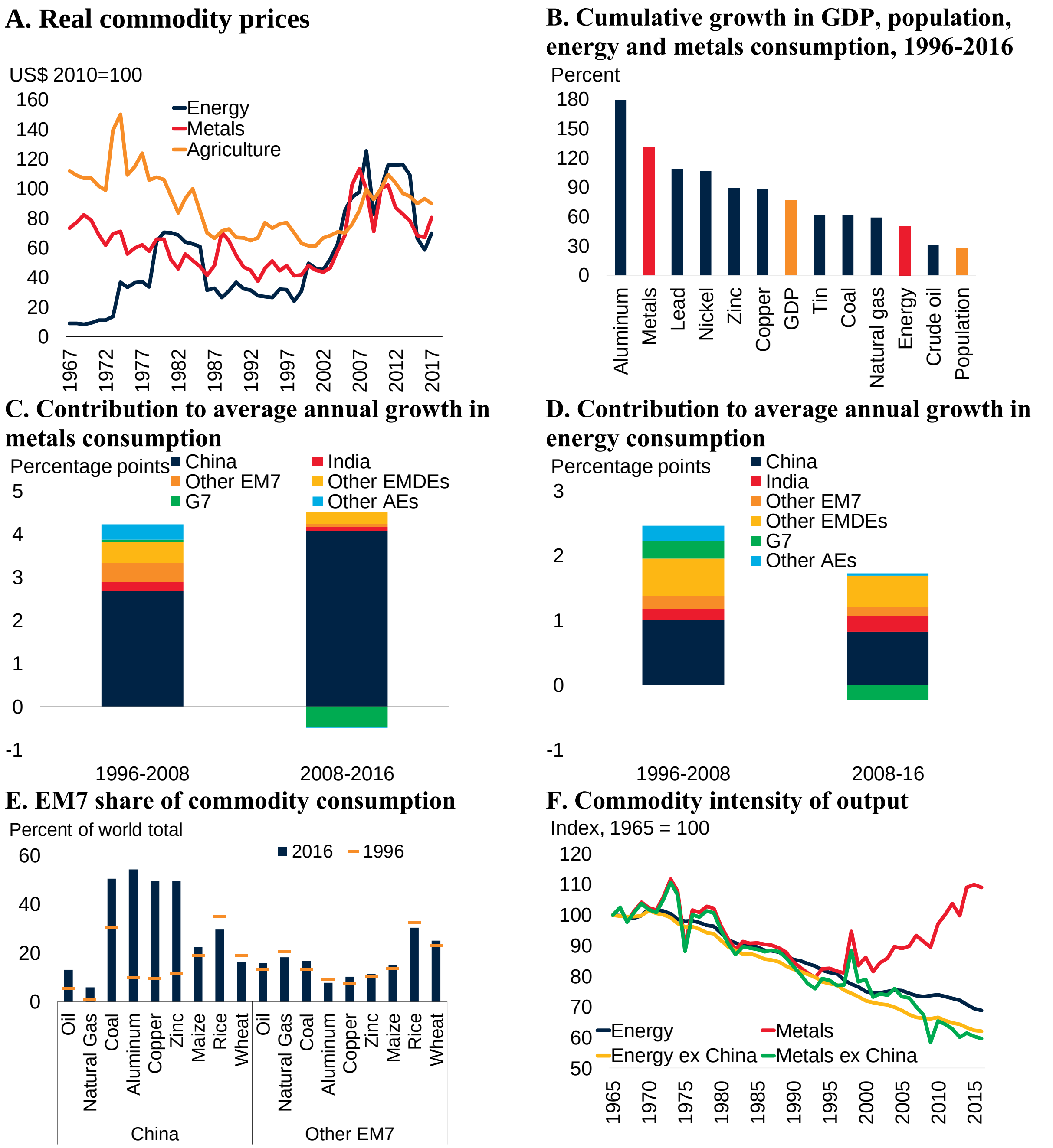
Global commodity prices underwent an exceptionally strong and sustained boom beginning in 2000. Between 2000-08, real energy prices rose 154 percent, metals prices increased 107 percent, and food prices rose 62 percent (Figure 1). Unlike a typical price cycle, this boom has been characterized as a "super cycle", i.e., a demand-driven surge in commodity prices lasting possibly decades rather than years (Radetzki, 2006; Erten and Ocampo, 2013). The rapid industrialization of China and other large emerging market economies led to a substantial, sustained increase in demand for all commodities. Indeed, over the past two decades, the seven largest emerging markets (Brazil, China, India, Indonesia, Mexico, Russia and Turkey) 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. This group now accounts for a larger share of global consumption than the G7 of coal, all base metals, precious metals, and most foods (rice, wheat, soybeans).[1]

