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# 11 The Transport of Bulk Cargoes

*God must have been a shipowner. He placed the raw materials far from where they were needed and covered two thirds of the earth with water.*

(Erling Naess)

## 11.1 THE COMMERCIAL ORIGINS OF BULK SHIPPING

There is nothing particularly new about bulk shipping. Cutting transport costs by carrying cargo in shiploads is a strategy that has been around for millennia. The grain fleet of ancient Rome,[1] the Dutch ‘fly boats’ of the sixteenth century, and the nineteenth-century tea clippers are all examples. However the bulk shipping industry which has such an important place in the shipping industry of the twenty-first century has its roots in the eighteenth-century coal trade between the North of England and London. At first the standard ‘collier’ was a wooden sailing collier brig, but between 1840 and 1887 the coal trade grew from 1.4 mt to 49.3 mt and better ships were needed.[2] The new designs are recognizable as close relations of modern bulk carriers, incorporating screw propulsion, a double bottom for the carriage of water ballast and the location of machinery fore and aft, leaving the entire hold amidships available for the carriage of cargo.

Commercially the most successful of the pioneer designs was the *John Bowes*. Built at Palmer’s Shipyard in Jarrow in 1852, she was iron-hulled, screw-propelled and could carry 600 tons of coal per voyage, compared with about 280 tons for a good sailing collier. Independent of wind and with much greater carrying capacity, the steam colliers could make many more round trips than a sailing vessel. These economic advantages more than compensated for their higher capital cost,[3] making possible the rapidly growing coastal trade between Newcastle and London. Since the nineteenth century the fleet of general purpose bulk vessels has become one of the major components of the world fleet, and bulk transport economics has been so successfully applied that coal can be shipped across the world for much the same money price per ton as it would have cost 125 years ago.

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Our aim in this chapter is to discuss the bulk fleet, the commodities traded, the general principles which drive bulk transport systems, and the transport of liquid and dry bulk commodities.

## 11.2 THE BULK FLEET

In July 2007 the bulk fleet consisted of 14,756 vessels divided into the segments shown in Figure 11.1. The two main fleets are tankers (8040 ships) and bulk carriers (6631 ships), with a smaller fleet of combined carriers (85 ships) which can carry both tanker and bulk carrier cargoes. There is also a sizeable MPP and tramp fleet which can carry dry bulk, general cargo and containers, providing a link between the dry bulk market and the container business. Finally, container-ships are a significant market force in some of the small bulk cargoes such as forest products.

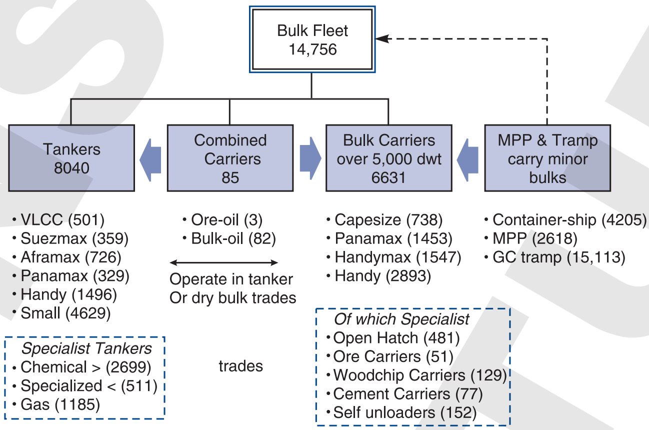


**Figure 11.1**
The bulk fleet showing main segments, 1 July 2007
Source: Table 2.5

The two defining characteristics of the 21 segments are ship size and hull design. Size is the dominant feature, and between 1976 and 2006 the average size of bulk carrier almost doubled from 31,000 dwt to 56,000 dwt, and the average tanker increased in size by 20% from 75,000 dwt to 90,000 dwt. As the ships got bigger the markets evolved into the ship size segments shown in Figure 11.1. The tanker fleet is divided into five main size segments: VLCCs which carry the long-haul cargoes; Suezmaxes which operate in the middle-distance trades such as from West Africa to the USA; Aframaxes which trade in shorter-haul trades such as across the Mediterranean; Panamaxes which trade in the Caribbean; and the Handy tankers which carry oil products. There is also a fleet of 4629 small tankers which operate in the short sea trades. In addition, there are a large number of specialized tankers. These are discussed in Chapter 12 and include a fleet of 2699 chemical tankers which transport chemicals, vegetable oils and other 'difficult' liquid cargoes, a small fleet of 511 specialized tankers built for a single commodity such as wine, and 1185 gas tankers which carry LNG, LPG, ammonia and other gases. Although these segmentations are generally accepted in the industry and, for example, shipbrokers often organize their broking desks around them, there is much overlap. Since the trend in size is generally upwards, typically the fleet segments with bigger ships grow faster as port improvements and increasing trade volumes widen their market, whilst the segments of smaller ships grow more slowly.

The dry bulk carrier fleet is divided into four main size segments 'Capesize, Panamax, Handymax and Handy', plus five groups of specialist bulk carriers, open hatch vessels, designed for unit loads; ore carriers, designed to carry high-density iron ore; woodchip carriers, designed for low-density wood chips; cement carriers, designed to handle cement efficiently; and self-unloaders capable of discharging cargo at very high rates using conveyor belts'. Finally, there is the swing tonnage. The small fleet of combined carriers can carry either oil or dry bulk, though the three remaining ore-oilers in 2007 were limited to iron ore. This fleet moves from dry to wet cargo depending on freight rates and the vessels can 'triangulate', carrying dry and wet cargo on alternate legs to reduce ballast time. In the depressed markets of the 1980s and 1990s this flexibility spread the surplus between markets and never produced the returns investors had hoped for, with the result that few replacement vessels were ordered and the fleet has been declining for 20 years. The link between the dry bulk trades and the general cargo trade is the fleet of MPP vessels and tramps which can carry dry bulk or containers, and operate in regular services carrying mixed general cargo or carrying dry bulk if freight rates are favourable, though container-ships increasingly carry minor bulk cargoes. Finally, there are the specialist bulk vessels distinguished by hulls designed for the carriage of specific cargoes such as gas, iron ore, forest products and cement. The self-unloaders carry their own high-speed cargo-handling gear. These vessels are discussed in Chapter 12, which examines the trades and markets, and Chapter 14, which discusses the economics of ship design.

Although Figure 11.1 presents the bulk fleet as having many segments, in practice ships can move between adjacent segments in response to changes in freight rates. For example, a VLCC might move into the West African oil trade, generally a Suezmax trade, if the freight makes it worth the effort, and the same is true of Panamax bulk carriers which compete closely with Handymax vessels and Capesize bulk carriers. In extreme circumstances chemical parcel tankers will even carry clean products and, during the boom of 2004, fuel oil, which would normally be transported in a 30,000 dwt vessel, was shipped in 440,000 dwt ULCCs. So the segments are a convenient way of recognizing demand differences within the trades, but not impenetrable barriers. If that was not the case, managing investment in bulk shipping would be far more difficult than it already is.

## 11.3 THE BULK TRADES

Our first task is to distinguish a 'bulk commodity' from a 'bulk cargo'. In the shipping industry a bulk commodity is a substance like grain, iron ore and coal which is traded in large quantities and has a physical character which makes it easy to handle and transport in bulk. Bulk commodities are generally carried in bulk carriers, in which case they are 'bulk cargo', but if they are shipped in a container they become 'general cargo'. So, strictly speaking, 'bulk cargo' describes the transport mode not the commodity type. In practice, commodities such as iron ore and coal are almost always shipped in bulk so the terms are often used synonymously – iron ore is referred to as a bulk

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cargo or a bulk commodity. But non-ferrous metal ores, for example, are often bagged and containerized, so the volume of cargo is different from the commodity trade. The distinction is even more blurred when we turn to commodities which can only be shipped in bulk if a special ship is constructed – for example, such diverse trades as meat, bananas, motor cars, chemicals and live animals. We refer to these as 'specialized cargoes' and discuss them in Chapter 12. This distinction between commodity and cargo is important even if we cannot always record it in statistical terms.

## The bulk cargoes shipped by sea

An idea of the sort of commodities shipped in bulk is provided by Table 11.1, which analyses 2549 bulk cargoes fixed in 2001 and 2002. The table lists 28 commodities along with details of the number of cargoes shipped and the average size. At the top of list is iron ore, with an average cargo size of 147,804 tonnes, followed by coal with an average cargo size of 109,046 tonnes. But the parcel sizes gradually diminish, with many parcels in the 20,000–45,000 tonne range, and the smallest is bagged rice with an average size of 7893 tonnes. This gives a sense of the variety and the range of parcel sizes carried by bulk carriers. Although the oil trade has fewer commodities, the range of parcel sizes is equally wide.

Some of the cargoes listed in Table 11.1 are also shipped by the liner services discussed in Chapter 13, or by the specialist carriers discussed in Chapter 12, the obvious cases being bagged sugar, steel pipes, fertilizers, scrap and agricultural products. From a transport viewpoint there are four main characteristics of bulk commodities which influence their suitability for transport in bulk:

- *Volume*. To be shipped in bulk there needs to be enough volume moving to fill a ship.
- *Handling and stowage*. Commodities with a consistent granular composition which can easily be handled with automated equipment such as grabs and conveyers are more suitable for bulk transport. Grain, ores and coal have these characteristics. Large units such as forest products (logs, rolls of paper, etc.) and vehicles can be shipped in conventional bulk carriers but cargo-handling efficiency and stowage can be improved by packing into standard units – timber may be packaged; ores and fertilizers put in large bags; or sacks loaded onto a pallet. In these cases ships can be designed to match the dimensions of the cargo. Cargoes susceptible to damage require special facilities. For example, alumina, sugar, manufactured fertilizers and grain need protected storage. Dangerous cargoes such as chemicals must be carried in ships which meet international regulations on the carriage of hazardous cargoes (see Chapter 16). Finally, some cargoes are very dense (e.g. iron ore), leaving much space in the hold if a standard ship is used. Others are very light (woodchips, naphtha), creating the need for a ship with a large volume that can carry a full cargo deadweight.
- *Cargo value*. High-value cargoes are more sensitive to inventory costs, which makes them advantageous to ship in smaller parcels, whereas low-value commodities like iron ore can be stockpiled.

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**Table 11.1** Bulk cargoes fixed spot 2001–2

| Type of cargo | Number of cargoes | Tonnage of cargo (tonnes) | Average size (tonnes) |
|---|---|---|---|
| *Major Bulks* | | | |
| Iron ore | 889 | 131,397,500 | 147,804 |
| *Coal* | | | |
| Coking coal | 72 | 3,114,500 | 43,257 |
| Coal | 743 | 81,021,000 | 109,046 |
| *Grain* | | | |
| Oats | 2 | 197,000 | 98,500 |
| Grain | 326 | 16,540,135 | 50,737 |
| Heavy grain | 104 | 4,639,787 | 44,613 |
| Barley | 15 | 554,000 | 36,933 |
| Wheat | 64 | 2,175,960 | 33,999 |
| Corn | 14 | 444,000 | 31,714 |
| Maize | 13 | 322,000 | 24,769 |
| *Agribulks* | | | |
| Canola | 3 | 110,000 | 36,667 |
| Agriprods | 4 | 69,000 | 17,250 |
| Rice – bagged | 7 | 55,250 | 7,893 |
| *Sugar* | | | |
| Sugar – bulk | 116 | 1,981,400 | 17,230 |
| Sugar – bagged | 47 | 518,575 | 11,034 |
| *Fertilizers* | | | |
| Fertilizers | 18 | 468,000 | 26,000 |
| Phosphates | 7 | 168,000 | 24,000 |
| Phosphate rock | 8 | 171,000 | 21,375 |
| Urea | 16 | 287,000 | 17,938 |
| *Metals & minerals* | | | |
| Manganese ore | 9 | 185,000 | 20,556 |
| Concentrates | 2 | 160,000 | 80,000 |
| Pig iron | 2 | 75,000 | 37,500 |
| Cement | 4 | 261,000 | 65,250 |
| Bauxite | 20 | 1,097,000 | 54,850 |
| Petcoke | 13 | 600,000 | 46,154 |
| Coke | 7 | 198,000 | 28,286 |
| *Steel products* | | | |
| Scrap | 16 | 334,000 | 20,875 |
| Steel billets | 4 | 98,600 | 24,650 |
| Steel pipes | 4 | 91,000 | 22,750 |
| Grand Total | 2549 | 247,333,707 | 30,119 |

Source: Various

- *Regularity of trade flow*. Cargoes shipped regularly in large quantities provide a better basis for investment in bulk handling systems. For example, the sugar trade, which is very fragmented, has benefited less from bulk transport systems.

In most cases the overlap is relatively small, with the bulk shipping business focusing primarily on a few high-volume commodities, with the 'crossover' commodities occupying

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**Table 11.2** Bulk commodities transported by sea

| Million tons | 1985 | 1990 | 1995 | 2004 | 2005 | Growth 1985–2005 (% pa) |
|---|---|---|---|---|---|---|
| **1. Liquid bulks** | | | | | | |
| Crude oil | 984 | 1,190 | 1,450 | 1,802 | 1,820 | 3.1% |
| Oil Products | 288 | 336 | 381 | 219 | 488 | 2.7% |
| Totals | 1,272 | 1,526 | 1,831 | 2,021 | 2,308 | 3.0% |
| **2. Three major bulks** | | | | | | |
| Iron ore | 321 | 347 | 402 | 589 | 650 | 3.6% |
| Coking coal | 144 | 342 | 160 | 186 | 184 | 1.2% |
| Thermal coal | 132 | | 242 | 475 | 498 | 6.9% |
| Grain | 181 | 192 | 216 | 273 | 242 | 1.5% |
| Total | 778 | 881 | 1,020 | 1,523 | 1,574 | 3.6% |
| **3. Minor bulks (see Table 11.12 for more details of the commodities)** | | | | | | |
| Agribulks | 79 | 87 | 106 | 136 | 158 | 3.5% |
| Sugar | 28 | 28 | 34 | 37 | 46 | 2.6% |
| Fertilizers | 96 | 90 | 93 | 100 | 109 | 0.6% |
| Metals and minerals | 170 | 188 | 217 | 235 | 310 | 3.1% |
| Steel and forrest products | 301 | 325 | 365 | 345 | 387 | 1.3% |
| Total | 673 | 719 | 815 | 852 | 1,010 | 2.0% |
| Total bulk trade | 2,723 | 3,126 | 3,666 | 4,396 | 4,892 | 3.0% |

Source: Major bulks, *Fearnleys Review* 2005, minor bulks Clarkson Research Studies, various

Note: The minor bulk data includes some land trade

a relatively small proportion of the businesses activity, and mainly in the smaller ship sizes. This point is apparent when we look at the statistics of the bulk commodities traded by sea in Table 11.2. In 2005 there were 4.9 billion tons of bulk commodities, about two-thirds of sea trade. This total included 2.3 billion tons of liquid, 1.6 billion tons of 'major' dry bulk commodities and 1 billion tons of 'minor' dry bulk commodities. The list of commodities is not comprehensive, but when viewed in the context of the cargo data in Table 11.1 it provides a more detailed account of the commodities most commonly traded in bulk carriers. The overlap is mainly in the minor bulks which only account for 17% of the bulk commodities. But the size of vessel required is also a central issue and in Chapter 2 we explored how the parcel size distribution function is determined by the commodity's economic and physical characteristics which influence the size and type of ship used to transport the cargo.

## 11.4 THE PRINCIPLES OF BULK TRANSPORT

At the heart of this analysis are the ships used by the transport system. A transport system is designed so that its parts work together as efficiently as possible, and sea transport is just one stage in the transport chain moving bulk commodities between producers and consumers. Cargo flows through the system as a series of discrete shipments, with the storage areas acting as buffers to allow for timing differences in the arrival and despatch of the commodity. For example in a grain system barges may be delivering grain every day, but the grain elevator may only load two ships a week.

The stages in a typical bulk transport system are shown in Figure 11.2. It consists of a sea voyage and two land journeys which could be by lorry, train, conveyor, or pipeline. There are four storage areas located at the origin (e.g. mine, oilfield, factory or steel mill), the loading port, the discharging port and the destination, and no less than 17 handling operations as the cargo moves through the system! These are listed in the diagram and include a ship loading and discharge; four handling operations on and off land vehicles, and eight movements to and from storage. No wonder transport system designers are so interested in finding ways to reduce this cost.

Building ships which fit into the bulk transport systems used by the cargo shippers presents shipowners with a challenge. For example, the transport system places constraints on ship size. The depth of water and berth length at the loading and receiving ends of the operation determine the maximum size of ship which can be used.

