The Role of Income and Substitution in Commodity Demand

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Outline

- ***Stylized facts***
- ***A commodity demand model***
- ***Conclusions and implications***

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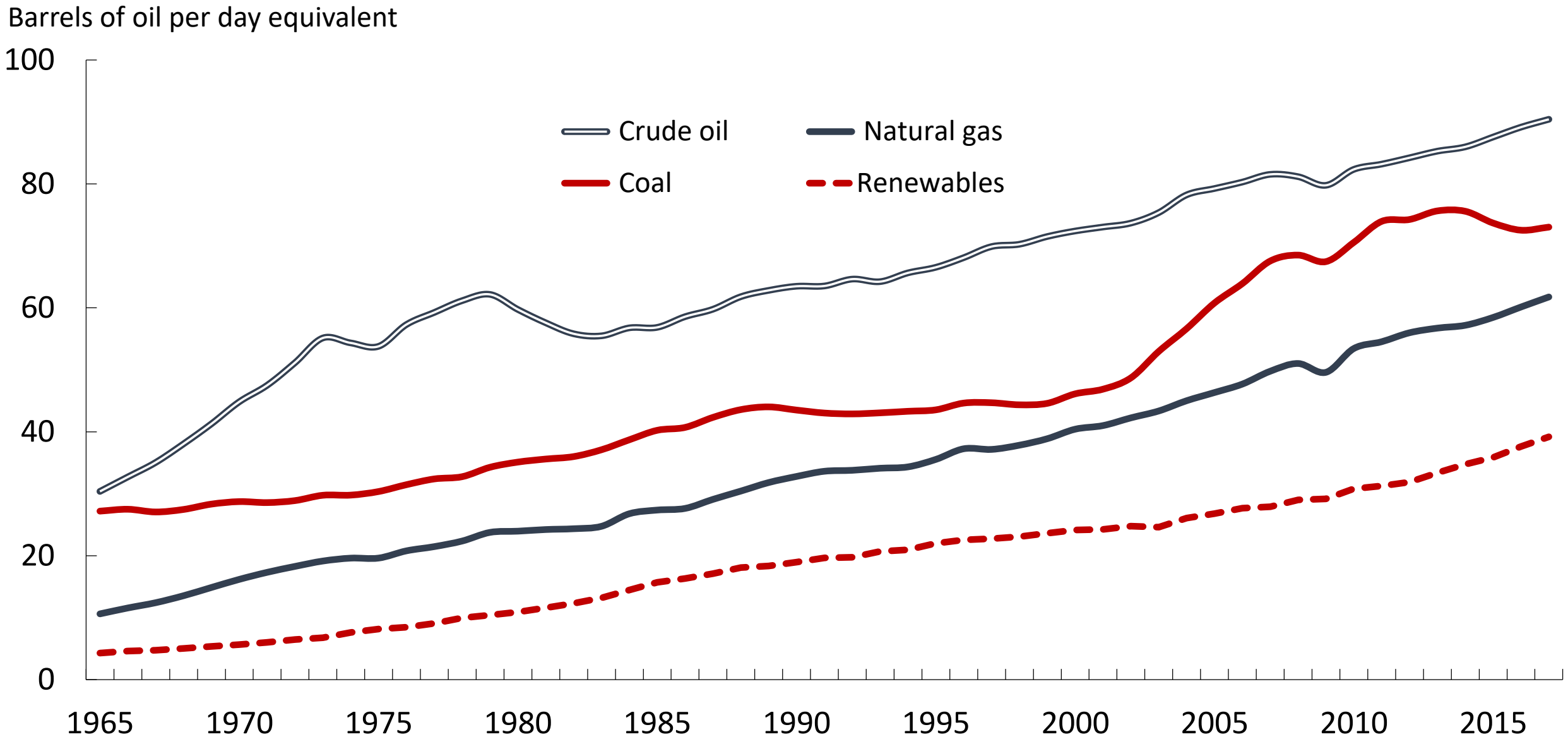
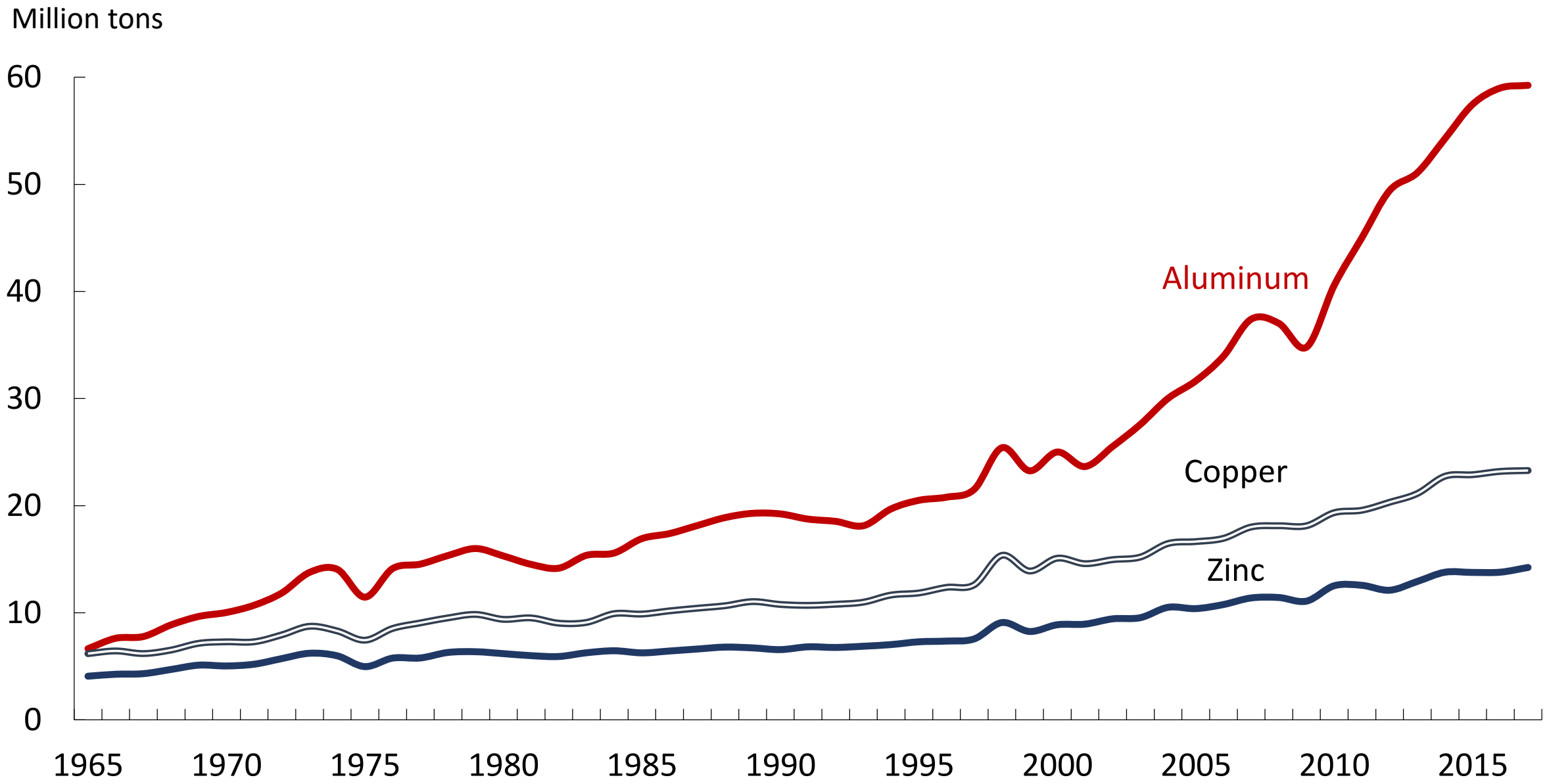
Global energy consumption



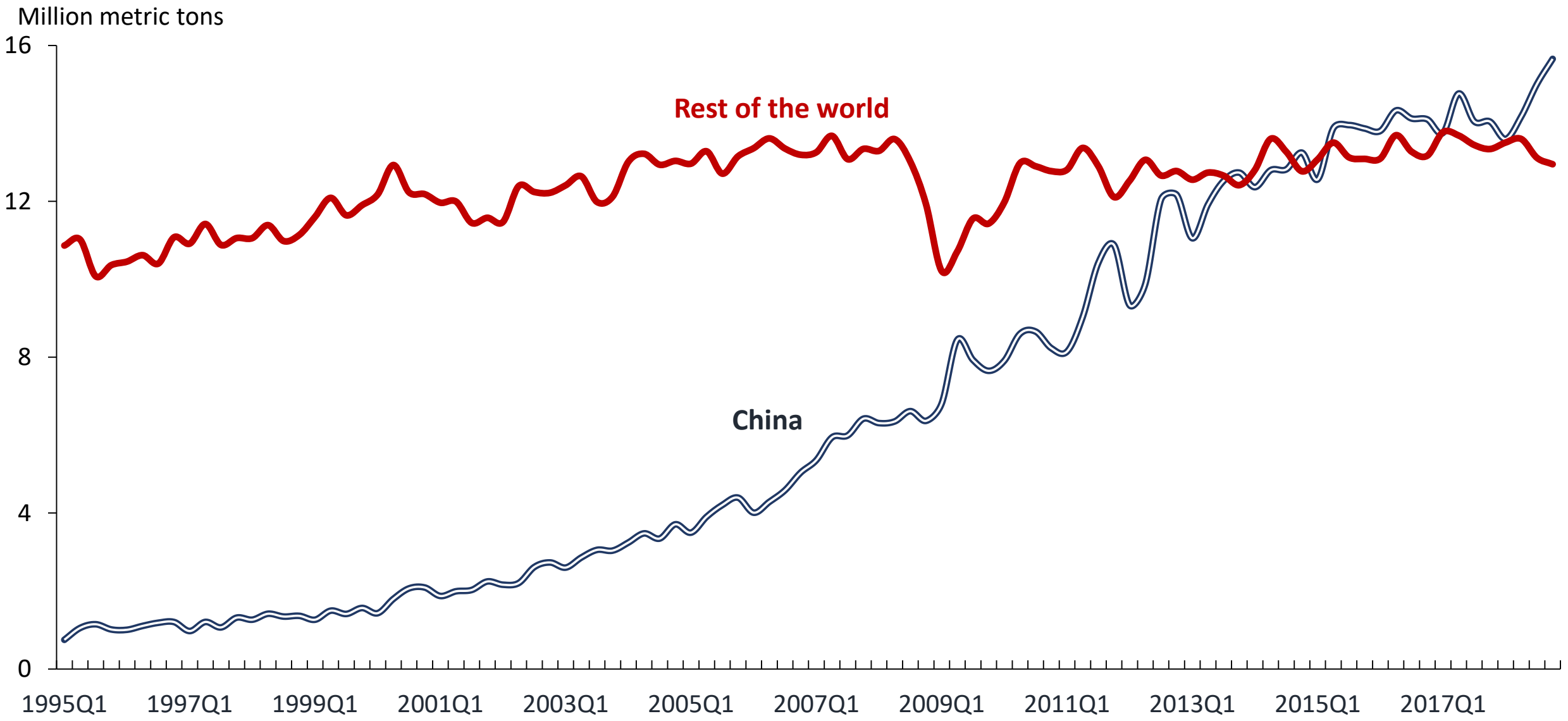
Source: BP Statistical Review and World Bank.