While commodity demand tends to increase rapidly as economies industrialize, growth has been observed to slow as economies further develop, and consumer demand switches to services, which are less commodity intensive than goods (Tilton 1990; Radetzki et al. 2008). Malenbaum (1978) first suggested the existence of an inverted U-shape relationship between income and commodity use, defined as the "intensity of use" hypothesis—the amount of material used per unit of output. As economies industrialize, their demand for commodities rapidly increases, but then plateaus and beings to decline as they develop further, and demand switches to services. Indeed, the global intensity of use of energy and metals had been declining prior to the 1990s, driven by increasing economic maturity in advanced economies (Figure 1). However, the intensity of use for metals reversed trend and started to rise rapidly by the turn of the century. This largely reflected developments in China, which accounted for 83 percent of the increase in global consumption of metals between 1996 and 2016, and occurred despite rising global demand for services. 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.

Over the longer term, economic developments in major emerging market and developing economies (EMDEs) will be a critical factor for the path of demand. The intensity of use hypothesis, if it holds across commodities, implies commodity demand growth from EMDEs is likely to slow as their economies develop. EMDEs are likely to remain important drivers of commodity market developments, but 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 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. Such a slowdown in growth would dampen global commodity prices, and 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

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.

Figure 1. Developments in commodity markets



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.D. "AEs" stands for advanced economies. Other EM7 includes Brazil, Indonesia, Mexico, Russia, and Turkey.
C. "Other AEs" contains 18 advanced economies. Other EMDEs contains 32 countries.
D. "Other AEs" contains 17 advanced economies. Other EMDEs contains 31 countries.
E. Other EM7 includes Brazil, India, Indonesia, Mexico, Russia, and Turkey.
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.

price shocks (Didier et al. 2016; Baffes et al. 2015). 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).

The intensity of use hypothesis has been the subject of a significant amount of research, primarily focused on estimations of income elasticities of commodity demand. Dahl (2012) compiles a database of 240 papers estimating income elasticities of demand for gasoline alone. The majority of research tends to focus on a single commodity or commodity group, such as energy (Burke and Csereklyei 2016; Csereklyei and Stern 2015; Jakob et al. 2011), or metals (Stuermer 2017; Fernandez 2018). Estimates for elasticities can vary widely and can be contradictary. For example, Csereklyei and Stern (2015) find per capita energy use rises as income rises, in contrast to other studies such as Foquet (2014) and Jakob et al (2011), who find the income elasticity of energy demand follows an inverted-U shape. Huntington, Barrios and Arora (2017) provide a comprehensive review of 48 empirical studies estimating elasticities of energy demand in large EMDEs. They document a wide variation in techniques used, and a wide range in estimates for price and income elasticities. The paper suggests that variation in methodologies likely explains much of the variation between countries. It also highlights that an important gap in the literature is a systematic study of all commodities, for many countries.

This paper complements the existing literature by investigating the relationship between income and commodity consumption for a range of energy, metals, and food products. It extends existing work by calculating income elasticities using a consistent methodology across different types of commodities for a broad range of countries. The paper also develops a set of stylized scenarios of commodity consumption growth prospects based on estimated income elasticities, together with long-term population and GDP projections.

The rest of this paper is divided into four sections. Section 2 examines the role of economic development and income growth on commodity consumption. Section 3 estimates income elasticities of demand for ten commodities. Section 4 outlines potential scenarios for commodity growth over the next 10 years based on these elasticities of demand. Section 5 considers the policy implications of these scenarios, and concludes.

2. Economic development and commodity consumption

Economic development, as reflected in rising GDP per capita, has been a key driver of global demand for key commodities. This section, and the rest of this paper, considers the relationship between per capita income growth and consumption of a range of commodities. These include three energy products (crude oil, coal, and natural gas) and three metals (aluminum, copper, and zinc), which collectively 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 paper 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.

