

B. Natural resources: Definitions, trade patterns and globalization

This section provides a broad overview of the role that trade in natural resources plays in the global economy. It begins with a discussion of definitions and terminology, focusing on key features that distinguish natural resources from other types of traded goods. These features include the exhaustibility of natural resources, the uneven geographical distribution of resource endowments, the presence of externalities in the spillover effects of extraction and use of natural resources, the dominance of the natural resources sector in many national economies, and the high degree of price volatility in this class of goods. A variety of statistical data related to natural resources are presented in order to illustrate the magnitude and direction of global trade flows.

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Since most natural resources trade is conducted through organized commodity exchanges, we examine the role that financial markets play in determining prices and quantities. This is followed by a historical account of trade in natural resources since the industrial revolution, touching on the recurring themes of technological change, trade liberalization and scarcity. This account also elaborates the evolution of thinking about how perceptions of natural resources have evolved over time, including their role in determining economic and political outcomes. Together, these analyses provide essential background information for the theoretical and policy-related discussions in subsequent chapters.

1. Definitions and key features of natural resources

Natural resources are difficult to define precisely, particularly in the context of international trade. Most people have an intuitive idea of what natural resources are, but “common sense” definitions cannot be relied upon since they eventually run into problems when dealing with ambiguous cases. For example, crude oil and wood are clearly natural resources, but it is less obvious how intermediate and final goods made from these products should be classified.

All goods either embody natural resources (e.g. automobiles contain iron ore) or require resources for their production (e.g. food crops require land and water to grow), so all goods could conceivably be classified as natural resources. Such an approach would be logically consistent but otherwise unenlightening. At another extreme, one could choose to focus strictly on resources in their natural state. However, even clear-cut examples of natural resources would be difficult to classify as such under this approach, since most resources require at least some processing before they can be traded or consumed. Regardless of the choice of definition, the line of demarcation between natural resources and other goods will always be somewhat arbitrary.

For the purposes of this report we define natural resources as “stocks of materials that exist in the natural environment that are both scarce and economically useful in production or consumption, either in their raw state or after a minimal amount of processing”.¹ Note the qualifier “economically useful” in this definition. For example, sea water is a natural substance that covers much of the earth’s surface, but it is of limited intrinsic or direct value for consumption or production. Goods must also be scarce in the economic sense to qualify as natural resources; otherwise people could consume as much as they wanted at no cost to themselves or to others.

Air would not be considered a natural resource under this definition because people can obtain it freely simply by breathing. This is not to suggest that air (especially clean air) or for that matter sea water (e.g. as a carbon sink) are without value, but it does mean that they are not commodities that can be traded in markets. In this

report, the term “resources” is used interchangeably with “natural resources”.

A useful definition should not only identify the nature of natural resources but also distinguish what is and what is not a natural resource. Under the above criteria, it is clear that manufactured goods such as automobiles and computers would not be considered resources, since both are subject to more than a minimal amount of processing. However, this should not be taken to imply that all primary products are covered as natural resources in the report. For example, while most agricultural goods including food are primary products, we do not classify them as natural resources for a number of reasons. To begin with, their production requires other natural resources as inputs, particularly land and water but also various types of fertilizer. More importantly, agricultural products are cultivated rather than extracted from the natural environment.

Two important exceptions in this report relate to fish and forestry products, which are normally classified under agriculture in WTO trade statistics, but which are treated here as natural resources. Both fish and forestry products can be cultivated, for example in aquaculture for fish or through forest management for wood. However, traditionally they have simply been taken from existing natural stocks, and still are for the most part. Unfortunately, it is impossible to distinguish between cultivated and non-cultivated varieties of these products in standard databases on international trade, but some effort has been made to identify these in the case of fish.

Natural resources can be thought of as natural capital assets, distinct from physical and human capital in that they are not created by human activity. Natural capital may be a potentially important input in a country’s “production function” – that is, $Y = f(K, L, N)$, where “ Y ” is output, “ K ” is capital, “ L ” is labour and “ N ” is natural resources. It is important to distinguish between natural resources as factors of production and natural resources as goods that can be traded internationally. For instance, minerals, oil, and various other materials can be extracted and enter into trade. However, other resources may form the economic basis for various sectors of the domestic economy, and therefore are only involved in trade in an indirect way (Josling, 2009). For example, climate and scenery can be exported through tourism. Similarly, agricultural land, which is the archetypal “fixed, immobile” natural resource, can be exported through agricultural commodities grown on that land. Hence, at a fundamental level, natural resources are often a reason for trade rather than tradable goods in their own right.

A more precise statistical definition that identifies exactly which products are to be counted as natural resources in trade data is provided in a Statistical Appendix, but the main product groups covered in this report are fish, forestry products, fuels, ores and other minerals, and non-ferrous metals. Taken together, the product groups ores and other minerals and non-ferrous metals are referred to as mining products. Broader conceptions of natural resources will also be employed from time to time, particularly as they relate to non-

tradable resources such as scenery, bio-diversity or non-traded goods such as water or land.

As noted earlier, natural resources falling under our definition typically share a number of key features, including exhaustibility, uneven distribution across countries, negative externalities consequences in other areas, dominance within national economies and price volatility. We now examine each of these features and illustrate them with some concrete examples.

(a) Exhaustibility

In resource economics, a distinction is usually made between renewable and non-renewable resources. A renewable resource is a resource that either increases in quantity or otherwise renews itself over a short (i.e. economically relevant) period of time. Hence, if the rate of extraction takes account of limitations in the reproductive capacity of the resource, renewables can provide yields over an infinite time horizon. Of course, the timeframe must be economically relevant, since some resources may be renewable in principle but not in practice. For example, it takes hundreds of millions of years for dead trees to be transformed into coal and oil (Blundell and Armstrong, 2007), and hundreds of years for certain kinds of trees to grow to maturity (Conrad, 1999), so old growth forests would not be considered renewable resources despite the fact that they do renew themselves over time. Classic examples of renewable resources are fisheries and forests.

Non-renewable resources are defined as all resources that do *not* grow or otherwise renew themselves over time. Another way of putting this is that non-renewable resources exist in finite quantities, so every unit consumed today reduces the amount available for future consumption. The most common examples of non-renewable resources are fossil fuels and mineral deposits. The term exhaustible is sometimes used as a synonym for non-renewable, but it is worth noting that renewable resources may also be exhaustible if they are over-exploited.

In general, the sustainable management of any resource rests on a capacity to monitor the evolution of stocks and take corrective action in cases of significant degradation or decline. In the case of man-made physical assets, the cost of maintaining, renewing, expanding and improving the capital stock is an explicit part of production costs (capital depreciation is accounted for as an expense). For natural resources, however, this is not always the case. The value of natural capital is often not accounted for at the level of the individual firm or in national accounts. This implies that neither their contribution to growth nor the extent and impact of their degradation are fully measured and recognized by policy makers.

Another type of cost that is related to exhaustibility but not explicitly accounted for in natural resources use is the effect of rent-seeking behaviour. The scarcity of natural resources generates economic rents (i.e. the

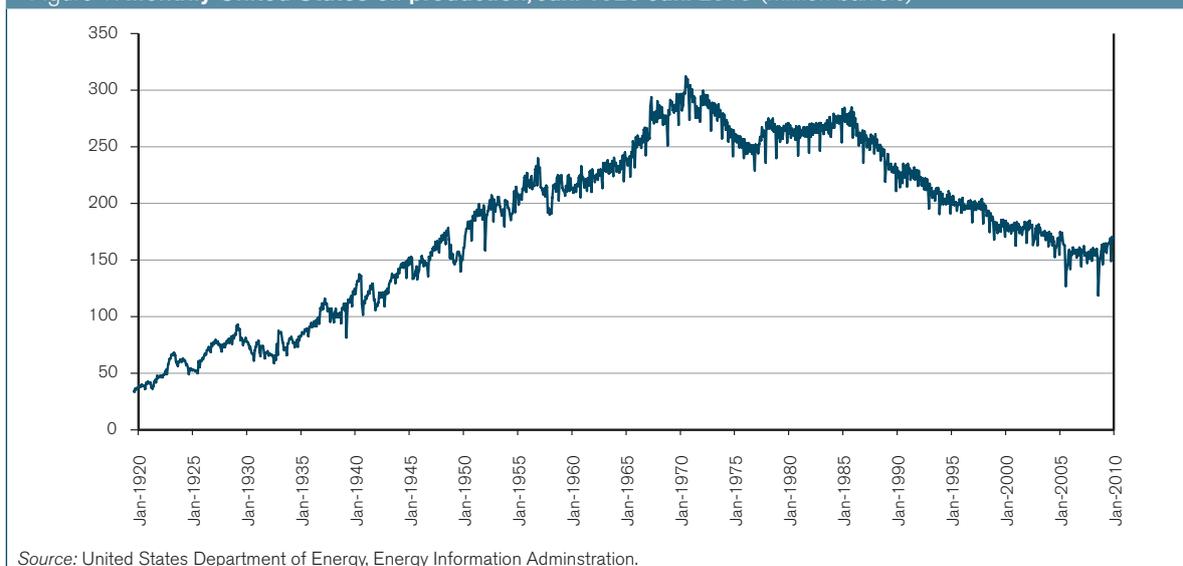
premium that the resource owner receives above opportunity cost, or the cost of the next best alternative use of the relevant assets). Policies, including trade measures, that alter the supply and demand and hence the price of resources alter the distribution of rents across time and countries, sometimes lead to international tension.

Technological change can effectively increase the supply of resources by contributing to new discoveries and allowing extraction of stocks that could not be reached before. According to the BP World Energy Review (2009), proven world oil reserves² rose from 998 billion barrels in 1988 to 1,069 billion barrels in 1998 and 1,258 billion barrels in 2008, thanks largely to new discoveries and advances in extraction technology. Changes in technology can also influence the rate of depletion of a resource by either increasing its rate of use (e.g. electrical energy for increased use of electronics, computers, etc.) or decreasing it (e.g. improvements in the efficiency of automobiles). Technological developments like these would change the rate at which a resource was used up, but it would not alter the fact of its exhaustibility.

Many petroleum experts believe that world oil production has or soon will reach its maximum point, known as “peak oil” (Hackett, 2006). Once oil production peaks, it is believed that future supplies will become more and more difficult to obtain, causing the flow of oil to decline inexorably according to a logistic distribution known as the Hubbert curve. This bell-shaped curve is named after M. King Hubbert, who accurately predicted in the 1950s that United States oil production would peak around 1970 and decline thereafter (see Figure 1). More pessimistic peak oil theorists predict enormous economic disruptions in the near future as a result of rapidly dwindling supplies, while more optimistic observers put the date of world peak oil production many years, if not decades, in the future. Peak oil theory has been less successful at predicting maximum oil production in countries other than the United States or at the world level, but few would dispute the notion that oil production will begin to decline at some point in the future if current rates of consumption continue.

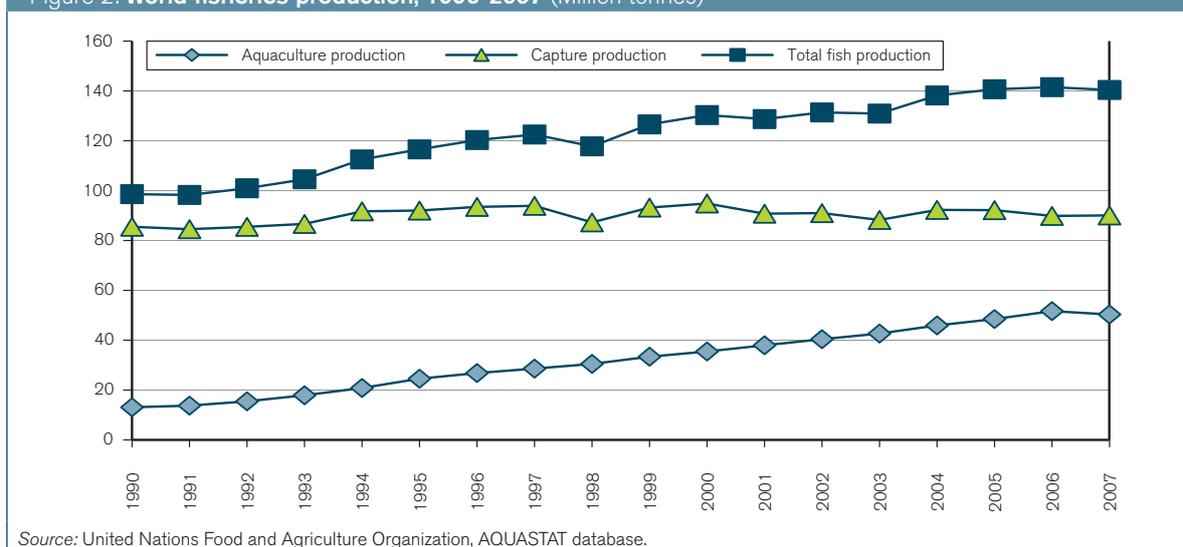
Another example of a renewable resource that may be in decline is fish. According to statistics from the United Nations Food and Agriculture Organization (FAO), total world fisheries production rose from 98 million tonnes in 1990 to 140 million tonnes in 2007, an increase of 42 per cent. During the same period, total world exports of fish jumped 60 per cent from 33 million tonnes to 53 million tonnes. The share of trade in world fish production also advanced from 34 per cent in 1990 to 38 per cent in 2007. Despite rising production and trade, annual catches from oceans and fresh water fisheries have been mostly flat during this period, at around 90 million tonnes, with nearly all growth in recent years accounted for by aquaculture, otherwise known as “fish farming” (see Figure 2). This could indicate that the world’s oceans and fresh water fisheries have reached peak production and are in danger of over-exploitation in the face of growing demand.

Figure 1: Monthly United States oil production, Jan. 1920-Jan. 2010 (Million barrels)



Source: United States Department of Energy, Energy Information Administration.

Figure 2: World fisheries production, 1990-2007 (Million tonnes)



Source: United Nations Food and Agriculture Organization, AQUASTAT database.

