Chapter 2. An evolving economic context and new environmental challenges

The last decades have witnessed unprecedented growth in demands for raw materials worldwide, driven in particular by the rapid industrialisation of emerging economies and continued high levels of material consumption in developed countries. At the same time, international commodity markets have expanded, with increasing international trade flows, and increasing mobility and fragmentation of production. This has been accompanied by increases in, and volatility of, commodity prices, and by growing competition for selected raw materials.

These developments have implications for the ways in which natural resources are supplied to and used in the economy. Hence, natural resource consumption and the economic efficiency of materials use have become important issues, and the nature of the environmental challenges with which governments are confronted has changed.

RISING DEMAND FOR NATURAL RESOURCES AND COMMODITIES

Demand for material resources has accelerated over the last decade

The last century has witnessed strong growth in the use of natural resources worldwide. Growth in demand has been virtually continuous with only a few instances of stagnation coinciding with periods of global economic downturn – the economic crisis of the 1930s, two World Wars, the oil price shocks of the 1970s – revealing the strong link between resource use and economic development. In the last 10 to 20 years there has been a marked acceleration in the demand, spurred by the rapid industrialisation in the large emerging economies.

Metals

The production of **major industrial metals** has risen particularly rapidly over the past 30 years, although with important differences between different metals. Between 1980 and 2010 the production of aluminium rose by 170%, copper production by 125% and the production of steel, zinc and nickel by around 100%. With the exception of copper, all of these metals saw the strongest growth in production in the last decade. Conversely, the production of lead and tin grew more modestly.

Fossil energy carriers

The production of **coal and natural gas** has doubled since 1980. Natural gas production has been trending steadily upward since the 1970s. Coal production grew steadily until the 1990s then remained flat until the beginning of the 2000s when it began to expand at an accelerated rate. Although concerns over coal's high carbon content and CO_2 emissions have lead to declining consumption in some developed countries, coal's abundance and low costs make it a fuel of choice in other countries particularly in light of the increasing price of oil.

Compared to coal and natural gas, the production of **crude oil** and NGL has grown relatively modestly; global production increased by 35% between 1980 and 2012. Energy consumption varies significantly around the world. A person living in an OECD country consumes on average more than 3.4 tonnes of oil equivalent (toe) per year compared to less than 0.9 toe per person in low-income regions (Africa and parts of Asia and Latin America) (OECD, 2011d).

Wood

Global harvesting of **wood** decreased in the 1990s, but has since returned to previous levels – 3.4 million cubic metres per year globally (FAO, 2010b).[1] Over two-thirds of wood harvesting takes place in OECD countries. However, most of the loss of forest continues to occur in countries and areas in the tropical regions.

Food

Food production has also been growing, expanding at a rate faster than the world's population. Global **fish** production reached 156 million tonnes in 2011 (FAO, 2012a). Capture fisheries continue to provide the largest share of fish supply (94.5 million tonnes in 2011), but most of the growth in global fish production has come from fish farming, which increased at an annual rate of 7.4% between 1990 and 2011 (compared to 0.5% for capture fisheries). Over the last decade the production of **cereals and meat** expanded by over 2% per year while the global population

increased by 1.3% annual. Since 1980 meat production has more than doubled while cereal production has risen by 64%.

A CHANGING GEOGRAPHY OF DEMAND AND SUPPLY

Material resources represent an important and growing share of international trade

The globalisation of resource consumption has increased with the expansion of international trade over the last century. Important improvements in transportation technology, which dramatically reduced the costs of shipping, and the liberalisation of natural resource markets contributed to a massive expansion in the volume and range of raw materials traded internationally.

Today almost every commodity is being traded internationally, allowing countries with limited natural stocks to benefit from the use of these materials. The proximity of natural resource supplies is not as important today as it was a century ago, freeing up industries to establish themselves in the most cost-efficient locations (e.g. aluminium refineries in Iceland and the Middle East) and accelerating the trend towards international specialisation (i.e. as resource suppliers or demanders) (WTO, 2010).