Global aluminum, copper, and zinc consumption



Source: World Bureau of Metal Statistics and World Bank

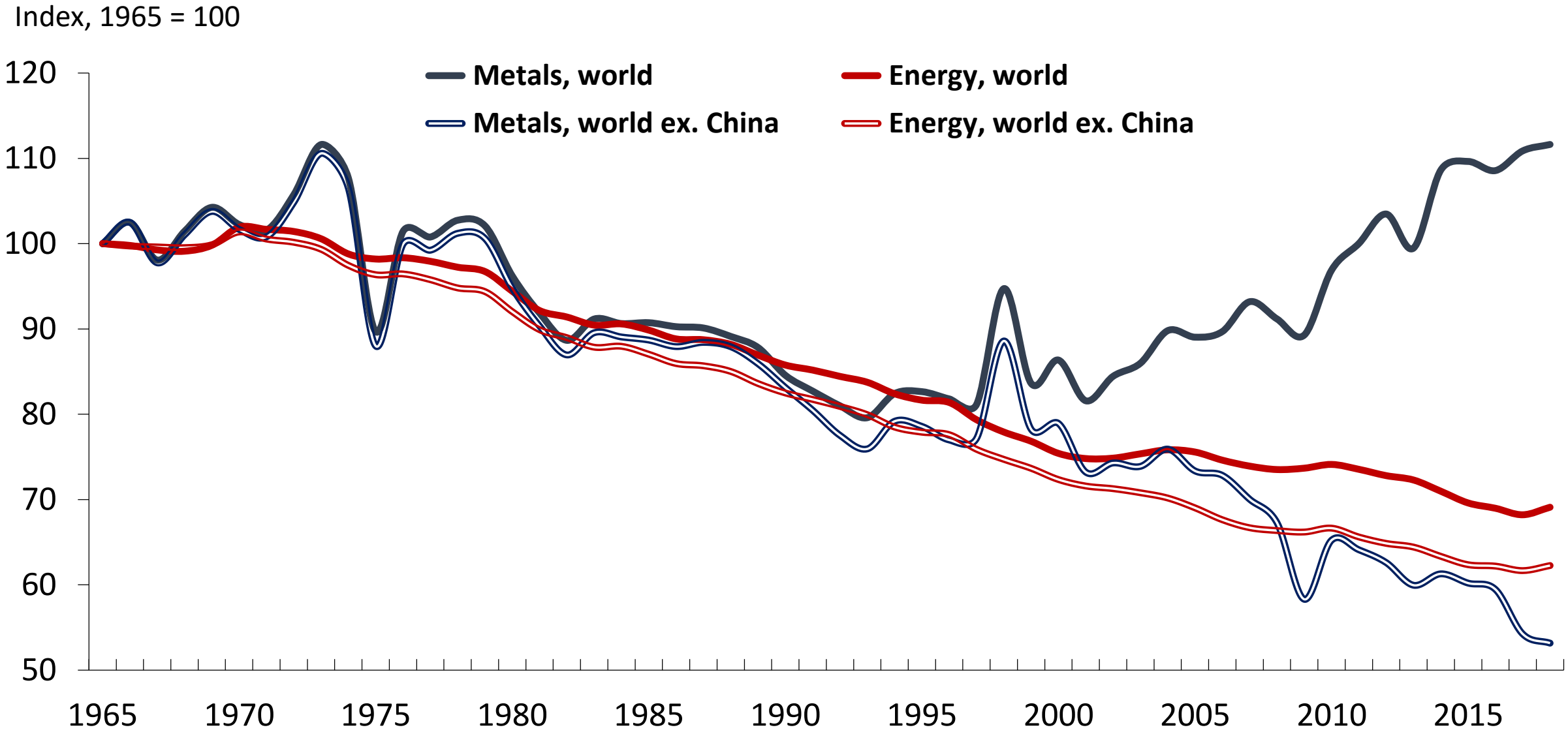
China dominates metal consumption



Source: World Bank and World Bureau of Metal Statistics

Notes: Last observation is 2018Q4.

Energy and metals intensity

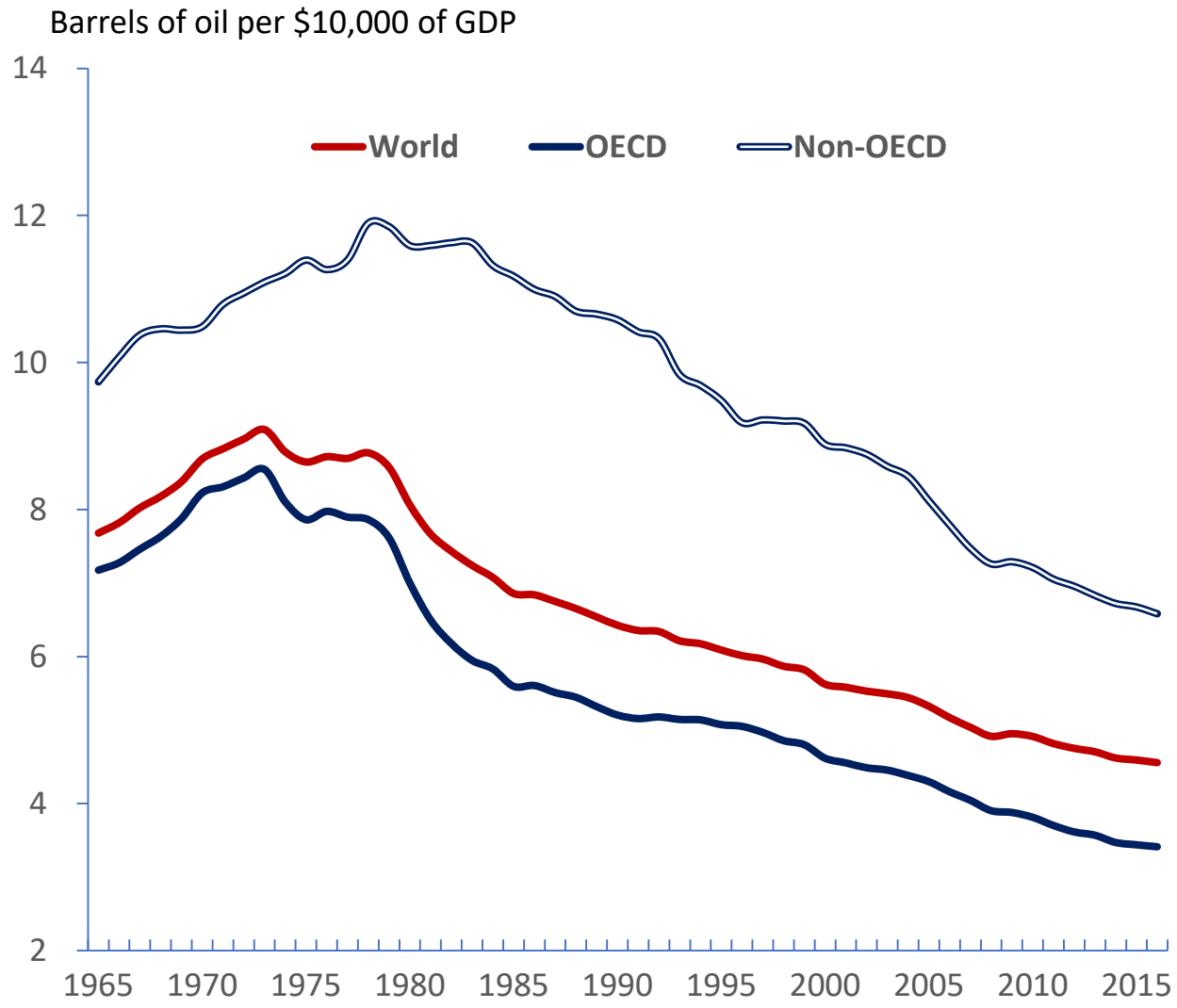


Source: BP Statistical Review, World Bureau of Metal Statistics, and World Bank.