2.1 Income elasticity of consumption

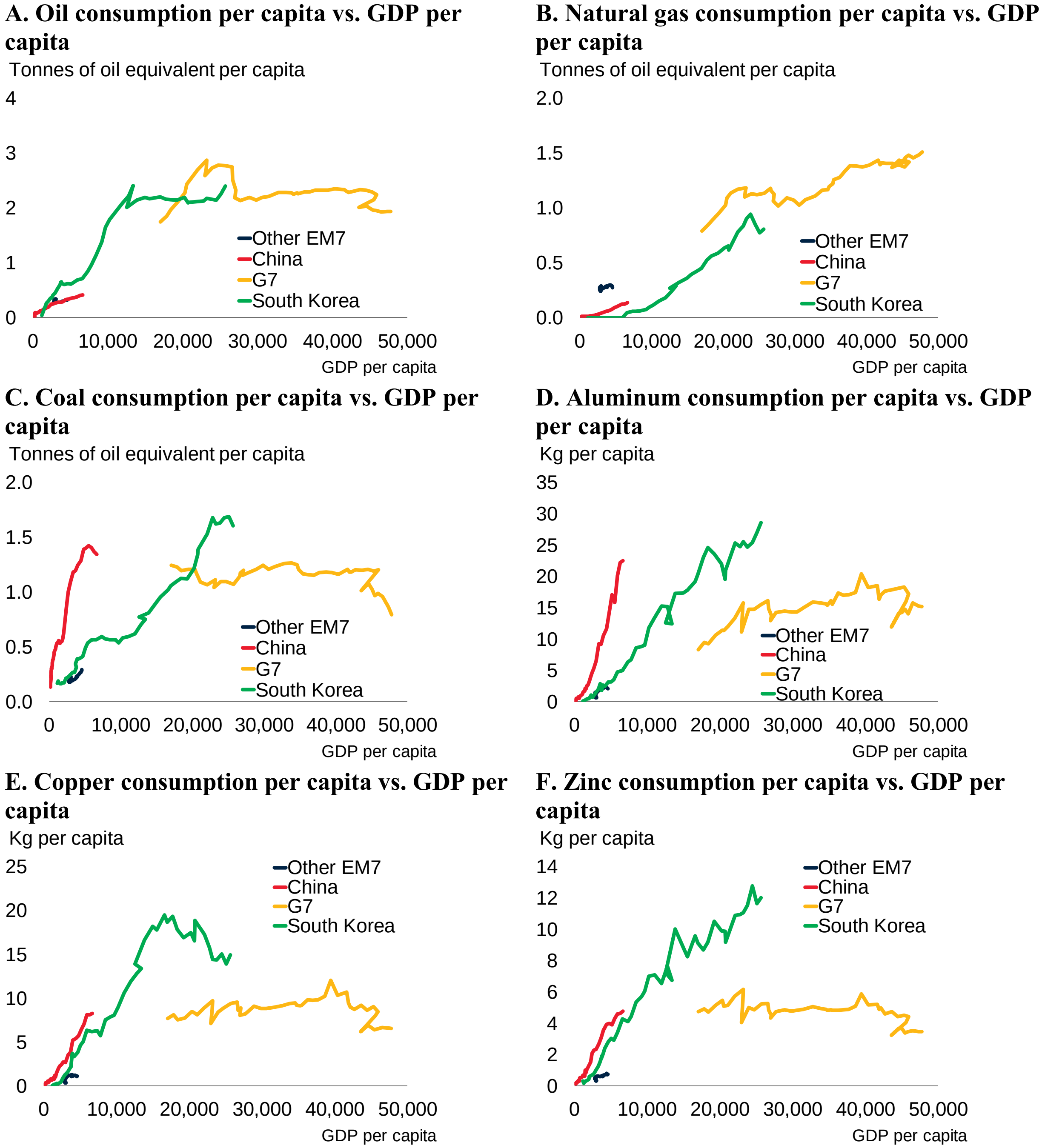
Figure 2 plots per capita income and per capita commodity consumption for a range of energy and metals commodities over the period 1965-2016. Per capita consumption of most commodities generally plateaus as per capita income rises, and there is evidence of declining consumption at higher levels of income for some commodities (crude oil, coal, copper, zinc). Natural gas shows less sign of plateauing than other commodities, which may reflect a shift in consumer demand to cleaner fuels as incomes rise. However, different countries have seen different experiences, with China in particular experiencing a much faster increase than other countries in its per capita use of commodities, particularly aluminum and coal, for a given level of per capita income.