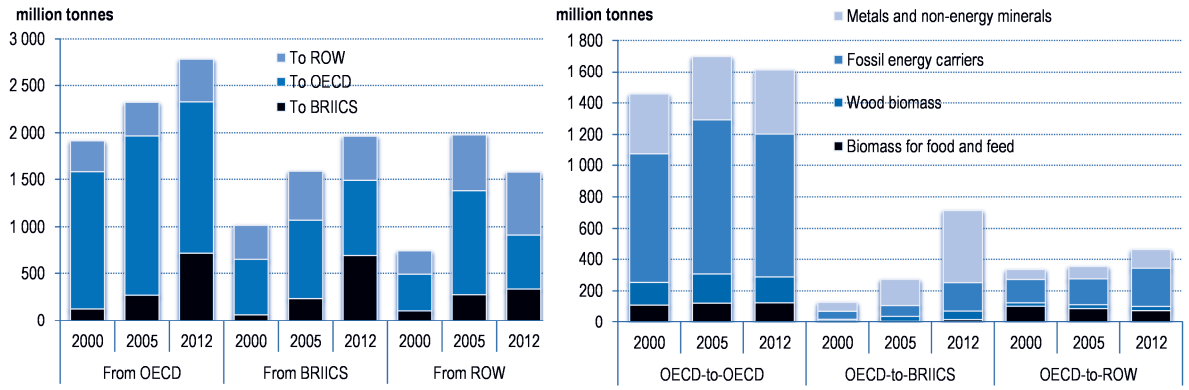
In 2012, the dollar **value** of global trade in raw, semi-finished and finished materials reached USD 3.6 trillion, a more than 4-fold increase from the beginning of decade.[2] The value of global trade in these materials has been growing faster than manufactured goods, increasing their share of total trade from 8% to 17% from 2000 to 2012; however, manufactured goods continue to dominate world merchandise trade in dollar terms.[3]

Looking at trade flows in terms of **weight** rather than dollar value reveals that much of the growth in the monetary value of trade in materials over the last decade has been driven by prices as opposed to increased physical trade volumes. The weight of global trade in raw, semi-finished and finished materials reached an estimated 6.3 billion tonnes in 2012, a 60% increase relative to 2000 (compared to a 360% increase in terms of monetary value).[4] While the value of material trade contracted by a third in 2009, the weight of trade decreased more modestly (-10%).

In 2008, **OECD** countries accounted for half of the world's exports of raw materials, semi-finished and finished products, **BRIICS** countries represented roughly 30% and the rest of the world the remaining 20%.

For OECD countries, intra-regional trade is significant – in 2012 roughly 60% of all materials exported by OECD countries were to other member countries. However, intra-OECD trade has been declining in favour of increased exports to BRIICS countries. The global financial crisis, which contracted consumer demand in many OECD countries, amplified this trend. Between 2000 and 2012, the weight of intra-OECD trade declined from 76% to 58% of total OECD country exports. Exports to BRIICS countries more than quadrupled, increasing from 7% to 26% of total OECD material exports.

Figure 2.1. Trade in selected raw, semi-finished and finished materials, by region and by material groups, 2000-2012



Notes: For definition of raw, semi finished and finished products see footnote 2.

Source: OECD based on UN COMTRADE.

Box 2.1. Is trade good or bad for the environment?

The expansion of international trade has both positive and negative implications for the environment. Trade liberalisation can allow for more efficient use of resources in one country, but can also exacerbate resource extraction in other countries. For example, increased Chinese imports of timber relieves pressures on the country's forests; on the other hand, China's huge demand for raw materials is putting more pressure on exporting countries, and can result in overall negative impacts. Trade also facilitates the dissemination and development of environmental goods, services and technologies, as well as the substitution of materials, which can help mitigate negative environmental externalities For example, through trade, countries primarily reliant on oil or coal for energy production can gain access to cleaner burning natural gas imports. A growing number of regional trade agreements include environmental provisions (most commonly environmental co-operation mechanisms and standards).

Source: Adapted from World Bank (2010) and OECD (2008c).

Demand is shifting from developed to developing and emerging economies

Demand for raw materials has been historically driven by the economies of the United States, Europe and Japan – traditionally the largest consumers of the world's raw materials. But rapid economic growth in the emerging and developing economies over the last decade has shifted global demand for material resources. This is particularly true for **non-renewable resources** that are integral to industrial development (i.e. fossil energy carriers and metals).

