Box 2 **Global reserves, demand growth, and the "super cycle" hypothesis**

In 1990, the world consumed less than 43 million tons of metals. By 2012, this had increased to 91 million tons. All of the growth was driven by China—in 1990, China accounted for a mere 4 percent of global consumption; today it accounts for almost 45 percent. In 1990, the world consumed 66 million barrels of oil per day (mb/d), 37 percent of which was consumed by OECD economies. In 2012, it exceeded 90 mb/d, half of which is consumed by non-OECD economies. Despite these strong consumption growth patterns, the assumed resource depletion that has occupied headlines often is less of an issue now than it used to be. Nevertheless, problems exist, including environmental concerns, concentration of resources, and the high cost of extracting such resources.

Metal consumption by China during the past decade has been so strong that it reversed the downward trend of global metal intensity (that is, metal consumption per unit of GDP), a turnaround that continues today. Thus, metal intensity now is the same as it was the early 1970s—on the contrary, food and energy intensities have continued their long term downward trend. On the other hand, despite the strong demand growth of oil by non-OECD economies, they still consume 2.6 barrels per year on a per capita basis, as opposed to 13.7 by OECD economies.

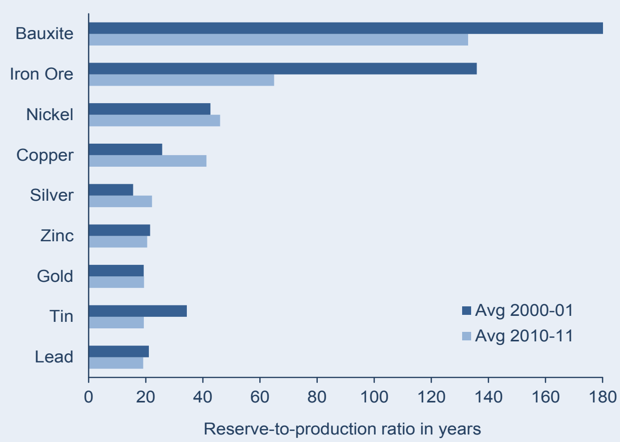
The strong growth in consumption of industrial commodities by emerging countries, along with the likelihood that these countries will experience sustained high growth rates, inevitably raises the issue of resource depletion. The issue of non-adequacy of resources to sustain projected population and income growth rates has been debated frequently, especially in periods of high prices. Examples include the peak oil hypothesis for crude oil reserves and the Club of Rome arguments regarding food supplies (Meadows and others 1972).

Based on U.S. Geological Survey data, box figure 2.1 reports global reserves for two ores (bauxite and iron ore), five base metals (nickel, copper, zinc, lead, and tin), and two precious metals (gold and silver). The reserves are expressed in terms of years of current production (the so-called reserves-to-production ratio, R/P), evaluated at two 2-year periods (2000-01 and 2010-11) spanning the recent price and consumption boom. (According to the U.S. Geological Survey, reserves refer to the part of the reserve base which could be economically extracted or produced at the time of determination but do not imply that extraction facilities are in place and operative).

Numerous stylized facts emerge from the analysis. First, the R/P ratios for various metals paint a mixed picture regarding resource scarcity. Specifically, the ratio increased in three of the nine cases: nickel (from 43 to 46 years), copper (from 26 to 41), and silver (from 16 to 22). It did not experience any appreciable change for gold and zinc but declined marginally for lead (from 21 to 19 years). Yet, three metals exhibited significant declines: Tin (from 34 to 19 years), iron ore (from 136 to 65 years), and bauxite (from 180 to 133). Second, the declines in the R/P ratios reflect increased production, not declining reserves. In fact, with the single exception of tin (for which reserves declined nearly 40 percent during the 10-year period under consideration) and gold (for which reserves increased only 4 percent), reserves increased between 16 percent (bauxite) and 94 percent (copper). Third, the two largest declines in the R/P ratio—iron ore, down by 71 years, and bauxite, down by 47 years—took place in markets where the respective metals are relatively abundant, hence less of a need to invest in exploration and development activities. Thus, of the nine metals examined here, tin appears to be the only reserve-constrained commodity.

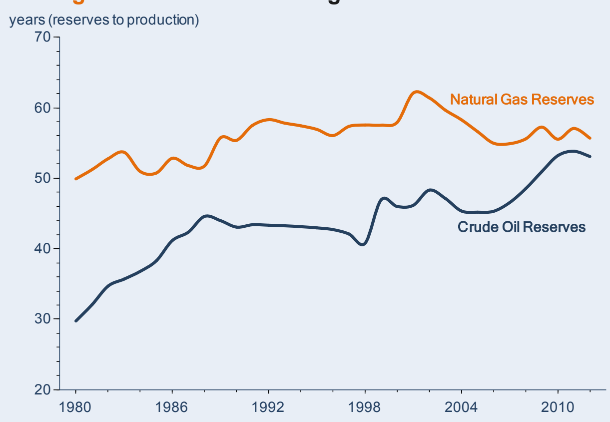
What about energy? Box figure 2.2 depicts R/P ratios for natural gas and crude oil between 1980 and 2011. In both markets the ratios have been increasing, a significant 3.0 percent per annum for crude oil and a marginal 0.3 percent for natural gas. In fact, the R/P ratio for crude oil exceeded 54 years in 2011 for the first time. (According to BP, "[reserves] are generally taken to be those quantities that geological and engineering information indicates with reasonable certainty can be recovered in the future from

Box figure 2.1 **Global metal reserves**



Source: U.S. Geological Survey.