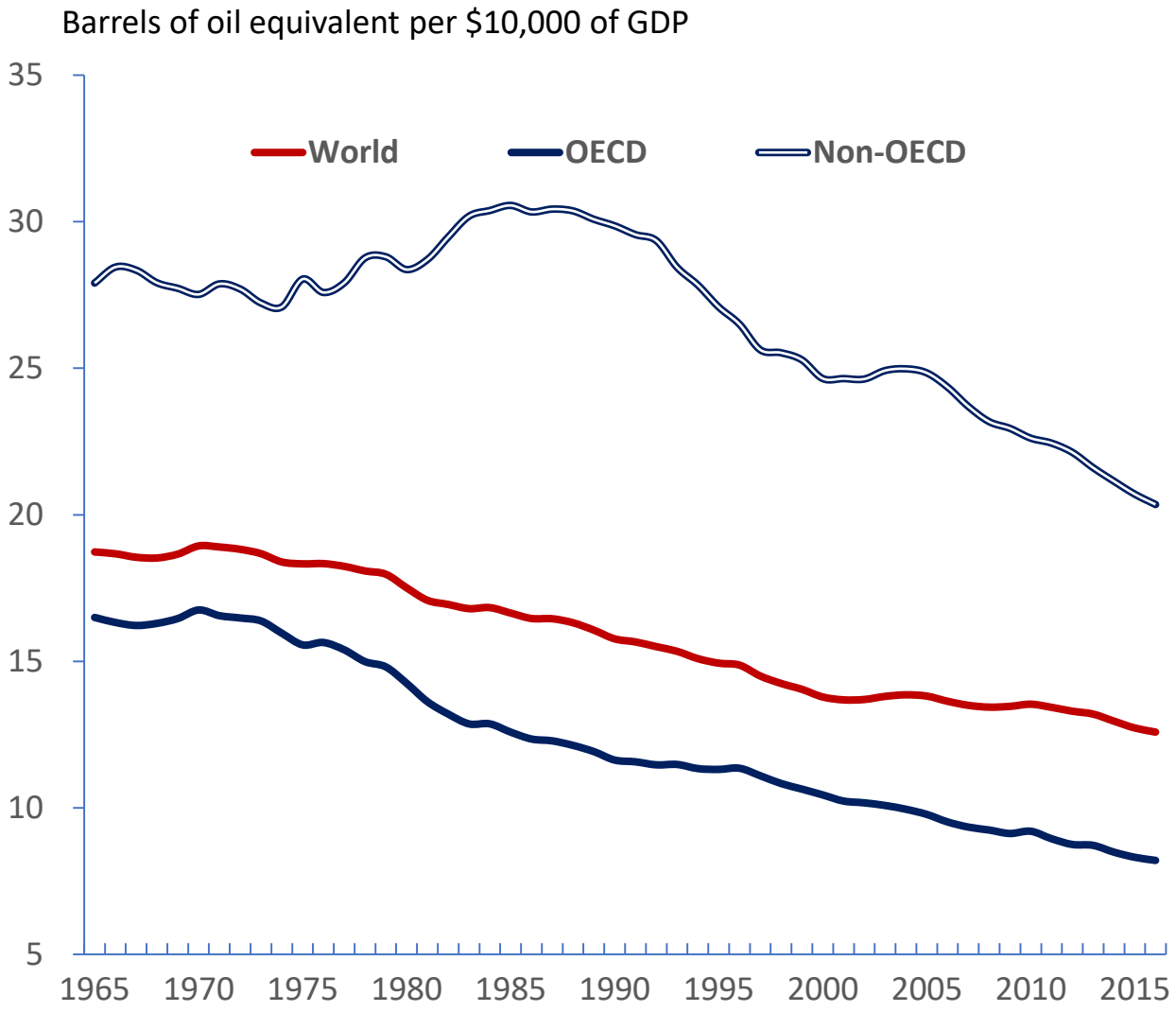
Notes: Intensity is defined as the ratio of consumption to GDP.

Oil and energy intensity of GDP have been declining

Oil

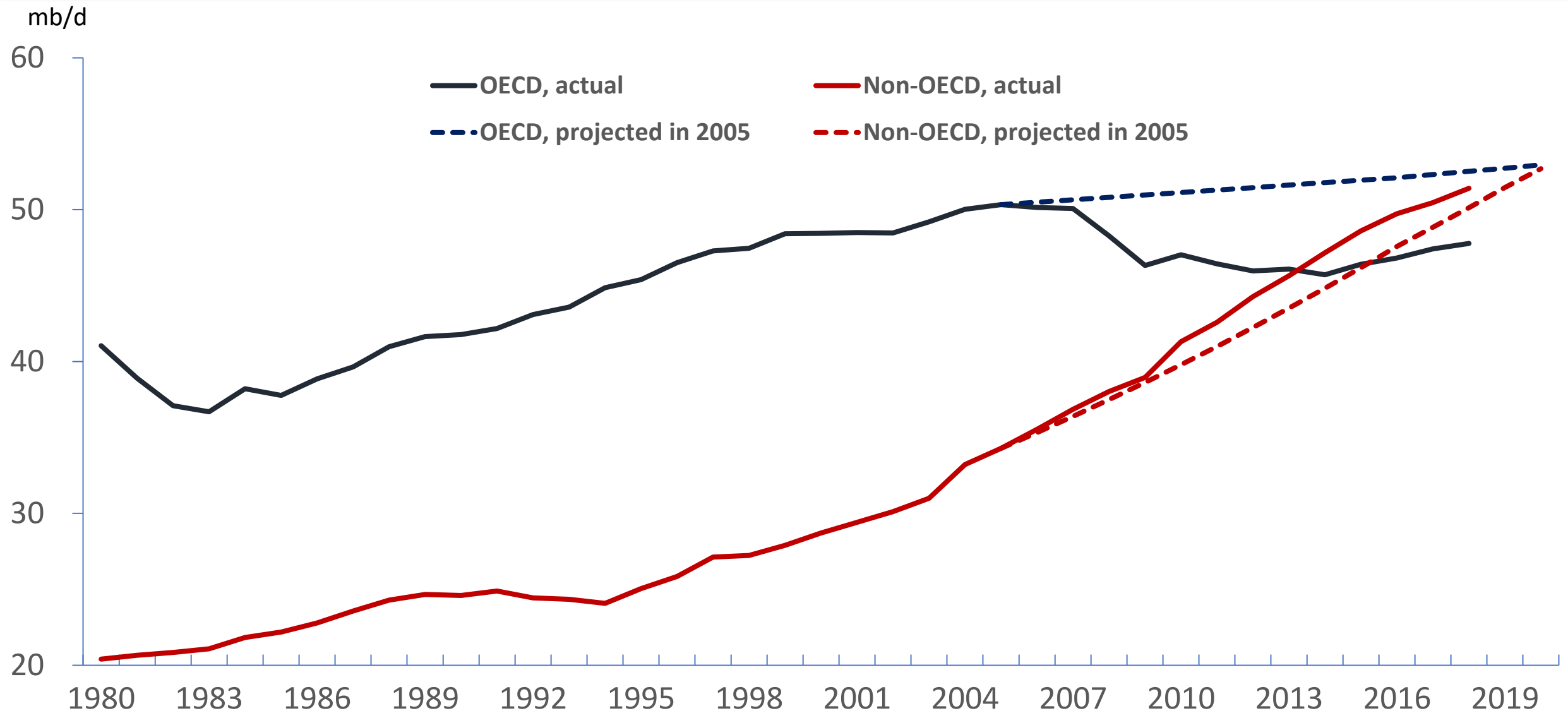


Energy



Source: BP Statistical Review and World Bank.

Oil consumption and prospects as envisaged in 2005

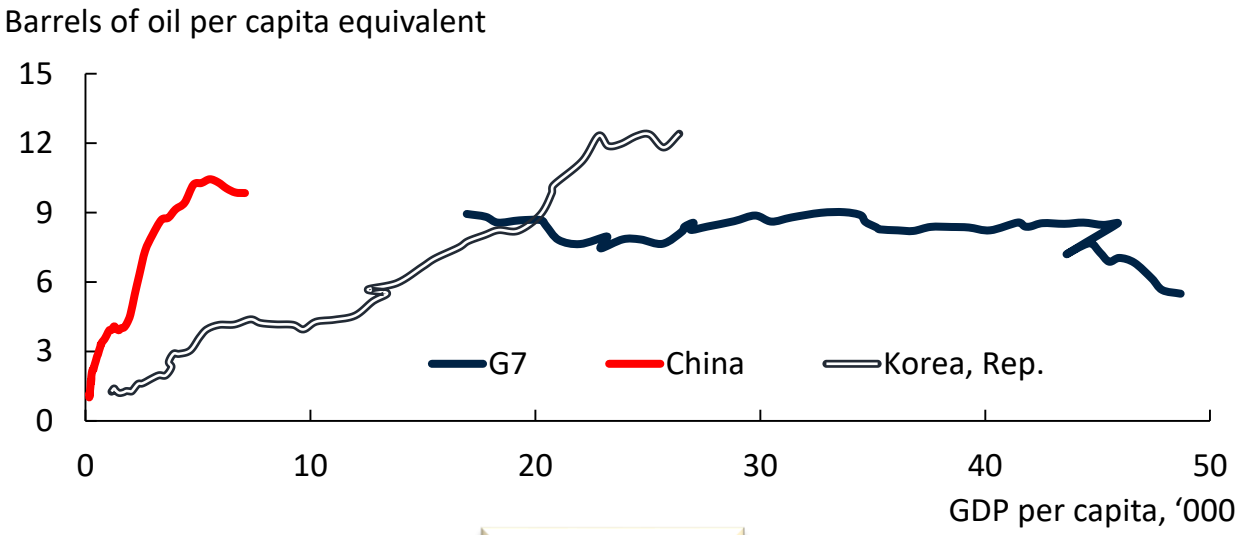


Source: International Energy Agency and World Bank.

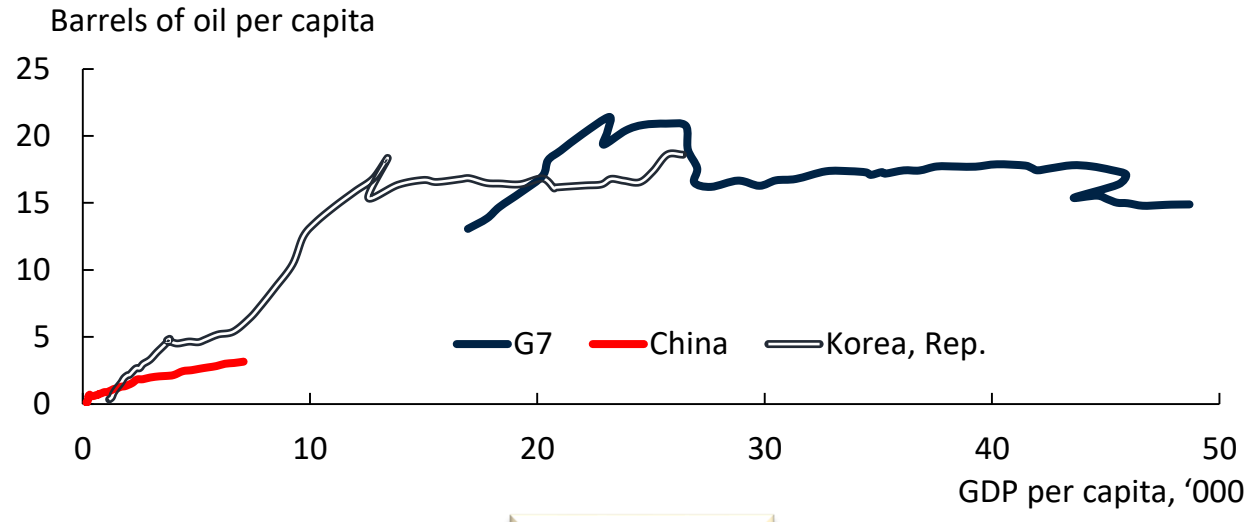
Note: The projection was taken from the 2005 IEA *World Energy Outlook*.