Between 2000 and 2012 OECD economies grew on average by 1.5% annually (GDP 2005 USD PPP) while the BRIICS economies expanded by nearly 7% per year, led by China, India, Indonesia and Russia. China surpassed the United States as the world's largest consumer of metals. Between 2000 and 2008, China's consumption of metals like aluminium, copper, lead, nickel, tin, and zinc grew on average by around 15% a year, while in the rest of the world demand for metals grew by less than 1% annually (World Bank, 2010b). China is also now the second largest consumer of energy behind the United States. India is the fourth.

But this shift in demand is not isolated to non-renewable resources. Rising incomes and increased urbanisation in the large emerging economies and population growth in less developed countries are contributing to an unprecedented expansion of **global food markets** and a change in global **dietary patterns**. Demand for animal protein, especially from meat, milk, eggs and fish products,

is rising while the share of basic cereals (except rice) is decreasing. Annual global per capita consumption of meat almost doubled in the period 1961–2011, rising from 23 kg to 42 kg (FAOSTAT), with growth led by the rapidly industrialising emerging economies and less developed countries. As dietary habits are fairly established in developed countries and protein levels already saturated, growth in food demand is expected to continue to be led by emerging and developing economies.

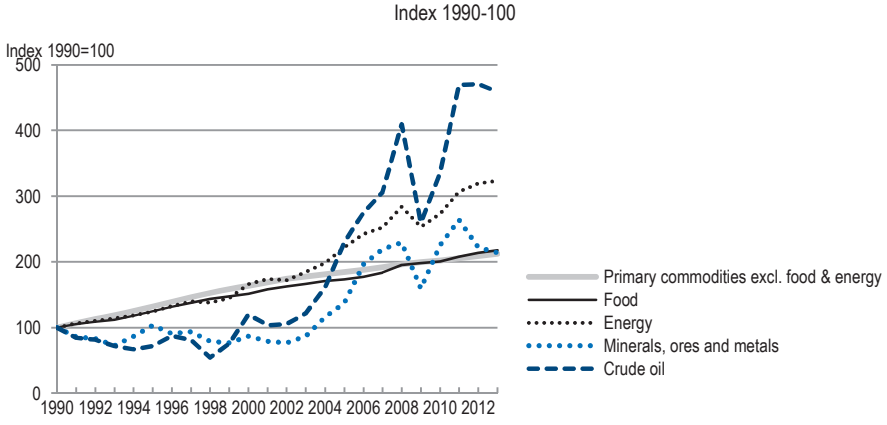
Many OECD countries continue to feel the lingering effects of the crisis and real GDP growth is modest – 2.3% in 2011, 2.8% in 2012 and 1.3% in 2013. As a result, growth in demand for raw materials continues to be fuelled by economic expansion in the BRIICS countries, led by the Chinese economy which grew by 9.0% in 2011 followed by India (8.5%) and Indonesia (6.6%).

The last decade has witnessed sharp increases and volatility of commodity prices

Growing demand for raw materials began to propel **commodity prices** sharply upward starting in the early 2000s, with some commodity prices reaching record highs in 2008 prior to the financial crisis. Between 2000 and 2010 the price of minerals and metals increased by 12% annually on average and crude oil prices increased by 10% a year compared to annual growth rates of 4.5% for minerals and metals and 7.6% for crude oil since 1960 (when expressed at current prices).[5] Similarly the price of food and non-food agricultural raw materials rose more rapidly over the last decade (over 8% annually) than over the last 40 years (3% annually) The strong upward trend broke with the 2008 financial crisis, but prices of many commodities have since rebounded and remain at historically elevated levels. However, in real terms, the prices of many raw materials – with the exception of crude oil – remain well below peaks reached in the early 1970s.

Fluctuations and volatility in the market prices of raw materials have a number of important **environmental implications**. Manufacturing, mining and agriculture are typically more responsive to demand and supply shocks, while non-financial services are less so. Swings in economic activity are thus likely to be more correlated with swings in environmental pressures when countries are orientated towards energy-intensive manufacturing and resource-intensive primary sectors (OECD 2011).