(b) Uneven distribution across countries

Many natural resources are concentrated in a small number of countries, while others have limited domestic supplies. For example, Appendix Table 1 shows that nearly 90 per cent of the world's proved oil reserves are located in just 15 countries (out of slightly more than 200 in the world today), and 99 per cent of oil reserves are found in 40 countries.³ International trade can help to alleviate these kinds of disparities in natural endowments by allowing resources to move from areas of excess supply to areas of excess demand, which may also serve to promote the most efficient use of these products. However, since natural resources are indispensable inputs for production and are also necessary for maintaining a high quality of human life, the unequal distribution of resources can cause friction among nations.

The nature of the friction associated with natural resources may be different from that observed in the case of other types of goods. In most trade disputes involving agricultural or manufactured goods, a country seeks to restrict imports. Many reasons may be given for this, including fiscal needs, support for an infant or a "strategic" industry, public considerations (health, environment, safety etc.), or as a response to trade practices that the importing country perceives to be unfair. Conversely, most importing countries are eager to obtain natural resources from foreign suppliers. But exporting countries may be reluctant to allow their resources to flow freely to other nations, also for a variety of reasons. These include fiscal needs, the desire for economic diversification through additional processing of raw materials, ensuring adequate domestic supplies, and protecting the environment.

The uneven geographical distribution of traded natural resources is further illustrated by Maps 1 to 5 in the

Appendix, which show net exporters and net importers by product, based on merchandise trade data from the UN Comtrade database. The distribution of fuels and non-ferrous metals is particularly noteworthy, since all of the world's largest industrial economies are net importers of these goods. With few exceptions, European countries are net importers of all types of natural resources, as are Japan and the Republic of Korea. The United States is a net exporter of forestry products and mineral ores, but a net importer of all other tradable resources. India and China are only net exporters of fish, while they are net importers of the other resource products dealt with in this report. Russia is a net exporter, except of fish. Among major developed economies, only Canada is a net exporter of all types of natural resources discussed here.

Water is mostly non-traded but it is also very unevenly distributed across countries. According to the United Nations, humanity is facing a drastic problem of water scarcity (United Nations, 2009). The vast majority of the earth's water resources are salt water, with only 2.5 per cent being fresh water. Approximately 70 per cent of the fresh water available is frozen in the icecaps of Antarctica and Greenland, leaving just 0.7 per cent of total world water resources for consumption, and of this 0.7 per cent, roughly 87 per cent is allocated to agricultural purposes. The world's limited reserves of clean, fresh water for human consumption are shrinking fast, posing a serious threat to public health, political stability and the environment.

Among the main factors aggravating water scarcity are population growth, increasing urbanization, and high levels of per capita consumption. Climate change is also expected to contribute to greater water scarcity in the future, as rising temperatures lead to droughts, desertification and increasing demand for water. The problem of water scarcity is more acute in some countries than in others, which is illustrated by Map 6 in the Appendix. It shows that per capita water supplies are many times greater in countries like Canada, Russia and Brazil than they are in the Middle East and large parts of Africa. For example, Canada's supply of 87,000 m³ per person per year is roughly nine times greater than the 9,800 m³ available to citizens of the United States every year. However, the US supply is nearly 14 times greater than that of Egypt, at 700 m³ per person per year. Moreover, Egypt's water supply is roughly seven times greater than that of Saudi Arabia, with resources of just 95 m³ per person per year (UN Food and Agriculture Organization, AQUASTAT database).

International trade could conceivably help to alleviate local problems of water scarcity by moving resources to where they are most needed. However, countries are unable or unwilling to do so, as large-scale shipments are essentially non-existent. Reasons for this lack of trade are largely technical, since water is bulky and is therefore difficult to transport. Water scarcity or abundance also tends to be shared by most countries within a given region, so water would have to be transported long distances to make a difference to the problem of scarcity.

Although water itself may not be tradable, international trade can have an indirect and beneficial effect on domestic supplies of water. Exports of water-intensive products (e.g. agricultural goods) from regions of water abundance to regions where water is scarce can generate savings in importing countries by freeing up resources for other uses. For example, from 1997 to 2001, Japan's imports of water-intensive goods saved the country 94 billion m³ of water that would have been required if Japan had produced the goods domestically (Hoekstra, 2008b).

(c) Externalities

An externality occurs when the actions of one economic agent affect other agents indirectly, in either a positive or negative way (Nicholson, 2001). Another way of expressing this is that the outcomes of certain activities may impose external costs on, or provide external benefits to, consumers or firms not involved in the relevant production or consumption decision. These "externalities" can be negative or positive. An example of a negative externality would be when a production process results in pollution that adversely affects the health of people who live nearby, or that damages the natural environment in a way that reduces the well-being of individuals indirectly. A positive externality might occur when homeowners make improvements to their properties that raise the market value of neighbouring houses as well.

From a perspective of social well-being, externalities cause goods to be over-produced or under-produced, depending on whether the externality is positive or negative. This is because the market price of the good in question does not reflect its true cost or benefit to society. A good whose production and use imposes external costs on other agents would tend to be over-produced because these additional costs are not included in the buyer's calculations. On the other hand, goods that provide external benefits tend to be under-produced because their market price is too low. The solution to the problem of externalities, whether positive or negative, is to internalize all costs and benefits into the price of the good, but this is difficult to achieve in practice without the intervention of an external agent such as a government.

Natural resource economics is mostly concerned with negative externalities arising from the extraction and consumption of resources, but positive externalities in this area are not inconceivable. For example, over-fishing of one species of fish may benefit another competing species and improve the welfare of other fishing enterprises. Another example would be when a mining company builds a road that enables nearby farmers to ship their goods to market. Since this kind of unintended consequence is rare, the remaining discussion will focus exclusively on negative externalities. Externalities will be discussed in greater detail in Section C, but the following examples illustrate the problem in the context of natural resources.

The burning of fossil fuels produces a variety of pollutants that directly harm human health, while also emitting large quantities of greenhouse gases (mainly CO₂) that contribute to global warming. Since global warming affects everyone on the planet, including people who consume little fuel, the consumption of fuels results in large externalities.

According to statistics from the International Energy Agency, annual world CO₂ emissions from fuel combustion more than doubled between 1971 and 2007, rising from 14.1 billion tonnes to 28.9 billion tonnes (International Energy Agency (IEA), 2009a). During this period the share of developing countries in world emissions increased from 34 per cent to 55 per cent (see Figure 3). This increase can be attributed to population growth, rising GDP, and increasing per capita CO₂ emissions in a number of developing countries. Global CO₂ emissions per person grew by around 17 per cent between 1971 and 2007, with sharper increases towards the end of the period on

account of rapid growth in some emerging economies (see Figure 4). Per capita CO₂ emissions of most developed economies rose through the 1970s, but have since either stabilized or declined slightly.

The above figures are not adjusted for levels of economic activity. The influence of this factor is observable in terms of the carbon intensity of world output, or the CO₂/GDP ratio (see Figure 4). The ratio declined 33 per cent at the global level between 1971 and 2007. To the extent that globalization raises consumption of fossil fuels through higher incomes and industrialization, it can be seen as having a negative impact on the environment, but the increased efficiency of production and the spread of technology associated with globalization may create some countervailing benefits.

Another example of a negative externality is Hardin's well known "tragedy of the commons" (Hardin, 1968) in which lack of ownership rights over a common pool

Figure 3: Total world CO₂ emissions by level of development, 1971-2007 (Million tonnes of CO₂)

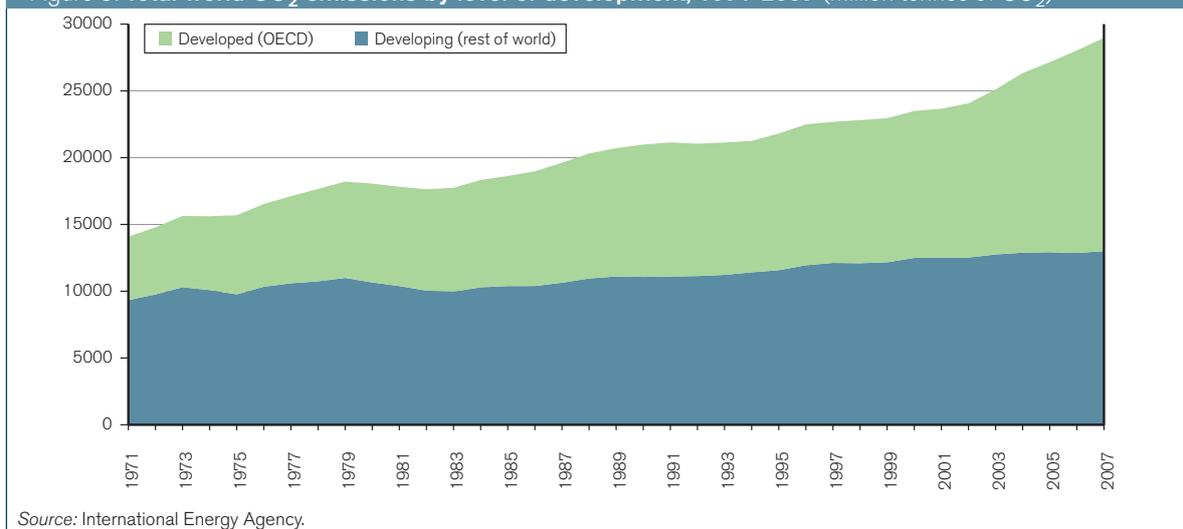
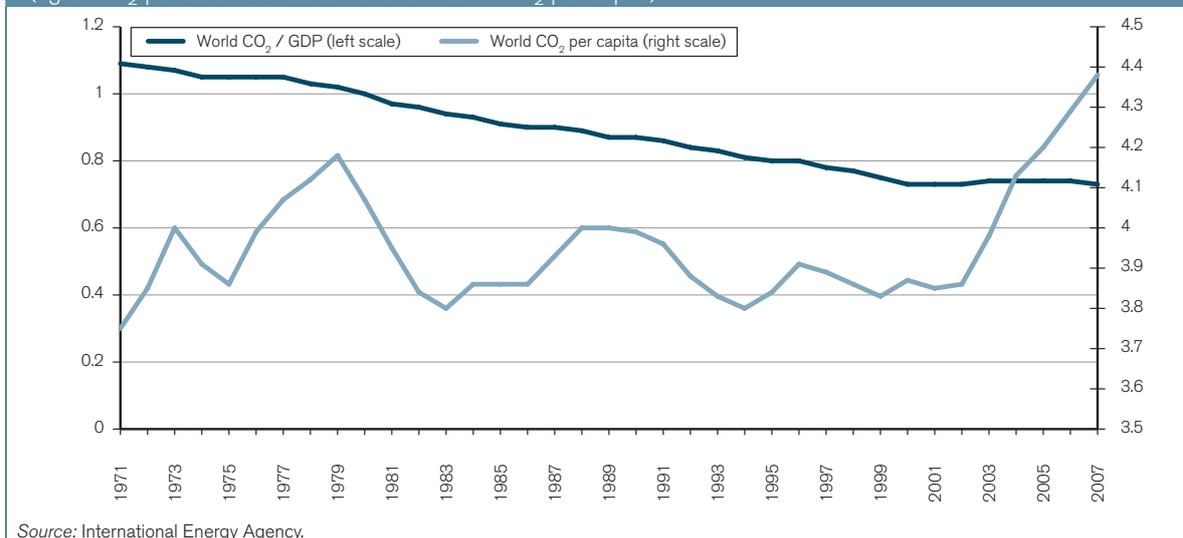


Figure 4: World CO₂ / GDP and CO₂ per capita, 1971-2007 (kg of CO₂ per 2000 US dollars and tonnes of CO₂ per capita)



resource leads to depletion of that resource. The tragedy of the commons was first used to explain overgrazing on public land, but the concept can also be applied to other common pool resources such as forests. Table 1 shows the countries with the largest declines in forest land between 1990 and 2005, based on data from the World Bank's World Development Indicators database. Countries in South America and Africa experienced the biggest declines during this period, while other regions recorded smaller drops, or in some cases small increases. Europe saw its forest area rise more than any other region, but there is considerable uncertainty surrounding increases in other areas, particularly in Russia. It should be noted that forests differ significantly in the number of plant species they contain and the number of animal species that inhabit them, so that a given decline in forested land may have a greater impact on biodiversity in some regions than in others. As of 2005, 11 per cent of the world's forests were designated for the protection of biodiversity (FAO Global Forest Resources Assessment, 2005).

(d) Dominance of natural resources

Another important feature of natural resources is the dominant position of this sector in many national economies. Many of these countries tend to rely on a narrow range of export products. Table 2 shows export concentration indices from the 2008 UNCTAD Statistical Handbook, along with shares of natural resources in total merchandise exports for selected economies. Concentration indices are based on the number of products in the Standard International Trade Classification (SITC) at the 3-digit level that exceed 0.3 per cent of a given country's exports, expressed as a value between 0 and 1, with values closer to 1 indicating greater concentration. It is clear that with very few exceptions, countries with the highest export concentration scores also have high shares of natural resources in total exports.

Appendix Tables 8 and 10 show leading traders of fuels and mining products in 2008 and also illustrate the importance of these products for exporting and importing countries alike. For example, the share of fuels in Saudi Arabia's total merchandise exports was some 90 per cent in 2008, while the equivalent share for Iran was 82 per cent. Export shares for Kuwait, the Bolivarian Republic of Venezuela, Algeria, Nigeria and Angola were all in excess of 90 per cent. Although not as high as the shares for exports, fuels made up a significant part of imports for the leading developed economies in 2008, including the United States (23 per cent) and Japan (35 per cent).

Shares of mining products in total exports are much smaller than the equivalent shares for fuels, but mining products still dominate exports in many countries, including Zambia (80 per cent), Chile (60 per cent), Niger (58 per cent), Jamaica (56 per cent) and Peru (43 per cent).

The dominance of natural resources in exports conforms with predictions from trade theory that countries will specialize in the production of goods where they have a comparative advantage, and export them in exchange for other goods. However, the fact that many countries are both exporters and importers of natural resources is harder to explain. The Grubel-Lloyd (GL) index provides a useful measure of this kind of "intra-industry" trade. For a given country, the share of intra-industry trade in sector *i* is defined as follows:

$$GL_i = 1 - (| \text{export}_i - \text{import}_i | / (\text{export}_i + \text{import}_i))$$

If a country only exports or imports good *i*, then the GL index for that sector would be equal to 0, whereas if a country imports just as much as it exports it would have a GL score of 1 for that sector.