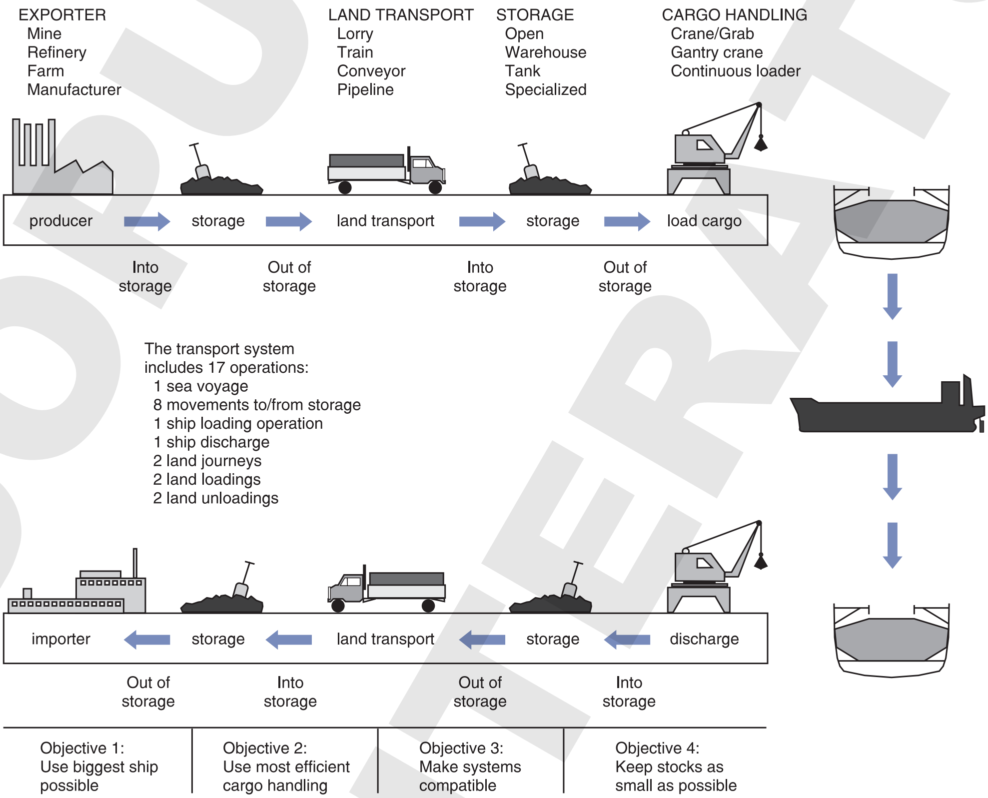


**Figure 11.2**
Elements in the bulk transport system

**Table 11.3** Examples of monthly plant throughput

| Commodity | Economic plant size ('000 tons) Year | Month | Typical ship size ('000 dwt) |
|---|---|---|---|
| Oil refining | 10,000 | 833 | 30–320 |
| Steel-making | 5,000 | 417 | 120–180 |
| Power station (coal) | 3,000 | 250 | 60–120 |
| Cement | 2,000 | 167 | 20–50 |
| Sulphuric acid | 1,000 | 83 | 20–50 |
| Automobiles (no. cars) | 1,000 | 83 | 1,000–6,000 cars |
| Sugar refining | 500 | 42 | 20–35 |
| Ammonium nitrate | 350 | 29 | 20–30 |
| Ethylene | 300 | 25 | 5–8 |
| Aluminium smelting | 200 | 17 | 20–30 |
| Synthetic fibres | 80 | 7 | Container |

Source: Compiled by Martin Stopford from various sources

Storage facilities are another potential constraint, since there must be enough storage capacity in the port to allow the ship to load and discharge its cargo. There is no point in shipping 70,000 tons of grain if the grain elevator in the terminal can only handle 60,000 tons. Another important issue is the amount of raw materials a manufacturing plant processes in a year, since this determines the size of cargo the plant will be able to absorb, placing a constraint on ship size even when the terminal facilities to handle big ships are available. The capacities of various manufacturing plants shown in Table 11.3 put this into perspective. A steel mill producing 5 million tons of steel a year needs roughly 700,000 tons of iron ore and 200,000 tons of coal each month. With these volumes it would make sense to use 180,000 dwt ships, even if they were not cheaper – managing 17 Handy bulk carrier shipments each month would be far too much trouble. However, a sugar refinery with an annual capacity of 500,000 tons and a monthly requirement for 42,000 tons of raw sugar is hardly likely to want 180,000 tons of raw sugar in a single cargo. It might well go for two 25,000 dwt bulk carrier shipments a month. With this sort of volume it is easy to see why the size of bagged sugar parcels in Table 11.1 is so small. So plant size is just as important as terminal facilities and economies of scale in determining the size of ship that can be used.

## Principles of bulk transport

Whether transport is between a coalmine and a power station or between a chemical plant and a fertilizer wholesaler, the aim is to move the cargo as cheaply and efficiently as possible. Inevitably this involves compromises. Each commodity and industry has specific transport requirements and no single system is ideal for every situation. But there are certain principles which make a useful 'checklist' when thinking about the transport systems in which bulk shipping plays a part. In this context there are four issues to consider: first, gaining maximum economies of scale by using a

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bigger ship; second, reducing the number of times the cargo is handled; third, making the cargo-handling operation more efficient; and fourth, reducing the size of stocks held. The problem for the system designer is that each of these objectives has a capital cost and some work in opposition. The challenge is to develop a system which gives the best overall outcome in terms of the transport user's priorities which are not only determined by cost.

### PRINCIPLE 1: EFFICIENT CARGO HANDLING

A fundamental principle of bulk transport is that unit costs can be reduced by increasing the size of the cargo on the shipping leg. Bigger ships have lower unit costs, and unit cargo handling and storage are also cheaper at high throughput volumes. As a result, the bulk trades are under constant economic pressure to increase the size of cargo consignments. But big is not always best. As we discussed in Chapter 10, the savings diminish as the ships get bigger, and big ships need more cargo to fill them. From the shipper's point of view delivery frequency is also important and bigger ships need fewer trips to deliver the same cargo volume. Cargo handling, which does not change with voyage distance, also becomes proportionally less important in the unit cost equation as the length of haul increases. So it is more important to have efficient terminals for products tankers operating in north-west Europe than for VLCCs plying between the Middle East and the US Gulf. Finally, very big ships are less flexible and have fewer trading options if their preferred trade disappears for some reason. All of which suggests that economies of scale must be viewed in the context of the transport system as a whole, and in practice the market provides its service with a portfolio of ships of different sizes.

A timeless example of the evolution of ship size is provided by the shipment of nickel matte (a concentrate of nickel ore) from Canada to a processing plant in Norway. The change from one transport system to another was described by an executive of the company in the following terms:

> As the size of the trade increased we decided to go from the barrel system to the bulk system of matte shipping and we proceeded to purchase a 9,000 ton vessel, which was to move matte from North America to our refinery at Kristiansand South, and return to North America with finished metal. As part of the overall operation, we had to provide a storage and loading facility at Quebec City; we had to increase our storage at Kristiansand, and we also had to consolidate our storage and handling facilities at a location just outside of Welland, Ontario. I would say not only the acquisition of the ship, but also the acquisition of the storage facilities at these various locations, has improved our metal and matte movements considerably.[4]

In this case we see bulk shipping as a natural stage in the development of the business and also the importance of making bulk shipping an integral part of the whole manufacturing operation. The same process is seen in the steel industry, where the size of ore carriers has increased from 24,000 dwt in the 1920s to 300,000 dwt in the 1990s.

Many of the bulk commodity trades discussed in this chapter travel partly in bulk and partly as general cargo, depending on the size of the individual trade flow. For example,



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50,000 tons of wheat transported from New Orleans to Rotterdam would certainly travel in a bulk carrier, but 500 tons of malting barley shipped from Tilbury to West Africa would probably travel bagged on pallets or in containers. Because this depends on a commercial decision, there is no specific size at which a trade flow 'goes bulk'. In effect, the smallest practical bulk unit is a single bulk carrier hold; as the size of parcel falls below 3,000 tons it becomes increasingly difficult to arrange bulk transport. One expert puts the watershed at 1,000 tons.[5]

### PRINCIPLE 2: MINIMIZE CARGO HANDLING

Minimizing the cost of cargo handling is the second principle. Each time the product is handled during transport it costs money. The economic costs of cargo handling can be illustrated with an example from the grain trade. A 15,000 dwt 'tweendecker discharging in a small African port might take several weeks to discharge its cargo. Typically, the grain is unloaded on to the quayside with grabs, bagged by hand and transported to the warehouse by lorry. In contrast, a large modern grain elevator can discharge barges at the rate of 2,000 tons per hour and load ships at the rate of 5,000 tons per hour. With these facilities the same vessel could be handled in a day.

A radical solution is to reduce the number of transport legs by relocating the processing plant. Manufacturing plants such as steel mills can be relocated to coastal sites to avoid land transport of raw materials. Where cargo must be handled, the emphasis is on reducing cost by using specially constructed bulk handling terminals. Most large ports have specialist bulk terminals for handling crude oil, products, dry bulk and grain. The use of high-productivity cargo-handling equipment contributes to the overall cost efficiency of the operation by reducing the unit cost of loading and discharging, and minimizing the time the ship spends handling cargo.

Homogeneous dry bulks such as iron ore and coal can be handled very efficiently using continuous loaders and discharged with cranes and large grabs. Cargoes such as steel or forest products, which consist of large, irregular units, benefit from packaging into standard unit loads. In some cases, such as vehicles and refrigerated cargo, bulk shipping requires the construction of special vessels. Powdery cargoes like bulk cement shipped loose in a specially designed cement carrier can be discharged mechanically using pumps, stored in silos and loaded direct into suitable bulk railcars.

### PRINCIPLE 3: INTEGRATE TRANSPORT MODES EMPLOYED

Cargo handling can be made more efficient if care is taken to integrate the various stages in the transport system. One way to do this is to standardize cargo units. Cargo is packaged in a form that can easily be handled by all stages in the transport system, whether it be a ship, lorry or rail truck. Containerization of general cargo is an outstanding example of this principle. The standard container can be lifted off the ship and on to the lorry. In bulk shipping, intermediate units such as large bags, packaged lumber and pallets can be used to reduce handling costs.



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Another is to design a system which covers all stages in the transport operation. This approach is used in many large industrial projects involving raw materials systems. Ships, terminal facilities, storage areas and land transport are integrated into a balanced system. The first integrated bulk transport system was probably in the iron ore trade. Through-transport from the iron ore mine to the steel plant was planned in detail at the time the plant was built. This approach works best where the cargo flows are regular, predictable and controlled by a single company, making it possible to justify special investment in ships and cargo-handling equipment. The key word here is *integration*. What matters is that the transport system is designed as a whole and sufficiently stable to operate as a whole.

#### PRINCIPLE 4: OPTIMIZE STOCKS FOR THE PRODUCER AND CONSUMER

The transport system must incorporate stockpiles and parcel sizes which are acceptable to the importer and exporter. There are two issues to consider. One is the size of the trade flow. Although it would be cheaper to ship manganese ore in a 170,000 dwt bulk carrier, in practice steel-makers use much smaller ships – the parcel size in Table 11.1 is 20,000 tons. This is partly a matter of annual throughput which does not justify investment in high-volume cargo-handling facilities, but there are also inventory costs to consider. Even if the storage facilities are available to handle 170,000 tons of manganese ore, the cost of holding stock for a year could well exceed the freight saving. Under 'just in time' manufacturing systems the product should arrive at the processing or sales point as close as possible to the time when it is used, minimizing the need for stocks. This approach, which calls for a transport system with many small deliveries, conflicts with Principle 1 which favours a few very large deliveries.

The size of parcel in which a commodity is shipped is thus a trade-off between optimizing stockholding and economies of scale in transport. High-value cargoes, which are usually used in small quantities and incur a high inventory cost, tend to travel in small parcels. This is most noticeable in the minor bulk trades such as sugar, steel products and non-ferrous metal ores, where physical characteristics permit large bulk parcels but stockholding practices impose a parcel size ceiling on the trade. As far as the commercial structure of the transport of a commodity like iron ore is concerned, some is transported in ships owned by the steel mills; another proportion by ships on time charter to the steel mills; a third segment is moved on COA; and the remainder gets shipped through the spot market. Naturally the form which a particular commodity market takes makes a big difference to the shipowners offering transport.

## 11.5 PRACTICAL ASPECTS OF BULK TRANSPORT

### Participants in the transport system

The bulk transport system has four main participants. First there are the 'cargo owners', the businesses with bulk cargo to transport on a regular basis. Their approach to the business varies enormously. For basic industries such as oil refineries, steel mills or paper and pulp manufacturers, cost-effective transport of the raw materials and products is crucial. They need the cheapest possible transport, and generally have transport departments whose primary task is to minimize the cost of transport. Sometimes they approach this in a long-term manner by developing their own transport system. This involves the construction of specialist terminals, and obtaining a fleet of ships, either owned or on charter, under their own management. Many steel mills follow this approach. When there is a well-developed charter market, even very large businesses may choose to leave the task of owning ships and transport systems to other investors. They may prefer to charter ships on the spot market or, if they have a longer-term requirement for transport, arrange a COA, leaving responsibility for managing the ships with the shipowner.

A second important group of bulk transport users are commodity traders. They buy and sell commodities at different locations, and transport costs affect their margins. Traders are particularly active in the energy and agricultural commodity markets, where much of the cargo is bought and sold. In this case the charterers are rarely in a position to arrange long-term transport. Their focus is on the immediate cost of shipping today, so they generally use the spot market, though some build up fleets of chartered vessels.

The third participants are the shipowners who invest in ships to trade in the various markets described in Chapter 5. Their focus is on making the right investment and minimizing capital and operating costs.

Finally, sitting between the cargo owners and the shipowners are the bulk 'operators'. These are companies which do not own ships or cargo but take cargo contracts, often on a COA basis, and charter in ships to service them. They work at the margin, and this is risky business, but larger operators can use the size of their fleets and their knowledge of the trades to manage the risk and improve their margins, for example by developing favourable ballast patterns.

## Bulk shipping investment – the criteria and approach

Most bulk shipping investment does not follow the rigorous investment appraisal processes that would be used, for example, by charterers ordering ships for a specific trade such as an LNG plant. The investment proposal with operations analysis and discounted cashflows is not really appropriate for the sort of speculative investment that most bulk shipping investors are involved in.

Of course, this is not always the case. For regular cargo flows, such as iron ore shipments to a specific steel mill, analysing investment returns using an economic model is possible because the operating pattern of the ship is known in advance. However, for cargoes appearing on the market irregularly, the process is more complex. For most bulk shipping investors the market is a changeable mix of the cargoes listed in Table 11.1 and the variety is extreme.

Investors must look ahead and balance such issues as ship size, utilization of cargo space, backhaul, speed, cargo-handling gear and cargo access in a way that will work over whatever period the ship will be retained in the fleet. Developing a profitable fleet



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of bulk ships has at least three different dimensions. Size, as we saw earlier in the chapter, imposes many different constraints on the ship's operations, including the size of parcels of the commodities it is carrying, storage facilities, port draft, and trader preference. Utilization is another issue. Very big ships or specialized ships may be unable to get backhaul cargoes, so what they gain on economies of scale, they may lose on vessel utilization.

So how does the industry deal with this complex balance of issues? Shipping investors are inherently conservative and they often simplify the problem by operating a portfolio of ships of different sizes. In the bulk carrier market there are four sizes – Handy, Handymax, Panamax and Capesize – for bulk carriers, and five sizes – Handy, Panamax, Aframax, Suezmax and VLCC – in the tanker business. The way these size segments developed over the period from 1974–2005 is shown in Figure 11.3(a) for tankers and Figure 11.3(b) for bulk carriers. Investors must choose their segments and decide what type of fleet to develop. For example, in the second half of the 1990s Aframax tankers did particularly well thanks to the growing role of short-haul oil, especially Russian exports to Europe, much of which was best suited to the Aframaxes which took market share from the bigger VLCCs which focus on the long-haul Middle East export trades. Several companies built up very large fleets of Aframax tankers and did very well. But soon VLCCs started to move into the Atlantic shorter-haul trades, for example West Africa, demonstrating how the market is constantly adjusting to changing trade patterns.

Ultimately investors are paid for their ability to anticipate what ships will be needed in future. This is not an exact science and investment often follows cyclical patterns, with vessels being ordered through a combination of factors – market analysis, instinct and the availability of funds. The result can be a heavy ordering at the top of the market because the companies are liquid and finance is available, or at the bottom of the cycle because ships are cheap and recovery is thought to be in sight. But one way or another, the ships get ordered.

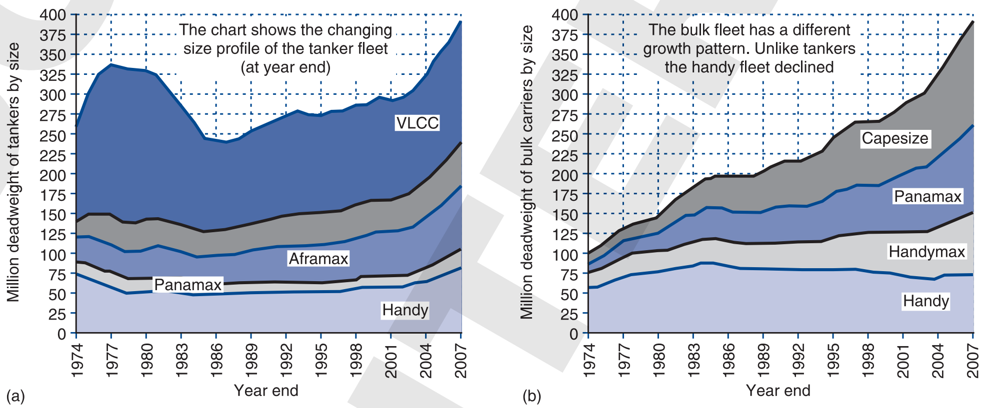


**Figure 11.3**
(a) The tanker fleet, 1974–2007; (b) The bulk carrier fleet, 1974–2007

Finally, we must not forget the specialized and MPP ships. In some trades the physical characteristics, volume and regularity of the cargo make it possible to customize or redesign the ship to suit that particular trade, giving rise to a substantial fleet of specialist bulk vessels. The more important of these specialist types are listed at the bottom of Figure 11.1 and their trades are discussed in more detail in Chapter 12. Bulk cargo is also sometimes transported in MPP vessels which can trade in both the liner and bulk segments and, at the other end of the scale, the combined carrier fleet which can move between the dry and oil markets. The hybrid tramp market in particular has recently been the focus of much new design work to develop vessels capable of operating effectively in bulk and general cargo trading under modern conditions, for example transporting heavy and awkward cargoes.