Figure 2.2. Commodity prices, world price index, 1990-2012



Source: OECD Main Economic Indicators, *http://dx.doi.org/10.1787/mei-data-en*

Higher prices for raw materials increase the cost of production; this can encourage greater efficiency in the use of more expensive materials and the development of more cost effective substitutes. Changes in the prices of primary commodities also alter the relative costs of recycling and secondary production. Rising copper prices have led to higher prices for secondary copper and

increasing instances of copper theft from rail lines, telephone lines, electrical substations, highway infrastructure and residential homes.

Fluctuations in the prices of raw materials can also have **socio-economic consequences**. Increases in raw material prices are often passed directly onto consumers, particularly for food and energy where demand is fairly inelastic. Also for resource-based export economies, lower resource prices mean decreased export earnings.

NEW ENVIRONMENTAL CHALLENGES AND POLICY DIRECTIONS

These developments have implications for the ways in which natural resources are supplied to and used in the economy. Hence, natural resource consumption and the economic efficiency of materials use have become important issues, and the nature of the environmental challenges with which governments are confronted has changed. This influences the policies put in place in many countries.

The nature of the environmental implications of resource use has evolved

The extraction of resources was once primarily viewed of as a **local** issue, with the most immediate environmental impacts occurring around the area of extraction. Climate change, air and water pollution, and loss of biodiversity have broadened the scope of environmental policies issues. Today the environmental consequences of resource use extend well beyond national orders and many are **global** in nature (e.g. climate change).

The environmental burden is shifting between regions with potential displacement effects to emerging economies

The **expansion of international trade** in raw materials over the last century has added an important new dimension, changing the nature of the environmental implications of their use and raising concerns regarding the distribution of **environmental impacts**. Associated with trade and foreign investment are changes in the international chain of value-added and a trend towards greater specialisation. The stages of the material life cycle have thus become '**displaced**'. Today the extraction, production, consumption, and recycling and/or final disposal of a material often take place at great distances from one another and/or in completely different countries. This process has allowed companies to take advantage of costs savings by outsourcing to countries where the necessary factors of production are plentiful and cheaper (e.g. labour, energy, land). This process has also displaced the potential environmental impacts associated with each stage of the material life cycle, shifting the environmental burden between regions of the world.

Resource exploration and extraction are moving afield

At the same time, **resource extraction has grown** to meet ever-increasing demand for raw materials. Projects are increasing in size while exploration and harvesting activities are **moving farther afield** (e.g. high seas fisheries, seafloor mining, Arctic oil and gas exploration). Moving extraction into these new environments poses new challenges. The rights to the resources in these areas are sometimes not yet well defined (e.g. outer continental shelf) leading to international disputes or tensions. Our scientific knowledge of the ecology of these less developed areas is also often limited.

FROM WASTE TO RESOURCES: CLOSING THE MATERIAL CYCLE

Growing material use is raising waste management issues
Many valuable materials get lost for the economy when disposed of as waste

With rising global demand for raw materials and economic growth, the **amount of waste** generated by economic activity is growing. Waste can be generated at any stage of the material cycle – during the extraction of raw materials, in the processing of raw materials into intermediate or final products, during the consumption of final products or post-consumption when the product is recycled or disposed of. The amount and composition of waste generated depends on a number of factors, including production processes, consumption patterns, waste and materials management approaches, population growth and wealth.

Waste management is also a resource management issue. Many **valuable materials** are disposed of as waste, or in waste, and are **potentially lost to the economy**. This is particularly true for e-waste (electric and electronic waste) as modern electronics can contain up to 60 different elements, including precious and special metals (UNEP, 2009). E-waste is creating an increasingly important management challenge in both developed and developing countries. Markets in electronic equipment change rapidly and the useful life of such appliances is constantly shrinking, resulting in an exponential growth in e-waste. Globally, some 50 million tonnes of e-waste are estimated to be generated every year[6]. This represents an important source of secondary raw materials for industry.

Despite renewed focus, recycling rates for key materials remain low

Reducing the waste of raw materials, reusing products and recycling materials contained in waste can reduce pressure on landfills, virgin stocks of resources and the environment by reducing waste and saving both energy and water.