Table 1: **Countries with the largest declines in forested land, 1990-2005**
(1000 sq. km and percentage of land area)

	1000 sq. km		% of land area
Brazil	-423	Honduras	-24
Indonesia	-281	Solomon Islands	-21
Sudan	-88	Korea, Rep of	-17
Myanmar	-70	Indonesia	-15
Congo, Dem. Rep.	-69	Cambodia	-14
Zambia	-67	Zimbabwe	-12
Tanzania	-62	Nicaragua	-12
Nigeria	-61	Philippines	-11
Mexico	-48	Timor-Leste	-11
Zimbabwe	-47	Myanmar	-11
Bolivarian Rep. of Venezuela	-43	Ecuador	-11
Australia	-42	Liberia	-9
Bolivia	-41	Zambia	-9
Philippines	-34	Benin	-9
Cameroon	-33	Ghana	-8

Source: World Bank World Development Indicators.

Table 2: Export concentration and share of natural resources in merchandise exports, 2006
(Indices and percentage)

	UNCTAD Concentration Index (0-1)	Share of natural resources in total exports (per cent)
World	0.08	24
Angola	0.96	100
Iraq	0.95	100
Bolivarian Rep. of Venezuela	0.91	96
Sudan	0.87	95
Congo	0.87	..
São Tomé and Príncipe	0.87	47
Nigeria	0.86	92
Yemen	0.85	91
Libyan Arab Jamahiriya	0.84	97
Gabon	0.84	95
Bahrain	0.79	90
Iran	0.78	86
Tajikistan	0.77	67
Solomon Islands	0.77	81
Maldives	0.77	99
Saudi Arabia	0.76	88
Guinea-Bissau	0.75	1
Oman	0.75	79
Mali	0.75	75
Mauritania	0.74	87

Source: UNCTAD Handbook of Statistics 2008 and WTO Secretariat estimates.

Table 3 shows GL indices for natural resources in major economies at the 3-digit SITC level. Figures closer to 1 indicate more trade in similar products, whereas smaller figures indicate less intra-industry trade. Some products have relatively high scores, including fuels and non-ferrous metals. This could be explained by the fact that these products may be differentiated at lower levels of aggregation, but it is also possible that large diverse economies contain some regions that export natural resources and others that import them. Canada provided an example of this when, in 2006, the province of Ontario imported electricity from the United States while the province of Quebec exported the same product. This conjecture is supported by Table 4, which shows average GL indices for natural resources and manufactured goods for a larger group of countries. The average GL scores for manufactured goods are consistently higher than the scores for resources, but smaller countries also tend to have lower average GL values in both manufactured goods and natural resources.

(e) Volatility

The final characteristic of natural resources examined here is their occasional extreme price volatility. This is especially true for fuels, which have experienced sharp price rises from time to time since the 1970s, only to collapse at a later date. Prices for minerals and metals have also fluctuated dramatically in recent years, although their importance for the world economy is perhaps lessened by their smaller share in world trade. Price volatility for forestry products and fish is much

less than for other types of natural resources. According to the International Monetary Fund's International Financial Statistics, fuel prices jumped 234 per cent during 2003-08, while mining products rose 178 per cent. During the same period, prices of fish and forestry products advanced at the relatively modest rates of 38 per cent and 26 per cent, respectively.

Figure 5 shows the evolution of prices for West Texas Intermediate (WTI) crude oil from 1970 to 2009. The first big price increase occurred in 1973, when members of the Organization of Petroleum Exporting Countries (OPEC) proclaimed an embargo against the United States and other countries that supported Israel in the Arab-Israeli war. Prices again rose sharply in 1979-80 following the Iranian revolution and the outbreak of the Iran-Iraq war. This was followed by a steep slide between 1982 and 1986, during which oil prices fell roughly 75 per cent in real terms. A prolonged period of weakness ended in 2003, when prices began their climb to the record levels of mid-2008. This was followed by yet another collapse brought on by the global recession.

The most noteworthy features of this chart are the sustained deviations of oil prices from their long-run average. Between 1979 and 1986 prices were consistently above their average level during the period 1970-2009. Then, with the exception of a brief spike that coincided with Iraq's invasion of Kuwait, oil prices stayed below average from 1986 until 2005. Since 2005 prices have remained above average except for a brief period in February 2009.

A number of possible explanations for these large swings in oil prices have been put forward, including geopolitical uncertainty, shocks to the flow of oil, changes in demand and speculation. There is no consensus in the relevant literature on which of these

forces is most important, but recent research suggests that changes in supply are relatively unimportant, while changes in demand associated with global business cycles have significant effects (Kilian, 2009).

Table 3: Grubel-Lloyd (GL) indices for selected economies, 2008 (Index, 0-1)

United States		European Union (27)	
Stone, sand and gravel	0.93	Briquettes, lignite, peat	0.96
Other crude materials	0.92	Petroleum products	0.93
Iron ore, concentrates	0.91	Wood, simply worked	0.89
Natural abrasives	0.83	Non-ferrous waste, scrap	0.86
Fuel wood, wood charcoal	0.78	Silver, Platinum, etc.	0.86
Petroleum products	0.73	Electric current	0.84
Pulp and waste paper	0.69	Nickel	0.84
Residual petroleum products	0.68	Natural abrasives	0.82
Nickel ore, concentrates, etc.	0.67	Stone, sand and gravel	0.78
Fish (fresh, chilled, frozen)	0.67	Residual petroleum products	0.77
Ores, concentrates of base metals	0.65	Copper	0.73
Aluminium	0.64	Ferrous waste, scrap	0.72
Nickel	0.64	Pulp and waste paper	0.68
Petroleum gases	0.62	Coal gas, water gas, etc.	0.65
Silver, platinum, etc.	0.60	Lead	0.63
Japan		China	
Lead	0.95	Petroleum gasses	0.91
Aluminium ore, concentrates, etc.	0.85	Crustaceans, molluscs, etc.	0.85
Petroleum products	0.84	Fish (fresh, chilled, frozen)	0.85
Residual petroleum products	0.84	Coal, not agglomerated	0.81
Pulp and waste paper	0.71	Residual petroleum products	0.80
Non-ferrous waste, scrap	0.68	Fuel wood, wood charcoal	0.78
Precious metal ores, concentrates	0.66	Silver, platinum, etc.	0.74
Nickel	0.62	Wood, simply worked	0.73
Zinc	0.61	Other crude minerals	0.68
Petroleum gases	0.54	Natural gas	0.66
Natural abrasives	0.53	Petroleum products	0.63
Coke, semi-coke	0.51	Lead	0.62
Aluminium	0.42	Aluminium	0.61
Copper	0.42	Natural abrasives	0.46
Silver, platinum, etc.	0.40	Liquified propane, butane	0.42

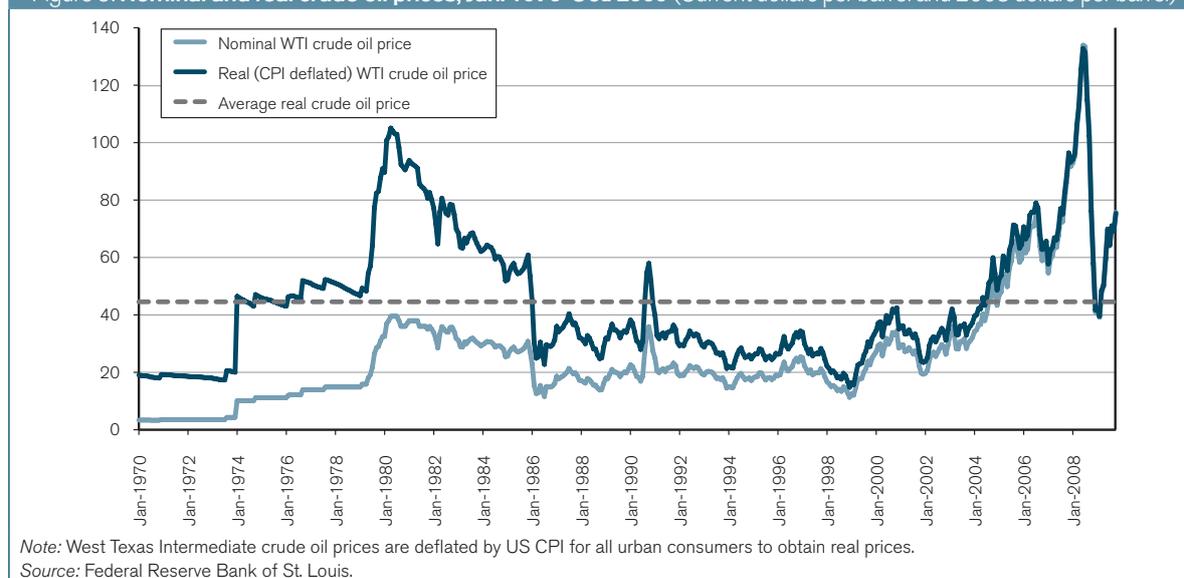
Source: UN Comtrade database.

Table 4: Average GL indices for manufactured goods and natural resources, 2008 (Index 0-1)

	Natural resources	Manufactured goods
Australia	0.28	0.33
Bahamas	0.06	0.13
Brazil	0.29	0.52
Canada	0.49	0.59
China	0.34	0.47
European Union (27) extra-trade	0.47	0.68
Iceland	0.09	0.14
India	0.27	0.53
Japan	0.29	0.49
Russian Federation	0.25	0.32
South Africa	0.33	0.46
Sri Lanka	0.16	0.20
United States	0.49	0.68

Source: WTO Secretariat estimates.

Figure 5: Nominal and real crude oil prices, Jan. 1970–Oct. 2009 (Current dollars per barrel and 2008 dollars per barrel)



2. Natural resource trade flows and related indicators

Having defined natural resources in general terms as the sum of forestry products, fish, fuels and mining products, we now present a variety of descriptive statistics on international trade in these products. Merchandise trade data are first shown at the world level, but are then progressively broken down by product and region to give a more detailed picture of global trade flows. Tables on trade of individual countries by product are provided in a statistical appendix, which also contains illustrative maps showing a variety of resource-related indicators.

Two definitions of natural resources are used in the merchandise trade statistics, with one slightly broader than the other. Tables showing country and product shares in world natural resources trade use the narrower definition that only includes forestry products, while tables on trade by geographic region use the slightly broader definition that includes all agricultural raw materials. This is solely for reasons of data availability, and the difference is minimal at the world or regional level.

Some grey areas in product coverage should be noted. In addition to raw fossil fuels such as coal, crude oil and natural gas, the fuels product group also encompasses refined petroleum products and electricity. It may seem odd at first to count electricity (see Box 1) and refined fuels as resources, since their production requires substantial capital inputs, and the final output is produced by human activity rather than simply extracted from the natural environment. However, fossil fuels are rarely consumed in their raw form, so we may still consider refining and electricity generation to represent the minimum amount of processing necessary to allow these goods to be traded.

Nominal trade flows are expressed in current US dollars and are strongly influenced by changes in exchange rates and commodity prices. This is especially true of fuels, which represent the largest component of natural resources trade in dollar terms, making up some 77 per cent of world natural resources trade and 18 per cent of total merchandise trade in 2008.

(a) World trade in natural resources

The dollar value of world exports of natural resources increased more than sixfold between 1998 and 2008, rising from US\$ 613 billion to US\$ 3.7 trillion, thanks in large part to steadily rising prices for primary commodities (see Figure 6). Higher oil prices in particular helped push the share of fuels in world natural resource exports to 77 per cent in 2008 (US\$ 2.9 trillion), up from 57 per cent in 1998 (US\$ 429 billion). Although prices for metals have also risen sharply in recent years, they have not kept pace with fuels, and as a result the 2008 shares of ores and other minerals and non-ferrous metals in natural resources trade fell to 8.2 per cent (US\$ 308 billion) and 9.6 per cent (US\$ 360 billion), respectively. Shares for these products were also below their respective long-run averages of 8.3 per cent and 13.3 per cent.

The value of global fish exports rose from US\$ 53 billion in 1998 to US\$ 98 billion in 2008, while exports of forestry products increased from US\$ 52 billion to US\$ 106 billion. Despite the growing dollar value of fish and forestry exports, shares of these products in world natural resources trade fell from 8.6 per cent to 2.6 per cent and from 8.5 per cent to 2.9 per cent, respectively, due to the even faster growth of fuels and mining products.

Higher commodity prices also boosted the share of natural resources in world merchandise trade from 11.5 per cent in 1998 to 23.8 per cent in 2008 (see Figure 7). Meanwhile, the share of fuels in world trade jumped

Box 1: Is electricity a natural resource?

Electricity is generated from natural resources such as coal, gas, water, and uranium, but should it also be considered a natural resource? Since its production requires other natural resources as inputs, it is perhaps more natural to view electricity as a manufactured good. However, electricity arguably should be counted as a natural resource since some processing must be applied to most resources before they can be traded or consumed. In this respect, electricity can simply be seen as transformed coal, natural gas, etc. Electricity also allows energy resources that are normally untradable (e.g. flowing water in rivers used for hydroelectric generation) to be traded across national borders.

Electricity has a number of unusual properties that distinguish it from other goods. First, it is intangible and can only be stored in very small quantities. (An exception is pumped-storage of hydro energy, where water is pumped uphill into a reservoir during low demand periods and released later during high demand periods in order to generate additional electricity to balance supply and demand more efficiently.) Also, it must be produced at the same time that it is consumed, making it more like a service than a good. Electricity is classified as a fuel in international trade statistics, but it is not recorded systematically by all countries. As a result, merchandise trade statistics on electricity may be incomplete or inaccurate.

Generation facilities can be classified as base-load capacity or peak-load capacity depending on the type of fuel used. Base-load capacity has low marginal cost but usually has very large fixed costs. Examples include hydroelectric and nuclear power plants. Peak capacity has high marginal cost but is usually much more flexible in terms of scheduling output. Natural gas is often used for peak-load generation. Patterns of international trade in electricity depend to some extent on the type of generating capacity that a country possesses. Some countries export large quantities of nuclear energy (e.g. France) or hydroelectric power (Canada), resulting in large volumes of trade but lower cost per unit. Other countries may engage in international trade only during times of peak demand (e.g. to meet air-conditioning demands on hot summer days) in order to maintain the stability of their electricity grids. In such cases, the volume of electricity trade could be quite small but the dollar value might be large.