## Handling liquid bulk cargoes

Crude oil and oil products require different types of handling terminals. Since the carriage of crude oil uses very large tankers, loading and discharge terminals are generally found in deep-water locations with draft of up to 22 metres. Often these requirements can only be met by offshore terminals with strong fendering systems to absorb the berthing impact of large tankers. The berthing arrangements for a typical offshore oil terminal are shown in Figure 11.4. Storage tanks on land are linked by pipeline to the piers where tankers are berthed. These storage tanks must have enough capacity to service vessels using the port. There are two piers with four berths, one with a maximum size of 65,000 dwt, two 135,000 dwt berths and

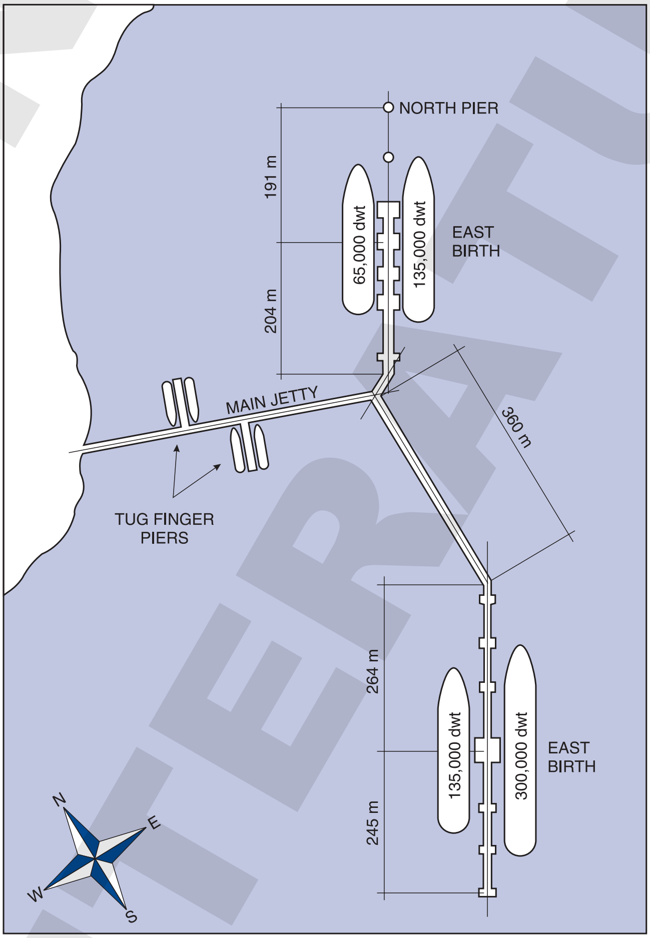


**Figure 11.4**
A crude oil export terminal
Source: UNCTAD (1985)

one VLCC berth. The exact combination would be adjusted to the trade. Note also the finger piers for tugs. Cargo is loaded by pumping oil from the storage tanks to the ship using the terminal's own pumping capacity. Discharge relies on the ship's pumps. Large tankers generally have four cargo pumps, located in a pump room between the engine room and the cargo tanks. Typical combined discharging rates are 6,500 cubic metres per hour for a 60,000 dwt tanker and 18,000 cubic metres per hour for a 250,000 dwt tanker.

Products terminals are generally smaller and as a result can often be accommodated within the port complex. Handling techniques are broadly similar to those of crude oil, but must be capable of dealing with smaller parcels of different products. These include black oils such as furnace oils and heavy diesel oils; and white oils, which include gasoline, aviation spirits, kerosene, gas oil and MTBE (an octane booster used in gasoline).

## Handling homogeneous dry bulk cargoes

Homogeneous dry bulks such as iron ore and coal are handled very efficiently using single-purpose terminals. The iron ore loading facility shown in Figure 11.5 illustrates the way the industry tackles the problems encountered in transferring cargo to and from the ship.

Cargo arrives at the terminal reception facility in railcars designed to tip or drop their cargo into a hopper below the track. From here the ore moves to the stockpile by wagon or, more usually, by conveyor. The stockpile acts as a buffer between the land and sea transport systems, ensuring the terminal has sufficient ore to load ships when they arrive. If stocks are inadequate, congestion builds up as ships wait to load cargo. In the iron ore terminal shown in Figure 11.5 the stockpile consists of long rows of ore, known as 'windrows'. Commodities such as grain require protection and are stored in silos.

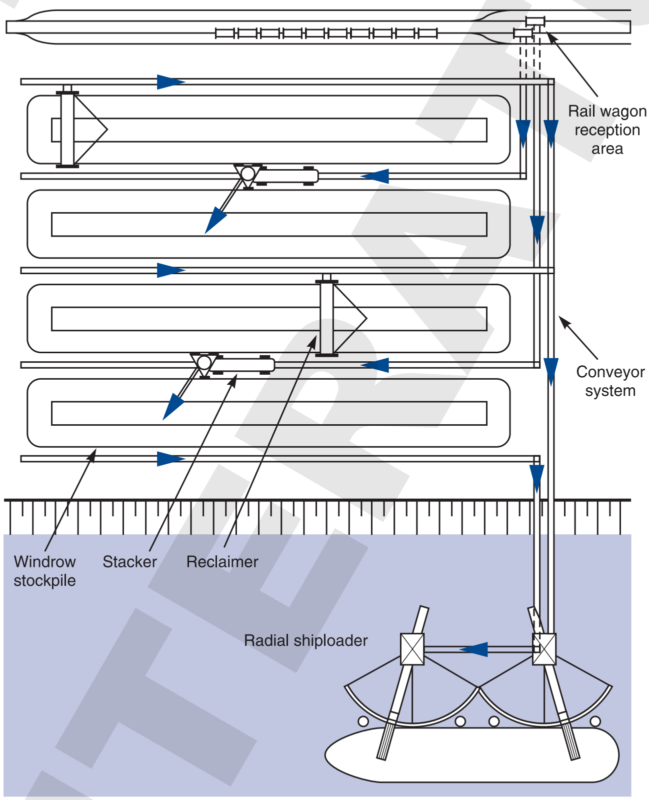


**Figure 11.5**
An iron ore export terminal
Source: UNCTAD (1985)

Moving material into the stockpile is known as 'spreading', while removing it is referred to as 'reclaiming'. Both processes are highly automated. The spreader moves slowly along the stockpile rows, receiving ore from the conveyor and dropping by gravity on to the stockpile at a rate of several thousand tons an hour. When the ore is needed the reclaimer, a revolving drum with buckets, moves along the wind-row, scoops ore from the stockpile and drops it on to a belt conveyor. From the conveyor the ore is taken to the quayside where it is loaded on to the ship. There are various other designs.

Material is weighed before loading or after unloading, to check shipping documentation, using an automatic weighing machine in the conveyor system. Sampling is also required to satisfy the purchaser that the material is in accordance with specifications.[6] The ship loader receives cargo from the conveyor and deposits it in the ship's holds in a planned sequence (the 'loading plan') which avoids putting structural stresses on the hull. Various loading systems are used. In the example illustrated in Figure 11.5 a radial arm loader is used. The ship is moored alongside the loader and the two loading 'booms' (i.e. arms which extend over the ship's hatches) move from hatch to hatch, loading ore by gravity. Other designs of loader use a loading arm on rails running alongside the berth. Loading rates of 16,000 tons an hour may be achieved, but at higher loading speeds a limit may be imposed by the rate at which the ship can be de-ballasted. During loading the boom moves from hatch to hatch. To allow for temporary interruptions to the loading operation, for example when moving from one hatch to another, there is generally a surge hopper in the system.

At the other end of the voyage the ore is unloaded with a grab unloader which picks material from the hold and discharges it into a hopper at the quay edge, from which it is fed onto a belt conveyor. The cargo-handling rate for a grab depends on the number of handling cycles per hour and the average grab payload. In practice, about 60 cycles per hour can be achieved. Grab designs range from light grabs for animal feedstuffs and grain, to massive 50-ton lift ore handlers. The grab unloader is used mainly for iron ore, coal, bauxite, alumina and phosphate rock. Other commodities handled by smaller mobile grabbing cranes include raw sugar, bulk fertilizers, petroleum coke and various varieties of bean and nut kernels. Pneumatic systems are suitable for handling bulk cargo of low specific gravity and viscosity such as grains, cement and powdered coal. Pneumatic equipment is classified into vacuum, or suction types and pressure, or blowing types.

## 11.6 LIQUID BULK TRANSPORT

Transporting liquids by sea raises a whole set of special challenges. There is a diverse fleet of tankers which transport crude oil, oil products, chemicals, liquid gases and specialist cargoes. Figure 11.6 shows how these ships serve the energy, chemical and agricultural businesses which are their main customers. The primary material production is shown in column 1, the primary sea transport in column 2, industrial processing in column 3, and secondary sea transport in column 4. The industrial processing plants are power stations, organic chemicals plants, inorganic chemicals plants, oil refineries,

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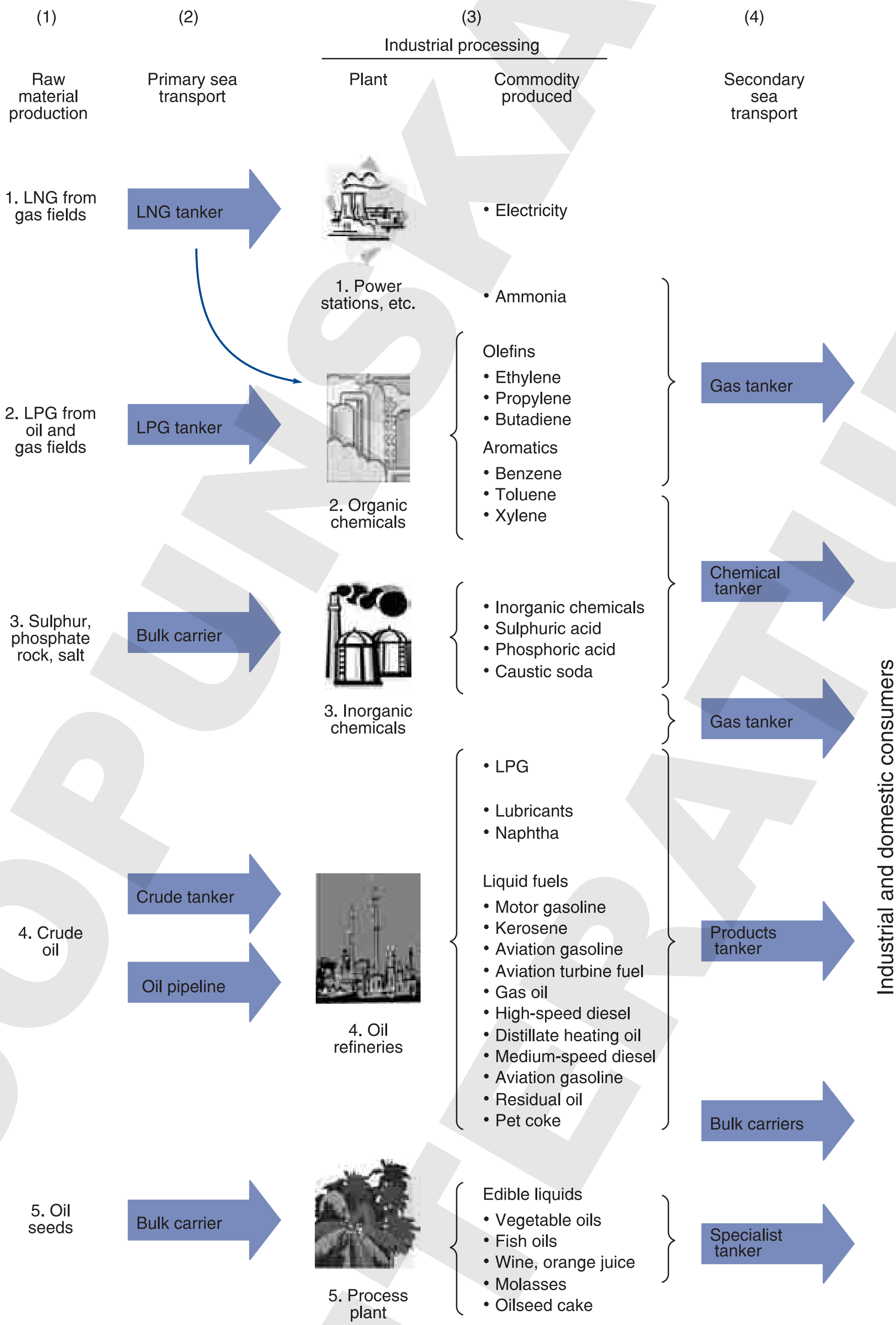


**Figure 11.6**
Principal sources of demand for tankers

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and other processing plants. The purpose of Figure 11.6 is to summarize the part tankers play in these industries, making it clear why this is not an easy business to understand in detail.

Tankers are mainly employed carrying cargo between these three groups, ferrying in the raw materials and shipping out the product, as shown in columns 2 and 4. LNG tankers carry natural gas to power stations, though small amounts also go as a feedstock to chemical plants. Below that are LPG tankers carrying butane and propane from gas fields to petrochemical plants producing and exporting two main product groups, olefins (which are chemical gases) and aromatics (which are liquids). The gases travel in LPG tankers as semi-processed product, whilst the liquid aromatics travel in chemical tankers. Below that we come to the inorganic chemical trade, with bulk carriers and the various specialist tankers such as molten sulphur tankers, carrying raw materials to inorganic chemical plants which manufacture them into acids for onward shipment in chemical tankers. Then there is the crude oil trade, most of which is shipped to refineries, where it is refined into a whole range of products: LPG, liquid fuels, lubricants and heating oils. These are shipped on in gas tankers, chemical tankers or products tanker is as appropriate. Finally, at the bottom of the chart are the agricultural trades, notably vegetables, fish oils, wine, orange juice and molasses. Vegetable oils are the biggest trade, and recent regulations call for dedicated vessels which are not alternating with other chemical products.

All this adds up to a sophisticated transport network, operating the fleet of tankers discussed in Section 11.2 and ranging in size from the biggest crude oil tankers of 441,000 dwt at one extreme to a 2,000 dwt bitumen carrier at the other extreme. The task of shipping investors is to improve the efficiency of this transport business by improving the productivity of the transport system by means of better ships, greater flexibility and, where appropriate, specialized investment.

## 11.7 THE CRUDE OIL TRADE

### Origins of the seaborne oil trade

Crude oil was first produced commercially in 1859 when Colonel Edwin Drake struck oil at Titusville, Pennsylvania.[7] The first oil cargo was shipped two years later. Peter Wright & Sons of Philadelphia chartered the brig *Elizabeth Watts*, 224 tons, to load oil in barrels for London. Oil already had a reputation as a dangerous cargo and when that ship was ready for sea, her captain could not find seamen willing to sail with him. He enlisted the aid of a press gang and in November 1861 the first oil cargo sailed down the Delaware, and into history, with a drunken crew.[8]

For the next 25 years shipowners searched for better ways of transporting this disagreeable cargo.[9] Barrels, which were big and awkward to stow, were soon replaced by seven-gallon rectangular tins, packed in pairs in wooden cases. Known as ‘case oil’, these could be shipped as general cargo and for some years they became the standard cargo unit. As the trade grew, sailing ships were fitted with tanks, and some with cargo pumps, to carry petroleum ‘without the aid of casks’. A few such as the *Ramsay* (1863) and the *Charles* (1869) were built for the trade but most were converted. The *Vaderland*, built in Jarrow in 1872 for Belgian owners, was the first effort to build an ocean-going tank steamer. It was designed to carry passengers to the USA and return with oil in tanks.[10]

The first purpose-built tanker to use the outer skin as the containment vessel was the *Glückauf*, 2307 tons, built for the German-American Petroleum Company and launched in 1886. As a safety measure, to avoid the build-up of dangerous gases, the double bottom was eliminated, except under the engine room. Several similar vessels, including the *Bakuin* built for Alfred Stuart and the *Loutsch*, were launched later in the year. [11]The savings by shipping bulk (4*s*. a barrel) were so great that within three years half of the oil imported into the UK came in bulk.[12] Thus started the era of bulk oil transport. From 12 bulk tankers in 1886, the fleet grew to 90 tankers operating in the Atlantic in 1891.

## The sea transport of oil, 1890–1970

Once the ships were available the newly emerging oil companies, which were deeply involved in distribution, were quick to see the advantages of bulk transport. In the late 1880s the US company Standard Oil, the world's biggest oil company, entered the tanker business.[13] They set up the Anglo-American Oil Co. Ltd and, in a typical grand gesture, purchased 16 tankers including the *Duffield* and the *Glückauf*.[14] At about the same time Marcus Samuel, who was distributing Russian case oil in the Far East, decided to build a fleet of tankers to transport Russian oil in bulk to the Far East, thus undercutting Standard Oil.[15] The first was the *Murex*, delivered in 1892, and by the end of 1893 ten ships had been launched for the Samuels.[16] In 1892 the Suez Canal permitted tankers to pass through, reducing the voyage to a competitive distance. Oil was loaded at the Black Sea port of Batum and delivered by tanker to the Far East. To improve profits, the tankers carried a backhaul of general cargo. After discharging oil at Bombay, Kobe, or Batavia, the tanks were steam-cleaned, whitewashed and loaded with a backhaul cargo of tea, cereals or rice. In 1897 Shell Transport & Trading was formed and in 1907 Anglo-Saxon Petroleum Co. Ltd was formed by merging the Shell and Royal Dutch fleets, creating a total fleet of 34 ships.

Over the next 50 years the oil trade grew steadily, reaching 35 mt in 1920 and 182 mt in 1950 (Figure 11.7).