International initiatives, such as the 2008 G8 Kobe **3R Action Plan**, as well as a variety of policies and programmes by national, sub-national and municipal governments (e.g. public collection schemes, deposit-refund systems, take-back programs, product standards on minimum standards of recycled content, and bans), the private sector (e.g. take-back programs, cradle-to-cradle product design, recycling targets) and non-governmental organisations (e.g. charitable collection programs), have been put in place to encourage the 3Rs.

Some materials and products have already experienced considerable **success in terms of recovery,** recycling and re-use rates, such as glass, beverage containers, automobiles, lead-acid batteries, paper and paperboard, and waste recycling rates continue to improve in OECD countries. However, recycling **rates for some key materials remain low**, particularly specialty metals used in a wide variety of emerging technologies (UNEP, 2011b).

Increasing recycling is not always straightforward. The amount of materials and products being recycled depends on the existence of well functioning recycling markets. The growth of markets for recyclable materials faces a number of challenges:

- Predicting how much recyclable material will be available, where and when, is difficult, since it is by its very nature the by-product of other decisions. The life-span of end-uses, the rate of in-use dissipation, the efficiency of collection and recycling processes, and commodity prices, all affect the development of secondary material markets.
- Product design determines the ease, and hence cost, with which scrap can be recovered. Both products and materials are becoming increasingly complex, driving up the costs of recovering recyclable materials and often times making it prohibitively expensive (e.g. post-consumer electronics, plastics).

- Post-consumer scrap is of variable quality and can contain impurities and contaminants, including substances that could be hazardous if handled improperly. As a result, secondary producers must incur additional costs to sort, clean and purify recovered scrap.

Recycling and re-use may not always be the most appropriate option in terms of reducing environmental impacts. As with primary production, the environmental implications of secondary (recycled) production need to be considered from a **life cycle perspective**. Although recycled production often requires less energy, water and other raw material inputs than production from virgin materials, the collection and transportation of recovered materials to recycling facilities may result in greater transportation fuel consumption. Keeping or reusing electric appliances helps to reduce pressure on virgin materials, but older appliances are typically less energy efficient than newer models and may consume more energy over their lifetime.

The rationale for end of life recycling also depends on local conditions that determine the access to recycling infrastructure and the availability of appropriate technologies, which change and improve over time. In some cases improving the quality of the separating and sorting stages of the recycling process helps increase recovery of materials embodied in products, particularly in complex consumer appliances (e.g. platinum in notebooks) and reduce harmful chemicals involved in the treatment processes (e.g. when separating ink from paper).

TECHNOLOGY DEVELOPMENT AND INNOVATION

Technology offers opportunities for improved resource productivity …

Technology and innovation play important roles in improving resource productivity and mitigating the negative environmental impacts of resource use and material consumption. Their role is complex, with the power to alter both supply and demand for primary and secondary raw materials.

More **efficient extraction and production** processes can reduce waste and alleviate pressure on natural stocks, as can improvements in the **recyclability, re-usability and substitutability** of materials and products. In addition to increasing the supply of materials for recycling, advances in geological science and technology can lead to the discovery of new resource stocks and unlock stocks whose extraction was previously considered unfeasible for technical or economic reasons (e.g. unconventional gas, bitumen, sea floor mining, deepwater offshore oil and gas).

… and presents new challenges

How we use resources and materials evolves over time with developments in science and technology. Many new technologies have the potential to generate additional **environmental pressures** or to **strain material availability**. New technologies frequently involve the use of new materials or the substitution of materials and the consequences of using these new materials need to be known.

Materials can fall in and out of favour with the products that embody them, making long-term demand predictions challenging. For example, new insights from medical science, particularly with regard to the human health effects of some substances (e.g. BPA, asbestos, cadmium, PCBs), can reduce their demand. Concerns regarding climate change are increasing demand for certain materials, such as those used in energy efficiency and renewable energy technologies (e.g. lithium in rechargeable batteries, platinum in fuel cells, rare earth elements in LED light bulbs and wind turbines, aluminium in automobiles to improve fuel efficiency, biomass for biofuels).