Box figure 2.2 **Global oil and gas reserves**



Source: BP Statistical Review.

known reservoirs under existing economic and operating conditions.")

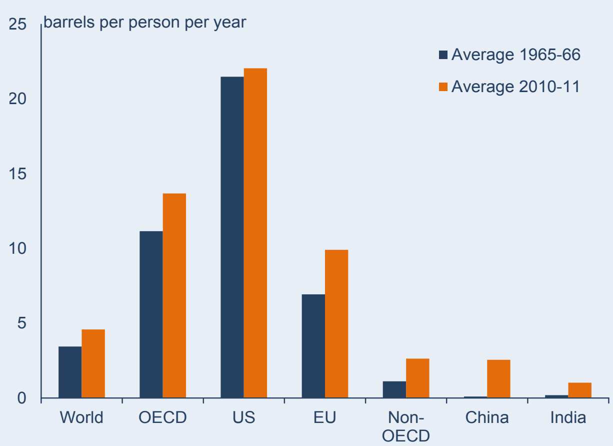
The increase in global crude oil reserves during the 1980s is due to additions by OPEC members. The 1999 uptick reflects the addition of 120 billion barrels from Canada's oil sands (equivalent to four years of current global consumption), while the increase in the mid-2000s was due to Venezuela's Orinoco Belt oil, currently estimated at 220 billion barrels (seven years of global consumption). The R/P ratios for both crude oil and natural gas are likely to increase substantially when the unconventional reserves are added in the economically recoverable resource pool. Indeed, industry experts have noted that when all global recoverable reserves are considered, the world may have as much as two centuries' worth of natural gas, evaluated at current consumption rates, prices, and technology.

While adequacy of reserves per se does not seem to be a problem, at least in the foreseeable future, there are several issues of concern, including environmental problems, concentration of ownership, further demand strengthening, and increasing extractions costs. First, by their very nature, extraction of these resources may be associated with environmental issues, such as contamination of ground water resources or concerns that excessive fracking may be linked to increasing frequency of earthquake activity.

Second, reserves are becoming concentrated. For example, currently OPEC accounts for more than 72 percent of oil reserves, nearly half of which are located in Saudi Arabia and Venezuela. Natural gas reserves are concentrated as well, with the Russian Federation and Turkmenistan accounting for more than one-third and Iran and Qatar accounting for nearly 28 percent. (The Herfindahl concentration indexes for crude oil and natural gas reserves were 9.8 and 10.7 percent, respectively, in 2011.)

Third, extracting natural resources is becoming increasingly costly. The marginal cost of oil production, for example, is currently estimated at $80/bbl for Canadian oil sands (this cost forms the basis for the World Bank's long-term oil price assumptions).

Box figure 2.3 Per capita oil consumption



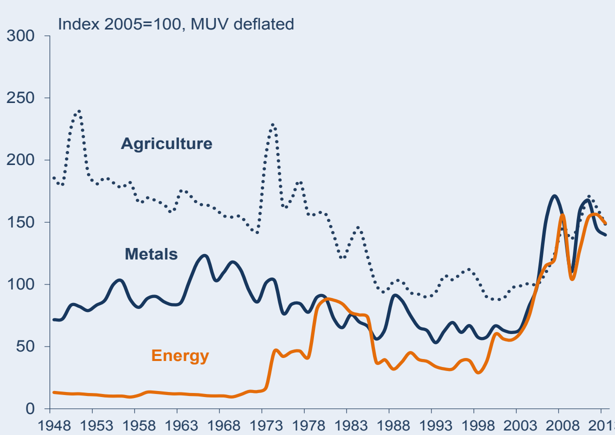
Source: BP Statistical Review; UN; OECD; Eurostat.

Finally, a key issue on resource adequacy and prices will be the strength of demand. Future fluctuations in metal markets will depend heavily on the metal intensity of the Chinese economy. Oil consumption will depend on demand by emerging economies and whether their energy intensities emulate that of high-income countries. Consider, for example, that in per capita terms, OECD countries consume five times more crude oil than non-OECD countries—or, more strikingly, that the United States consumes 23 times as much oil as India (box figure 2.3).

Many observers (see, for example, Heap 2005) have argued that, because of the extremely robust demand for metals and rapidly rising metals intensity of the Chinese economy, along with strong oil demand by emerging economies, these commodities go through a super cycle where prices are likely to stay high for an extended period of time. The so-called "super cycle hypothesis" has been empirically verified for a number of metals (Jerrett and Cuddington 2008). Super-cycles of this nature, have taken place in the past rather infrequently (for example, during the industrial revolution in the United Kingdom, and the westward expansion of the late 1800s/early 1900s in the United States). Erten and Ocampo (2012) identified four such super cycles in real prices of agriculture, metals, and crude oil during 1865-2009; the length of the cycles ranged between 30-40 years with amplitudes 20-40 percent higher or lower than the long-run trend (similar estimates have been given by Cuddington and Zellou (2013) for metals.) Furthermore, the mean of each super cycle was lower than for the previous cycle, thus supporting the view that nominal prices of primary commodities grow at a slower rate than nominal prices of manufacturing commodities (the Prebisch-Singer hypothesis).

Indeed, energy and metal prices (expressed as ratio to manufacturing prices) experienced the largest and longest boom since (box figure 2.4). Though most of the conditions behind the post-2004 price boom are still in place, there are signs that conditions may be easing. The 2008 and 2011 commodity price peaks may have marked the beginning of the end of the current super cycle. In that case, the current super cycle will be much shorter than previous ones. But, it is too early to tell.

Box figure 2.4 Commodity prices, MUV-deflated



Source: World Bank.