Energy: per capita consumption and income, 1965-2017

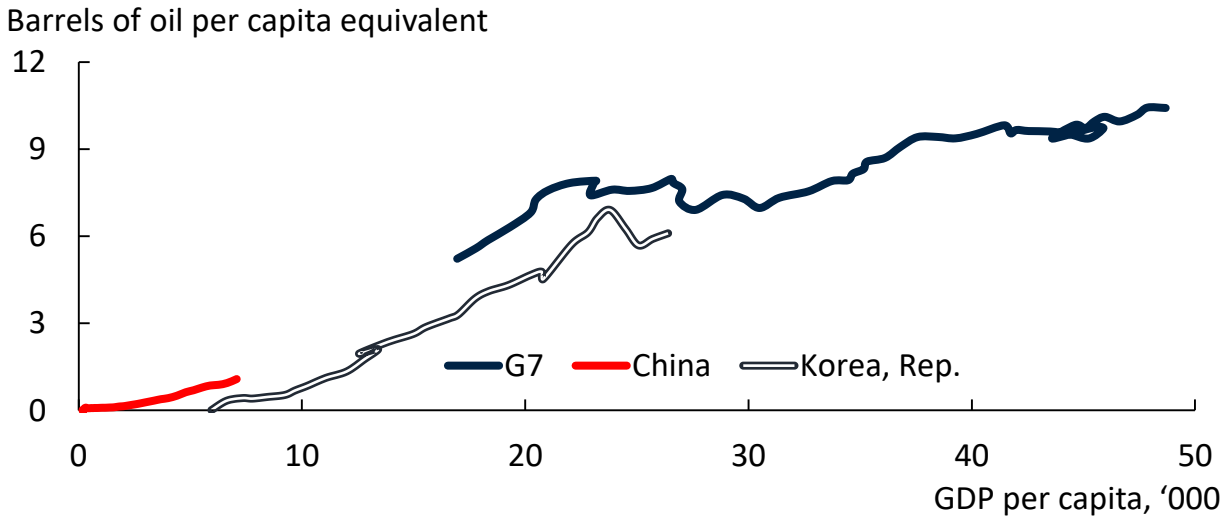
Coal



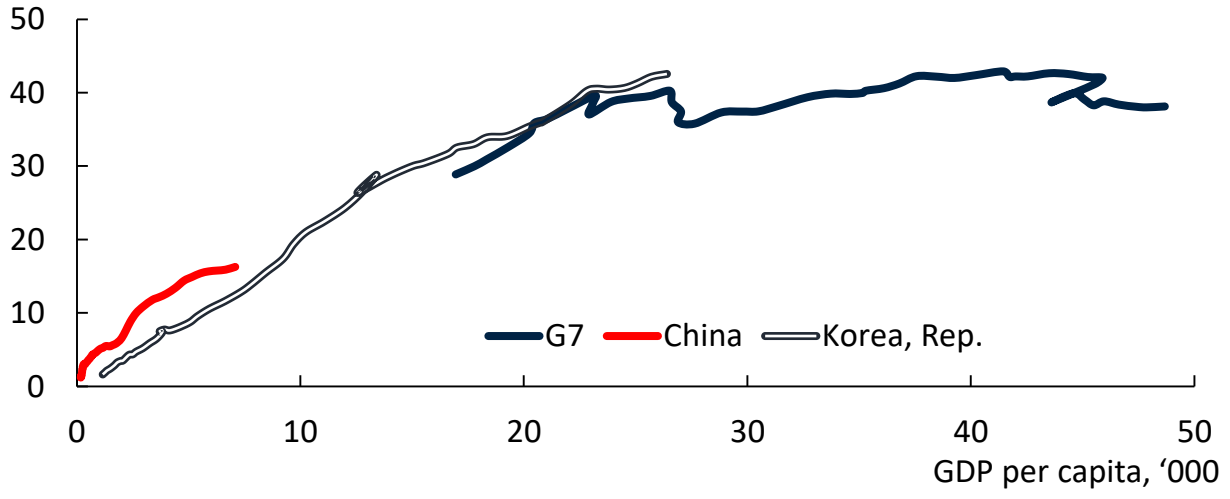
Oil



Natural gas



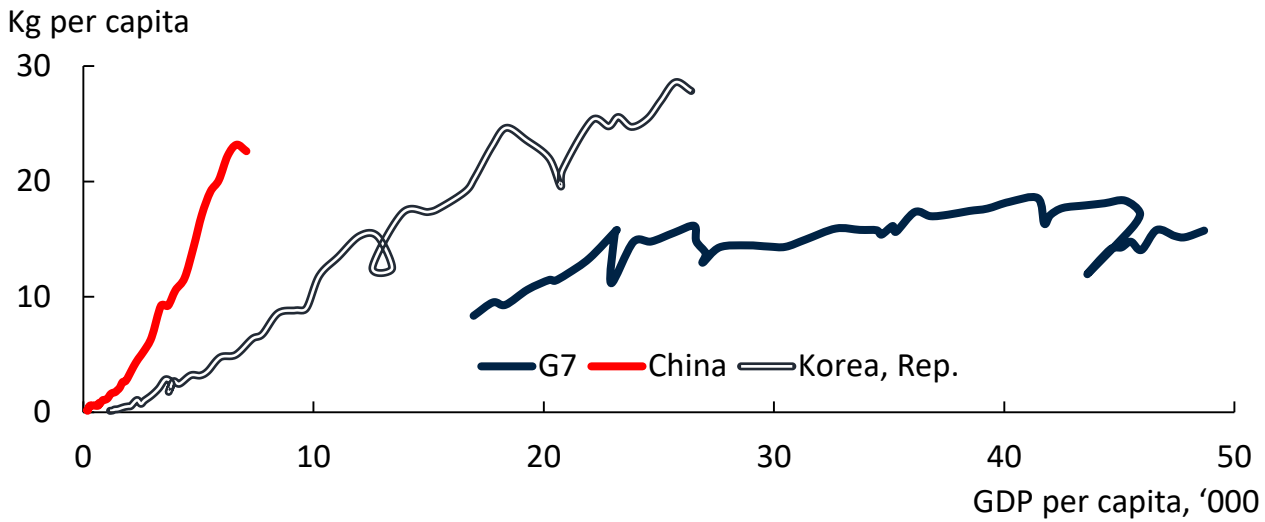
Energy



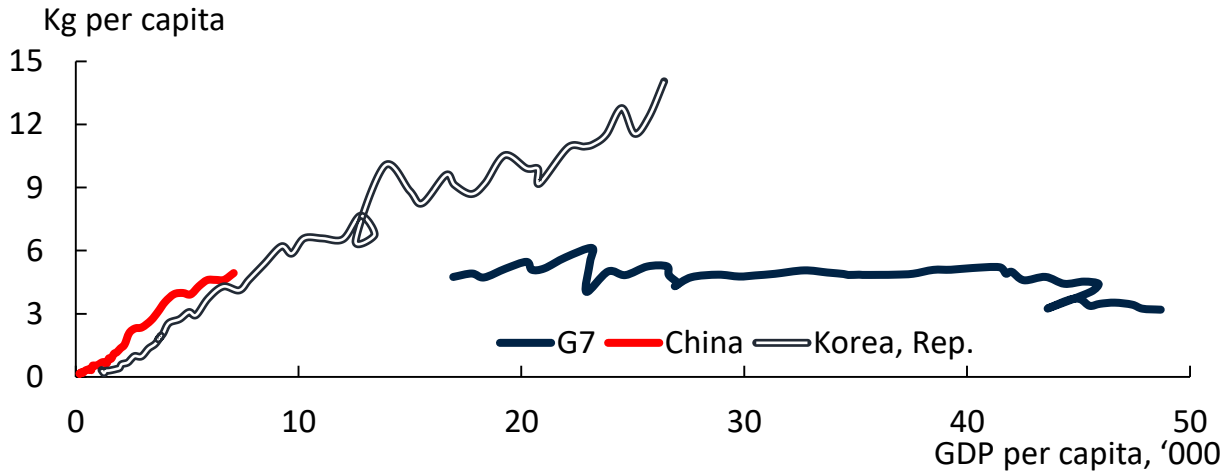
Source: BP Statistical Review, International Energy Agency, World Bank