New products and applications, and their increasing complexity, also bring new environmental considerations, many of which relate to waste management and recycling (e.g. e-waste, plastics, compact fluorescent light bulbs, portable batteries), others to air pollution and chemical safety. Environmental and product standards have a role in influencing the material composition and recyclability of new products. All these externalities and their consequences need to be understood and addressed.

CONSUMPTION PATTERNS AND CONSUMER BEHAVIOUR

Attention is shifting to consumption-based approaches

In 2010, each person on earth directly and indirectly consumed approximately 29 kg of material resources each day (SERI/WU material flows database). But how much we each actually consume varies significantly between countries and regions of the world. Developed countries consume significantly more on a per capita basis than less developed countries. Per capita consumption in OECD member countries is nearly 60% above the global average. There is also wide variation among OECD member countries, ranging from over 100 kg per person per day in resource-rich exporting countries to an average 38 kg in the OECD Europe region.

The decisions made by individual consumers on how, what, and how much to consume can support sustainable resource use. In many countries household consumption accounts for 60% or more of the environmental impacts associated with final consumption (UNEP, 2010b). In industrialised countries, housing, mobility, food and manufactured products determine about 70% of the impacts of household consumption, while in developing and emerging economies, consumption related to food and housing is responsible for most of the impact, while mobility is less of a factor.

Consumption patterns are complex and changing consumer behaviour is challenging. The consumption of one product is often linked to the consumption of other products, or determined by history or national circumstance.

ENDNOTES

1 According to the FAO (2010b) the figure is "undoubtedly higher" considering that informally and illegally removed wood is not captured. Wood fuel is the most commonly under-reported category. Wood fuel accounts for about half of the wood removed globally.

2 Data based on OECD analysis of UN COMTRADE data. Trade is measured as one-way trade (i.e. exports). The sample includes 178 countries. "Raw, semi-finished and finished products" are defined materials and products falling under the following broad material categories: cereals, wood, paper, fish, meat, dairy, fossil fuels, ferrous and non-ferrous metals and phosphates as well as products mainly derived from these materials. This list corresponds largely with the material categories outlined in Eurostat's questionnaire on economy-wide material flow accounts, with the exception of non-metallic, non-energy minerals and some types of food biomass (e.g. fruits, vegetables). Save for phosphate rock, non-metallic minerals are rarely traded between countries and their inclusion/exclusion is not expected to materially influence trade flows (when expressed in terms of weight or volume).
(*http://epp.eurostat.ec.europa.eu/portal/page/portal/environmental_accounts/methodology/data_collections*)

3 These findings are consistent with World Bank (2010), which found that in the decade prior to the global economic and financial crisis, the value of global trade in natural resources had been growing 20% annually, rising from USD 0.6 trillion in 1998 to 3.7 trillion in 2008 and increasing its share of total trade from 11% to 24% over the time period. Results from the OECD's analysis differ from World Bank results due to differing definitions of natural resources. The World Bank defines natural resources as including the following product groups according to revision 3 of the Standard International Trade Classification (SITC): fish (division 03); raw hides, skins and fur skins (21); crude rubber (23); cork and wood (24); wood pulp (25); textile fibres (26); crude animal and vegetable materials, n.e.s. (29); Crude fertilizers, other than those of division 56, and crude minerals, excluding coal, petroleum and precious stones (27); metalliferous ores and metal scrap (28).

4 Figures have been estimated using physical trade volume data (i.e. weight) from the UN Commodity Trade Statistics Database (Comtrade). Although Comtrade is regarded as the most comprehensive source of information on international trade flows, physical trade volume data are incomplete. Our analysis found coverage fairly complete for OECD and BRIICS countries (over 95% from 2000-2009), but significantly lower for other countries (around 40% of weight values are missing between 2000 and 2009). OECD and BRIICS countries account for the bulk of world trade so coverage of trade flows overall is expected to be fairly complete, except for certain materials such as phosphate rock and tin where other countries are important global suppliers.

5 Price of metals and minerals: annual price index for minerals, metals and ores calculated by UNCTAD. Price of crude petroleum: average of UK Brent (light), Dubai (medium), and Texas (heavy) equally weighted USD/barrel.

6 *www.step-initiative.org/index.php/overview-world.html*

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