International trade in electricity is limited by physical constraints, including geographic proximity and infrastructure requirements. Only neighbouring countries trade electricity. Furthermore, power systems across countries must be interconnected. Importantly, international trade in electricity can result in better use of complementary resources (e.g. using flexible hydro generation to export peak power and importing thermal power during off-peak hours), the balancing of annual demand variations and of current versus future needs, and the pooling of reserve capacity.

Figure 6: World natural resources exports by product, 1990-2008 (Billion dollars)

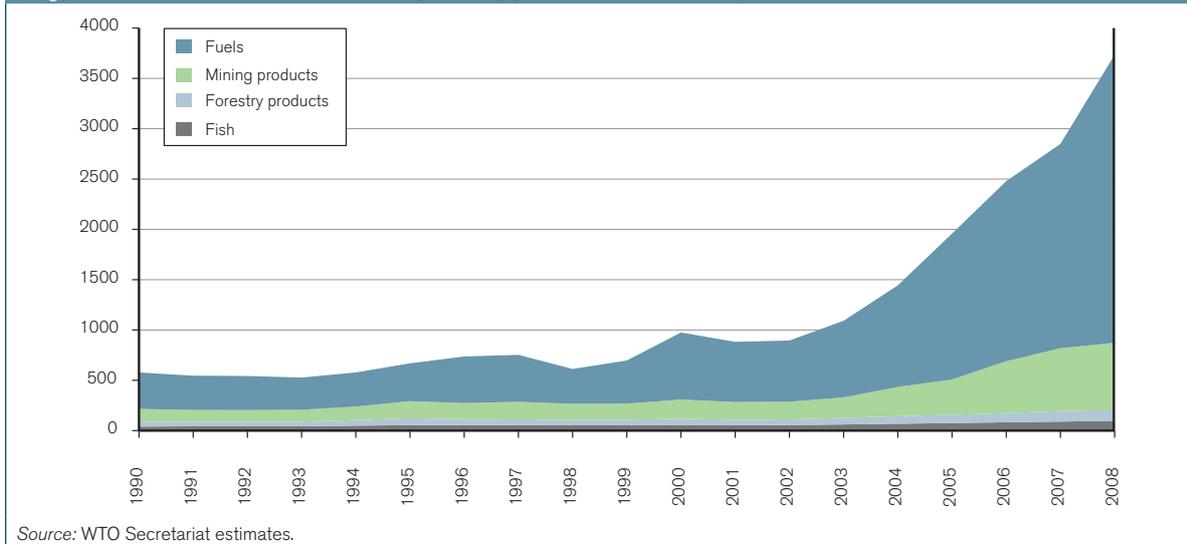
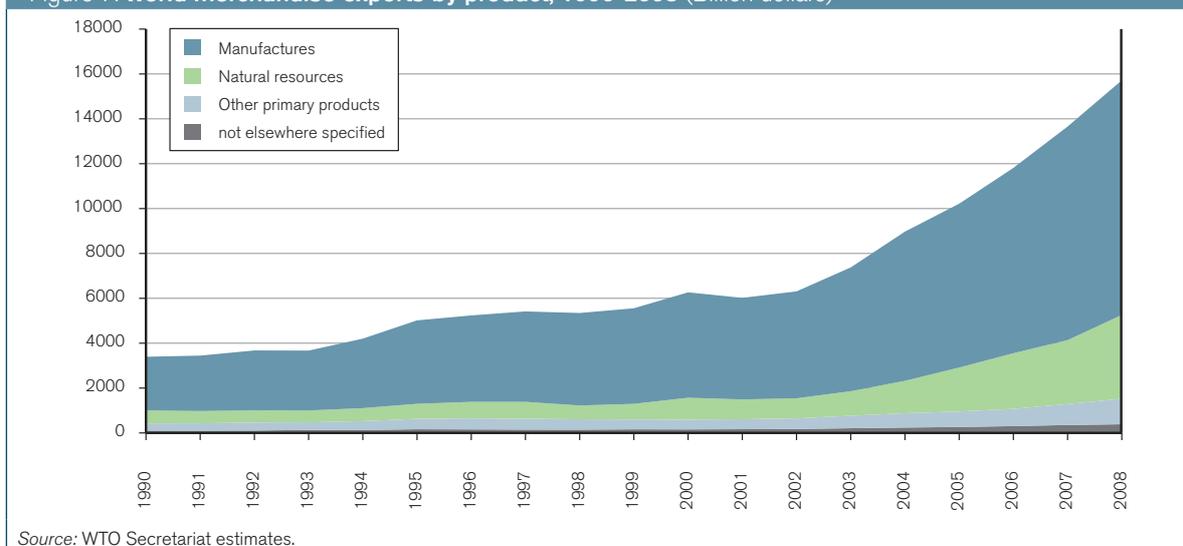


Figure 7: World merchandise exports by product, 1990-2008 (Billion dollars)



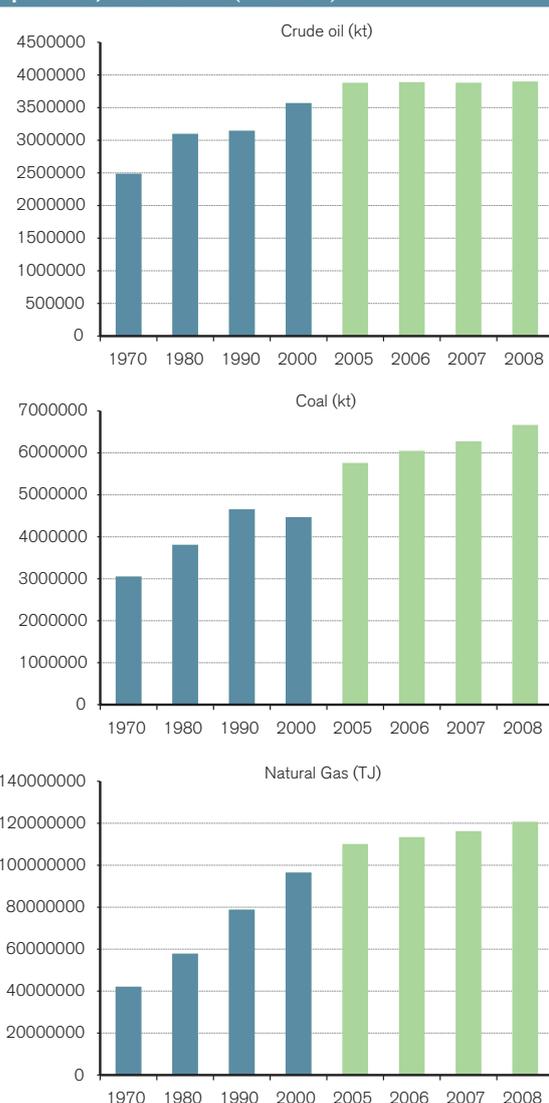
Source: WTO Secretariat estimates.

from 6.5 per cent to 18.2 per cent. Total merchandise exports increased from US\$ 5.3 trillion to US\$ 15.7 trillion during the same period, implying an average annual growth rate of 12 per cent, while natural resource exports grew 20 per cent per year on average over this period. Exports of manufactured goods increased from US\$ 4.1 trillion in 1998 to US\$ 10.5 trillion in 2008, an average growth rate of 10 per cent per year, or about half the rate of increase of natural resources. Despite the rapid growth of natural resources trade, manufactured goods still made up the bulk of world merchandise exports in 2008, at 66.5 per cent.

The growing share of oil in world trade is mostly the result of higher prices rather than increased quantities. This is illustrated by Figure 8, which shows world production of fossil fuels including crude oil since 1970. Output of oil has been remarkably steady in recent years, but this has coincided with rising demand on the part of major developing countries such as China and India, which has put upward pressure on prices. Constant oil production also fails to keep up with demand due to normal population growth. It should be noted that the relationship between world oil trade and production is not one-to-one, but given the uneven distribution of these resources across countries, it is reasonable to link the two. The share of world oil production that is exported has in fact been remarkably steady over time, rising from 50 per cent in 1970 to 55 per cent in 2000, and remaining unchanged since then. Coal and natural gas production has continued to expand in recent years, mostly to meet growing demand for electricity generation (International Energy Agency (IEA), 2009b).

For a longer-term perspective on natural resources trade, we must resort to estimation, since breakdowns of merchandise trade statistics by product are not readily available for the years before World War II. Using historical data from the United Nations and the General Agreement on Tariffs and Trade (GATT), it is possible to construct a data series going back to 1900

Figure 8: World production of fossil fuels by product, 1970-2008 (kt and TJ)



Source: International Energy Agency.

that shows the split between manufactured goods, natural resources and other primary products, with a more detailed breakdown of natural resources available beginning in 1955 (see Figure 9). These data show that manufactured goods only made up about 40 per cent of world merchandise exports at the beginning of the last century, with the remaining 60 per cent being primary products, including natural resources and agricultural products. However, between 1955 and 2000 the share of manufactured goods in world trade increased steadily from 45 per cent to 75 per cent, largely at the expense of agricultural products. The share of natural resources also tended to fall after 1955, but the decline was less pronounced than for agricultural goods and was punctuated by increases coinciding with oil price rises.

Between 1955 and 2004 the share of natural resources in world trade fell from 22 per cent to 14 per cent, but rose to 30 per cent in 1980 and to 24 per cent in 2008 due to higher prices for oil and other commodities. The rising share of natural resources between 1900 and 1955 is probably explained by trade in fuels, which was negligible at the beginning of the century but which expanded as use of the automobile became more widespread.

The pre-war shares for natural resources in Figure 9 are very rough estimates and therefore should be interpreted with caution. The definition of manufactured goods also differs slightly in the earlier period since it includes non-ferrous metals, which means that the rise of manufactured goods depicted in Figure 9 may be slightly understated. Whether the share of manufactured goods will continue to rise is difficult to say, but this chart suggests a large part of international trade in natural resources may be in the form of manufactured goods.

(b) Natural resources trade by region

Due to the uneven distribution of natural resource deposits across countries, the pattern of exports is quite different from one region to another. For some regions (e.g. the Middle East, Africa, the Commonwealth of Independent States), resources represent a significant proportion of merchandise exports, while others (Asia, Europe and North America) have more diverse export profiles (see Table 5). South and Central America is an intermediate case, with resources making up a significant, but not dominant share of merchandise exports. In 2008, the Middle East had the largest share of resources in merchandise exports, at 74 per cent, with total shipments of resources valued at US\$ 759 billion.

Figure 9: Shares of product groups in world merchandise trade since 1900 (Percentage)



Table 5: Natural resources exports by region, 2008^a (Billion dollars and percentage)

	Value	Share in total merchandise exports
World	3855.4	25
Middle East	758.7	74
Africa	406.0	73
Commonwealth of Independent States (CIS)	489.7	70
South and Central America	281.3	47
North America	397.8	20
Asia	630.4	14
Europe	891.5	14

^a This table uses the broad definition of natural resources to include all agricultural raw materials rather than just forestry products. As a result, the world total is slightly larger than the US\$ 3734.2 shown in Appendix Table 1.

Source: WTO Secretariat estimates.

The total value of Africa's exports of natural resources was just under US\$ 406 billion, representing 73 per cent of the continent's exports. Resource exports from CIS countries were worth US\$ 490 billion, equal to 70 per cent of total merchandise exports. Europe had the smallest share of resources in total exports at 14 per cent, although the value of this trade was greater than any other region at nearly US\$ 892 billion. Asia's share of resources in exports was relatively low, at just over 14 per cent, but the total value of resource exports was the second largest of any region at nearly US\$ 630 billion. South and Central America exported natural resources worth US\$ 281 billion, or nearly half of the region's total exports. In general, more industrialized regions have smaller shares of resources in exports than less industrialized regions.

Regions that predominantly export natural resources tend to ship these goods to other regions, whereas

regions that produce more manufactured goods have much higher intra-regional shares in natural resources trade (see Figure 10). For example, 82 per cent of Europe's exports of natural resources were shipped to other European countries. Similarly, 78 per cent of Asia's exports were intra-regional, as were 62 per cent of North America's exports. On the other hand, the intra-regional shares for the Middle East, Africa and the CIS were 2.3 per cent, 5.3 per cent and 11.8 per cent, respectively. The intra-regional share of South America was higher than those of other resource exporting regions at 22 per cent, but this is still well below the levels recorded by industrialized regions.

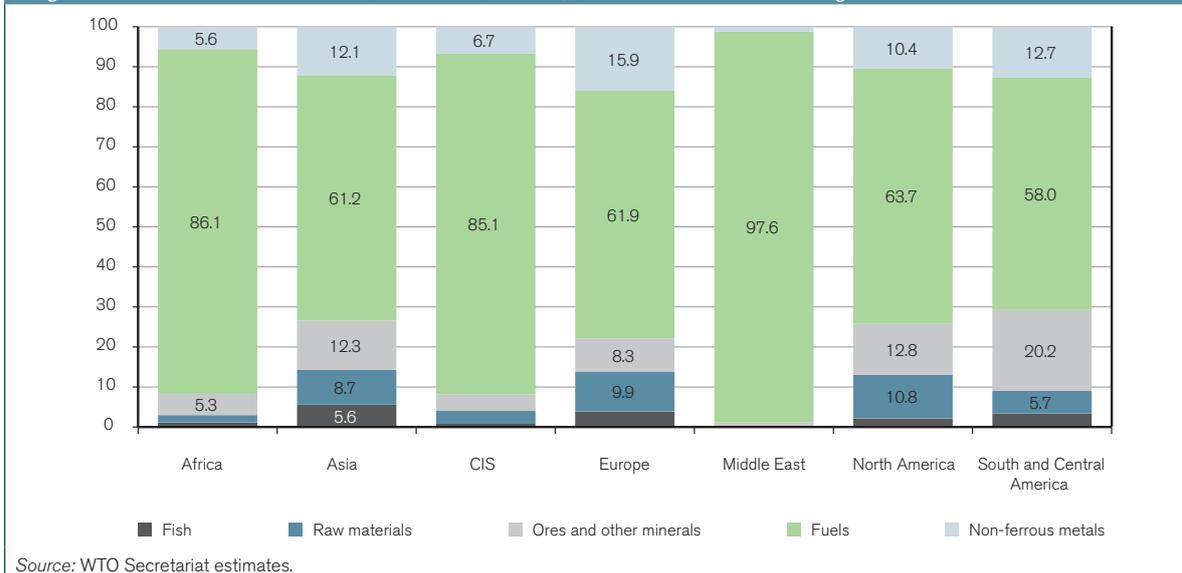
Fuels were the largest component of natural resource exports for all regions in 2008 (see Figure 11). Resource exports from the Middle East were almost entirely composed of fuels, with a 98 per cent share in resource exports. South and Central America had the smallest

Figure 10: Natural resources exports of regions by destination, 2008 (Percentage)



Source: WTO Secretariat estimates.