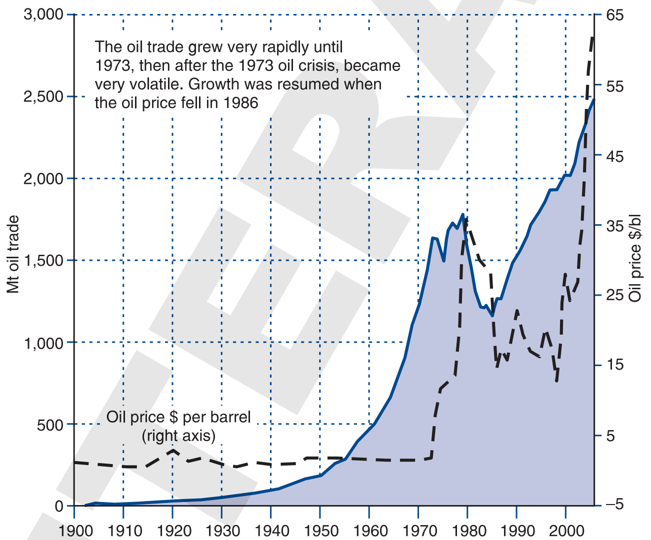


**Figure 11.7**
World oil trade, 1900–2006
Source: Sun Oil, *Fearnleys Review*, CRSL

Trade was controlled by the 'oil majors' and transport dominated oil industry economics. In 1950 the cost of a barrel of oil in the Middle East was about $1. It cost another $1 to ship it to western Europe, so transport accounted for about half the c.i.f. price. Every cent shaved off transport costs contributed to profitability. Shipping was a 'core' business for the oil companies, who developed a policy of balancing owned ships with time charters to independent tanker owners. In the 1950s and 1960s the growth rate of trade increased to 8.4% per annum, compared with 5.9 per cent per annum previously, and since the Middle East was the marginal supply source, ton miles grew even faster. Planning the supply of transport became a major part of the oil industry's business, and they tackled it with characteristic thoroughness. In the 1950s the 'oil majors' set about creating a sophisticated machine for cutting the cost of oil transport. Their three guiding principles were as follows.

1. *Economies of scale*. Throughout the 1950s and the 1960s each generation of tankers was bigger than the last. The size increased from 17,000 dwt in 1950 to the first VLCC in 1966 and the first ULCC in 1976. The economics was simple and clear-cut. In 1968 an 80,000 dwt tanker such as the *Rinform* cost about 27*s*. 5*d*. per ton of oil to make the round trip from Rotterdam to Kuwait. On the same voyage a 200,000 dwt vessel returning via the Cape could do the voyage for 18*s*. 1*d*., a 34% saving.[17]
2. *Transport planning*. The majors developed a logistic network which used tankers to their maximum efficiency. They sailed with a full cargo; waiting time was negligible; regular maintenance minimized breakdown; and when problems occurred they were smoothly dealt with through inter-company cooperation. By the early 1970s the transport performance of the fleet was within a few per cent of the theoretical optimum.
3. *Subcontracting*. To avoid corporate overheads and to spread the risk, a large part of the fleet was subcontracted to independents, with Greeks and Norwegians serving the Atlantic market and Hong Kong serving Japan. To begin with in the 1950s the time charters were generally 5–7 years, but by the time VLCCs were being ordered in the 1960s charters of 15 or even 20 years were not uncommon. By the end of the 1960s the oil companies owned about 36% of the tanker fleet; they time-chartered another 52%; and they topped up their seasonal requirements from the spot market which accounted for about 12% of supply. The spot market was inhabited by the small, uneconomic elderly tankers and a few speculators trading modern tonnage through the boom and bust cycles.

This 'charter back' policy (*shikumisen* in Japan) enabled independent tanker owners to build up their tanker fleets by borrowing against the security of the oil company charter. By July 1971 there was a fleet of 178 m.dwt available for oil transport. The oil companies owned 48 m.dwt (27%), with an additional 79.8 m.dwt (45%) on time charter from independents. As fall-back, there was 19.5 m.dwt (11%) of the independent fleet trading spot, and 17 m.dwt of combined carriers.

Independent tankers thus outnumbered the oil company ships by a ratio of two to one. They made their profits by careful management and asset appreciation rather than speculation.[18] However, the oil companies were hard taskmasters. The charter rates they negotiated usually left little margin for error. As inflation and currency volatility



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developed in the late 1960s, some tanker owners became disenchanted with their role as subcontractors, especially as some owners seemed to be doing spectacularly well on the spot market.

## Growth of the tanker 'spot market',1975–2006

In the 1970s the factors that had worked so positively in favour of an integrated transport operation for oil were reversed. Everything went wrong. The oil trade fell sharply and at the same time supply got out of control, and the oil companies decided oil transport was no longer a core business and reduced their exposure to it. In the next 20 years the transport of oil changed from carefully planned industrial shipping to a market operation. As a result the independent tanker fleet, which in 1973 was mainly trading on time charter to the oil companies, gradually transferred to the spot market. By the early 1990s over 70% of this fleet was trading spot, compared with only about 20% in the early 1970s (see Figure 5.2).

This fundamental change in the organization of oil transport was precipitated by a period of volatility in the oil trade. Trade had reached 300 mt in 1960, and peaked at 1530 mt in 1978. From there it fell to 960 mt in 1983, then grew to 1480 mt in 1995 and 1820 mt in 2005 (Figure 11.8). The fall in the oil trade in the early 1980s had three causes. First, the European and Japanese energy markets were maturing. By the 1970s the transition from coal to oil was over, and lower growth was inevitable. Second, there were two deep economic depressions, one in the mid-1970s and the other in the early 1980s. Third, higher oil prices, which reached $30 per barrel in 1980, meant that other fuels were substituted for oil and fuel-saving technology became viable. In particular, the power station market was lost to coal, and technology reduced oil consumption in other areas.[19] In 1986 the oil price fell to $11 per barrel and remained in the $15–25 per barrel range until the end of the 1990s. This reversed the process of decline and the trade started growing again. But by the 1990s the oil trade had changed from the predictable trade for which transport was carefully planned by the oil companies to a volatile and risky business in which traders played a substantial part and transport was, to a large extent, left to the market place to manage.

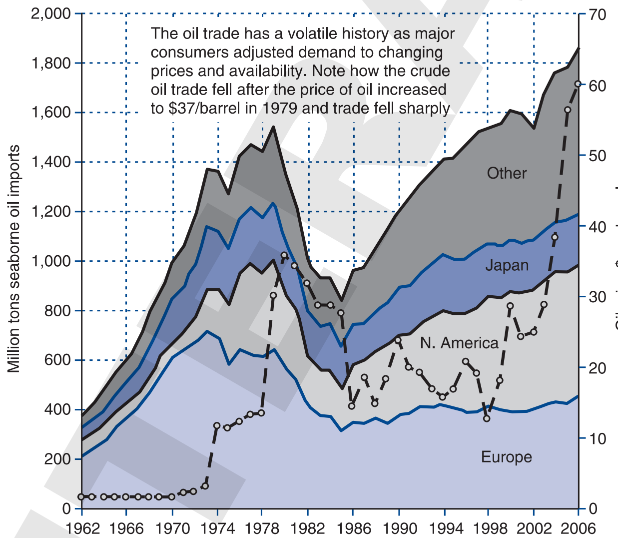


**Figure 11.8**
Crude oil imports, 1962–2005
Source: *Fearnleys Review* 2005 and earlier editions

## Geographical distribution of the crude oil trade

The geographical location of oil supplies plays an important part in determining the number of tankers needed to carry the trade. The location of the world's major oil exporting countries is shown in Figure 11.9, whilst the trade pattern in 2004 is shown in Table 11.4. The largest known source of crude oil outside the consuming areas is the Middle East. This region has 60% of world proven crude oil reserves and acts as marginal supplier of oil to the West, accounting for 47% of exports in 2004. No other supplier comes close to this. Most of the others are clustered around the North Atlantic, including Mexico, Venezuela, West Africa, North Africa, the North Sea and Russia (the main exporter in the 'others' category in Table 11.4). Finally, there are a few smaller producers in South East Asia, notably Indonesia, Australia and China. Since the Middle East lies further from the market than most of the other smaller export oil producers – it is 12,000 miles around the Cape to western Europe and over 6,000 miles to Japan – the ship demand depends upon the source from which oil is obtained and the route taken by the oil to market.

During the 1960s, the share of Middle East oil in the total trade grew very rapidly and the average haul for crude oil increased from 4500 miles to over 7,000 miles, giving a massive boost to ship demand. From a peak of 7,000 miles in the mid-1970s the average haul fell to a trough of 4450 miles in 1985. This fall was partly driven by increased

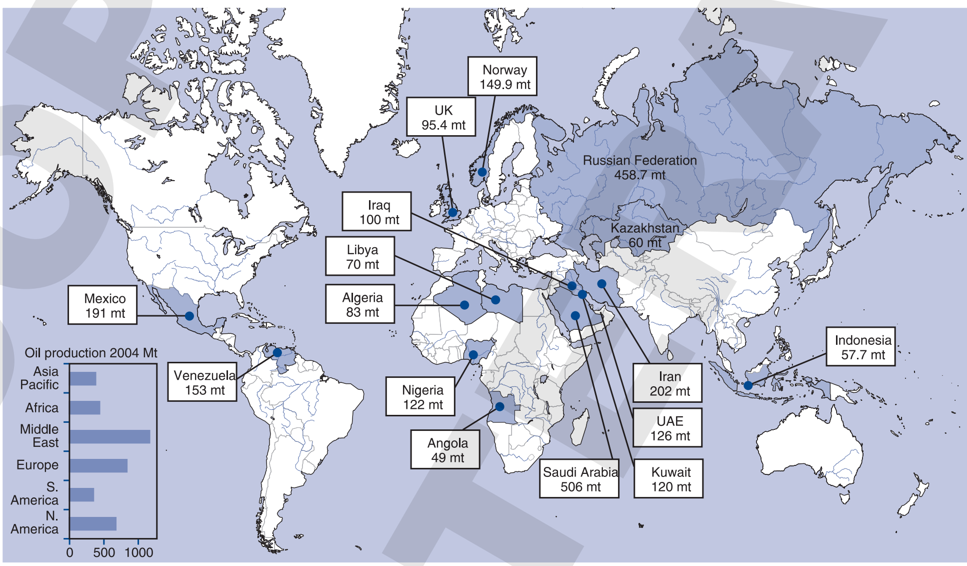


**Figure 11.9**
Major crude oil exporters, 2005
Source: BP Annual Review

**Table 11.4** Crude oil seaborne trade 2004 (million tonnes)

| To: From: | Western Europe | North America | South America | Japan | Other Asia | Others | Total 2004 mt | Total 2004 % |
|---|---|---|---|---|---|---|---|---|
| Middle East | 129 | 130 | 11 | 180 | 353 | 30 | 832 | 47% |
| Near East | 11 | 1 | 0 | 0 | 0 | 0 | 12 | 1% |
| North Africa | 82 | 22 | 4 | 0 | 5 | 1 | 115 | 7% |
| West Africa | 26 | 92 | 9 | 8 | 67 | 4 | 206 | 12% |
| Caribbean | 14 | 189 | 13 | 0 | 6 | 0 | 222 | 13% |
| South East Asia | 0 | 5 | 0 | 10 | 25 | 15 | 56 | 3% |
| North Sea | 11 | 46 | 1 | 0 | 4 | 0 | 62 | 4% |
| Others | 155 | 40 | 14 | 2 | 32 | 6 | 250 | 14% |
| Total 2004 | 428 | 526 | 51 | 200 | 493 | 57 | 1,754 | 100% |
| % | 24% | 30% | 3% | 11% | 28% | 3% | 100% | |

Source: *Fearnleys Review* 2005

short-haul oil production. North Sea production started in 1975 and rose to 5.5 million barrels per day. At about the same time the Alaska North Slope came on stream, cutting US imports. Other factors contributing to the fall in ton miles were the reopening in 1975 of the Suez Canal which had been closed since 1967; the Sumed Pipeline which eventually carried 1.5 million barrels of oil per day to the Mediterranean; and in the 1980s the Dortyol pipeline built during the Iran–Iraq war diverted 1.5 million barrels of Arabian Gulf oil to the eastern Mediterranean. As a final complexity, in the early 1980s Saudi Arabia and Kuwait opened large refineries, with the capacity to export 100 mt of oil as products, not as crude. Taken together, over a period of 15 years these developments probably cut long-haul crude movements by about 10 million barrels per day. The cyclical role of the Middle East was repeated during the two decades from 1985 to 2005. After the oil price fell in 1986 there was a surge of Middle East exports which drove up ton miles and created demand for VLCCs. Then in the early 1990s there was a swing to short-haul oil, especially in the Atlantic, and ton miles fell as suppliers in the North Sea, West Africa and later Russia were able to meet the growing needs of the USA and Europe. Russia and Kazakhstan became the most important new exporters, with Russia shipping oil to Europe by pipeline, by sea through Primorsk on the Gulf of Finland and through the Black Sea. New supplies from Sakhalin on Russia's Pacific coast started to be shipped in 2006.

The position of the Middle East as marginal or 'swing' oil supplier and its geographical location relative to the other oil exporters creates a mechanism that we can refer to as the 'ship demand multiplier' – when oil exports are growing, the market share of the Middle East increases and the average haul rises; when the demand for imports is declining, the process goes into reverse. This means that upswings and downswings in the oil trade are intensified in terms of their impact upon the shipping market, and that predicting the demand for oil tankers must take account of the supply pattern for oil as well as the import requirement of each region.

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Finally, we must say something about the control of the oil trade. Oil is a strategic business and market economics operate within a political framework. Until the 1970s the seven major oil companies were responsible for something like 80% of all oil processing in the world and they operated or controlled, through long-term charters, most of the seaborne oil transport.[20] However, in the last thirty years the control of oil transport has changed and their role in transport has been diluted. Oil producers, especially in the Middle East, now actively market their oil through distribution organizations in the consuming markets and several have built their own tanker fleets. New oil companies have emerged in the rapidly growing Asian markets, with their own transport policies. Finally, large volumes are now handled by oil traders, some working for the oil companies and others for independent traders such as Vitol or Glencore. They own much of the oil during shipment and since they are constantly buying and selling oil cargoes, it suits their business model to charter ships as required on a voyage by voyage basis, and this has encouraged the growth of the spot market. However, some take longer-term positions, especially products tankers, where their cargo volume allows them to obtain above-average utilization of the vessels.

## The crude oil transport system

Although seaborne oil transport is often thought of as a relatively straightforward business – and indeed, this is true of the crude oils – when we include all the various oil derivatives it really becomes a complex activity. The best way to understand the trade is to start by looking at its physical characteristics. From a transport viewpoint, oil cargoes can differ in two important respects: specific gravity;[21] and the standards of cleanliness needed to transport it. This point is illustrated in Table 11.5, which ranks oil cargoes by specific gravity. At the top end of the table are heavy fuel oils which have a specific

**Table 11.5** Oil product characteristics

| | Density at 15°C | | | | | | Stowage/tonne | |
|---|---|---|---|---|---|---|---|---|
| | Specific gravity | °API | Range + or – | Cargo type | Special characteristics | Typical cargo size- tons | Cu. ft | $M^3$ |
| Heavy fuel oil | 0.98 | 13.53 | 3% | Dirty | Cargo heating | 50-80,000 | 32.8 | 0.93 |
| Heavy crude oil | 0.95 | 17.34 | 3% | Dirty | Cargo heating | 60-300,000 | 33.7 | 0.95 |
| Diesel oil | 0.86 | 32.92 | 3% | Dirty | | 40,000 | 37.2 | 1.05 |
| Light crude oil | 0.85 | 34.85 | 3% | Dirty | | 60-300,000 | 37.6 | 1.07 |
| Gas oil (light fuel oil) | 0.83 | 38.86 | 2% | Mainly clean | | 30,000 | 38.6 | 1.09 |
| Paraffin | 0.80 | 46.36 | 2% | Clean | Clean tanks | 30,000 | 40.3 | 1.14 |
| Motor spirit (petrol) | 0.74 | 59.58 | 5% | Clean | Clean tanks | 30,000 | 43.2 | 1.22 |
| Aviation spirit | 0.71 | 67.65 | 3% | Clean | Clean tanks | 30,000 | 45.1 | 1.28 |
| Naphtha | 0.69 | 73.43 | 4% | Clean | Clean tanks | 30,000 | 46.4 | 1.31 |

Source: Packard (1985, p. 129)

gravity close to 1, followed by heavy crude oil, diesel, and light crude oil. These are essentially the 'dirty' tanker products. Gas oil is a transitional product, in the sense that carrying several cargoes of gas oil helps to clean up the tanks after carrying a dirty cargo. Finally the lighter products fall into the 'clean' category, which simply means that the shippers are very sensitive that these products should not be polluted by any traces of the previous cargo. At the bottom of the table are petrol and naphtha, both of which have a substantially lower density than the dirty commodities. Finally, the table gives the typical parcel size in which these commodities are shipped. Crude oil is shipped in very large parcel sizes, typically over 100,000 tonnes, whilst most of the oil products are shipped in parcels of 30,000, 40,000 or 50,000 tonnes. However, diesel oil and heavy fuel oil are also shipped in relatively small parcels and need heating coils to keep the liquid at a pumpable viscosity.

These three characteristics – the density of the oil; the parcel size in which it is shipped; and the degree of care and cleanliness required in handling the cargo – set the framework for the oil transport system. Crude oil for export is usually transported from the oilfield to the coast by pipeline. A small-diameter pipe from each producing well connects to collecting stations from where it moves into large terminal areas with storage tanks capable of holding millions of barrels. The oil is then loaded into tankers and shipped to its destination, where it is offloaded into another bulk terminal. A typical 300,000 dwt VLCC would carry about 2 million barrels of oil, at a draught of about 22 metres, a speed of 15.8 knots and with a pumping capacity of between 15,000 and 20,000 tons per hour. The Suezmax tankers typically carry 1 million barrels with a loaded draught of 15.5 metres and a discharge pumping capacity of between 10,000 and 12,000 tons per hour.