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. 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.

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. For example, 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. The long-run elasticity is more relevant to the multi-decade trends described in this paper. Estimates of long-run income elasticities of demand vary by commodity, between countries, and over time (Table 3). 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 decline as income rises (Dahl 2012; Foquet 2014; Jakob et al. 2012). 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).

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). Fernandez (2018) also finds a higher income elasticity of demand for aluminum (and nickel and zinc), than for lead and tin. Elasticities of food products, meanwhile, 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

Figure 2. Consumption of industrial commodities and income



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. Other EM7 includes Brazil, India, Indonesia, Mexico, Russia, and Turkey.

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

2.2 Price elasticities of demand

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), while Fernandez (2018) generally finds modest price elasticities for metals. As with income elasticities, price elasticities of demand tend to be larger in the long-run than the short-run, as consumers have more time to respond to changes in prices by finding substitutes, or efficiency gains. 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.

3. Estimation of long-run income elasticities

This section estimates long-run income elasticities of the energy, metals, and agricultural commodities listed earlier, using an auto-regressive distributed lag model. The methodology is similar to that of Fernandez (2018).

3.1. Model specification

The empirical approach adopted in this paper 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:

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

where $c_{ij,t}$ is the logarithm of real per capita consumption (in millions of tonnes for metals and agricultural 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 world price of commodity *i*, 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 nonlinearity inherent in most demand functions which, in this case, represents the level at which income plateaus.

The error correction form of equation (1) is:

$$\Delta c_{ij,t} = \rho_i \left(c_{i,t-1} - \theta_{i,1} y_t - \theta_{i,2} y_t^2 - \theta_{i,3} p_t \right) + \sum_{k=1}^{p-1} \lambda_{ij,k}^* \Delta c_{ij,t-k} + \sum_{l=0}^{q-1} \delta_{ij,l}^* \Delta y_{ij,t-l} + \sum_{l=0}^{q-1} \varphi_{ij,l}^* \Delta y_{ij,t-l}^2 + \sum_{m=0}^{r-1} \gamma_{ij,m}^* \Delta p_{ij,t-m} + \alpha_{ij} + \Delta \varepsilon_{ij,t} \tag{2}$$

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

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

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

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

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

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

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

$\rho_i = -(1-\sum_{k=1}^{p}\lambda_{ij,k})$ 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. Due to data limitations, a different dataset was chosen for food commodities, with predominantly EMDE representation and fewer advanced economies (Table 3).

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), United States Department of Agriculture (food), 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. 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 (Table 6). Similarly, the results are qualitatively robust to including a time trend (Table 7).