Figure 11: Natural resources exports of regions by product, 2008 (Percentage)



Source: WTO Secretariat estimates.

share of fuels in natural resource exports (58 per cent) due to significant exports of ores and other minerals (20 per cent) and non-ferrous metals (12 per cent). Shares of fuels in natural resources trade for Asia, Europe and North America were all between 61 per cent and 64 per cent. North America had the largest share of raw materials in its exports, at 10.8 per cent, followed by Europe at 9.9 per cent and Asia at 8.7 per cent.

(c) Leading exporters and importers of natural resources

Appendix Tables 2 and 3 show the top 15 exporters and importers of natural resources, both including and excluding the member states of the European Union. The largest exporter of natural resources in 2008 (including EU members) was Russia, with exports of US\$ 341.2 billion or 9.1 per cent of world natural resources trade. The share of natural resources in Russia's merchandise exports rose to 72.9 per cent in 2008 as the value of resource exports jumped 34 per cent year-on-year. Russia was followed by Saudi Arabia (exports of US\$ 282 billion, or 7.6 per cent of world trade), Canada (US\$ 177.7 billion or 4.8 per cent), the United States (US\$ 142.5 billion or 3.8 per cent), Norway (US\$ 130.6 billion or 3.5 per cent) and Australia (US\$ 114.3 billion or 3.1 per cent).

The leading importer of natural resources in 2008 (also including EU members) was the United States. The country's resource imports were worth US\$ 583.4 billion, or 15.2 per cent of world natural resources trade. US imports of natural resources increased 27.9 per cent in 2008 while the share of natural resources in total imports rose to 27 per cent, mostly due to higher oil prices. Other leading importing countries include Japan (imports of US\$ 350.2 billion or 9.1 per cent of world trade), China (US\$ 330.3 billion or 8.6 per cent), Germany (US\$ 231.5 billion or 6.0 per cent), Republic of Korea (US\$ 182 billion or 4.7 per cent), France (US\$ 148.5 billion or 3.9 per cent) and India (US\$ 135.4 billion or 3.5 per cent).

If we consider the European Union as a single trader, it ranks fourth in world exports of natural resources after Russia, Saudi Arabia and Canada. The European Union exported US\$ 176.6 billion worth of natural resources to the rest of the world in 2008 and imported US\$ 766.6 billion, making it the largest single market for natural resources, with a share in world imports (excluding trade within the EU) of nearly 23 per cent. Tables on leading exporters and importers by product are also provided in the Appendix.

Appendix Table 12 shows imports of resources by region and supplier for some of the world's largest economies (the European Union, the United States, Japan and China.) It should be noted that the figures for the European Union include trade within the EU: in 2008, nearly 37 per cent of EU imports originated from within the trading bloc. EU imports overall totalled US\$ 1.1 trillion for the year. The top five suppliers of resources to the EU were Russia (16 per cent), Norway

(8 per cent), Libya (4 per cent) and the United States (2 per cent). Most of the European Union's imports of natural resources come from Europe, the Commonwealth of Independent States and Africa, which together made up almost 80 per cent of resource imports in 2008.

Total US imports of natural resources in 2008 were valued at US\$ 583 billion. The country's top five suppliers of resources were Canada (24 per cent), Saudi Arabia (10 per cent), the Bolivarian Republic of Venezuela (9 per cent), Mexico (8 per cent) and the European Union (7 per cent). Japan's imports for the year came to US\$ 350 billion, and its leading suppliers were Saudi Arabia (14 per cent), the United Arab Emirates (13 per cent) Australia (12 per cent), Qatar (8 per cent) and Indonesia (7 per cent). China imported US\$ 331 billion worth of natural resources from other countries in 2008. Top suppliers include Australia (10 per cent), Saudi Arabia (8 per cent), Angola (7 per cent), Russia (6 per cent) and Brazil (6 per cent).

3. Modes of natural resources trade

Many natural resources are fairly homogeneous and may be classified as "commodities". Unlike the many varieties of manufactured products – automobiles, for example – they are suited to centralized trading and the formation of a unified price. In addition, characteristics, such as the uneven geographical distribution of natural resources around the world, and the consequent accumulation of market power, has triggered the evolution of alternative modes of trade that reduce market risks, such as disruptions in the supply of critical natural resource inputs. It is important to keep in mind these particular modes of natural resources trade when considering the consequences that some of the key features of natural resources, such as volatility, may have for trade and trade policy.

This sub-section first describes the role of centralized spot and futures markets in commodities trade, notably in the context of organized exchanges. It also provides an account of the evolution of these exchanges, describes their geographical distribution, and highlights their principal functions. These include price discovery, liquidity, management of risk, financial intermediation and clearing house guarantees. Second, we analyze alternative arrangements for trade in commodities that may be important for strategic reasons or quality control. These include bilateral long-term contracts, which are relevant for certain energy and metal commodities. We also explore the prevalence of vertical integration in some natural resource sectors.

(a) Commodity exchanges

(i) Key definitions

A commodity is typically defined as a homogeneous product which can be exchanged among consumers and producers. The term "commodities" is often used in the relevant literature to refer to agricultural goods, but it also

includes a number of other products that are classified as natural resources in this report. Examples are fuels, forestry products, minerals and metals. Given their mostly homogeneous nature and the fact that their quality can usually be easily verified, trade in commodities is facilitated by organized market places where trade is centralized (UNCTAD, 2006). A concentration of buyers and sellers in one place reduces the transactions costs that would be incurred in the search for a suitable counterparty (Thompson and Kunda, 2000).

Trades in organized commodity exchanges are carried out either electronically or verbally in a trading pit between buyers and sellers who are anonymous to each other (Stroupe, 2006). Trades are carried out both "on the spot" and via "futures" contracts, usually on a daily basis. In "spot" markets, physical delivery to the importing nation, via tankers or pipelines, is immediately arranged (Neuhoff and von Hirschhausen, 2005). Commodity producers, marketers, trading companies, local distribution companies and consumers are the major participants in these markets.

In "futures" markets, contracts represent a commitment to buy or sell a given quantity of an underlying product on a given date in the future at a price agreed upon now (Valdez, 2007).⁴ This enables market participants to "hedge" or eliminate price uncertainty. For example, a gas distributor may purchase a futures contract to set a price cap on the gas it buys in some future period. Futures contracts dating anything between a few months and several years are traded. Most often, these contracts are settled in cash and do not result in physical delivery of the underlying commodity as the existing position of a trader is negated with the polar-opposite contract and his or her account is closed (Smith, 2009). In futures trading, others in the market besides those involved in the commodity business include hedge funds, banks and commodity index funds. These "non-traditional" investors use commodity markets to diversify their total investment portfolio. Their possible contribution to increased commodity price volatility has given rise to controversy (see Section C.5).

(ii) Evolution

The evolution of modern commodity markets may be traced back to the beginning of agricultural mechanization and the industrial revolution in present-day advanced countries. At the time, trade in agricultural crops was a hit-or-miss proposition. In the United States, for example, farmers went to Chicago to sell their goods because of its central location. However, having little idea of crop demand, farmers took whatever price they could get and unsold crops went to waste in the streets. In the mid-19th century, a central grain commodities market, which allowed farmers to sell their crops directly and on the spot for cash, was created. This market, named the Chicago Board of Trade, is the oldest organized commodity exchange in the world (Nathan, 2008). It reduced transactions costs and enabled buyers and sellers to find a ready market.

Subsequently, forward delivery also became an option. Over time, these forward contracts evolved as more farmers began committing their grains to future exchanges for cash. For example, if a producer no longer needed the commodity, he or she would sell it to another producer who did. This dynamic, coupled with the uncertainty of price change over time, led to the rise of futures contracts (UNCTAD, 2001).

(iii) Geographical distribution

The old exchanges are located mainly in the United States (Chicago Board of Trade, Chicago Mercantile Exchange, New York Mercantile Exchange (NYMEX)), the United Kingdom (London Metal Exchange, International Petroleum Exchange) and Japan (Tokyo Commodity Exchange). The 1980s and 1990s saw a proliferation of commodity exchanges in emerging economies such as the Dalian Commodity Exchange, the Zhengzhou Commodity Exchange, and the Shanghai Futures Exchange in China, and various exchanges in East Asia (for example, in Kuala Lumpur, now part of Bursa Malaysia Derivatives), in Latin America (for example, Bolsa de Mercadorias & Futuros in Brazil and Bolsa de Cereales in Argentina) and in Eastern Europe (UNCTAD, 2006).

The 21st century is seeing the onset of a third wave in the evolution of commodity exchanges, driven primarily by developments in information technology. Examples include the National Multi-Commodity Exchange of India, established in 2002, the Dubai Gold and Commodity Exchange (2004) and the Dubai Mercantile Exchange (2005). Africa has seen the least success in developing its commodity exchanges, with the South African Futures Exchange (SAFEX), established in 1987, being the only major commodity exchange (UNCTAD, 2006).

Despite the development of organized commodity exchanges in different parts of the world, there is still a high degree of market concentration with the bulk of commodity trading occurring in just four countries, namely the United States, the United Kingdom, Japan and China. In fact, the top 11 commodity exchanges, in terms of market turnover, are located in one or other of these four countries (Lewis, 2005). Moreover, these exchanges are dominated by certain commodity groups. For instance, in the United States, energy and agricultural futures constitute the lion's share of turnover. In the United Kingdom, commodity trading is highly skewed towards the metals sector. In Japan the focus is on energy commodities and precious metals, and in China trading is dominated by agricultural commodities (Lewis, 2005).

(iv) Key functions

Price discovery

Organized commodity exchanges form natural reference points for determining market prices – the price discovery process – because they enable market supply

and demand forces to determine spot and futures prices. Exchange trading may bring about greater volatility in commodity prices. At the same time, by enabling effective competition (Thompson and Kunda, 2000), it may also result in lower prices, relative to those negotiated by parties in a bilateral contract.

Liquidity

Organized exchanges have facilitated the creation of a common global pool into which nearly all exporters sell their commodities and out of which nearly all importers purchase commodities, on a daily basis (Stroupe, 2006). Hence, they provide more liquidity, as disruptions in supply from one producer country may be offset by alternative supplies from elsewhere. This function of organized exchanges may have implications for price volatility, a key feature of resource commodities, which is analyzed in Section C.5.

Insurance against risk

An important function of futures markets is to allow suppliers and customers to hedge their future requirements for buying and selling commodities at a future contract price. By locking in the price for future delivery, market participants can hedge against unfavourable price movements that may occur before the delivery date (Valdez, 2007). For instance, if a future price rise can cause a loss to the prospective buyer of a commodity, the purchase of a futures contract ensures that the buyer can lock in the price at the current level. In this case, the market is used as an insurance mechanism. Futures contracts may also be bought and sold for speculative reasons, or in other words for profit (or loss) by betting against future price movements.

Clearing house feature

Every organized trading exchange operates with a clearing house, which takes initial margins or deposits from both parties of a contract. Subsequently, if the contract moves into loss, extra margin is debited on a daily basis from the relevant party in order to restore the amount of the initial margin available (Valdez, 2007). Hence, clearing houses provide financial intermediation services to major players in commodity markets and, if sufficiently well-capitalized, minimize risk of contemporary default. They also manage risk associated with exchange transactions by being a central counterparty to all exchange needs – that is, the buyer to every seller and the seller to every buyer (Valdez, 2007). Furthermore, clearing houses protect the integrity of the marketplace by ensuring that trades are executed in accordance with the rules (Neuhoff and von Hirschhausen, 2005)⁵ and guaranteeing that contracts are honoured (Valdez, 2007).

(b) Other trading arrangements

Besides organized exchanges, commodities are traded via spot and futures contracts in over-the-counter (OTC) markets. For certain commodities, bilateral trades are

important, notably taking the form of long-term supply contracts between countries. Finally, commodities may also be traded in the context of vertically integrated supply chains.

(i) Over-the-counter (OTC) markets

OTC trade is not conducted through a common trading facility, but directly between two parties, which in the case of commodity markets include both traditional (producers and consumers) and non-traditional (index funds and hedge funds) participants. Unlike organized exchanges, OTC markets are characterized by a lack of liquidity, the absence of competition and no protection against default. In addition, they are largely unregulated (Valdez, 2007). Although OTC markets are fundamentally bilateral trading arrangements, the negotiation process is often highly automated with dealers being interconnected among themselves as well as with major customers. This enables traders to survey the market almost instantaneously (Dodd, 2002).

(ii) Long-term contracts

Until the early 1970s, trade in energy commodities such as oil and natural gas, and in metals, such as copper, aluminium and iron ore was conducted primarily through long-term contracts between producer and consumer countries, mostly via state or multinational companies (Stroupe, 2006). These long-term take-or-pay contracts (ToP) join sellers and buyers in a bilateral contract, typically for about 15 to 20 years, during which time both have strictly defined obligations. In particular, these contracts require buyers to pay for a pre-specified minimum quantity of the commodity whether or not it is actually taken. At the same time, in most cases, some form of price indexation is used to protect the buyer against price changes on a long-term basis (Masten, 1988). Hence, the buyer bears the volume risk and the seller bears the price risk. Furthermore, under this system, if one exporting state fails to honour its delivery commitments to another, then the affected consumer state has to acquire replacement supplies (Stroupe, 2006). These arrangements are generally associated with limited market liquidity and significant difficulties can result from supply disruptions. Long-term contracts with price indexation can also have implications for price volatility.