Such large vessels require a dedicated port infrastructure and the terminals used in the oil trade, of the type illustrated in Figure 11.4, are often in remote locations, consisting of a tank farm for temporary oil storage and a jetty or single buoy mooring projecting into deep water where large tankers can load cargo. For example, Ras Tanura, the main export terminal of Saudi Arabia, has a series of jetties built offshore. From the discharge terminal the oil is delivered direct to a refinery, or to a crude oil terminal linked to refineries by a pipeline. In the early days of the oil industry much crude oil moved by rail tank car, but today pipelines, barges and ships dominate petroleum handling.

The deep draught of large tankers restricts their use of key shipping lanes such as the Straits of Dover, the Straits of Malacca and the Suez Canal. In the Straits of Dover, for instance, there is a maximum permissible draught of around 23–25 metres, which used to be on the margin for larger-size ULCCs, though in 2006 there were only four vessels of this draft in service. In the Straits of Malacca, on the route between the Middle East and Japan, the maximum draught of 21 metres precludes the larger ULCCs. However, from the shipping industry's point of view, the draught restrictions on the Suez Canal were the most important. Until the mid-1950s the Suez Canal was the main route for crude oil shipped from the Middle East to western Europe. At that time the draught was 11 metres, restricting the canal to loaded vessels of less than 50,000 dwt. The closure of the canal during the Six Day War in 1967 coincided with the trend to build VLCCs



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for the oil trade and as a result the imports of western Europe and the United States from the Middle East were diverted around the Cape of Good Hope.

After the Suez Canal was reopened in 1975, it was deepened to 16.2 metres, allowing vessels of up to 150,000 dwt to transit fully loaded, or larger vessels in ballast. As a result, shipments of oil through the canal edged up from 30 mt in 1976 to about 40 mt in 1995 and 85 mt in 2004, but remained well below the peak of 167 mt achieved before the canal was closed in 1967. This reflects the availability of bigger ships which cannot transit the canal fully loaded. One effect of the reopening of the Suez Canal was to generate a demand for intermediate-sized tankers of 100,000–150,000 dwt.

## 11.8 THE OIL PRODUCTS TRADE

The oil *products* trade is very different from the trade in crude oil. In 2005 about 500 mt of oil products were shipped by sea, about half of which were clean products and the other half dirty products. Clean products consist of the lighter distillates, principally kerosene and gasoline, which are usually shipped in vessels with coated, clean tanks. Dirty products include the lower distillates and residual oil, which can generally be shipped in conventional tankers, though the low viscosity sometimes necessitates steam-heating coils in the cargo tanks.

In the 1950s much of the oil trade was shipped as products, but as the market developed in the 1960s the oil company strategy was generally to ship crude oil to refineries located close to the market. Improved refining technology contributed to this trend, allowing the mix of refined products to be more closely matched to local demand and bigger crude oil tankers reduced transport costs, an important factor on the long sea journey from the Middle East to western Europe. Finally, politics played a part, since nationalization of the oil refineries of the Anglo-Iranian Oil Company in 1951 provided an incentive to locate refining capacity in the more politically secure consuming countries. As oil became more important to the economies of western Europe, so the degree of risk that they were prepared to accept became smaller. Thus ‘there was an escalating interest in the development of market-based refineries, and by the end of the 1950s Western Europe had developed sufficient refinery capacity to meet its main oil products needs’. [22]

Despite these developments, in 2004 all the major oil-consuming areas imported products, notably the USA, Europe, China, Japan and the Asian tigers, whilst exports came from the Middle East, Venezuela, the Caribbean, Europe, Russia and India. This trade pattern, which is shown in Table 11.4, is shaped by a mix of economic and technical factors of which three are particularly important:

- *Refinery location*. There has been a gradual revival in the construction of export refineries located in producing areas, lead by the oil producers, for example in the Middle East, especially Saudi Arabia. Table 11.6 shows that in 2006 the Middle East was the biggest exporter, with a trade of 117 million tonnes, but India was also expanding its exports.
- *Balancing trades*. The mix of products refined from a barrel of oil does not always meet the precise market structure of the market adjacent to the refinery.



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**Table 11.6** Oil products imports and exports, 2006 (million tonnes)

| | Imports | % | Exports | % |
|---|---|---|---|---|
| USA | 168.2 | 26% | 60.4 | 26% |
| Canada | 13.5 | 2% | 26.1 | 2% |
| Mexico | 20.1 | 2% | 6.9 | 2% |
| South & Central America | 24.0 | 3% | 63.8 | 3% |
| Europe | 131.4 | 22% | 75.9 | 22% |
| Former Soviet Union | 5.6 | 1% | 78.5 | 1% |
| Middle East | 7.3 | 1% | 116.7 | 1% |
| North Africa | 8.4 | 1% | 31.1 | 1% |
| West Africa | 7.5 | 2% | 7.5 | 2% |
| East & Southern Africa | 6.4 | 1% | 0.8 | 1% |
| Australasia | 13.9 | 2% | 4.1 | 2% |
| China | 45.9 | 9% | 13.5 | 9% |
| Japan | 48.4 | 9% | 5.5 | 9% |
| Singapore | 55.8 | 19% | 58.3 | 19% |
| Other Asia Pacific | 101.5 | 0% | 72.0 | 0% |
| Unidentified * | — | | 36.8 | |
| TOTAL WORLD | 657.8 | | 657.8 | |

Includes changes in the quantity of oil in transit, movements not otherwise shown, unidentified military use, etc.
Source: BP *Statistical Review of World Energy*, June 2007

For this reason there is a constant movement of specific oil products from areas of surplus to areas of shortage, driven by price differences.

- *Deficit trade*. Local shortages of refined products may occur either because demand grows faster than refining capacity can be expanded, or because the market is not large enough to support local refining operations. In these circumstances the import trade will take the form of oil products rather than crude oil.

The growth trends of the major importers are shown in Figure 11.10. Until the 1950s the principal products trades were from refineries in Venezuela and the Caribbean to the United States and from the Middle East to western Europe. The Caribbean to US trade built up to a peak of 150 mt a year in the early 1970s, then fell sharply to 75 mt as the US expanded its domestic refining capacity. However, in the 1990s the Clean Air Act legislation and the difficulty of building new refinery capacity started imports edging up again to 137 mt in 2004. European oil imports were mainly shipped as crude oil rather than products. Products imports fell to a trough of 35 mt in 1971, then revived to about 80 mt in the 1980s, compared with over 400 mt of crude imports. Towards the end of the 1990s European imports started to increase, following a similar pattern to the USA. The explanation of this trade pattern can be found in a combination of technical, economic and political factors. Figure 11.10 shows that a major change came in the 1980s when the 'other' countries' imports started to grow rapidly, quadrupling from 75mt in 1984 to 309mt in 2006. The split of the 2005 trade in Figure 11.10 shows that Asia accounts for two-thirds of this trade, in particular China, Korea and the many growing Asian economies which have a shortfall of particular product types.

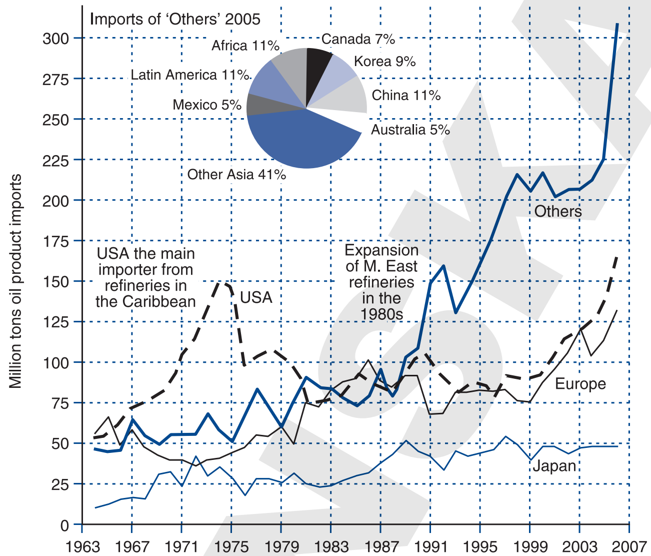


**Figure 11.10**
Oil product imports, 1963–2007
Source: BP, *Statistical Review*

Finally, we should note that to some extent this trade is supply-driven. Following the 1973 oil crisis several oil producers became interested in investing in refineries, which would enable them to export oil products rather than crude, increasing their value-added. The most prominent was Saudi Arabia, which has built a series of refineries aimed at the export market. In contrast, the US oil industry found itself with surplus refining capacity and started to withdraw from the refining operations in the Caribbean.

## The transport of oil products

The economics of the transport system for oil products is in many ways similar to that for crude oil, but there are some important differences. One is that most of the trade moves in small tankers of between 6,000 and 60,000 dwt, often with epoxy-coated tanks.[23] The size restriction arises from the smaller parcels of oil products traded by the oil industry and the many short-haul trades which limit economies of scale and terminal restrictions. However, there are no firm rules about size. Even VLCCs are occasionally chartered for long-haul parcels of fuel oil, and many Aframax tankers are coated to carry long-range products cargoes.[24]

An analysis in Table 11.7 of 11,577 vessels chartered in 2005–6 to carry oil products shows that gasoline is the biggest commodity, followed by fuel oil, gasoil and naphtha. The average parcel size was 44,600 tonnes, and the average ship size was 53,800 tonnes, so there was 18% 'dead freight' (un utilized space in the tankers). This is partly due to the low density of some oil products. For example, naphtha has a specific gravity of 0.69, and the dead freight for naphtha cargoes was 22%. The other reason for the high dead freight is that the available ships often do not exactly match the parcels for transport. For example, many 37,000 ton parcels of gasoline are shipped in products tankers of 48,000 dwt, and products tankers are sometimes designed with a hull optimized to a lower cargo parcel than the full deadweight (see Figure 14.7 for an example of a chemical tanker with a design deadweight 14% lower than its scantling deadweight). Products tankers trading switching from dirty to clean products need to go through a rigorous tank cleaning process.

**Table 11.7** Oil products cargo types Jan 2005 to July 2006

| | Ships fixed | | | | | |
|---|---|---|---|---|---|---|
| | Number | Mill. dwt | Cargo Mill. (t) | Cargo % dwt | Av. cargo '000 t | Av. ship '000 dwt |
| Gasoline | 5,390 | 254.5 | 198.5 | 78% | 36.8 | 47.2 |
| Fuel oil | 3,431 | 216.6 | 192.7 | 89% | 56.2 | 63.1 |
| Gasoil | 1,169 | 57.5 | 47.8 | 83% | 40.9 | 49.2 |
| Naphtha | 1,002 | 57.7 | 45.3 | 78% | 45.2 | 57.6 |
| Jet/kerosene | 393 | 22.2 | 19.1 | 86% | 48.5 | 56.6 |
| Condensate | 155 | 11.9 | 10.3 | 87% | 66.7 | 76.9 |
| Other | 37 | 1.8 | 2.9 | 166% | 79.5 | 47.8 |
| TOTAL | 11,577 | 622 | 517 | 83% | 44.6 | 53.8 |

Note: In some instances vessels have not been named for individual fixtures – as a result 'total vessel deadweight' may under-report actual tonnage used

Source: Sample of products tanker fixtures, 2005

The transport of oil products should be distinguished from the more specialized trade in small liquid parcels such as chemical and vegetable oils. These appear on the market in quantities which are large enough to make them prohibitively expensive to ship in drums or tank containers, but not in sufficiently large packages to justify the charter of a whole ship. This has led to the development of 'parcel' tankers which contain many segregated tanks, sometimes 30–40, with separate pumping arrangements, some of them with special coatings to resist toxic or corrosive liquids. This enables the shipowner to load many different cargoes of liquid into a single vessel. Some products tankers are designed with segregated cargo-handling systems which enable them to carry several different products or to trade in the easy chemicals market. A transport operation of this type is inevitably more complex, involving carefully planned investment decisions supported by a professional operating service to schedule the cargo and ensure that high utilization levels are achieved. The carriage of chemicals and other specialized liquid cargoes is discussed more fully in Chapter 12.

## 11.9 THE MAJOR DRY BULK TRADES

If oil is the energy of modern industrial society, the major bulks are the building-blocks from which it is constructed. *Iron ore* and *coking coal* are the raw materials of steel-making, and steel is the principal material used in the construction of industrial and domestic buildings, motor cars, merchant ships, machinery and the great majority of industry products. *Steam coal* is a major energy source for power generation. The staple foods of the modern industrial society are bread and meat, both of which require large quantities of *grain* – for baking and as the raw material of the modern factory farming

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**Table 11.8** The three 'major' bulk commodities shipped by sea (mt)

| Commodity | 1965 | 1975 | 1985 | 1995 | 2005 | % pa 1965–2005 |
|---|---|---|---|---|---|---|
| Iron ore | 152 | 292 | 321 | 399 | 650 | 3.7% |
| *growth % pa* | | 7% | 1% | 2% | 5% | |
| Coal | 59 | 127 | 272 | 403 | 690 | 6.3% |
| *growth % pa* | | 8% | 8% | 4% | 6% | |
| Grain | 70 | 137 | 181 | 184 | 242 | 3.1% |
| *growth % pa* | | 7% | 3% | 0% | 3% | |
| Total | 281 | 556 | 774 | 986 | 1,582 | 4.4% |
| *growth % pa* | | 7% | 3% | 2% | 5% | |

Source: Fearnleys *World Bulk Trades*, CRSL

of meat. It follows that in discussing these bulk trades we are concerned with the whole material development of the world economy that uses these materials.

Because of their volume, the three major bulk trades are the driving force behind the dry bulk carrier market. In 2005 the trade totalled 1.58 bt, accounting for almost one quarter of total seaborne cargo, and in terms of tonnage about the same as the crude oil trade. The tonnage of cargo in each commodity and its growth rate in each of the last four decades are shown in Table 11.8.

Over the four decades 1965–2005 the major bulk trades grew at an average of 4.4% per annum, but each followed a different growth pattern. Coal grew much the fastest (6.3% pa), followed by iron ore (3.7% pa) and grain (3.1% pa). In addition, the table shows that the rate of growth varied from decade to decade. For example, iron ore grew at 7% pa in the first decade, and 1–2% pa in next two, and 5% in the last. One of the principal reasons for studying commodity trade economics is to explain why such changes take place. As we shall see in the following brief review, there is no simple pattern. Each commodity has its own distinctive industrial characteristics, growth trends and impact upon the dry bulk shipping industry.

## The seaborne iron ore trade

Iron ore is the largest of the major bulk commodity trades and the principal raw material of the steel industry with a trade of 590 mt in 2004 (Table 11.9). Like crude oil, the iron ore trade is determined by the location of the processing plant in relation to raw material supplies. During the industrial revolution, steel plants were located on sites close to major sources of raw materials, notably iron ore, coal and limestone, and access to materials was a major concern in the economics of the industry. However, as transport technology developed, it became clear that the distance over which the materials were shipped was less important than the freight-rate structure, the transport service and the quality of the raw materials.[25]

Today developments in bulk shipping technology mean that steel plants located near to raw material supplies no longer have a significant cost advantage, particularly when land transport is required. For example, in the United Kingdom, Northamptonshire ores



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were trebled in cost by transport to Middlesbrough, making them unable to compete with high-grade ore shipped from Brazil to Middlesbrough by sea for around $7 per tonne. [26] As the demand for steel expanded in the twentieth century, the industry gravitated towards coastal steel plants, which could import raw materials at minimum cost by using a carefully planned integrated bulk shipping operation. This had the advantage that, with the resources of the world accessible by sea, it was possible to find higher-quality raw materials than were available locally, particularly in the traditional steel-making areas of western Europe where the better-quality ores were already depleted.

The prototype for the modern integrated dry bulk transport operation was the steel plant built by Bethlehem Steel at Sparrow's Point, Baltimore, in the early 1920s. This plant was designed specifically to import iron ore by sea from Cruz Grande in Chile, taking advantage of the newly opened Panama Canal. To service the trade, a contract was placed with the Brostrom group, which ordered two ore carriers of 22,000 dwt. At the time these were two of the world's largest ocean-going cargo ships. Details of the shipping operation are recorded as follows:

> The contract, signed in 1922, called for two ships to carry ore from Chile through the Panama Canal to Bethlehem Steel Company's plant at Sparrow's Point, Baltimore. The ships had no conventional cargo handling gear, and hinged corrugated steel hatch covers. These were the full width of the holds, weighed 8 tons apiece and were clamped down to thick rubber gaskets. The *Sveland* was delivered on 9th April 1925 and *Americaland* on 29th June and they promptly entered their designed service between Cruz Grande and Baltimore. It was an exacting schedule and the average time spent at sea each year was 320–330 days. At Cruz Grande the 22,000 tons cargo was normally loaded in two hours, though the record was 48 minutes. Discharging at the other end required about 24 hours. Routine engine maintenance was carried out at sea, one of the two engines being shut down for eight hours per trip. Painting was also carried out while underway. [27]

This strategy of using large, specially designed ships on a shuttle service between the mine and the steel plant has become standard practice in the steel industry and the size of ship increased from 120,000 dwt in the 1960s to 170,000 dwt in 2007, with some units of 300,000 dwt built for stable ore trades.

The East Coast development of the US steel industry proved something of a false start, and the major portion of US steel-making continued to be concentrated around the Great Lakes, using locally produced ores supplemented by imports from Canada via the St Lawrence Seaway when the Labrador iron ore fields were developed. As a result, the USA did not figure prominently in the post-war overseas iron ore trade.