3.2 Estimation results

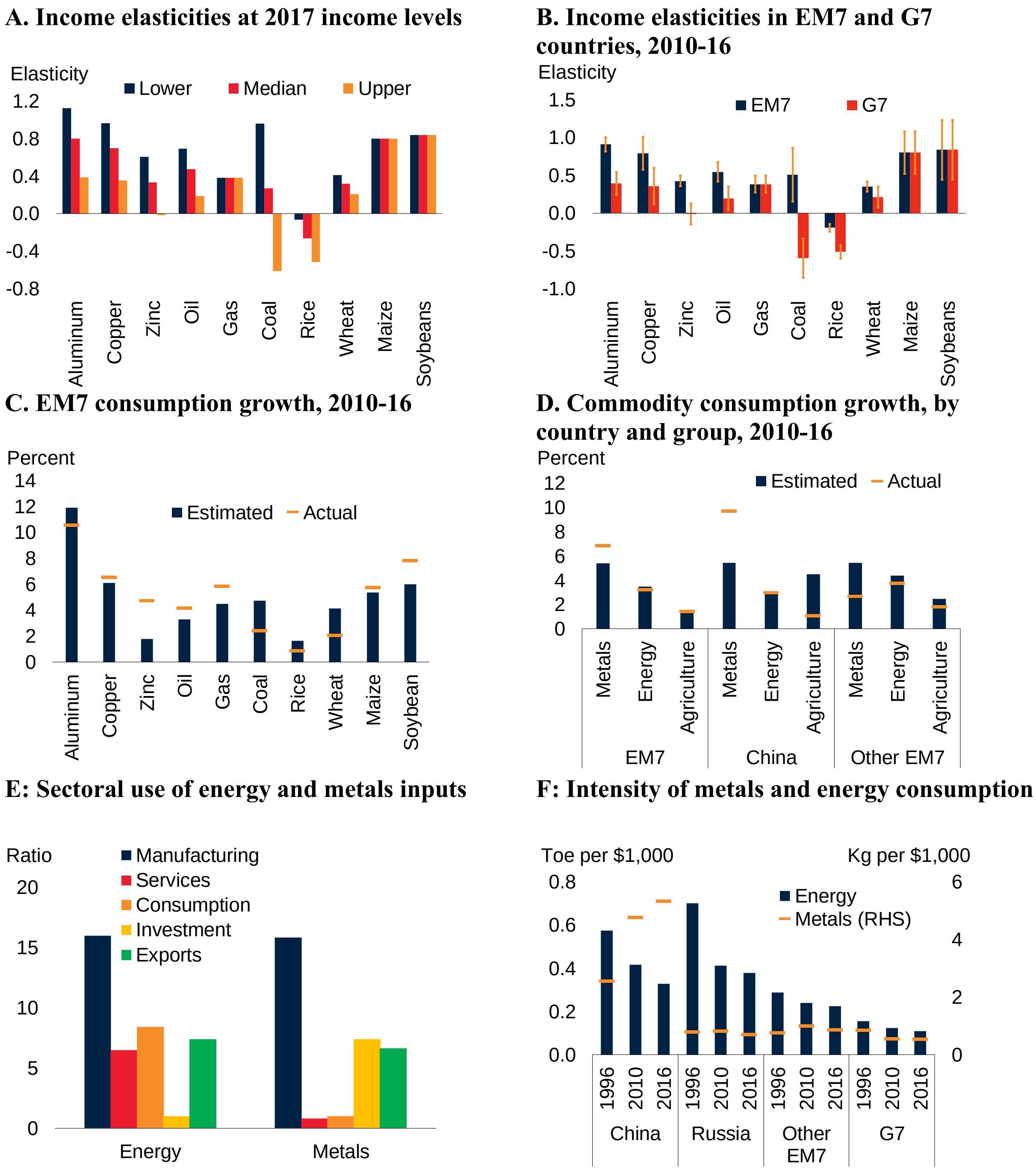
The results are reported in Table 4. The majority of commodities were found to have a nonlinear relationship between income and consumption, with statistically significant results for the coefficients of both the linear and quadratic income variables. The exceptions were natural gas, maize and soybeans, where a linear relationship was estimated. Long-run income elasticities calculated from the coefficients are reported in Table 5. The estimated long-run elasticities differ widely across commodities and across income levels (Figure 3). As expected, for most commodities long-run elasticities decline with rising per capita income (as a result of the negative coefficient on squared per capita income in Table 4). In general, long-run income elasticities for metals tend to be above those of energy and food.

Elasticities of metals decline with rising incomes, but remain elevated 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), while **zinc** is considerably lower at 0.3. 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.

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

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. 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). In contrast, for maize and soybeans the relationship between income and

Figure 3. Estimated commodity consumption growth



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.
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 Table 4.
E. Use of energy and metals 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. 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.

consumption appears to be linear, and elasticities are much higher than rice and wheat at 0.8. The regression results suggest 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. 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 EMDEs are much higher than for advanced economies. 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. In line with the literature, the model also generates modest price elasticities, but the emphasis here is on income elasticities.

3.3 EM7 commodity 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) for the seven largest emerging markets, the EM7. The regressions capture well consumption growth among the EM7 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. 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.