Metals: per capita consumption and income, 1965-2017

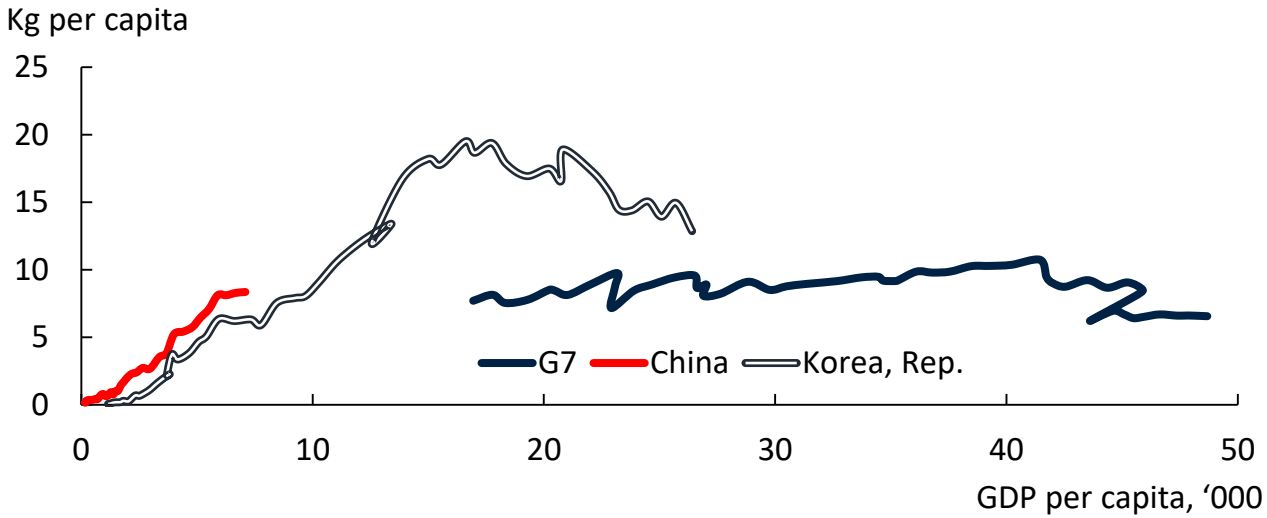
Aluminum



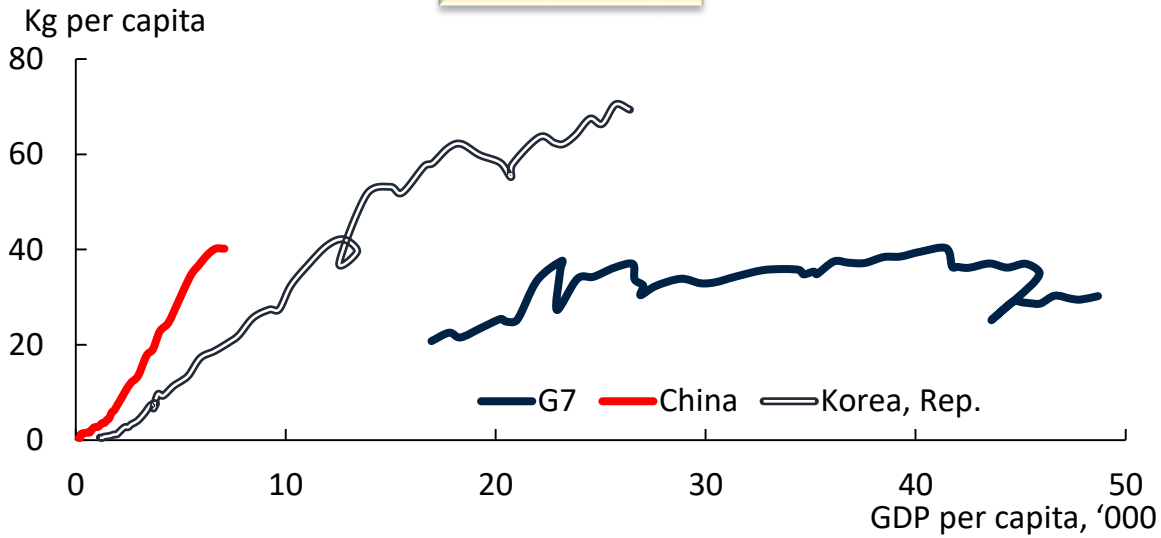
Zinc



Copper

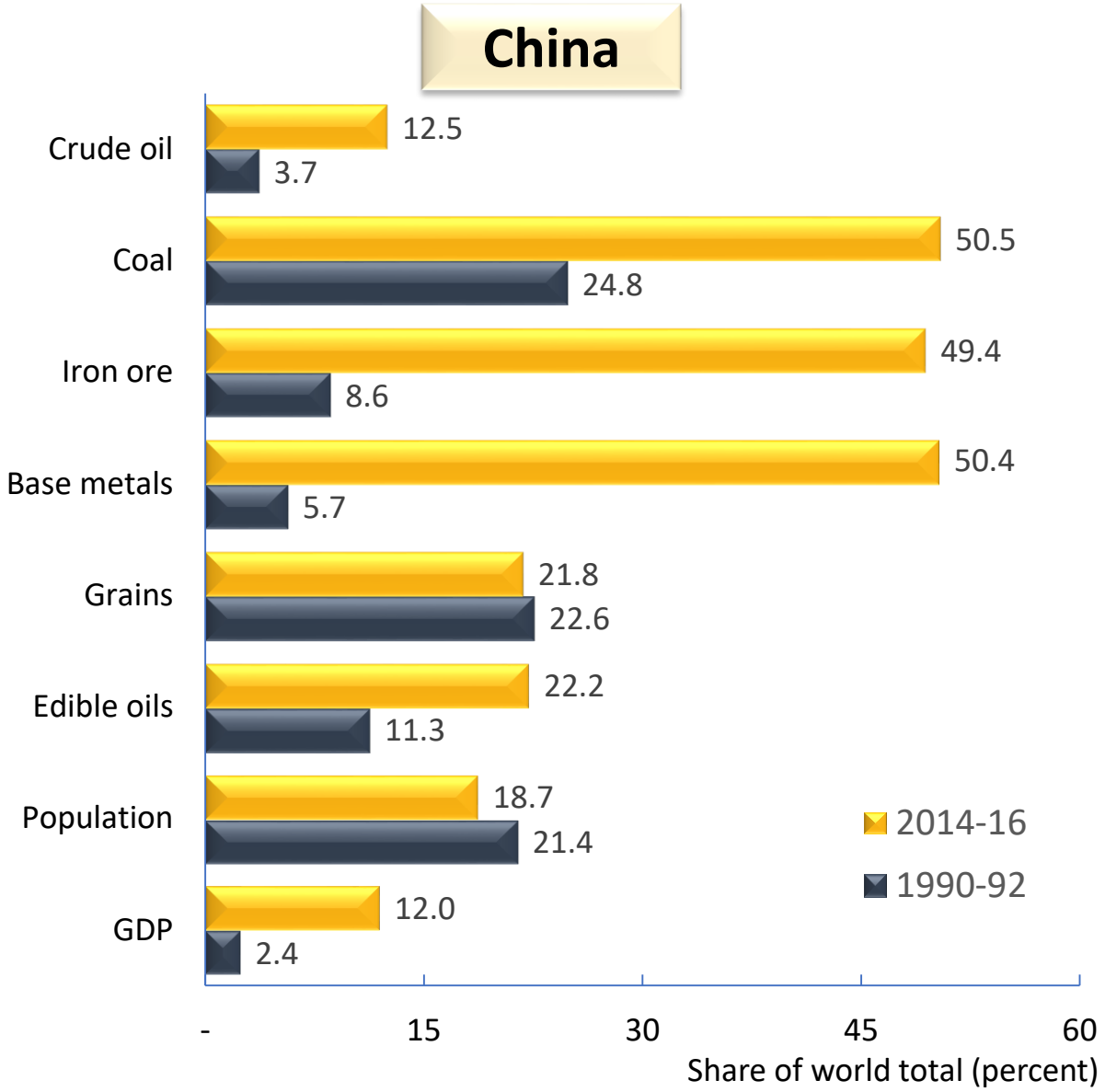


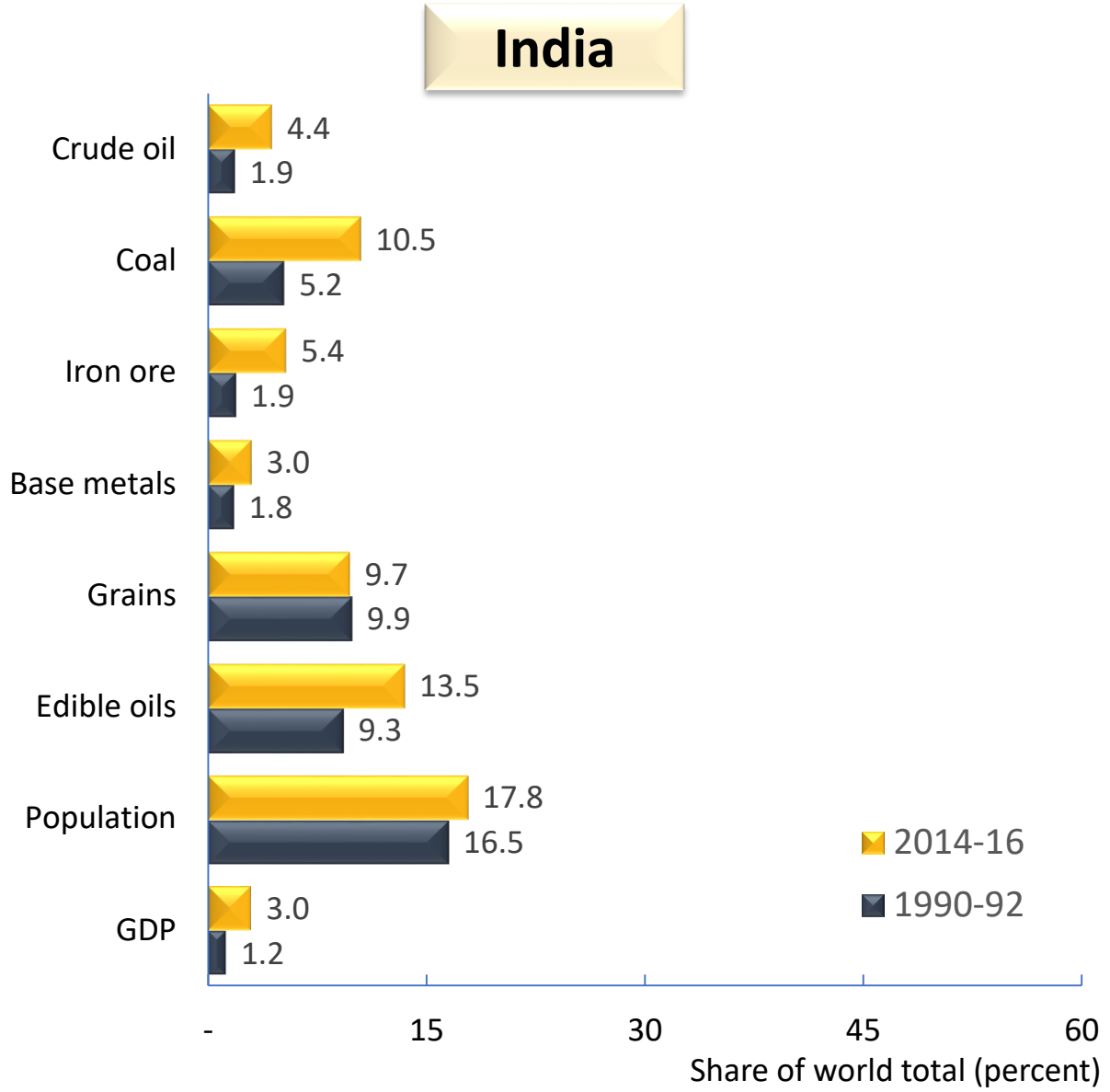
Base metals



Source: World Bank, World Bureau of Metal Statistics

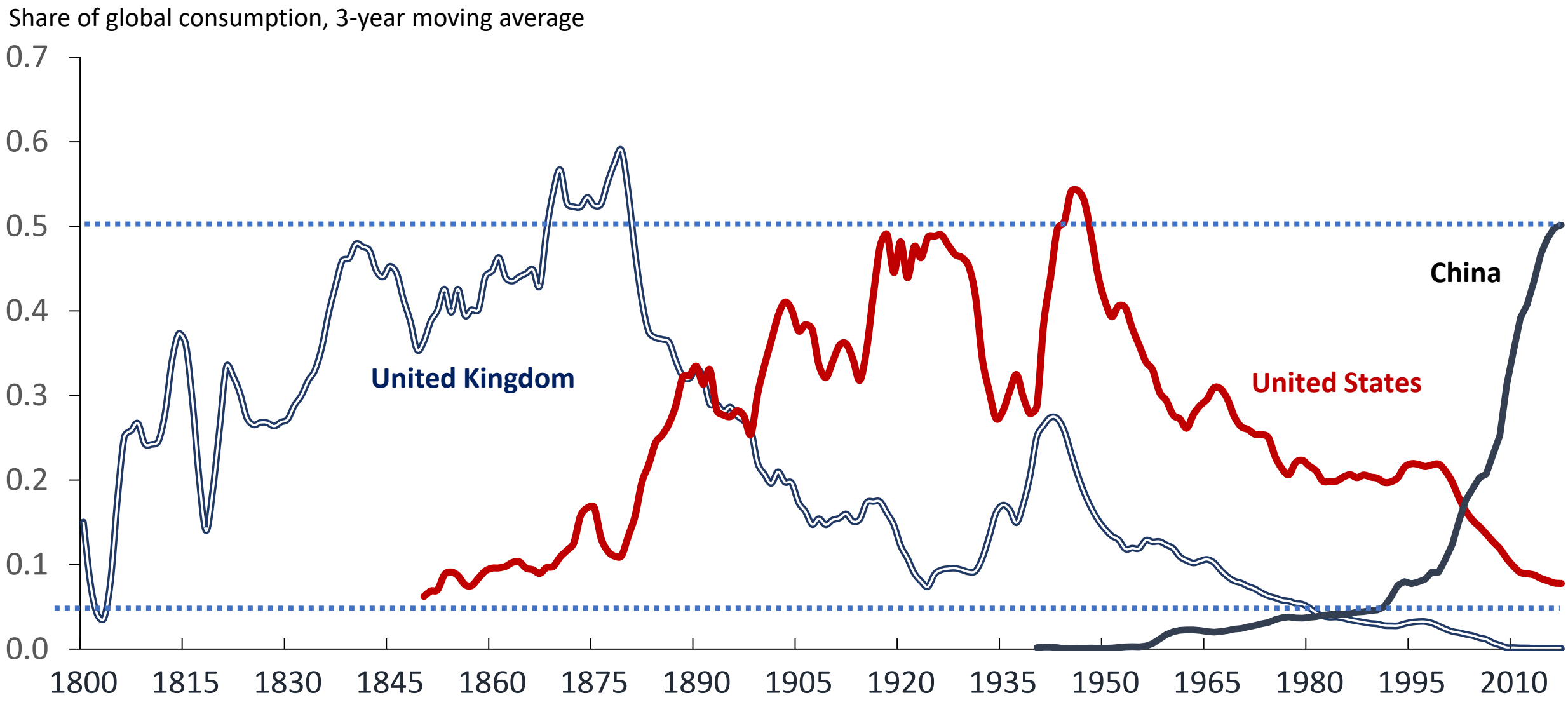
Commodity consumption: Shares of China and India





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

Two centuries of copper consumption



Source: Abstract of British Historical Statistics, Bureau of Mines Minerals Yearbook, Lemon (1838), Mineral Statistics of the British Empire and Foreign Countries, Statistical Summary of the Minerals Industry, Schmitz (1979), Stuermer (2017), Symons (2003), The Copper Handbook, World Bureau of Metal Statistics.
Notes: The data set for this figure was compiled by Wee Chain Koh.

Consumption of resources and transmaterialization

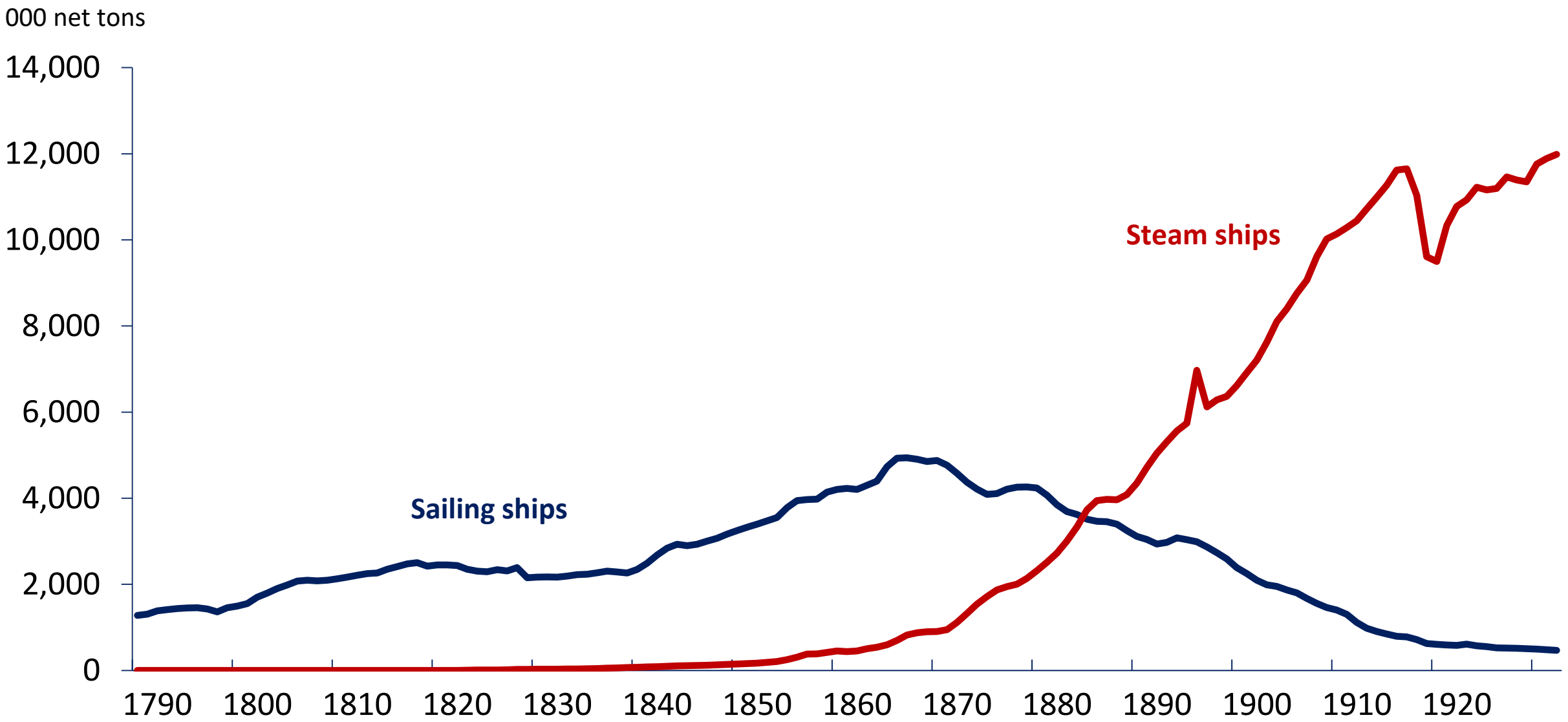
We do not consume resources per se but their inherent functions or their physical and chemical properties. We do not need one tonne of copper: we need its electrical conductivity for transmitting power supply or transferring messages via electric pulses in telephone wires. This latter function can be ensured via fiber cables, directional antennae or mobile phone. So, we have substitution in the narrow sense (glass fibre vs. copper) and functional substitution to obtain the same function. Every technical solution has its own raw-material profile.

Wellmer (2012, p.11)

Transmaterialization implies a recurring industrial transformation in the way that economic societies use materials, a process that has occurred regularly or cyclically throughout history. Instead of a once-and-for-all decline in the intensity of use of certain materials, transmaterialization suggests that materials demand instead experiences phases in which old, lower-quality materials linked to mature industries undergo replacement by higher-quality or technologically more advanced materials.