In fact, the principal growth in imports of iron ore came from western Europe, Japan, Korea and most recently China, as can be seen in Figure 11.11. During the post-war period of industrial expansion, steel demand grew rapidly. In Europe and Japan this growth was met by building modern integrated coastal steel plants using imported raw materials. In Japan there was little choice since there were no domestic reserves of iron ore, but even in Europe where extensive iron ore reserves are available these were of

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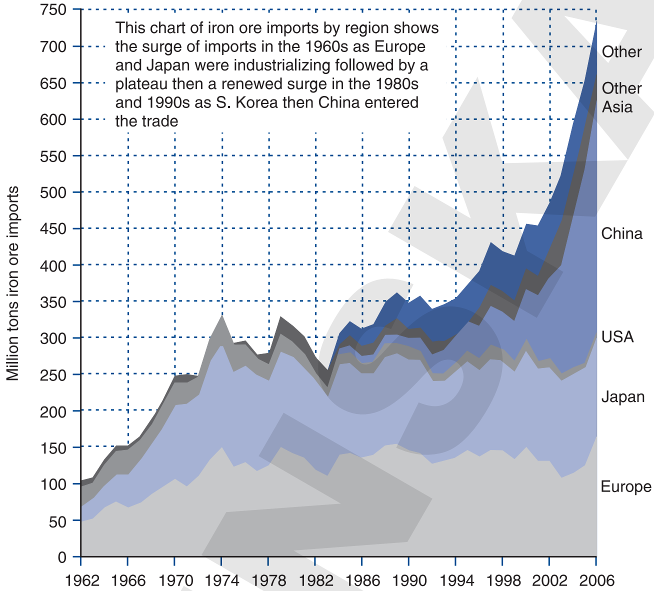


**FIGURE 11.11**
Iron ore imports, 1962–2005
Source: *Fearnleys Review* 2005 and earlier editions

lower quality than the imported variety. For new developments, the shorter land transit leg offered little cost advantage over seaborne transport using large bulk carriers. It was the rapid expansion of iron ore imports by the steel industry that underpinned the bulk carrier boom of the 1960s. The Japanese and European steel companies were prepared to offer long-time charters to meet the regular raw material requirements of the new coastal steel plants. These charters provided many growing bulk shipping companies with the stable foundation on which to base their fleet development strategy. In the early 1970s, however, the growth subsided. After a decade of expansion the steel companies found themselves facing excess capacity and for twenty years ore imports stagnated, as can be seen in Figure 11.11. The explanation is that steel production in Europe and Japan had reached a level which was sufficient to service their ongoing domestic needs: between 1975 and 2005, western European steel output fell from 170 mt to 162 mt; during the same period Japanese production fluctuated around 110 mt. [28] There are many reasons for this radical change of trend, but the most important was that the industries that use steel intensively (principally construction, vehicles and shipbuilding) had all reached a plateau in their output. [29] As a result, the growth had been removed from the largest iron ore importers.

The next turning point came in the 1980s when South Korean steel production started to grow, and a decade later that was dwarfed by the industrialization of China which, during a sudden burst of growth, added 300 mt of steel capacity in the four years 2002–6, driving the iron ore trade up to 720 mt.

Although we have concentrated on the demand for seaborne imports of iron ore, the trade also depends crucially upon the development of a global network of iron ore supplies, and the map in Figure 11.12 shows the pattern that developed. Generally at the initiative of the steel companies, iron ore resources were identified across the globe and the necessary capital raised to develop the mines and install the requisite transport infrastructure.

By far the largest iron ore exporters are Australia (206 mt in 2004) and Brazil (205 mt), together accounted for 70% of iron ore exports (Table 11.9). The Brazilian iron ore

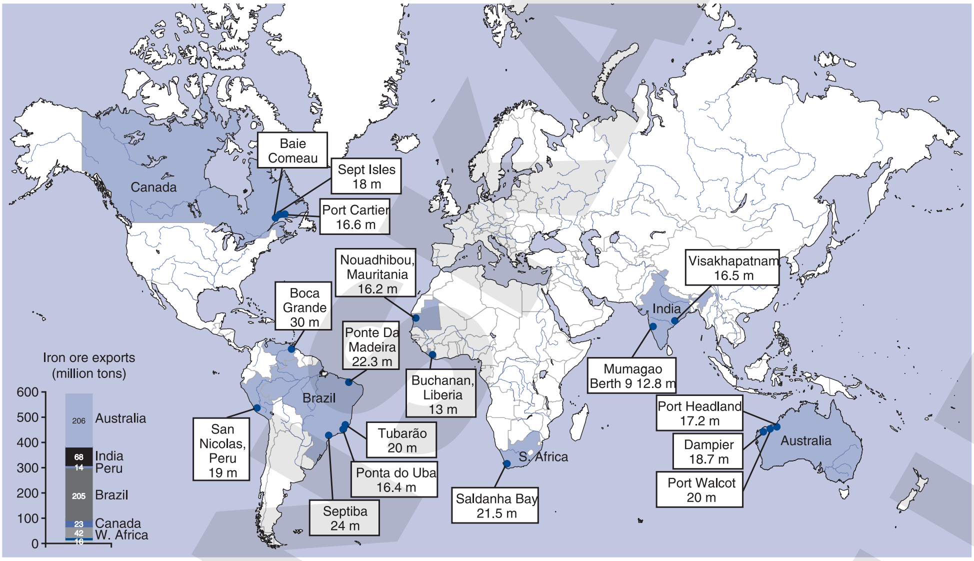


**FIGURE 11.12**
Major iron ore exporters and ports, 2005.
Note: The numbers against each port indicate the approximate maximum draft in metres.

reserves are located in the famous Iron Quadrangle of Minas Gerais which exports through the ports of Sepetiba and Tubarão Carajas, and a major iron ore development in the Pará region of Northern Brazil with port facilities at Itaqui geared to 300,000 dwt bulk carriers. Australia's mines are mainly located in north-west Australia, and its ore, exported mainly through the three ports of Port Hedland, Dampier and Port Walcott.

**Table 11.9** Seaborne iron ore trade 2004

| To: From: | UK/ Cont. | Mediter- ranean | Other Europe | USA | Japan | China | Other Far East | Others | Total mt | Total % |
|---|---|---|---|---|---|---|---|---|---|---|
| Scandinavia | 7 | 1 | 1 | | | 1 | 0 | 7 | 16 | 3% |
| Other Europe | 0 | | | | | 0 | 1 | 3 | 5 | 1% |
| West Africa | 8 | | 1 | | | | | 3 | 11 | 2% |
| S. Africa | 7 | 0 | 3 | | 10 | 17 | 2 | 2 | 42 | 7% |
| North America | 12 | 1 | 0 | | 1 | 2 | 2 | 4 | 23 | 4% |
| Brazil | 46 | 2 | 8 | 7 | 27 | 54 | 21 | 38 | 205 | 35% |
| S.America Pac. | | | | 0 | 4 | 6 | 3 | 1 | 14 | 2% |
| India | 1 | 0 | | | 22 | 40 | 4 | 2 | 68 | 12% |
| Australia | 15 | 1 | 1 | 0 | 76 | 70 | 39 | 5 | 206 | 35% |
| Total 2004 | 95 | 6 | 14 | 8 | 140 | 190 | 71 | 66 | 590 | 100% |

Source: *Fearnleys Review*, 2005

The remaining third of the iron ore trade is supplied from a variety of smaller exporters, of whom the most important are India, South Africa, Liberia and Sweden.

## The transport system for iron ore

Iron ore is a low value commodity worth about $40 per tonne and very dense, with a stowage factor of 0.3 cubic metres per ton. It is almost always transported in bulk and in full shiploads. Over the past decade there has been great competition between suppliers in the Atlantic and Pacific for the markets in Asia and the North Atlantic, leading to increasing distance between source and markets and the employment of the largest ships possible.

At the mine earth-moving equipment removes the ore from open pits and transfers it to special trains or trucks that transfer it to port, where it is placed in storage areas. When needed it is reclaimed and transferred by conveyor to the quayside where it is loaded (see Figure 11.5) by gravity or cranes. The ship then steams to a port or coastal steel mill where the process is reversed. The entire system is geared to anticipate mill needs with a continuous flow of the ore from mine to mill. Discharge is at a special terminal similar to the loading terminal, but with grabs of up to 50 tons used to handle the cargo. The throughput of the system is determined by cargo-handling capacity, storage and the availability of ships.

Although the economies of scale which can be achieved through the use of large bulk vessels were well known in the 1950s, the transition from small vessels to the larger sizes was a slow process. In 1965, 80% of all iron ore was carried in vessels below 40,000 dwt; forty years on, by 2005, 80% was carried in ships over 80,000 dwt. The process of introducing large ships was gradual, with the bulk carriers built for the trade increasing steadily from around 30,000 dwt in the early 1960s to 60,000 dwt in 1965, 100,000 dwt in 1969, 1,50,000 dwt plus in the early 1970s, and 300,000 dwt in the 1990s. For example, the *Bergeland*, delivered in 1991, was a 300,000 dwt vessel designed exclusively for the carriage of iron ore, and in 2007 four 388,000 dwt bulkers were on order for the China trade. In fact the size of ship has grown with the volume of trade and the improvements in port facilities, though many small vessels built in previous periods continue to be used.

## The seaborne coal trade

Coal is the second largest dry bulk trade, with imports of 665 mt in 2004 (Table 11.10), principally into western Europe and Japan, as can be seen in Figure 11.13. It is a complex trade with two very different markets, ‘coking coal’ used in steel-making, and ‘thermal coal’ used to fuel power stations. As the inset chart in Figure 11.13 shows, in recent decades the two trades have followed very different growth paths, with the thermal coal trade growing rapidly at 9% per annum between 1980 and 2005, whilst the coking coal trade only managed 2% per annum.

Coking coal is a major raw material of the steel industry. The coal is first converted into coke in a coke oven, and then mixed with iron ore and limestone to form a charge



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that is fed into the top of the blast furnace. As the charge works its way down the blast furnace, the carbon in the coke combines with oxygen in the iron ore and at the bottom of the blast furnace the pig iron is drawn off, leaving a residue of slag. This process requires a special type of coal. To do its job satisfactorily the coke 'must be porous to allow air circulation, strong enough to carry the weight of the charge in the furnace without being crushed, and low in ash and sulphur'.[30] Many varieties of coal locally available do not meet these requirements, and some grades are naturally more satisfactory than others. By moving to coastal steel plants steel-makers can import the most suitable metallurgical grade coals from foreign mines and blend them to give the precise requirements for efficient steel-making. As a result, coking coal imports grew rapidly during the 1960s, but stagnated in the 1970s in the same way as the iron ore trade and for the same reason. However when China started to expand its steel industry in the late 1990s, coking coal imports did not expand because China has very large coal reserves (114 billion tons of recoverable coal in 2004) and was able to meet its coking coal requirements from domestic sources.

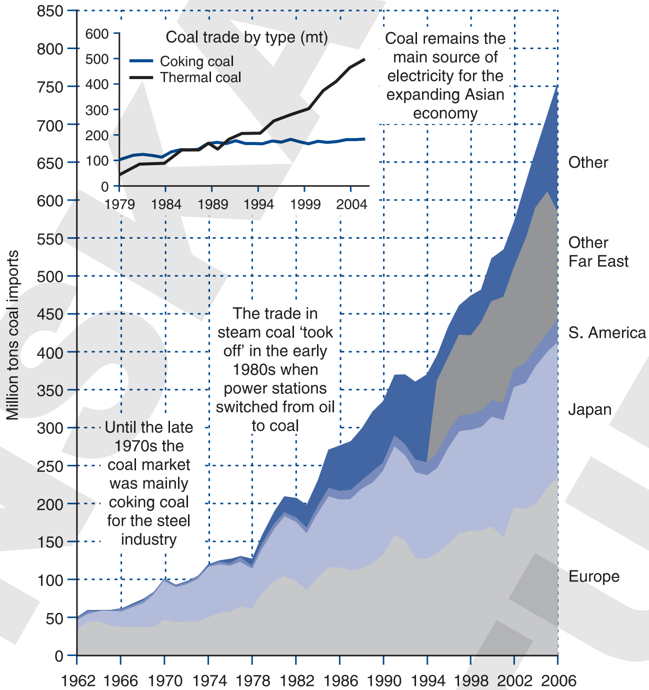


**FIGURE 11.13**
Coal imports, 1962–2005
Source: *Fearnleys Review* 2005 and earlier editions

Coal is also widely burned in power stations and is in competition with oil and gas. During the 1950s the falling price of oil made coal uncompetitive, and by the early 1960s the thermal coal trade had disappeared. For the next decade almost the only coal moved by sea was for steel-making. With the increase in oil prices during the 1970s, however, coal became more competitive and its supply base more stable. It took several years to mobilize the necessary volume and handling infrastructure.[31] But from 1979 onwards there was a rapid increase in thermal coal imports, as is clearly visible in the inset graph in Figure 11.13.

The main coal importers and exporters are shown in Figure 11.14 and Table 11.10. Europe, Japan and other Far East countries are the main coal importers. Europe and Japan both use substantial amounts of coking coal, as does South Korea which is included in the 'other Far East' category, but power generation is also a substantial

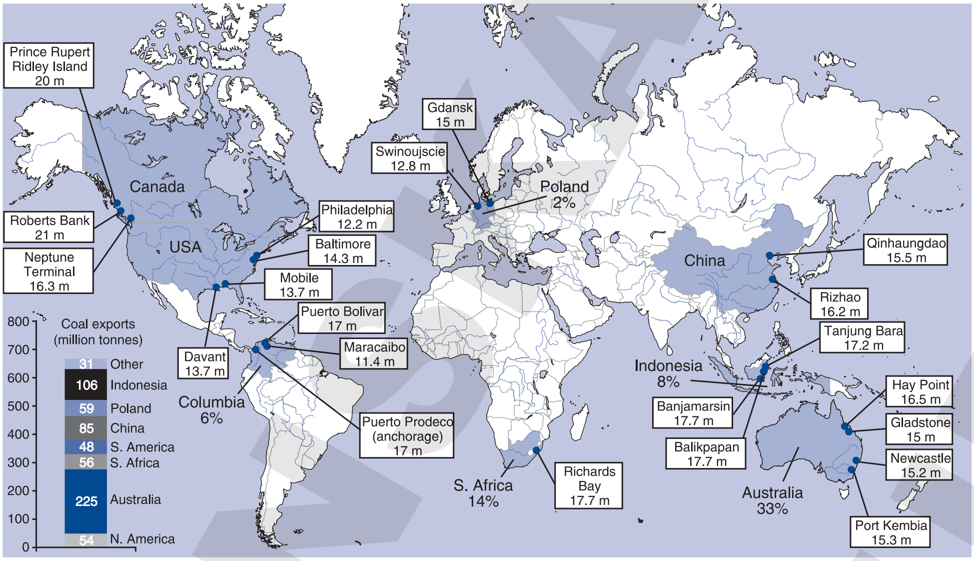


**FIGURE 11.14**
Major coal exporters and ports, 2005.
Note: The numbers against each port indicate the approximate maximum draft in metres.
Source: *Feamleys Review* 2005

market and there are many power stations scattered across Asia which import coal by sea. Australia provides more than a third of the exports, followed by Indonesia and a number of smaller exporters such as Colombia (South American Caribbean) and Canada. One of the attractions of coal over oil is the wide range of different suppliers available. During the boom of 2006 China started to cut back on its exports and

**Table 11.10** Seaborne coal trade 2004

| To: From: | Europe | South America | Japan | Other Far East | Others | Total mt | Total % |
|---|---|---|---|---|---|---|---|
| N. America | 23 | 8 | 10 | 9 | 3 | 54 | 8% |
| Australia | 29 | 10 | 103 | 59 | 23 | 225 | 34% |
| S. Africa | 46 | 2 | | 1 | 6 | 56 | 8% |
| S. Am. Caribbean | 25 | 2 | 0 | 0 | 21 | 48 | 7% |
| China | 4 | 1 | 29 | 44 | 7 | 85 | 13% |
| FSU | 42 | 0 | 9 | 7 | 1 | 59 | 9% |
| 0th.E Europe | 13 | 0 | | | 1 | 14 | 2% |
| Indonesia | 14 | 1 | 25 | 55 | 10 | 106 | 16% |
| Others | 4 | 1 | 4 | 8 | 1 | 17 | 3% |
| Total | 200 | 26 | 180 | 184 | 75 | 665 | 100% |
| | 30% | 4% | 27% | 28% | 11% | 100% | |

Source: *Fearnleys Review* 2005

increase its coal imports. On the export side, Australia exported 225 mt of coal in 2004, accounting for one-third of the coal export trade, followed by Indonesia with exports of 106 mt and China with 85 mt, whilst South Africa, Colombia and Poland all supplied about 50 mt. In Australia, the major coal reserves are in Queensland and New South Wales which in 2004 produced 169 mt and 117 mt of coal respectively. South African coal is shipped by rail to Richards Bay for export. In Canada, the mines are mainly in British Columbia, where 20 bt of reserves are accessible to surface or shallow mining. Most of the coal exported from British Columbia comes from the Kootenay and Peace River coalfields which lie in the foothills of the Rockies. The coal is shipped 700 miles by rail for export through bulk handling terminals at Vancouver, mainly to Asian markets.

The bulk carriers used in the coal trade are generally smaller than in the iron ore trade – the analysis in Table 11.1 shows that ships transporting iron ore averaged 148,000 dwt compared with 109,000 dwt for coal. The main reason appears to be the smaller volume of coking coal used in the steel making process, relative to iron ore, its greater volume to stockpile, the higher value and the risk of spontaneous combustion in very large cargoes. An example of a coal transport system is provided by the Hunter Valley/Port of Newcastle complex in Australia. The Port of Newcastle services the export trade of over 30 coalmines located in the Hunter Valley behind Newcastle. The coal moves by rail through marshalling depots to two port stockpile areas. The port has three coal loaders loading up to four ships at once, ranging from vessels of only 10,000 dwt to coal carriers of 150,000 dwt. The water draught is maintained at 15.2 metres by a dredging programme which is paid for by the coal and steel companies. The cargo-handling equipment used for coal is very similar to the iron ore system described earlier.