3.4 Model limitations

Other factors, beyond income and prices, can also affect demand for commodities, and so will not be picked up by our model. Crowson (2018) provides an excellent critique of the limitations of focusing on income to explain commodity demand. Among others, it assumes the relationship between intensity of use and per capita income is stable over time and between countries, however, structural factors can distort the relationship between income and consumption. Technological developments can lead to efficiency improvements which reduce commodity demand, such as improved fuel efficiency. New technologies can also lead to shifts in demand for commodities—the uptake of more climate-friendly technologies has led to increased demand for the metals and minerals that are required to manufacture these technologies, but reduced demand for fossil fuels. Consumer preferences can result in shifts in demand as incomes rise—for example, a preference for cleaner fuels such as natural gas over polluting fuels such as coal. Resource endowments can also play a role, as countries with significant natural resources tend to consume more of them per capita (particularly for energy, e.g. Russia and the United States), than countries without domestic resources. Finally, different growth models can lead to differing rates of commodities consumption, given the different commodity-intensity of sectors.

To analyze the impact of different growth models, we calculated the metals and energy intensity of demand of different sectors of the economy using the GTAP (Global Trade Analysis Project). The metals intensity of global manufacturing was found to be 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. 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, although that of investment is actually smaller than 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. This may have accounted for the more rapid increase in China's commodity consumption than its peers. Investment accounted for half of cumulative growth during 2010-16 in China, compared to one-quarter of cumulative growth in India, 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.

4. 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.

4.1 Baseline scenario

The baseline scenario for the period 2018-27 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 predicted per capita consumption levels (in physical units) are multiplied by total population from United Nations (2017). 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. 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. In the baseline scenario, global population growth is projected to slow slightly from 1.2 percent on average during 2010-16, to a 1 percent on average during 2018-27 (Figure 4). The slowdown is most pronounced in the EM7 countries. Real per capita income growth is expected to be broadly constant on average but slow by 0.2 percentage point in the EM7 countries. 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.

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. 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.

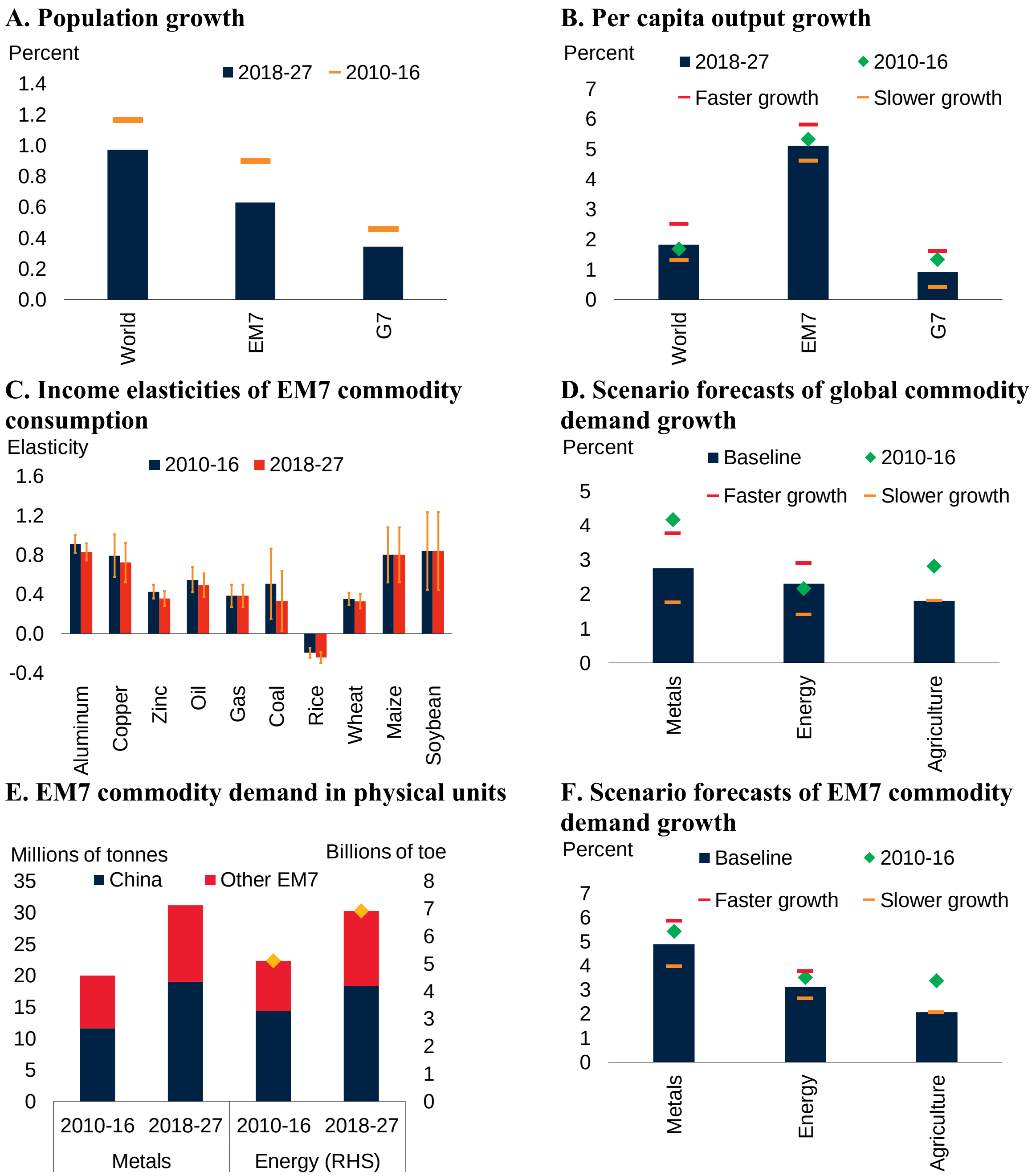
By commodity, global metals consumption growth would slow by 1.4 percentage points to just under 3 percent on average during 2018-27. Because of still-high EM7 income elasticities and robust growth, the slowdown in EM7 consumption would be milder, by 0.4 percentage point to 4.9 percent. Growth in aluminum and copper would remain high, reflecting their high income elasticity of demand, while growth in zinc would be slower, reflecting a near-zero G7 income elasticity. 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. 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. 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. Consumption growth of the foodstuffs included here would slow by 1 percentage point to 1.8 percent over 2018-27. For comparison, OECD (2017) expect a slowing in growth of consumption of cereals of about 1 percentage point. Rice and wheat would drive the slowdown because of their low-income elasticities and slowing population growth. In contrast, consumption growth of maize and soybeans would strengthen slightly.