Labys (2002, p.202)

Transmaterialization: Shipping capacity in the U.K., 1790-1930



Source: British Historical Statistics (Mitchell, 2011)

Notes: Denotes ocean transport capacity of ships registered in the United Kingdom.

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A demand model

$$c_t = \mu + \theta_1 y_t + \theta_2 y_t^2 + \theta_3 p_t + \varphi' X_t + \varepsilon_t$$

$\boldsymbol{c_t}$: Per capita commodity consumption at year t
$\boldsymbol{y_t}$: Real per capita income
$\boldsymbol{y_t^2}$: Quadratic term capturing nonlinearities
$\boldsymbol{p_t}$: Real price of the commodity
$\boldsymbol{X_t}$: $h \times 1$ vector of control variables, such as fixed effects, cross-price impacts, and various country-specific characteristics
$\boldsymbol{\varepsilon_t}$: Stochastic error term
$\boldsymbol{\mu, \theta_1, \theta_2, \theta_3, \varphi'}$: Parameters and vector, all to be estimated.

Income varying elasticities

Differentiating the demand equation with respect to income gives the following:

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

η_t denotes the long-run income elasticity for the given commodity, which varies across time, thereby enabling us to see, as income rises, whether and when consumption of a commodity plateaus.

Data and estimation

- Annual data over the period 1965-2017.
- Up to 63 countries, including advanced and emerging economies.
- Three energy commodities: crude oil, natural gas and coal. Six base metals: aluminum, copper, lead, nickel, tin and zinc.
- Two "group" aggregates: energy and metals.
- Independent variables: Income, prices (own and cross), population, urbanization, population density, investment-to-GDP ratio.
- The model is estimated by a pool mean group (PMG) estimation procedure, which assumes homogeneity across all long-run estimators but allows for differences across countries in the short term.