## The seaborne grain trade

Although grain is grouped with iron ore and coal as one of the major bulks, in both economic and shipping terms it is a different business. Whereas iron ore and coal form part of a carefully structured industrial operation, grain is an agricultural commodity, seasonal in its trade and irregular in both volume and route. Consequently it is more difficult to optimize, or even plan, and the trade depends heavily on general-purpose tonnage drawn from the charter market.

In 2005, the grain trade was 236 mt (Table 11.1). Grain is used both as human food and as animal feed in the production of meat. Wheat accounted for about half of the grain trade, mostly destined for human consumption; the other half consisted of maize, barley and oilseeds, mainly for use as animal feed. The pattern of trade is shown in Figure 11.15. During the 1960s the grain trade was dominated by Europe and Japan, which accounted for more than two-thirds of grain imports. In tonnage terms this sector of the trade remained fairly static during the 1970s and early 1980s. Almost all of the growth in the volume of seaborne imports came from the entry of eastern Europe, including the USSR, and the developing countries into the market. After 1980 the trade grew more slowly and by 2005 the trade shares of Europe and Japan had fallen to 10%

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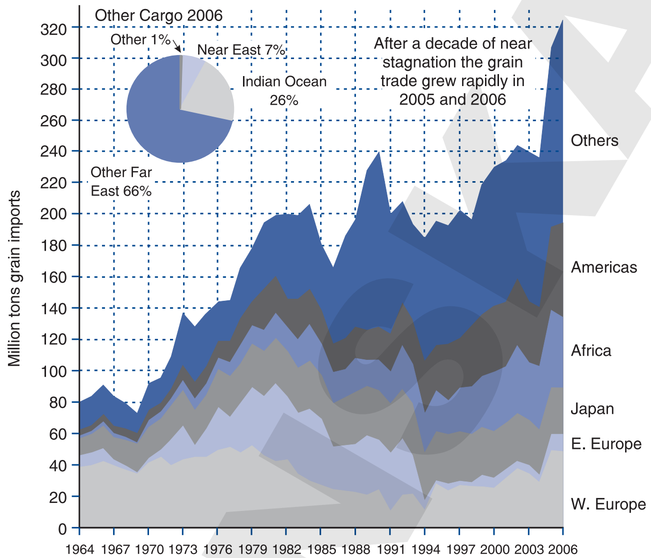


**Figure 11.15**
Grain imports, 1965–2005
Source: *Fearnleys Review* 2005 and earlier editions

and 12% respectively. Other Far East countries (29%), particularly China, the Americas (16%), and Africa (17%) had all become much more important (Table 11.11, right hand column).

The upward trend in seaborne grain imports shown in Figure 11.15 was to a large extent driven by the trend towards greater meat consumption at higher income levels. By commodity, in 2004 the seaborne grain trade was split between wheat (104 mt), and coarse grains (105 mt), most of which are fed to animals.[32]

The dietary pattern that underlies this situation, and its impact on grain demand in the post-1945 era, is described by Morgan as follows:

> Rising incomes put more money into people's pockets for buying food. Millions of families 'stepped-up' to diets that included more bread, meat and poultry. Livestock and poultry rather than people became the main market for American grain, and soya beans and corn ranked with jet aircraft and computers as the country's major exports. As more countries aspired to this grain based diet, the need for grain increased.[33]

Between 1950 and 2004, global meat production increased fivefold from 46 million tons to 248 million tons, and per capita production rates jumped from 18kg to 40.5 kg.[34] The 15 billion farm animals kept to supply this demand require on average about six units of feed for each unit of meat produced,[35] plus additional feed such as pasture in many cases. Broiler chickens are the most efficient, requiring 3.4 kg of feed (expressed in equivalent feeding value of corn) to produce 1 kg of ready-to-cook chicken. Pigs are the least efficient, with a feed to meat ratio of 8.4 : 1; eggs 3.8 : 1; beef about 7.5 : 1 and cheese, 7.9 : 1.

## The grain trade model

In view of the importance of the food–feed relationship in the grain trade, it is worth taking a look at the economics of the food trade. This is a typical supply–demand model of the type we discussed in Chapter 10. Food demand depends on income, population, prices, daily calorie intake and consumer tastes, while supply depends on land, yields, policies, prices and feed conversion efficiency.

The relationship between income and food demand is particularly important. The nineteenth-century statistician Ernst Engel discovered that as incomes rise the proportion spent on food declines.[36] He also found that within the food budget, the type of food purchased changes with income. At low income levels demand is for necessities such as rice, cereals and vegetables, but as income rises there is a tendency to substitute animal products such as meat and dairy for basic commodities such as cereals, root crops and rice. If we define 'income elasticity' as the percentage increase in demand for a 1% increase in income, we find that livestock-related food (i.e. meat and dairy products) tend to have a higher income elasticity than grains, vegetables and rice.[37] The feed conversion rates discussed in the previous paragraph mean that rapid growth in demand for these animal products as income rises has a multiplied effect on the demand for feedstuffs, and this filters through into the cereals trade.

The supply side of the food trade model is equally complex. Crop production depends upon crop yield and the area of agricultural land. Prices, political policies and stock changes are also important variables. Until the early years of the twentieth century most of the world's increase in crop production came from either an increase in land (e.g. the opening up of the North American grain lands) or from an increase in the amount of labour used. During the twentieth century, however, agricultural yields increased and the amount of arable land remained fairly constant. Higher yields were obtained from greater fertilizer application, improved seed varieties, mechanization, pesticides and better farming techniques. There are differences in productivity around the world. For example, the average level of France's cereal output per worker is ten times as great as in Japan and 40 times as great as in India.

Although in the short term the grain trade is influenced by local conditions such as harvests, in the longer term changing demand in response to income, prices, and, on the supply side, yields are more important. The rapid growth of imports by Asia, Africa and the Americas in the last twenty years (see Figure 11.15) was a response to rising incomes, the high income elasticity of animal products in these countries and the need to import animal feeds. As in the oil trade, the substitution effect of prices should not be overlooked.

## The transport of grain

Grain is traded on a wide range of routes, and the main trade volumes are shown in the matrix in Table 11.11. The United States is by far the biggest exporter, accounting for 46% of the trade, with other suppliers coming from Australia (10%) and South America, mainly Argentina. Imports are widely spread, with the Far East (29%) the biggest market, followed by Africa (17%), the Americas (16%), Japan (12%) and the Indian Ocean. The average trade flow is just 5 million tonnes, though the biggest route shown in this matrix is between the United States and the Far East.

Because this is an agricultural crop, subject to the vagaries of the weather and with many small ports, the transport system needs to be flexible. As an example of the grain transport system we can take the processing of Canadian wheat into consumer products. The wheat is harvested by large combines in the Canadian Prairies and moved by truck

**Table 11.11** Seaborne grain trade, 2004

| From: To: | USA | Canada | South America | Australia | Others | Total mt | Total % |
|---|---|---|---|---|---|---|---|
| Gulf/Continent | 2.8 | 0.7 | 6.0 | 0.0 | 0.3 | 9.8 | 4% |
| Total Europe | 5.0 | 1.8 | 8.9 | 0.7 | 7.4 | 23.9 | 10% |
| Africa | 14.6 | 2.2 | 7.4 | 3.8 | 12.0 | 40.1 | 17% |
| Americas | 26.5 | 3.2 | 7.8 | 0.2 | 0.2 | 37.9 | 16% |
| Near East | 3.6 | | 1.0 | 0.1 | 2.9 | 7.6 | 3% |
| Indian Ocean | 2.1 | 0.8 | 4.7 | 6.7 | 5.0 | 19.2 | 8% |
| Japan | 22.8 | 1.7 | 0.8 | 2.7 | 0.7 | 28.6 | 12% |
| Oth. FE | 30.1 | 5.2 | 16.4 | 9.9 | 6.7 | 68.4 | 29% |
| Oth. & Unspec. | | | | 0.5 | | 0.5 | 0% |
| Total | 107.6 | 15.7 | 53.0 | 24.6 | 35.1 | 236.0 | 100% |
| % total | 46% | 7% | 22% | 10% | 15% | 100% | |

Source: *Fearnleys Review* 2005

from the field to a storage elevator, into which it is transferred by conveyor or by an air pressure (pneumatic) system. During high harvests or when demand is low these storage facilities may become inadequate, and in the past farmers have been reduced to storing grain in sacks in any available covered storage. From the storage elevator the wheat is gravity fed to a railcar and shipped to port where it is offloaded from the railcar by opening a hopper in the bottom of the car to allow the grain to fall on to a conveyor under the rail track. From here the conveyor transfers the wheat into an elevator where it awaits transfer to a merchant ship. Naturally the elevator must hold enough grain to fill the ship.

At the other end of the voyage the process is reversed and the grain is offloaded from the ship into a storage elevator (i.e. silo) and shipped to a flour mill or feed compounder where it is again stored in silos. From the silos it moves to the grinding facility via a conveyor or an air slide. The finished flour coming from the end of the line is either packaged for the consumer market or shipped in bulk by rail and truck to bakeries, other large industrial users, or farmers.

At the bakery the flour is again placed in a silo or hopper, conveyed to a mixing unit for dough preparation, baked into bread or other products, sent to an automatic wrapping machine, and wheeled to trucks for delivery. In many cases the first time the product is handled as a single unit is when the consumer takes it from the shelf. Such an integrated transport system is made possible by meticulous attention to required materials handling systems within each process and to the transfers of material between processes.

Despite this organization, the sea transport of grain is not managed in the same carefully planned way as the industrial commodities. Because the trade is seasonal and fluctuates with the harvest in the exporting and importing regions, shippers rely heavily on the spot market, using the ships that are available. These fluctuations are not predictable, so planning transport is very difficult and complex. To load cargoes upwards of 70,000 tons involves careful scheduling of input barges or box cars from many different

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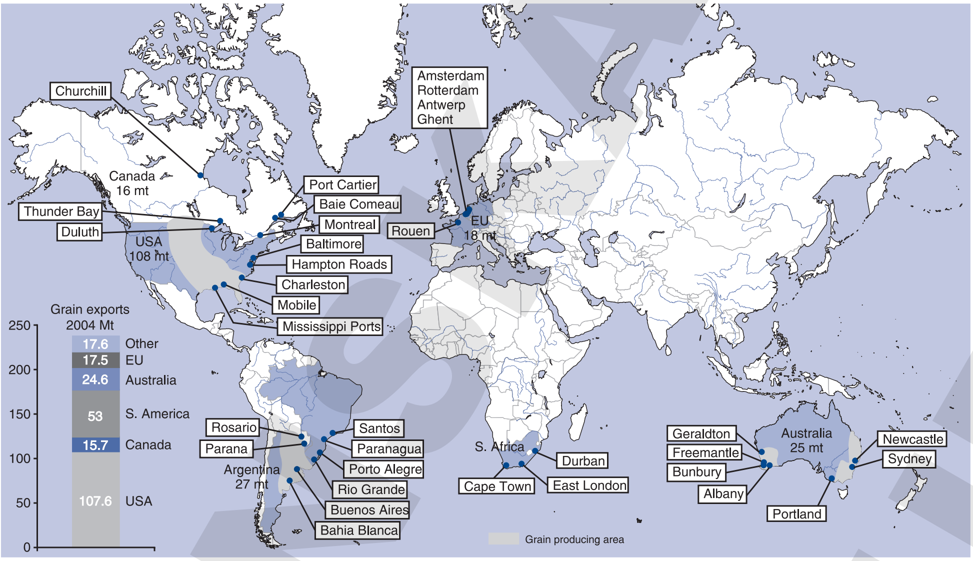


**FIGURE 11.16**
Major grain exporters and ports, 2005
Source: CRSL, *Dry Bulk Trade Outlook*, 2005

sources, often at the height of the season. Discharging can be equally hazardous since there are all the problems of ensuring the prompt arrival of a multitude of barges and coasters, and penalties for faulty consignment and demurrage charges grow more rapidly with large cargoes.[38] For this reason it is more difficult to introduce large ships into the grain trade than into the iron ore and coal trades and there is often congestion.

The major grain-exporting ports are shown in Figure 11.16 in relation to the grain-producing areas from which they draw their supplies. In 2004 over half of all grain exports were shipped out of Canada and the United States (see Table 11.11), so this is clearly the most important loading area. Essentially the US Gulf ports and the East Coast ports serve the southern end of the US grain belt, while the Great Lakes and the St Lawrence serve the north-east. Production from Saskatchewan and Alberta is shipped mainly through West Coast ports, especially Vancouver. Size limitations vary considerably, though ports on the lower St Lawrence and New Orleans can load vessels over 100,000 dwt. Argentina, Australia and the EU were the three other major exporters.

## 11.10 THE MINOR BULK TRADES

The third and most diverse sector of the bulk trades are the minor bulks, a mix of commodities which generated a billion tons of cargo in 2005, carried mainly by the smaller bulk carriers, but the container services also compete for many of these commodities. As Table 11.12 shows, this group comprises a mix of raw materials and semi-manufactures, divided into six groups: agribulks; sugar; fertilizers; metals and minerals; steel products; and forest products. This is not a complete list, and the statistics include some trade by land, but it covers the main items and gives a fair indication of

**Table 11.12** Selected minor bulk trades (mt)

| | 1985 | 1990 | 1995 | 2000 | 2005 | % p.a. growth '85–'05 |
|---|---|---|---|---|---|---|
| **1. Agribulks** | | | | | | |
| Soya beans | 25.5 | 28.2 | 32.2 | 45.5 | 64.9 | 4.8% |
| Soya meal | 23.2 | 26.0 | 30.9 | 39.0 | 45.4 | 3.4% |
| Oilseed/meals | 19.0 | 21.0 | 21.9 | 28.3 | 19.8 | 0.2% |
| Rice | 11.3 | 12.1 | 20.9 | 22.8 | 27.8 | 4.6% |
| Total agribulks | 79.0 | 87.3 | 105.9 | 135.6 | 157.8 | 3.5% |
| Average % pa | | 2% | 4% | 6% | 3% | |
| **2. Sugar** | | | | | | |
| White sugar | 9.9 | 10.5 | 17.9 | 16.1 | 21.4 | 3.9% |
| Raw sugar | 17.0 | 18.0 | 16.1 | 20.4 | 24.9 | 1.9% |
| Total sugar | 27.8 | 28.5 | 34.1 | 36.5 | 46.3 | 2.6% |
| Average % pa | | 0% | 4% | 1% | 5% | |
| **3. Fertilizers** | | | | | | |
| Phosphate rock | 43.0 | 35.0 | 30.0 | 30.0 | 31.0 | –1.6% |
| Phosphates | 9.6 | 9.9 | 14.2 | 14.7 | 16.6 | 2.8% |
| Potash | 16.6 | 17.7 | 20.6 | 23.3 | 26.0 | 2.3% |
| Sulphur | 17.3 | 17.7 | 16.6 | 20.4 | 22.4 | 1.3% |
| Urea | 9.4 | 9.7 | 11.2 | 11.7 | 12.7 | 1.5% |
| Total fertilisers | 95.9 | 90.1 | 92.6 | 100.1 | 108.7 | 0.6% |
| Average % pa | | –1% | 1% | 2% | 2% | |
| **4. Metals & minerals** | | | | | | |
| Bauxite & alumina | 44.0 | 49.0 | 50.0 | 53.0 | 73.0 | 2.6% |
| Manganese ore | 8.2 | 7.1 | 5.4 | 6.7 | 11.0 | 1.5% |
| Coke | 12.5 | 11.8 | 17.2 | 24.4 | 24.7 | 3.5% |
| Cement | 50.0 | 49.0 | 53.0 | 45.5 | 60.0 | 0.9% |
| Scrap | 25.5 | 35.8 | 51.1 | 62.4 | 93.5 | 6.7% |
| Pig iron | 10.6 | 13.2 | 14.4 | 13.1 | 17.0 | 2.4% |
| DRI/HBI[a] | 0.8 | 1.8 | 3.8 | 6.7 | 7.2 | 11.6% |
| Salt & soda ash | 18.0 | 20.1 | 22.2 | 23.0 | 23.9 | 1.4% |
| Total metals & mins. | 169.6 | 187.8 | 217.1 | 234.8 | 310.3 | 3.1% |
| Average % pa | | 2% | 3% | 2% | 6% | |
| **5. Steel products** | | | | | | |
| Steel prods. | 170.0 | 168.0 | 198.0 | 183.7 | 217.0 | 1.2% |
| **6. Forest products** | | | | | | |
| Forest prods. | 131.0 | 157.0 | 167.0 | 161.0 | 169.9 | 1.3% |
| Total minor bulk | 673.3 | 718.6 | 814.6 | 851.7 | 1,010.1 | 2.0% |
| Average % pa | | 1.3% | 2.7% | 0.9% | 3.7% | |

Source: CRSL, USDA, IISI, IBJ and various

[a]Dry reduced/hot briquetted iron.

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the growth trends. Not all of this cargo is shipped in bulk carriers. Shippers use whatever type of shipping operation is most economic for their particular cargo; usually they use bulk carriers, but containers or MPP services compete for smaller parcels. This variety of transport mode, combined with the fact that many of the minor bulk commodities are semi-processed, makes analysis more complex than for the major bulk trades.