4.2 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.

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

Figure 4. Commodity consumption scenarios



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.

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 4).

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

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). 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).

5. Conclusion and policy implications

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. 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. These trends have already become evident in advanced economies, and a similar path could be expected for the major EMDEs. More modest commodity consumption growth, all else equal, would dampen pressures on prices.

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.

Many EMDEs, especially smaller ones, are heavily exposed to commodity markets. 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).

TABLE 1. 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
2	United States	8.8	United States	7.7	United States	5.7	China	12.8	Russia	11
3	Germany	3.8	Germany	5.3	India	4.8	India	4.6	China	5.9
4	Japan	3	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	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	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

	Coal		Maize		Rice		Wheat	
1	China	50.6	United States	30	China	29.8	European Union	17.6
2	India	11	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	Vietnam	4.6	United States	4
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	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.

TABLE 2. 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.

TABLE 3. 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).

TABLE 4. 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***	0.3	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**	2.9	1.04	4.28*	-13.41***	31.6	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	5.8	2.52	1.45	1.62	5.43	5.86	2.31
p -value	0.15	0.05	0.35	0.3	0.21	0.39	0.06	0.47	0.69	0.66	0.07	0.12	0.32
log likelihood	886.27	711.2	743.02	3065.46	1557.88	1134.57	1141.82	1647.65	1141.82	1534.65	1462.82	85.7	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.

TABLE 5. Estimation results and income elasticities

Commodity	Log per capita income	Squared log per capita income	Income elasticity at 2017 median income
Aluminum	3.5	-0.15	0.8
Zinc	2.6	-0.12	0.3
Copper	2.95	-0.12	0.7
Crude oil	2.31	-0.1	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.

TABLE 6. Estimation results under generalized method of moments

	Aluminum	Zinc	Copper	Oil	Coal	Gas	Rice	Wheat	Maize	Soybeans
Log per capita	3.99***	3.81***	2.57***	2.41***	4.19***	0.27***	1.49***	0.70***	0.47***	0.48***
income	(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	-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	0.8	0.96	0.9	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.

TABLE 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	-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	0.03	-0.09	-0.02	-0.07	0
	(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	1.2	6.34	6.27
p -value	0.22	0.14	0.17	0.39	0.01	0.66	0.55	0.75	0.1	0.1
Log likelihood	889.59	694.75	755.16	3067.8	1546.83	1146.19	1529	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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