Commodity-specific results

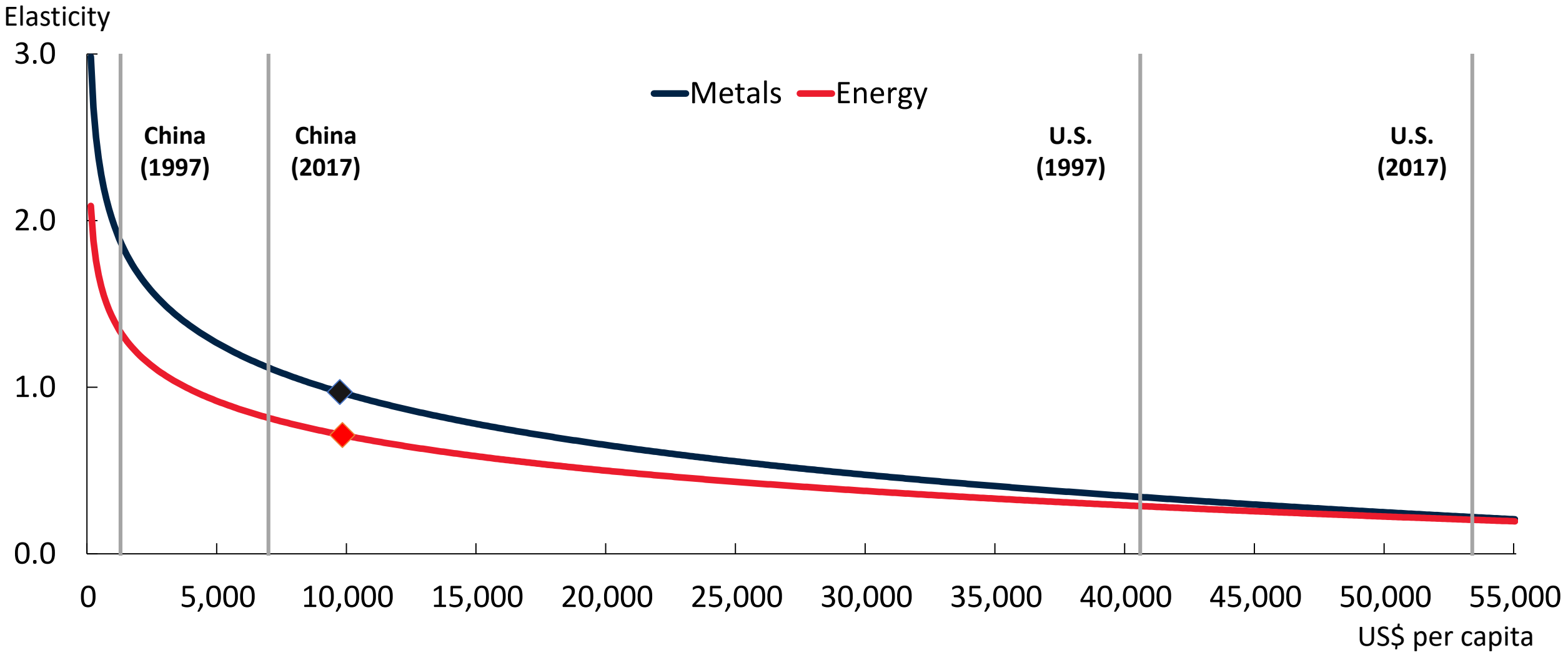
- **Commodity-specific equations**: Of the nine equations, only four (oil, aluminum, copper, and zinc) yielded parameter estimates for the two income and price variables that were both significantly different from zero at the 1 percent level as well as consistent with a priori expectations, which were calculated at the median income of our sample differ considerably among the four commodities, from a low of 0.3 for zinc to a high of 0.8 for aluminum. Indeed, the estimates exhibited a high degree of heterogeneity across commodities.
- **Cross-price effects**: The performance of most commodity-specific demand equations improves when cross-price effects are taken into consideration. Three results emerge from the cross-price analysis:
  - There is a high degree of substitutability for several commodity pairs, including oil–coal, aluminum–copper, and aluminum–tin. These commodities are also the most important ones in terms of volume of consumption.
  - There is complementarity between a few of the metals, consistent with patterns of use for some metals, such as in alloys.
  - In several cases, especially coal and tin, the results of the model improve considerably when cross-prices are included.

Group-aggregate parameter estimates

	Energy			Metals		
y_t	3.47***	3.83***	3.96***	5.01***	4.78***	2.45***
y_t^2	-0.15***	-0.17***	-0.16***	-0.22***	-0.22***	-0.09***
p_t	-0.17***	-0.15***	-0.10***	-0.26***	-0.25***	-0.12***
Urbanization	—	0.32***	—	—	0.39***	—
Pop. density	—	—	-0.28***	—	—	-0.24***
ρ	-0.08***	-0.11***	-0.12***	-0.19***	-0.21***	-0.29***

Notes: The dependent variable is the logarithm of aggregate energy consumption. Three (***), two (**), and one (*) asterisks denote significance of parameter estimates at 1, 5, and 10 percent level, respectively. "—" indicates that the corresponding variable was not included in the model.

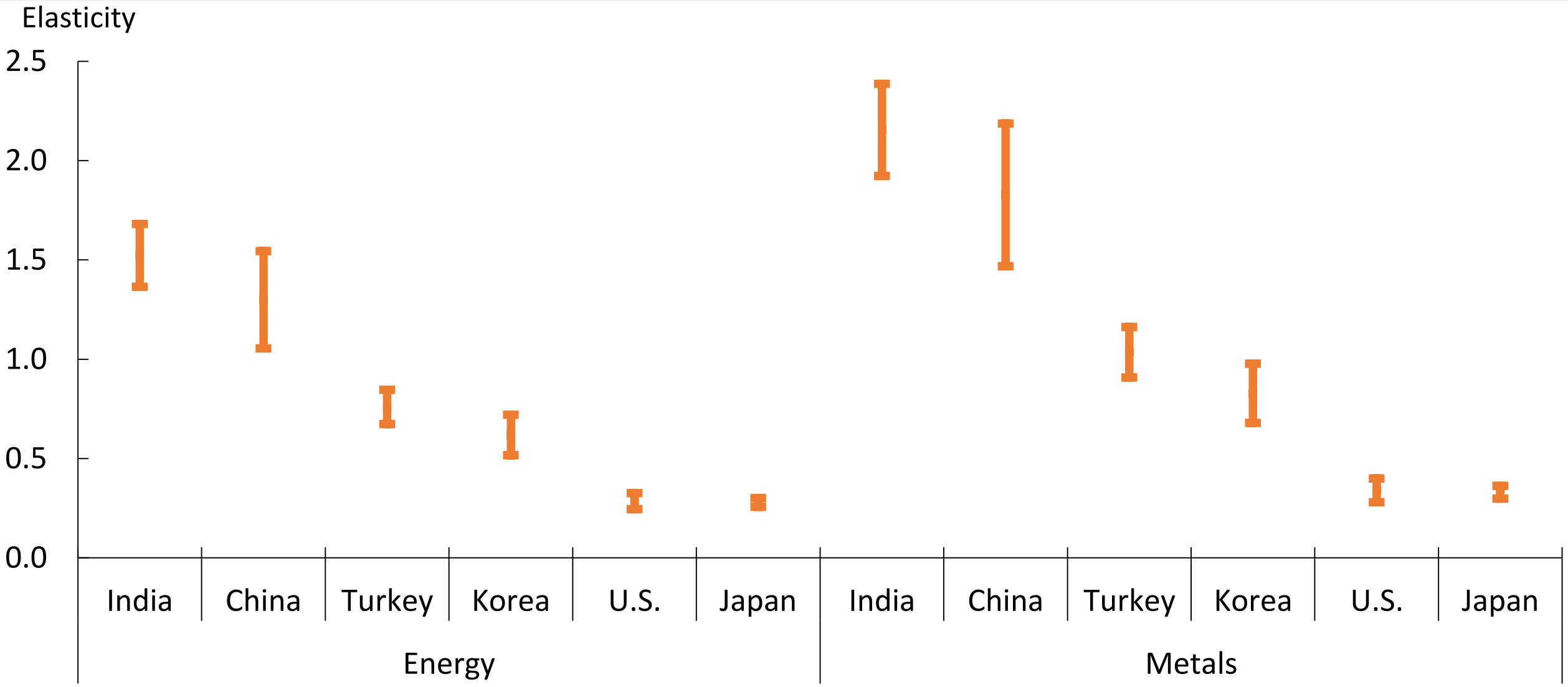
Elasticity estimates at various income levels



Source: Authors' calculations based on model's parameter estimates.

Notes: The vertical lines denote the level of per capita income of the respective countries and years. Diamonds mark elasticities at $ 9,900 per capita income (sample median).