A number of factors may explain the use of long-term contracts. First, several of the sectors involved are characterized by non-competitive producer structures (Golombek et al., 1987). Second, because of their strategic nature, the value of these commodities in long-term contracts may far exceed the sale price in a more competitive market (Parsons, 1989). Third, long-term contracts in commodities trade may function as a device to avoid the risks of opportunistic behaviour when there are high sunk investments (Klein et al., 1978; Williamson, 1983). Fourth, from the perspective of an importing country, long-term contracts are likely to increase the security of supply. Fifth, from the point of view of the exporting country, long-term contracts may serve as a barrier to entry for new market participants. Finally, a

preference for long-term contracts over exchange trading may relate to the nature of transport infrastructure. For example, the existence of a pipeline⁶ between two countries may favour long-term contracts, while the availability of tankers that can reach anywhere in the world may encourage trading through exchanges.

Over time, bilateral long-term supply contracts negotiated between exporting and importing states have been complemented and sometimes replaced by trading on organized exchanges. This was true for the United States, the United Kingdom and Western Europe in general.⁷ It has been argued that more exchange trading at the expense of long-term contracts may lead to a paucity of long-term information about future production capabilities, and provide an incentive for suppliers to overstate future production capacity in order to ensure high demand and less investment by competitors (Neuhoff and von Hirschhausen, 2005). Box 2 provides an account of this transition in the market for crude oil.

However, bilateral long-term supply contracts for certain natural resource products (energy products, metals and minerals) still exist, involving for instance, Russia or countries in Asia and Africa (Alden, 2009; Stroupe 2006; Energy Report, 2009). The signatories to these contracts are governments of resource-abundant countries and private investors or firms from abroad. Host country governments grant licences to these firms for exploration and extraction, and specify the accompanying fiscal regime. Contracts typically take the form of an initial payment for the licence and, subsequently, a royalty or tax on corporate profits (Collier and Venables, 2009).⁸ Of late, some of these bilateral long-term supply contracts have been characterized by pre-specified exchanges akin to barter arrangements. For example, the China International Fund is financing infrastructure investments worth US\$ 7 billion in Guinea in exchange for access to its natural resources such as bauxite (Alden, 2009).

Even more recently, there has been an increase in large-scale acquisitions of farmland (a natural resource) in Africa, Latin America, and Central and South-East Asia

via contracts between host country governments and private firms, sovereign wealth funds and state-owned enterprises from abroad. This is driven by the lack of arable land and competing uses for agricultural land in the countries making the purchases (Cotula et al., 2009).

(iii) Vertical integration

Supply chains may involve several production stages in certain natural resource sectors. For instance, in the case of energy commodities (oil and natural gas), minerals and metals, they include exploration, extraction, processing or refining, distribution and marketing. Hence, producers sell and convey their output to refiners or processing units. Subsequently, refiners sell their products to wholesale and retail marketers, who in turn sell these products to final consumers (Smith, 2009).

Each stage in the supply chain may be located in a different region of the world, on the basis of comparative advantage (WTO, 2008) (see Section C.1). Hence, firms can lower costs of production by locating different stages of the production process in a country where there is a relative abundance of inputs used relatively more intensively in that stage of production (Jones and Kierkowski, 2001). Firms can carry out this process in one of two ways: vertical integration of various stages of the production process within a single firm or arm's-length contracts between separate, independent firms. The rationale for choosing between the two is also based on comparative advantage (Coase, 1954). For vertical integration to make economic sense, internal suppliers must be more cost-efficient than external suppliers.

In addition to the more general efficiency argument, trade in natural resource commodities may take place within firms for several reasons. First, vertical integration reduces risk as profits in the different stages of the supply chain tend to fluctuate in different ways. For example, in the case of oil, when crude prices are low, refining and marketing margins are likely to be higher (Al-Moneef, 1998). This is especially relevant for resource commodities that are characterized by high

Box 2: The evolution of the market for crude oil trade from long-term contracts to exchange trading

Prior to the early 1970s, crude oil markets were characterized by bilateral long-term supply contracts (with a duration of 10 or 20 years, or more) between exporting and importing countries, usually through multinational oil companies. Eight big oil companies were the "common suppliers" and dominated crude oil trade. They sold large quantities of oil not needed for their own operations to other integrated oil companies, independent refiners and traders to balance out world markets (Mohnfeld, 1980). However, the strengthening of OPEC and the Arab-Israeli war of 1973 led to a wave of nationalization in a group of oil exporting nations. This, in turn, facilitated a targeted embargo of the United States and a dramatic increase in crude oil prices.

Following a brief period of strict price controls, the United States administration initiated a process of deregulation. Oil spot and futures markets were created, and the New York Mercantile Exchange (NYMEX) became the first central oil trading exchange. Over the years, a proliferation of many such organized exchanges have facilitated the creation of a global pool of oil, denominated in US dollars. At the same time, Russia and its producing and consuming partners continue to trade oil through bilateral long-term supply contracts. In addition, there is a trend towards the establishment of new oil exchanges in the Middle East and Asia as rivals to the New York and London exchanges. These more recently established exchanges may denominate trade in currencies other than US dollars (Stroupe, 2006).

Box 3: Chevron – A case of vertical integration

Chevron has extensive oil and gas exploration and production operations throughout the world.¹⁰ It is the largest private producer of oil in Kazakhstan, the top oil and gas producer in Thailand, the largest holder of undeveloped natural gas resources in Australia, among the largest holders of deepwater acreage in Nigeria, and it holds leases in the deepwater of the Gulf of Mexico. Furthermore, Chevron works in all segments of the downstream industry – manufacturing, marketing and transportation. The company's refining resources are concentrated in North America, Western Europe, South Africa and the Asia-Pacific rim, serving customers around the world. Chevron markets refined products primarily under three brands: Chevron, Texaco and Caltex. Under transportation, Chevron Pipe Line Co. transports crude oil, natural gas, natural gas liquid, CO₂, petrochemicals and refined products in the United States through an extensive system of pipelines and storage facilities. In addition, Chevron Shipping Co. manages a worldwide fleet of vessels that transport retail products.

price volatility. Second, as opposed to arm's-length trade, vertical integration ensures access to resources or security of supply (Al-Moneef, 1998).

Third, to sell an intermediate good to a particular downstream firm, an upstream supplier may make a location or site-specific costly investment upfront, in order to minimize inventory and transportation costs. Extraction or processing plants for mining products are good examples in this context (Joskow, 2005). Fourth, a shift from spot market exchange to vertical integration may also be attributable to the fact that producers wish to control their supply chains more tightly to satisfy consumer demand for quality and safety (Ménard and Klein, 2004). In the oil and gas sector, for instance, many drilling companies are broadening their functions to include reservoir development and resource management functions.⁹ Box 3 provides a brief account of Chevron, which is a vertically integrated oil and gas company with different segments located in different parts of the world.

To summarize, the above discussion has shown that the way in which natural resources are traded may differ from manufactured goods transactions on account of certain specific features. These include the homogeneity, storability, the uneven distribution of supplies and the strategic importance of many natural resources. In light of declining transport costs and the move towards more liberalized markets, a large part of natural resources trade is now conducted at a global level, often via organized commodity exchanges. At the same time, certain commodity markets continue to be characterized by widespread government intervention and market power. The reasons for this may be both economic and non-economic, ranging from industrial development considerations to geopolitical factors.

4. Natural resources: Globalization and the intellectual debate

(a) Globalization of natural resources

Over the past two centuries – and especially over recent decades – there has been a dramatic expansion of the volume and range of natural resources traded internationally. At one time only the most valuable resources were shipped to distant markets. Today vast quantities of almost every raw material imaginable are

traded around the planet – fuelling the rapid spread of industrialization and development that is defining the modern economic era. Although a number of factors have contributed to the “globalization” of natural resources – including population growth, colonization, industrialization, and the rise of developing countries – the following section looks at two key developments that have underpinned this process: first, the far-reaching improvements in transport technology since the mid-19th century which have dramatically reduced the costs of commodities trade; and second, the trend towards more liberal natural resource markets, especially since the 1980s, which have opened up an increasingly global marketplace for natural resources.

(i) *Shrinking distances*

The rise of a world market for natural resources is a relatively recent phenomenon. For most of human history, bulk raw materials were too costly to transport over great distances, which effectively tied economic production to the location of key natural resources, such as wood, coal or iron ore. A major factor in breaking down these constraints is what Nils-Gustav Lundgren describes as three “revolutions” in transport technology (Lundgren, 1996). The first such revolution occurred roughly between the 16th and 18th centuries with a series of incremental improvements to sailing ship design and efficiency. Although high costs still made it too expensive to ship all but the most expensive commodities, such as coffee, cocoa, spices and precious metals, across the oceans, sail transport gradually linked the coastal areas of North and South America, Africa and Asia with Europe, creating for the first time the broad outlines of a “world economy”.

A second transport revolution occurred in the mid-19th century when the introduction of steam power to land and sea transportation transformed the economics of moving low-value goods cheaply across great distances. As railways replaced overland transport by horses, and as metal steamships took the place of wooden sailing vessels, a wide range of primary commodities, particularly agricultural products, in North America, South America, Africa and Asia were suddenly economically accessible to the world's industrial centres. This, in turn, greatly expanded the incentive to engage in overseas trade, exploration and investment and significantly widened the scope for industrial expansion. Transatlantic transport costs fell roughly

60 per cent in the decades between the 1870s and the beginning of the 20th century, transforming agricultural trade as North American and Eastern European grain suddenly become competitive in European markets, and accelerating the process of industrial specialization (Lundgren, 1996).

A third revolution in transport technology occurred after the 1950s with the dramatic increase in the average size of merchant ships. The closure of the Suez Canal in 1956-57 (and again in 1965) played a major part in launching this process. Suddenly faced with the expense of transporting oil, coal, iron ore and other bulk commodities over much greater distances, the shipping industry decided to invest in huge, specialized bulk carriers, as well as in the harbour facilities needed to handle these new vessels. Whereas oil tankers averaged 16,000 deadweight tonnes (dwt) in the early 1950s (their design partly constrained by the need to navigate the Suez Canal), they averaged over 100,000 dwts by the 1990s – with modern “super-takers” exceeding 500,000 dwts and capable of carrying over 3 million barrels of oil. The same technological advances have transformed bulk freighters, with ships growing from an average of less than 20,000 dwts in 1960 to about 45,000 dwts in the early 1990s.

Just as the advent of steam transport dramatically reduced the cost of agricultural trade after the mid-1800s, new transport design technology has dramatically reduced the costs of shipping a vast range of low-value bulk commodities in the post-war period. Freight rates decreased by 65 per cent in the period between the 1950s and 1990s, while bulk commodity trade grew from about 500 million tonnes to 3,977 million tonnes – a 657 per cent increase.¹¹ Overall the cost of transporting natural resources has fallen an astonishing 90 per cent between 1870 and 1990. This, in turn, has massively expanded the volume of raw materials traded, the distances covered, and the commodities involved. Almost every conceivable bulk commodity – from iron ore and phosphate fertilizers, to crude oil and natural gas – is now routinely shipped vast distances across land and oceans. Even resource waste – such as metal scrap, mining tailings, or rejects from forestry and agriculture – is increasingly traded globally.

(ii) More open markets

A second major factor influencing global trade in natural resources has been the ebb and flow of government intervention in national and international commodity markets. While it is difficult to generalize, the extent and type of government intervention in resource markets has appeared to depend not simply on ideological views and trends, but on the relative abundance or scarcity of natural resources on world markets.

Certain interventions, such as international commodity agreements, have been devised to deal with problems of global surpluses and price volatility. Others, such as export restrictions, have been shaped by resource scarcity, the strategic competition among countries for

critical raw materials and the quest for economic diversification. If the general trend towards more open markets in recent decades has been driven in part by the relative abundance and price declines of many commodities, it remains an open question whether recent commodity price increases and signs of growing scarcity, especially for strategic raw materials, will give rise to greater government involvement and intervention in resource markets in the future.

An era of relatively free trade in natural resources during the 19th century came to an end in the first half of the 20th century. With the outbreak of the First World War and the effort to cut off enemy supplies, countries became increasingly concerned with securing access to strategic sources of food, fuels and raw materials needed to feed their populations and to supply their armies. The dramatic collapse in prices for many commodities after the war but especially during the Great Depression of the 1930s also led governments around the world to intervene in markets to assist farmers and miners. This trend continued through the Second World War and the beginning of the Cold War in the late 1940s, as governments again took action to secure access to raw materials, both at home and overseas, for strategic and security reasons.

The break-up of pre-war empires, and the resulting process of decolonization in the 1950s and 1960s, precipitated a new wave of government intervention in natural resource markets, as newly independent countries in Africa and Asia sought to gain control of mineral and energy sectors which had previously been in foreign hands. Underpinning many of the interventions during this period was a pervasive faith in the ability of governments and state planning to correct perceived failures in market systems (Skidelsky, 1996).

The various interventions over this period were diverse, wide-ranging and complex. A number of countries, in both the developed and developing world, imposed export tariffs or restrictions on wheat, sugar, rubber, tin and other commodities in an effort to control international supplies and bolster prices. From the 1920s to the 1980s a number of attempts were made – with varying degrees of success – to negotiate international commodity agreements between exporting and importing countries for key commodities, such as coffee, rubber or tin, to manage international supply and trade flows. One reason why these efforts often failed was because consumers were interested in reducing price volatility, while producers wanted to increase prices. For strategic and economic reasons, a number of countries also imposed export restrictions or domestic price controls on key commodities, such as oil. Concerns about growing reliance on foreign suppliers also encouraged some countries to amass strategic stockpiles of oil, tin and other key resources.

Another mechanism for influencing global commodity markets was foreign aid – either in the form of guarantees by importing countries to buy pre-determined quantities of a given commodity, or in the form of food aid or other types of aid, whereby exporting

countries effectively shifted their commodity surpluses on to poorer developing countries (Radetzki, 2008).

However, the trend towards government intervention in natural resource markets – and indeed in economies in general – had started to recede by the 1980s for a variety of reasons. One was the ideological shift away from state planning and controls towards market mechanisms to achieve economic growth.

With the partial exception of the energy sector, commodity markets have witnessed a general trend towards greater openness. Successive rounds of multilateral trade negotiations have resulted in low average tariff levels on most trade in raw materials. International commodity agreements have also declined in number and importance, and greater emphasis has been placed on hedging on commodity exchanges to help stabilize prices. Government-controlled strategic stockpiles have also fallen out of favour. Now largely limited to petroleum, they are a small fraction of what they were several decades earlier. Ideology is not the only explanation for this change. A long-term trend towards falling international prices across many commodities, combined with declining strategic concerns in the post-Cold War era, has reinforced this general shift away from state ownership and control and towards market mechanisms to bolster investment, improve efficiency and secure greater price stability.

While the retreat of governments from active intervention in natural resource markets has been significant, it is hardly universal or even necessarily permanent. The most obvious exceptions relate to agricultural commodities where developed-country tariffs, subsidies and regulations continue to significantly distort global trade. The energy sector represents another obvious example of state intervention in international commodity markets. Not only among OPEC members, but among other energy-producing states, governments remain the dominant players in the oil and gas industry, not only owning and managing the main assets, but actively shaping global markets through controls on output and investment (Institute of International Economics, 2004). Recent efforts by some countries to strengthen their grip over domestic natural resources or to limit supplies on world markets – especially of oil and gas – may foreshadow a new wave of state involvement in natural resource markets, especially as current high prices and profits increase the incentives to do so (Radetzki, 2008).

(iii) Summary

The on-going “globalization” of natural resources trade continues to transform not only the nature of commodity markets but also the structure of the global economy (Krugman, 1991). The huge expansion in the volume and range of natural resources on world markets in recent decades has helped to open up and equalize access to raw materials, lowering prices for many resources, encouraging investment in new, geographically dispersed sources, and generally

contributing to global economic expansion. Proximity of natural resources, such as coal or iron ore, is also much less significant to industrial production today than it was a century ago, gradually de-coupling industrial development from natural resource endowments, freeing up industries to establish themselves in the most cost-efficient locations around the world, and accelerating the trend towards international specialization (Radetzki, 2008; Sachs and Warner, 1995). At the same time, the expansion of natural resources trade – and its contribution to growing global consumption – may have implications for resource depletion and negative environmental spillovers.

(b) The intellectual debate: scarcity or surplus?

For over two centuries, a wide-ranging intellectual debate has taken place about the impact of economic growth on the earth's limited natural resources. Some have argued that unrestrained economic growth will lead inevitably to resource depletion and environmental degradation. Others have contended that economic growth and technological progress can help to manage scarce resources and develop alternatives. A central point of disagreement is whether markets, as presently structured, are equipped to deal with these pressures. Present-day concerns about the relationship between globalization, resource scarcity and environmental issues (such as climate change) have given a new sense of immediacy and relevance to these long-standing debates.

(i) *Free-market optimism*

Adam Smith was the first economist to systematize the argument for the central role of free markets in allocating resources, including natural resources, efficiently and productively. In his *Wealth of Nations*, he famously argued that the pursuit of self interest within a free marketplace was the key to economic growth and social improvement – “as if by an invisible hand”.¹²

Building on the ideas of the French physiocrats, Smith rejected the prevailing mercantilist belief that a nation's wealth is fixed, so countries should try to part with as little of it – and to hoard as much of it – as possible. Instead, he argued that wealth is created by productive work, the division of labour and international trade. In particular, he shared the physiocrats' view that the productivity of land (often synonymous with natural resources in his writing) and the expansion of agricultural output were central to prosperity – thus allowing a greater proportion of the population to earn its living from manufacturing.¹³ The problem was not a shortage of land, but rather a shortage of investment in land productivity. This, in turn, often reflected problems of government interference in markets and resulting disincentives to entrepreneurship.

Although his work did not focus explicitly on concerns about resource depletion or the limits of economic growth, Smith was essentially optimistic about

mankind's ability to prosper within the context of existing resource endowments – a view reinforced by his day-to-day observations about how the world around him was being transformed by dramatic advances in manufacturing, agriculture and mining (Kula, 1998). His faith in individual efforts and ingenuity, and in the power of the market's "invisible hand" to allocate resources efficiently, had a decisive impact on future thinking about resource management, and remains highly influential to this day.

(ii) *Malthusian pessimism*

The ideas of Thomas Malthus ran directly contrary to Smith's belief in the market's ability to help resolve the tension between growing human consumption and the earth's finite resources – and indeed against the broader Enlightenment faith in an improving and perfectable society. Malthus saw the idea of endless progress as not only naïve, but dangerous because of the inexorable pressures of population growth and the planet's limited capacity to support it. In his *Essay on the Principle of Population*, he argued that the impact of growing population on a fixed supply of land and other resources would result in starvation. Economic growth, international trade and social improvement were no solution because they would only lead to further, unsustainable population growth. This would, in turn, be checked by widespread famine, disease and death.¹⁴ Malthus believed there was a long-term tendency for the living standards of the mass of people to be driven down to a subsistence level – a level at which the population could only reproduce itself, not expand, and the economy would attain a steady state, with a constant population size and with constant, subsistence-level living standards (Perman et al., 1996).

Malthus's pessimism about the ability of economic growth to transcend the planet's natural limitations was as influential in its day – and indeed beyond – as was Smith's optimism. For example, David Ricardo shared his belief that diminishing natural resources as a result of expanding economic activity would eventually halt both population and economic growth. Although agricultural output could be expanded by exploiting existing land more intensively or by bringing new land into cultivation, Ricardo argued that the returns to increased inputs would steadily diminish, resulting in stagnant growth and living standards (Ricardo, 1817).

Like other classical economists, John Stuart Mill believed that economic development was destined to reach an eventual equilibrium or steady state. His contribution to the debate was to question the desirability, not simply the feasibility, of limitless economic growth (Mill, 1848). Writing at a time when output per person was rising, not falling, Mill accepted that technological innovation, the discovery of new sources of raw materials, and the application of fossil fuels to production processes were playing an important role in overcoming diminishing returns from natural resource constraints. However, Mill adopted a broader conception of the role of natural resources in the economy. Foreshadowing later thinking on conservation, he argued that the quality of the natural

environment not only shaped productivity, but the general living standards and conditions of present as well as future generations. According to Mill, the problem was not economic growth in the developed world – where material progress was already reaching its apogee – but its distribution and impacts (Perman et al., 1996).

Karl Marx, almost more than any previous economist, recognized the transformational power of capitalism and technology's ability to overcome resource constraints – although he shared the classical tradition's basic assumption that economic progress would reach an eventual end or steady state. He argued that the immiserization of the working class was the result not of population pressures on fixed natural resources, but rather of the theft of surplus labour and value by the capitalist class (Marx, 1867). Marx agreed that a crisis in capitalism was inevitable. However, whereas Malthus and Ricardo thought the crisis would result from diminishing returns in the face of a growing population, Marx argued that the crisis would flow from falling profits and the limited purchasing power of the impoverished masses (Kula, 1998).

(iii) *Neo-classical economists: Cautiously optimistic*

Not everyone shared the classical economists' pessimism about the limits of economic growth. Henry Carey, who became increasingly critical of classical political economy, believed in the possibility of steady economic progress and the potential for harmonizing diverse economic interests. In challenging the Malthus-Ricardo theory that economic expansion would lead inexorably to population growth, depleted resources and stagnating living standards, he noted that the history of agriculture and mining had been one of steadily increasing productivity over time, the result of capital accumulation and improved methods (Carey, 1840). Agricultural production had generally migrated from poorer to richer farmlands, a process aided by continuously improving agricultural and transportation technologies. A similar pattern was evident in the mining industry. Even as old mines were gradually exhausted, new and richer mines were constantly being developed, as a result of new investments, the application of new technologies and the discovery of fresh deposits.¹⁵

However, neo-classical economists also recognized the market's limitations in solving all of the problems associated with resource allocation and depletion – especially through their work on the exhaustion of resources and spillover effects. As early as the mid-1800s, Mill had recognized that mining was a different economic activity from farming or manufacturing, in the sense that it was a non-renewable resource that could eventually be exhausted (Perman et al., 1996). Extraction today meant a reduction in future profits; conversely, extraction tomorrow would involve a reduction in present profits. In his widely-read book *The Coal Question*, William Jevons built and expanded on this insight, drawing attention to the imminent

exhaustion of energy supplies and developing concepts of resource depletion that have recently been revisited in work on “peak oil”.

It was in *The Coal Question* that Jevons first outlined the so-called “Jevons Paradox” – i.e., that improving the efficiency of resource-use leads to an increase, rather than a decrease, in the consumption of that resource because of falling prices, eventually resulting in its depletion. Harold Hotelling offered a somewhat different and more optimistic perspective on the exhaustion of resources. In his seminal article, “The Economics of Exhaustible Resources”, he argued that rational speculators, anticipating future shortages of a non-renewable resource, will conserve or store that resource in expectation of rising future prices. These rising prices generated by speculators’ decisions to put supplies aside will in turn reduce consumption and encourage the search for cheaper substitutes (Hotelling, 1931).

Alfred Marshall took a further step towards an economic analysis of resource depletion and environmental degradation by highlighting the problem of unintended spillovers or “externalities” – i.e., the costs or benefits conferred on others that are not taken into account by the person taking the economic action. His student, Arthur Pigou expanded Marshall’s concept of externalities, and made the case for government intervention to correct for such market failures. The lack of market incentives to stop someone from creating a negative externality (such as pollution) or to encourage someone to create a positive externality (such as recycling) was why governments had a key role to play in natural resources and pollution management, typically by influencing private behaviour through taxes or subsidies (Pigou, 1929).

(iv) *Neo-Malthusians: Limits to growth*

Neo-Malthusian ideas were resurrected in a highly public way in 1972 with The Club of Rome’s publication, *The Limits to Growth*. Attempting to model the impact of a rapidly growing population and economic expansion on finite natural resource supplies, it predicted that existing trends could not continue indefinitely, and that “exponential growth would eventually lead to economic and environmental collapse” (Meadows et al., 1972). The study also appeared to claim that the world was already on the brink of running out of key resources (oil in 1975, gold in 1981, silver and mercury in 1985 and zinc in 1991) – a conclusion to which the 1973 oil crisis seemed to lend support. Similar conclusions were reached in a US multi-agency assessment of the earth’s future published in 1980 entitled *Global 2000*. This forecast that the world in 2000 would be “more crowded, more polluted, less stable ecologically, and more vulnerable to disruption than the world we live in now” and that “serious stresses involving population, resources, and environment [were] clearly visible ahead”.¹⁶

Even mainstream economists, such as John Kenneth Galbraith (1974) and Ezra Mishan (1967; and Potter and

Christy, 1962) questioned the ability of the planet’s resources to withstand the strains of modern society’s unrelenting and single-minded pursuit of economic growth.¹⁷ More recently, the focus of concern has expanded from dwindling supplies of natural resources to unsustainable consumption – and its adverse impact on the environment. Land, water and air pollution, species extinctions, and global warming all pointed to a future where unrestrained economic growth would outstrip the ecosystem’s ability to sustain it. Malthusianism had returned to the economics mainstream (Turner, 2008).

At the same time, a number of economists were arguing for the need to study economics within the wider context of natural systems. In 1966, Kenneth Boulding published a short but influential article entitled “The Economics of the Coming Spaceship Earth” in which he compared the planet to a small spaceship where all economic activity takes place within the context of ultimately exhaustible natural resources. He urged economists to shift their thinking away from the concept of an open economy with unlimited resources to a concept of a closed economy “without unlimited resources of anything, whether for extraction or for pollution, and in which, therefore, man must find his place in a cyclical ecological system” (Boulding, 1966).

Boulding argued that economics could only be constructively understood as a sub-system of a much broader natural system, and that to try to disaggregate economic theory from the natural world in which it operated risked environmental catastrophe. He is widely regarded as one of the founders of ecological or environmental economics, and subsequent work on sustainable development and “green accounting” (variously referred to as Natural Capitalism¹⁸ or Total Economic Value) often take as their starting point Boulding’s theories.

(v) *A resourceful earth*

A number of modern economists have criticized the assumptions, methods and conclusions of the Club of Rome. One criticism is that commodities have seemingly become more, not less, abundant on world markets over time.

In *The Resourceful Earth*, Julian Simon, one of the most prominent sceptics of the Club of Rome’s claims, pointed out that almost all commodities had experienced falling long-term prices over the previous century, which he argued was “prima facie evidence” of greater natural resources abundance, not increasing scarcity.¹⁹ Simon was not the first to make this observation. In the early 1960s, the claims about growing resource scarcity were tested by Potter and Christy (1962), and Barnett and Morse (1963), who analysed the long-term price trends across a range of natural resources. Assuming that rising prices would prove growing resource scarcity, their finding in fact revealed that, with one or two exceptions (such as timber), prices had followed a downward trend over the past century, implying that

natural resource supplies were becoming more plentiful, and that "technology could overcome increasing shortages of natural resources *ad infinitum*". At the same time, the researchers cautioned that a steady increase in the production of natural resources did not take into account the possible adverse effects on the environment of increased consumption.

More recently, William Nordhaus (1992) has levelled similar criticisms at the latest efforts to update the Club of Rome's projections, in the 1992 publication *Beyond the Limits*. While stressing that "our estimates are crude, the models are primitive, the future is uncertain and our ignorance is vast", he suggests that "environmental and resource constraints on economic growth should be only modest over the next half century" and that "it would take either a massive slowdown in productivity growth or a massive underestimate of the constraints to growth before the resource constraints would produce a decline in global living standards" (Nordhaus, 1992).

A more fundamental criticism was that the *Limits to Growth* theory failed to take into account mankind's capacity to innovate, adapt and harness technology to expand the use of natural resources or to find substitute products. As an economic law, diminishing returns holds only for a constant state of technology and not for a world in which methods and approaches are constantly improving. In the pessimists' models, noted Robert Solow (1986), population, capital and pollution always grow exponentially, but technology rarely does. Or as Nordhaus puts it, "for the past two centuries, technology has been the clear victor in the race with depletion and diminishing returns". Resource scarcity, far from being a problem, was the motor that encouraged investment in finding new resources, development of technologies to harness new, alternative resources, and improvement in efficiency so that resource consumption was reduced. As a result, supplies expanded, production grew more efficient, and costs declined.