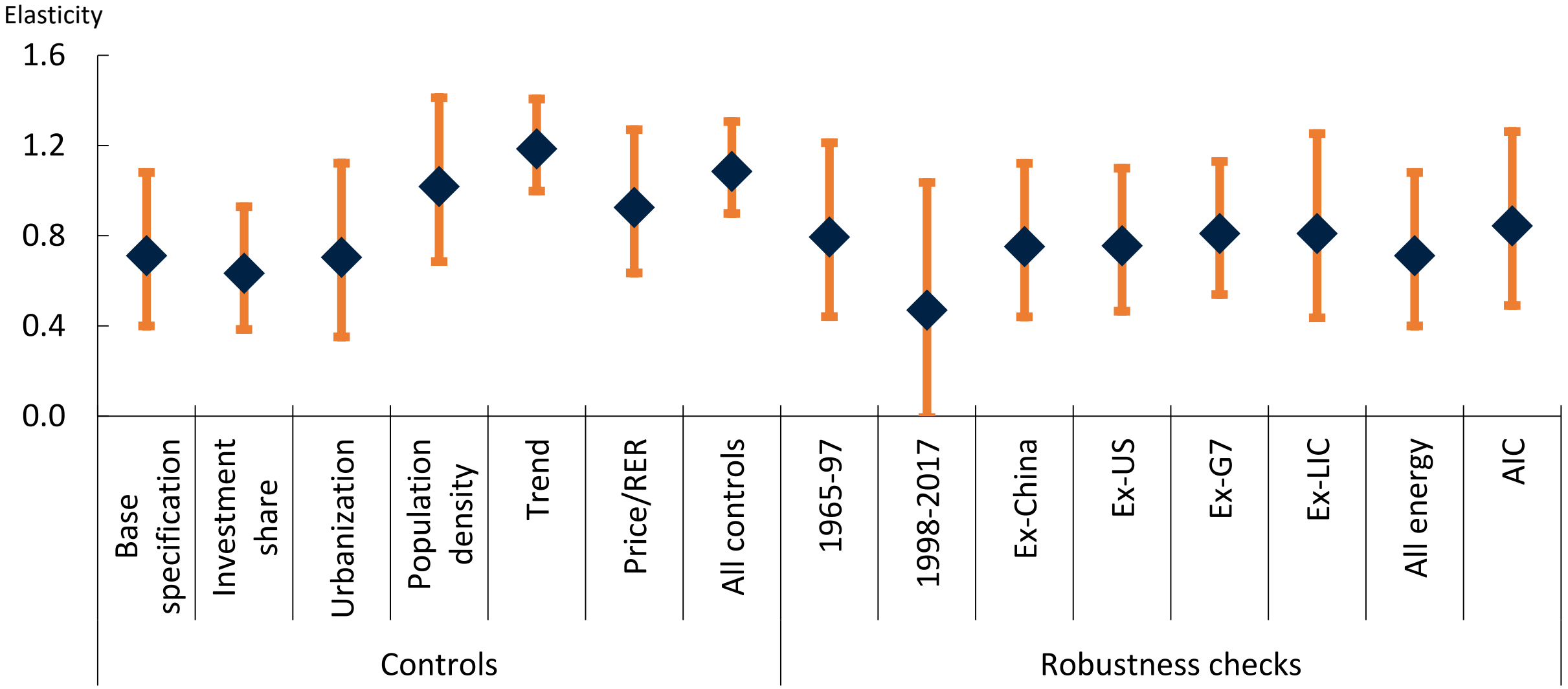
Elasticities for various countries



Source: Authors' calculations based on model's parameter estimates.

Notes: The upper and lower ends of the bars denote elasticity estimates for 1997 and 2017, respectively.

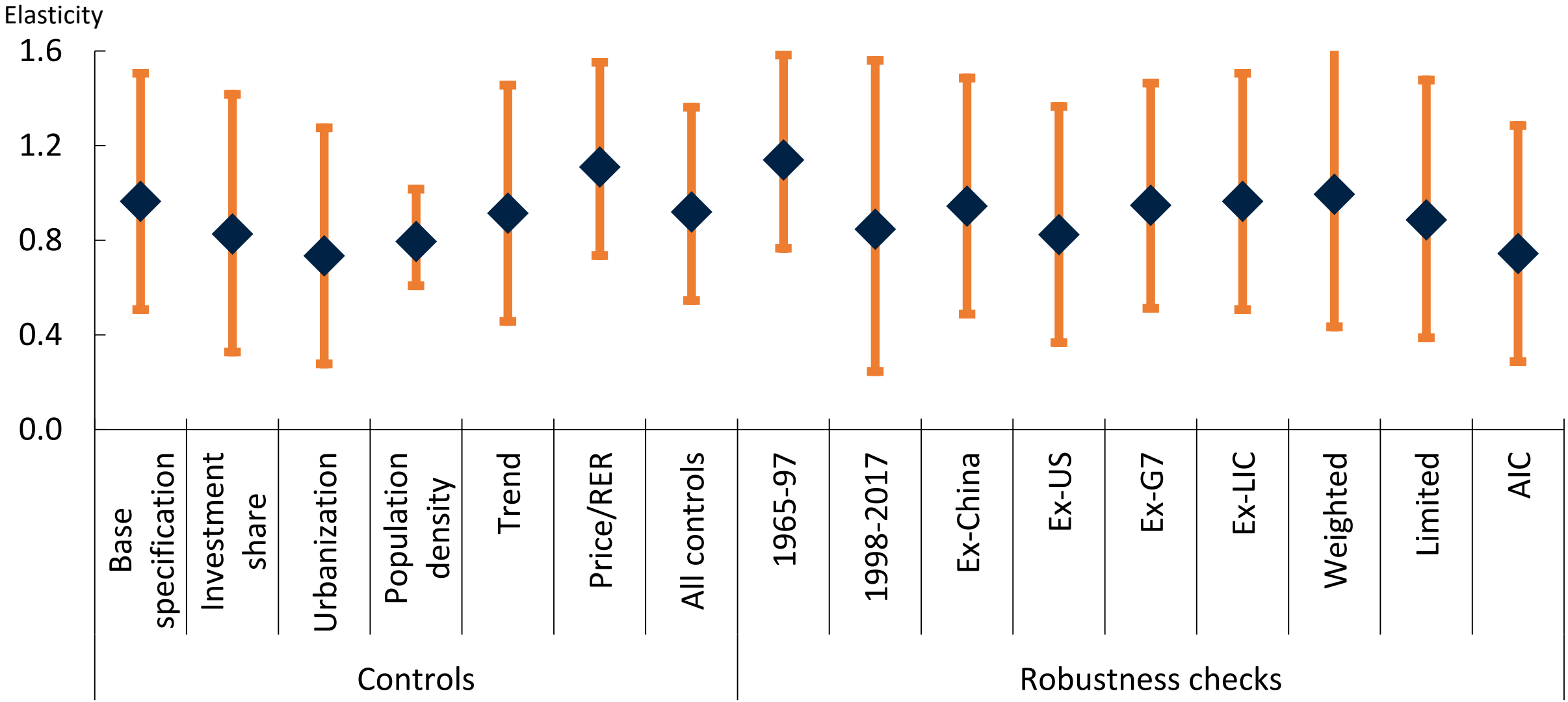
Controls and robustness checks for energy



Source: Authors' calculations based on model's parameter estimates.

Notes: Diamonds denote elasticities at $ 9,900 per capita income (sample median). The lower and upper ends denote elasticities at $ 28,000 and $ 9,900 per capita income, respectively. Definitions of Controls and Robustness checks can be found in Table C1 (Appendix C).

Controls and robustness checks for metals



Source: Authors' calculations based on model's parameter estimates.

Notes: Diamonds denote elasticities at $ 9,900 per capita income (sample median). The lower and upper ends denote elasticities at $ 28,000 and $ 9,900 per capita income, respectively. Definitions of Controls and Robustness checks can be found in Table C2 (Appendix C).

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Summary

- Individual demand equations gave highly heterogenous results across commodities.
- The inclusion of cross-price effects confirmed substitutability and (in some metals) complementarity.
- At median income levels of the sample (~ $ 10,000), income elasticity estimates based on group aggregates for both energy and metals are close to unity. At high income levels the elasticity is around 0.2 for both aggregates.
- Given that emerging market and developing economies grow three times as fast as advanced economies and they account for more than 80 percent of world's population (and almost all population growth), these economies will be the key drivers of industrial commodity demand growth for years to come.
- Because of substitution, especially in the long term, any price increases are likely to be temporary. Indeed, the commodity price increases during the first decade of the millennium turned out to be the expansion phase of the price cycle rather than a permanent price increase.

A final thought

- ***During the 20th century we learned how to produce commodities at a mass scale***
- ***During the 21st century we must learn how to produce and consume them in a sustainable manner***

The presentation draws from earlier and ongoing material

World Bank. 2015. *Commodity Markets Outlook: How Important Are China and India in Commodity Demand?* World Bank, Washington, DC.

World Bank. 2018. *Global Economic Prospects: The Turning of the Tide?* World Bank, Washington, DC.

World Bank. 2018. *Commodity Markets Outlook: The Changing of the Guard—Shifts in Commodity Demand*. World Bank, Washington, DC.

World Bank. 2019. *Commodity Markets Outlook: The Role of Substitution in Commodity Demand*. World Bank, Washington, DC.

Baffes, J., A. Kabundi, P. Nagle, and F. Ohnsorge. 2018. "The Role of Major Emerging Economies in Commodity Demand." Policy Research Working Paper 8495. World Bank, Washington, DC.

Baffes, J., A. Kabundi, and P. Nagle, 2020. "The Role of Income and Substitution in Commodity Demand." Policy Research Working Paper 9122. World Bank, Washington, DC.

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March 3, 2020 — All commodity groupings except fertilizers and precious metals fell in February. Energy commodity prices registered the steepest declines, tumbling 12.7%. Non-energy commodities fell 3.7%. Base metals dropped 5.6% while precious metals rose 1.8%. Read More »

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"Pink Sheet" Data	Commodity Markets Outlook	Special Topics
Commodity prices March 2020 (PDF)	Commodity Markets Outlook October 2019 (PDF)	The role of substitution in commodity demand October 2019
Monthly prices March 2020 (XLS)	Executive summary October 2019 (PDF)	Food price shocks: channels and implications April 2019
Annual prices March 2020 (XLS)	Price forecasts October 2019 (PDF)	The implications of tariffs for commodity markets October 2018
	Chart data October 2019 (ZIP)	Shifts in commodity demand over the past 20 years October 2018

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RELEASE SCHEDULE

Pink sheets are released on the second business day of the month. Next release: April 2, 2020.

The next Commodity Markets Outlook will be published in April 2020.

NEWS

News release, English (10/29/19):
Commodity prices revised down as global growth weakens and supplies remain ample

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Pink Sheet
Energy prices retreated while non-energy prices advanced in January—Pink Sheet (2/7/2020)

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Energy prices retreated while non-energy prices advanced in January—Pink Sheet

JOHN BAFFES & MARIA HAZEL MACADANGDANG | FEBRUARY 07, 2020

This page in: English

Energy commodity prices declined more than 3% in January, led by natural gas in Europe (-21%) and the U.S. (-9.5%) the World Bank Pink Sheet reported. Crude oil fell as well (-2.7%).

Non-energy prices increased more than 1%, led by agricultural commodities.

Agricultural prices rose 1.6% as gains in food (+2.6%) were partly balanced by declines in beverages (-1.8%).

Fertilizer fell 2.4% in response to large losses in potassium (-7.7%).

Metals prices were little changed (+0.3%), as gains in zinc (+3.6%) and iron ore (+3.4%) were balanced by declines in nickel (-2.3%).

Precious metals prices surged (+5.4%), on similarly large gains in all three components (gold, platinum, and silver).

The Pink Sheet is a monthly report that monitors commodity price movements.