(vi) Summary

The world of Adam Smith and Thomas Malthus was very different from our current one, but their concerns and insights remain highly relevant. Worries about peak oil, global warming and the many other resource and environmental challenges facing us today have reignited a two-centuries-long debate about whether continued economic development will save or destroy the planet.

It would seem that neither the pessimists nor the optimists offer a complete or satisfactory answer. What Malthus and his successors failed to take into account is an unfettered economy's adaptive power, and the extent to which technology and innovation have managed to overcome seemingly insurmountable resource and environmental constraints. Certainly the classical economists' assumption that an economy's potential (the "economic pie") is essentially fixed, that the challenge is merely to allocate resources (the "pieces of the pie") more efficiently, and that, because of resource limitations, economic growth and living standards will

sooner or later reach an equilibrium or plateau has so far been proved wrong. The planet's population is over seven times larger today than it was two centuries ago, and yet most people live lives that are longer, healthier and materially richer than those of all but the most privileged and wealthy in Adam Smith's day.

Despite the fact that today we use far larger quantities of minerals, metals and other raw materials than in the past – and despite repeated warnings of the imminent exhaustion of these materials – the market still provides viable supplies of most natural resources. What the pessimists also failed to see is that as income and educational levels improve, people tend to modify their behaviour, limiting the size of families, curtailing certain kinds of consumption, and investing more income in preserving natural resources and protecting the environment.

However, what Adam Smith and his successors often underestimated is the scope for market failure – and, indeed, the extent to which existing markets are undeveloped or incomplete. As recently as 1974, Robert Solow argued that because every natural resource has a potential substitute in the marketplace there can be no problem of depletion: "Exhaustion is just an event, not a catastrophe" (Solow, 1974). The problem is that the resources which are most threatened with exhaustion today, such as the atmosphere and the oceans, are precisely those without markets. Burning fossil fuels pollutes the air everyone breathes and warms the atmosphere everyone needs. Logging activity erodes soil and diminishes greenhouse-gas-absorbing forests. Over-fishing may lead to an irreparable loss of biodiversity. In each case, there are no viable markets to mediate between those causing the damage and those being harmed – especially future generations.

While most resource allocation decisions today, such as burning fossil fuels, entail consequences for tomorrow, the people making them do not always have to live with the consequences of their decisions. As Pigou (1929) argued a half century ago, it seems to be human nature to underestimate – and hence under-provide for – future needs. Current markets for natural resources are by definition incomplete if only because future generations cannot participate in them.

(c) The intellectual debate: Natural resource exports and economic dependency

Another important intellectual debate has focused on the question of whether natural resources are a "blessing" or a "curse" for the economic development of countries. Although economists have traditionally seen natural resource endowments as a key determinant of comparative advantage and critical to economic growth, some have argued that excessive dependency on natural resource exports can actually trap countries in a state of "underdevelopment".

(i) Singer-Prebisch thesis

The “underdevelopment” thesis was first advanced by Raul Prebisch (1950) and Hans Singer (1950) in the 1950s. Noting that the price of primary commodities had continued to decline over time relative to the price of manufactured goods, they argued that the resulting decline in the terms of trade of primary commodity-exporting developing countries locked them into a state of underdevelopment.

One source of the problem was the highly competitive nature of many commodity markets which meant that productivity improvements tended to result in declining prices rather than higher incomes (versus the more monopolistic organization of markets for manufactured goods, where productivity improvements could be captured in higher incomes). Another problem was that as incomes rose, the demand for manufactured exports grew faster than for commodity exports. Because falling commodity prices meant that developing-country exports had to grow continually in order to buy a given quantity of manufactured goods, poor countries were unable to accumulate the surplus capital needed for investments in the infrastructure, technology and industrial capacity that was a prerequisite for further development.²⁰

It was these differences in power between commodity-dependent developing countries and manufacturing-intensive industrialized countries – between the “periphery” and the “core” – that trapped poorer countries in a cycle of declining export earnings, weak investment and underdevelopment. In order to break this cycle, Prebisch and Singer urged developing countries to diversify their economies and lessen their dependence on primary commodities by developing their manufacturing industry – including through using selective protection methods and attempting to replace imports with domestically produced goods. More generally, the Singer-Prebisch thesis implied the novel concept that it was the intrinsic structure of world markets, not the failings of individual countries, that was responsible for widening inequalities in the global economy.

(ii) Dependency theory

The Singer-Prebisch thesis has underpinned a growing body of economic thought, broadly referred to as “dependency theory”, which built on the insight that the apparent failure of many countries to develop was the result of unequal power relations between a “periphery” of poor and underdeveloped countries and a “core” of wealthy, industrialized states. Because of these structural inequalities, resources flow from the periphery to the core, enriching industrialized countries at the expense of the poor, denying developing countries the capital and technology needed to industrialize, and perpetuating existing inequalities and disparities. Against the neoclassical idea that open trade and economic expansion benefits all countries and that growth in industrialized countries will eventually lead to growth in poorer countries (the “stage theory” of

development), dependency theory holds that existing economic relations – and the nature of global integration – lock developing countries into a state of perpetual underdevelopment and economic subservience.

Under the umbrella of dependency theory, a number of explanations have been advanced for how and why structural inequalities are perpetuated in the global economy. As we have seen, Prebisch (1950) and Singer (1950) focused on poorer countries’ declining terms of trade and how this contributes to underdevelopment. Paul Baran (1957) highlighted the ways that developing countries’ “economic surplus” is extracted by industrialized countries, and how the international division of labour (between skilled workers in the centre and unskilled workers in the periphery) reinforce dependency. Together with Samir Amin, he also emphasized how elites in peripheral countries cooperate with elites at the centre to perpetuate natural resource exploitation. Arghiri Emmanuel (1972) introduced the concept of “unequal exchange” to the debate, suggesting that it was historically established wage levels that set prices, not the other way around, further contributing to developing countries’ deteriorating terms of trade.

More recently, Matias Vernengo (2004) suggested that the dependency relationship is a reflection less of trade or technological inequality than of the differences in financial strength between the core and the peripheral countries – in particular, the inability of developing countries to borrow in their own currency. Andre Gunder Frank (1971; 1972) and other “world-system” theorists broadened this analysis, viewing the stratification of the world economy into “core” and “peripheral” countries as the global reflection of Marx’s class divisions – i.e., the owners versus the non-owners of the means of production. Similar ideas about the structural nature of “core” and “peripheral” relations can also be found in Johan Galtung’s (1971) structural theory of imperialism.

Dependency theorists also differed in their proposed solutions to unequal international economic relations. Writers ranging from Prebisch and Singer to Osvaldo Sunkel (1969) and Fernando Henrique Cardoso (1979), viewed the problem in terms of the nature of the global economy and the history of international economic development. Poorer countries needed to embark on a separate or autonomous development path and reduce their dependence on trade with developed economies, including by embarking on programmes of infant industry protection and replacing imports with domestically produced goods. In contrast, Marxist economists, such as Baran and Gunder Frank, tended to see the problem of developing-country dependency as endemic to the capitalist system itself. The movement towards worldwide socialism – and an end to foreign domination and imperialism – was a precondition for the elimination of underdevelopment.

5. Conclusions

Natural resources are indispensable for the functioning of modern economies, and for achieving and maintaining high standards of living in all countries. They are primary inputs in the production of all manufactured goods (e.g. ores and other minerals). They provide the energy needed to transport people and goods from place to place, to light our cities, and to heat our homes and places of work (fuels). They are also a potentially unending source of valuable materials and a habitat for wildlife and plant species (forests, oceans). Finally, in the case of water, they are necessary for sustaining all life on the planet. It is no exaggeration to say that the way the world manages its natural resources will go a long way towards determining the sustainability of the global economy.

In this section we have examined some of the factors that make natural resources trade different from trade in other types of products, surveyed data on global trade flows, taken a closer look at some of the mechanisms through which resources are actually traded in commodity exchanges, and sketched the history of this trade since the industrial revolution. Taken together, these analyses provide some insight into why trade in natural resources is sometimes controversial.

On the positive side, trade in resources allows countries with limited domestic supplies to benefit from the use of these materials. Trade also contributes to efficiency in production, provides exporting countries with earnings that can be re-invested in future production, and enables them to diversify their economies. On the negative side, by contributing to production, trade may exacerbate a number of adverse consequences associated with resource use, such as air pollution caused by the burning of fossil fuels, or a reduction in biodiversity brought about by the destruction of natural habitats. It should be borne in mind, however, that the solution to such problems is not likely to reside in the contraction of trade, but rather in the proper management of scarce resources and the mitigation of the harmful environmental effects of economic activity.

The intellectual and political debate about natural resources, summarized in Section B.4, has seen public attitudes and expert opinion alternate between optimism and pessimism about whether precious natural resources will continue to be available for future generations. Growing concern for the environment, combined with the steady rise in natural resource prices in recent years, has once again brought these issues to the forefront of public consciousness.

While trade in natural resources will almost certainly continue to grow in the future, improved international cooperation and domestic regulation should be able to contribute to efficiency gains, the elimination of the adverse consequences of extracting and using natural resources, and perhaps increased stability in the market prices of these goods. This section has presented some

essential background information on these issues, but for a deeper understanding of the challenges facing policymakers a coherent theoretical framework is needed. The development of this theoretical apparatus is the subject of Section C.

Endnotes

- 1 Another way of expressing the idea that natural resources must be scarce and economically useful is that they must command a positive price in markets and can be used either as inputs in production or directly as a source of utility to consumers.
- 2 Proved reserves are defined as “quantities of oil that geological and engineering information indicates with reasonable certainty can be recovered in the future from known reservoirs under existing economic and operating conditions”.
- 3 The distribution of other fuels is similarly concentrated, with 20 countries possessing 90 per cent of global natural gas supplies and just nine countries having 90 per cent of the world’s coal reserves(British Petroleum, 2009).
- 4 These are distinct from “forward” contracts, which are not traded in organized exchanges, but over-the-counter, i.e. directly between a buyer and seller (Valdez, 2007).
- 5 The clearing houses are under the watch of independent regulators.
- 6 These are likely to be important for landlocked routes.
- 7 In the case of natural gas, however, while markets in the United States and the United Kingdom, are dominated by organized exchanges, those in other European countries are dominated by long-term contracts (Neuhoff and von Hirschhausen, 2005).
- 8 Such contracts may be characterized by an acute “hold-up” problem, i.e. governments are unable to commit not to renegotiate the terms of any contract and hence investors are likely to be deterred by the consequent risk. This is likely to result in a systematic bias towards under-exploration and development (Collier and Venables, 2009). See Section E.3.
- 9 Smith (2009) notes that vertical integration in the oil industry has declined somewhat during the past two decades. This may simply be because several large oil producers have agreements to swap crude oil streams to minimize transport costs.
- 10 See www.chevron.com.
- 11 Long-distance iron ore trade rose from 23 per cent of world production in 1960 to 36 per cent in 1990. Trade in coal rose from 2 per cent in 1960 to 13 per cent in 2005. Tankers now carry some 2 billion barrels of oil annually – up from less than 400 million barrels in 1950. Natural gas, the bulkiest traded natural resource, is the latest commodity to be subjected to the forces of globalization due to declining transport costs. Until the 1980s, transport by pipeline was the dominant delivery mode, which meant that natural gas trade had a limited geographical reach and markets remained regionally segmented. However, advances in liquefied natural gas (LNG) technology and the ability to transport gas economically in large tankers are rapidly erasing these remaining geographical barriers. In 2005, 26 per cent of global natural gas production was traded internationally, more than a quarter of this as LNG (Lundgren, 1996; Radetzki, 2008).
- 12 As Smith explained, “every individual ... neither intends to promote the public interest, nor knows how much he is promoting it He is, in this, as in many other cases, led by an invisible hand to promote an end which was no part of his intention. By pursuing his own interest he frequently promotes that of society more effectively than when he really intends to promote it” (Smith, 1776).
- 13 He argued that “there would be no attempt by capitalists to invest in manufactures designed for distant sale as long as agriculture resources remained unused” (Smith, 1776).
- 14 “The power of population is indefinitely greater than the power in the earth to produce subsistence for man”, Malthus argued: “No fancied equality, no agrarian regulations in the utmost extent, could remove the pressure of it even for a single century” (Malthus, 1798).
- 15 “Increased capital enables the miner to descend double the distances and the value is now greater than at first. A further application of capital enables him to descend successively to 300, 500, 600, 1,000 or 1,500 feet, and with ever successive application the property acquires a higher value, notwithstanding the quality of coal that has been taken out” (Carey, 1840).
- 16 *The Global 2000 Report* was commissioned by President Carter in 1977. An additional report under the title *Global Future: Time to Act* was published in 1981 (Council on Environmental Quality (CEQ) and the U.S. Department of State, 1980).
- 17 “Growth, being the central goal of society, nothing, naturally enough, is allowed to stand in its way”, observed Galbraith: “That includes its effect, including its adverse effect, on the environment, on air, water, the tranquillity of urban life, the beauty of the countryside” (Galbraith, 1974; Mishan, 1967).
- 18 Natural Capitalism is a movement that sees the world’s economy as being within the larger economy of natural resources and ecosystem services that sustain us. This implies that we should attribute value to all things – from human intelligence and cultures, to hydrocarbons, minerals, trees, and microscopic fungi. The authors argue that only through recognizing this essential relationship with the earth’s valuable resources can businesses, and the people they support, continue to exist (Hawken et al., 2009).
- 19 In 1980, Julian Simon bet biologist Paul Ehrlich that after a decade, a set of natural resources (decided upon by Ehrlich) would be cheaper in constant dollars than they were at the start. Simon won the bet (Simon, 1984).
- 20 A modern variant of this terms of trade thesis has been put forward by Daron Acemoglu and Jaume Ventura. In attempting to explain the relative stability (and inequality) of world income distribution since the 1960s, they argue that countries that accumulate capital faster than average experience falling export prices and declining terms of trade – which in turn depresses the rate of return to capital and discourages further accumulation (Acemoglu and Ventura, 2002).