## The agribulk trades

As a group the agribulk trades are nearly as big as the grain trade, with 158 million tonnes shipped in 2005 and an average growth rate of 3.5% per annum. The main commodities shipped are soya beans (65 mt), soya meal (45 mt), various other vegetable meals and rice. Soya beans are an important global crop, with world production in 2005 of 205 million tons. More than half is traded by sea, and the USA was the biggest producer with an output of 75 mt, followed by Brazil (50 mt), Argentina (38 mt) and China (17 mt). The beans are processed into vegetable oil and soya bean meal which is used as an animal feed. About 60% of the trade is shipped as soya beans which are processed at the market, and the other 40% is processed and shipped as oil (see chemical tankers in Chapter 12) and soya meal. China accounted for one-third of the imports, following a surge in domestic demand in the late 1990s and stagnant production. The imports came mainly from Argentina and Brazil. The EU is the other major importer, mainly for animal feeds.

The major importers of soya meal in 2005 were the EU (20–22 mt), central Europe (3.5 mt), Thailand (2 mt), South Korea (1.5 mt), Indonesia (1.5–2 mt), Japan (1–1.5 mt), the Philippines (1–1.5 mt) and Canada (1–1.5 mt). The major exporters are Argentina (19–20 million tons), Brazil (14–15 mt), USA (4–6 mt), India (3–4 mt) and the EU (2 mt).

## The sugar trades

Sugar consists of three trades: raw sugar (which is shipped loose in bulk in parcels averaging 12,200 tons), refined sugar (which is generally shipped in bags in parcels averaging 5600 tons) and molasses (which is a by-product of sugar refining and is shipped in tankers, so it is not covered here). The sugar trade demonstrates a pattern that we see again and again in the minor bulk trades. Over the 20-year period reviewed in Table 11.12, the volume of trade increased by 2.6% per annum. However, this was a trade-off between the raw sugar trade which, for part of the period was stagnant, and averaged only 1.9% per annum over the 20-year period, and the processed white sugar trade which grew at a brisk 3.9% per annum.

World sugar production in 2004 was 280 million tonnes, and the total trade in that year was 46 million tonnes, so only 16% of the total sugar crop is traded. The sugar itself is produced either from sugar beet in temperate areas or cane sugar in the tropics, so trade volumes depend heavily on the relative economic and political factors which determine the split between these two sources. For example, in 2004 the EU produced 22 million tonnes of sugar, imported 2.4 million tonnes, exported 4.3 million tonnes and consumed 17.7 million tonnes. This situation makes trade forecasting tricky.



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**Table 11.13** Sugar Trade, 2004 (million tons)

| Exports | | Imports | |
|---|---|---|---|
| Brazil | 16.3 | Russian Fed. | 3.6 |
| Thailand | 4.9 | EU | 2.4 |
| Australia | 4.3 | Persian Gulf | 1.8 |
| EU | 4.3 | Indonesia | 1.7 |
| Cuba | 1.9 | Korea, Rep. of | 1.6 |
| Persian Gulf | 1.5 | U.S.A. | 1.4 |
| 91 others | 12.6 | 140 others | 33.2 |
| World | 45.8 | World | 45.9 |

Source: International Sugar Organization

Over 90 countries exported sugar in 2004, and the main ones are listed in Table 11.13. Brazil was much the biggest with 16 million tons of exports, followed by Thailand, Australia and the EU, all of which exported about 4 million tons. About a quarter of the trade is made up of 91 small exporters, mainly in the tropical areas. Many countries (such as Costa Rica, Pakistan and Indonesia) produce sugar as a cash crop and have exports of only a few hundred thousand tons at the most. Loading facilities in these countries are frequently very poor and, since the trade is seasonal and highly fragmented, there is little incentive to improve them. As a result, the trade mainly uses small ships. The import trade is very widely spread with over 140 countries importing sugar and the top six listed in Table 11.13 account for little more than a quarter. So this is a very diffuse trade which occupies the bottom end of the bulk shipping market, with a substantial overlap with the container sector.

## The fertilizer trades

The fertilizer trade was 77 mt in 2005 and, although relatively small, is a vital part of the world economy. Over the last fifty years the available arable land has not increased significantly and the growth of world food production depends on increasing yields, in which fertilizer application plays a major part and much of which travels by sea. The basic nutrients in fertilizer are nitrogen, which is obtained by fixation of atmospheric nitrogen; phosphate, which mainly comes from phosphate rock; potash; and sulphur. The manufacturing process is summarized in Figure 11.17. The intermediate products are ammonia, nitric acid, phosphoric acid and sulphuric acid which are used to manufacture the various fertilizers listed in column 3.

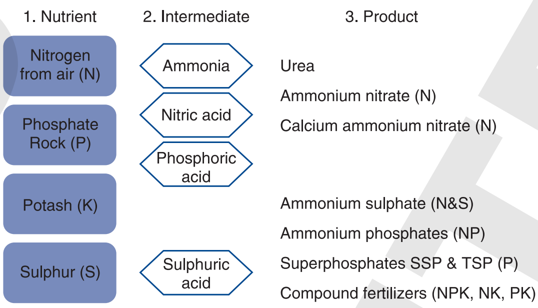


**Figure 11.17**
Manufactured fertilizer production processes
Source: European Fertilizer Manufacturers Association

These manufacturing processes can take place at source, near the market or at some intermediate location, and the location of these activities is subject to political as well as economic factors. Also the four intermediate products are toxic chemicals, usually carried in chemical or gas tankers (in the case of ammonia), as discussed in Chapter 12. Here we are mainly concerned with phosphate rock, phosphates, potash, sulphur and various manufactured fertilizers, of which ammonium sulphate and urea are the two most important. They are generally powdered or granular in form, and can travel loose or bagged in a bulk carrier or in containers.

### PHOSPHATE ROCK

Almost all phosphate fertilizers used today are derived from phosphate rock. The 'reserves' of phosphate rock (i.e. deposits which are viable with today's technology) are, according to a US Geological Survey, only 11 billion tons. Most of these reserves are located in Morocco (5.9 billion tons) and the USA (1.2 billion tons), though the USA produces slightly more rock than Morocco, despite its smaller reserves. Twenty years ago most phosphate rock was shipped raw to compound fertilizer plants located near the markets, but since then processing at source has become more common. In the case of the USA, for example, rock exports declined from 6.9 mt in 1990 to only 3,000 tonnes in 2004. As a result, between 1985 and 2005 the phosphate rock trade fell by −1.6% per annum (Table 11.12) from 43 mt to 31 mt, although it increased slightly during the last decade. Increased processing at source resulted in a growing trade in products such as phosphates and phosphoric acid, of which 5 mt was traded in 2005, mainly in Asia.

The main importers of phosphate rock are western Europe and Japan. Since the average size of fertilizer plant is comparatively small and they are often located in rural areas, the cargo parcel size remains small with little incentive to use very large bulk carriers except on major routes such as the North Atlantic. The main exporters of phosphate rock are Morocco, the USA and the USSR.

### PHOSPHATES

This trade grew from 9.6 mt in 1985 to 16.6 mt in 2005. It consists mainly of phosphate fertilizers such as diammonium phosphate exported from the USA, Africa and the former Soviet Union to a wide range of countries.

### POTASH

In the fertilizer trade the term 'Potash' refers to potassium fertilizers. Potassium is essential for plant growth, and potassium fertilizers improve growth. Approximately 95% of world potassium production is used for fertilizers, the remainder being used for various chemicals. Potassium chloride is the most common potassium fertilizer, followed by potassium sulphate. The world has 8.4 billion tonnes of commercially exploitable potassium-bearing rock reserves.



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World output of potash (potassium oxide equivalent) is around 32 million tonnes a year, of which three-quarters is produced by Canada, Russia, Germany and Belarus. In 2005 the potash fertilizer trade was 26 million tonnes, of which 10 million tonnes was imported by Asia, 5 million tonnes by Latin America, 5 million tonnes by the United States and 3 million tonnes by western Europe. Much of the US trade is by land rather than sea.

### SULPHUR

Sulphur is a small bulk trade, with imports of 27 mt in 2005. The major importers are western Europe, various developing countries (particularly India and Brazil), Australia, New Zealand and South Africa. Sulphur is transported either in dry form (crushed, flaked, slated or pelleted), or as a molten liquid. Although dry sulphur can be shipped in conventional bulk carriers or two-deckers, it is not an easy cargo. It ignites easily, there is a danger of explosion from sulphur dust, it is extremely corrosive, and in conditions of excess moisture it may produce hydrogen sulphide gas which is poisonous. For this reason a number of special dry sulphur carriers have been built, incorporating various features such as a double skin (so that the interior skin can be easily cleaned and replaced when corroded), sealed hatches, special gas monitoring equipment, intensive hold-washing equipment and mechanical ventilation. Flaking and pelleting of sulphur have brought some improvements, though the commodity remains a difficult one to transport.

To ship sulphur in liquid form special tankers are required, with heating coils, stainless steel tanks, special valve gear, and inert gas systems to prevent explosions. Although these vessels can be used in other chemical trades, the reverse is not true – conventional chemical tankers are not generally suitable for sulphur transportation. In addition, special loading and discharging facilities are required, so that trade is generally conducted under long-term contract. This is, therefore, a trade for which ships must be especially built or converted.

There are few handling problems, though they usually require undercover storage, and ammonium sulphate in particular is likely to absorb water from the atmosphere if not protected. Since their final market is in agriculture, individual consignments tend to be relatively small, so this is not a commodity that is likely to be shipped in 40,000 ton lots. Many shipments are to small ports in rural areas and may be only a few thousand tons. Another factor limiting the size of vessel in the fertilizer trade is that 70% of the trade is into developing countries and half is to very small importers, even the larger ones taking only a few hundred thousand tons each. This results in the trade travelling predominantly in the 10,000–18,000 dwt size group of vessels, while part still travels by container.

### UREA

Urea is a widely traded nitrogen fertilizer with 46.4% nitrogen content. About 100 mt is produced annually from synthetic ammonia and carbon dioxide and it can be shipped



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as prills, granules, flakes, pellets, crystals or in solution. More than 90% of world production is used as a fertilizer, and in 2005 the sea trade was 12.7 million tons.

### The metals and minerals trade

This important and diverse group of minor bulks includes a mixture of metal industry related products and other industrial materials. In 2005 the trade was 310 million tonnes, having grown at 3.1% per annum during the previous 20 years. However the growth rate between 2000 and 2005 was almost twice as much, due in particular to a sharp increase in the trades in bauxite, cement, scrap and pig iron. This was certainly associated with the expansion of Chinese industry.

Bauxite ore is the raw material from which aluminium is made, while alumina is its semi-refined product. It takes about 5.4 tons of bauxite to produce 2 tons of alumina, from which 1 ton of aluminium can be smelted. Shipments of bauxite ore and alumina totalled 73 mt in 2004.

The trade in bauxite and alumina follows the familiar industrial pattern we have already discussed under the heading of oil, iron ore and coal, but with some special features. In the early 1950s the trade was dominated by North American imports from the Caribbean, but in the 1960s both Europe and Japan entered the trade on a major scale. Although aluminium is used in much smaller quantities than steel, it has been finding new markets; consequently demand grew very rapidly during the first six decades of the twentieth century. To meet this demand, during the 1960s aluminium companies in western Europe and Japan built domestic aluminium smelters, importing bauxite from the Caribbean, the traditional producer, and also from newly developed reserves in West Africa and Australia. As a result, there was a rapid growth in the seaborne bauxite trade. This pattern changed fairly dramatically in the 1970s as the bauxite producers moved downstream into alumina refining and the aluminium smelters in Europe and Japan proved uneconomic owing to the high cost of electricity for aluminium smelting, particularly after the 1973 oil crisis. As a result, although the demand for aluminium continued to grow, the sea trade in bauxite and alumina remained at the same level of around 42–44 mt for the decade 1974–1984. After this structural adjustment, growth resumed, with the trade reaching 49 mt in 1995 and 73 mt in 2004.

Aluminium production technology follows the classic pattern of industrial integration, and in principle it is generally possible to optimize the shipping operation by using vessels of Panamax size or above. The alumina trade, on the other hand, does not generally favour the use of vessels of Panamax size and over, since alumina has a high value, needs to be stored under cover and the quantities of raw material required by a smelter are too small to encourage large bulk deliveries. An aluminium smelter producing 100,000 tons of metal per annum would require 200,000 tons of alumina, hardly a sufficient volume to justify the use of Panamax bulk carriers.

Manganese has a high density, with trade of about 11 mt a year shipped mainly to Europe, Japan and the USA from South Africa, the former Soviet Union, Gabon and Brazil. It has a low average value and differs little from iron ore, except that it is used in much smaller quantities. Consequently manufacturers keep small stores and large shipments are inconvenient. Various other non-ferrous metal ores are shipped by sea, including nickel, zinc and copper concentrates. Not shown in Table 11.12, these trades generally travel in small parcels owing to their high value and the small stocks carried by refineries. Transport is by small bulk carrier, container or bags.

Cement is another sizeable minor bulk trade and reached 60 mt in 2005. The trade is composed mainly of shipments to construction projects in Africa, Asia and the Middle East. By its nature the trade is volatile and ships tend to be chartered for either the carriage of bulk or bagged cement. Although small bulk carriers and 'tweendeckers are still used, in recent years the parcel size has increased sharply with Panamax bulk carriers moving into this trade and vessels of 50,000 tons and more operating in the export trade from Asia to the USA.

Steel scrap is traded as a source of raw material for steel production. Scrap comes from two sources: primary scrap, which is produced during the manufacture of steel products, and is generally recycled; and secondary scrap, which is derived from the recycling of various consumer and business durables such as motor vehicles. The international scrap trade is mainly from the mature areas such as USA to the developing steel-making areas, such as Asia. The large increase in the scrap trade during the period to 2000–5 was largely shipments into China which was expanding its steel business very rapidly at the time.

The salt trade is mainly into Japan. The Mexican trade to Japan was the first to develop in the early 1960s from the Mexican solar salt plant Exportadora de Sal. The trade is something of an oddity among the minor bulks, since it is shipped in very large bulk carriers. Shortly after the Japanese started to import salt from Mexico in 1962, D.K. Ludwig, the American shipowner, realized that he could radically reduce the c.i.f. price of salt in Japan by adopting a plan that involved building a 170,000 dwt bulk/oil vessel, the *Cedros*, which was launched in 1965, renting a small Japanese island as a bulk terminal, and obtaining a backhaul of crude oil from Indonesia to Los Angeles. The trade grew steadily throughout the 1960s. Salt is also shipped from Australia to Japan.

## Steel products trade

A good example of a trade that straddles the bulk and liner sector is *steel products*. In tonnage terms, steel is the largest minor bulk trade, with total imports of approximately 217 mt in 2005, though some of this was by land. Although a trade of this size might be expected to travel in large bulk carriers, the shipment of steel products involves a wide range of shipping activities.Take the exports of a large European steel producer as an example:

> for large contracts shipped on deep sea routes – for example, structural steel sections or tin plate exported to the Far East or the US West Coast – bulk carriers of 25,000–30,000 dwt would be chartered; in minor trades over long distances where the market volume fluctuates from year to year, liner services would generally be used depending on availability, or small conventional vessels chartered if sufficient cargo is available; in the short sea trades – for example, involving

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exports to continental Europe – small coasters of 500–3,000 dwt would be chartered; very small consignments on the short sea trades would be shipped on trailers using conventional ro-ro services; on deep sea routes, medium-size trades of, say, 50,000 tons per year may be sent by container or ro-ro service using half-size containers or other specially constructed stowage devices.[39]

## The forest products trade

Another high-volume minor bulk trade is forest products, of which approximately 169 mt a year were shipped in 2005. Forest products share many of the bulk handling problems raised by steel products. *Thomas's Stowage* lists 56 different types of timber, all with different weights per unit volume, and 26 forms in which they can be shipped, ranging from logs to batons and bundles.[40] Luan, the major export of Malaysia, has a density of about 1.25 cubic metres per ton, while Norwegian pine has a density of 1.8 cubic metres per ton. In practice, forest products stow at about 50% more than the above rates due to air space, which is high for logs and bundles and lower for loose sawn timber. Sawn timber packed to length, which is the practice of Canadian exporters, has a better stowage rate than timber that has been 'truck packed' – bundled together in different lengths. As a very rough guide, in purpose-built ships logs stow at 2.7 cubic metres per ton or more, bundled and sawn timber at 2.2 cubic metres per ton, and the best rate is rarely better than 1.7 cubic metres per ton.

In the 1950s the forest products trade consisted mainly of European imports, and formed a valuable backhaul cargo for liners that had discharged general cargo in Third World countries, for example West Africa. As the trade grew in the early 1960s it started to go bulk. Initially forest products shippers chartered in conventional tonnage, but this proved generally unsatisfactory. Since the mid-1960s there has been a trend towards building specialist ships, either small log carriers for use in South East Asia or specialized open hold bulk carriers with extensive cargo-handling gear for use in long-haul trades such as from West Coast North America to Western Europe.

As with other primary materials, the basis of the forest products trade is supply and demand. Much the largest component of the trade is within South East Asia, dominated by the Japanese who import logs from Malaysia, Indonesia and the Philippines. Japanese forests were depleted by over-cutting in the Second World War and the import trade developed through the established lumber mills. A trade also developed into Japan from West Coast North America, including a sizeable trade in woodchips, which were also imported from Australia and Siberia. A number of special woodchips carriers were built to service this trade, which requires a very high cubic capacity compared with normal bulk carriers. In total, Japanese imports account for about half of the forest products imports.

Europe is the other major importer of forest products, though on a much smaller scale. In Europe, much of the temperate forest is already intensively used, but northern Europe, particularly Scandinavia, is self-sufficient with an exportable surplus. Southern Europe has become a major importer, drawing imports from northern Europe, the



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former Soviet Union and North America, though some hardwoods come from West Africa and Asia. The West Coast North America to Europe trade is mainly lumber and pulp loaded at a number of ports in the Vancouver area and is almost entirely bulk. However, pulp, paper and logs continue to travel by liner in some cases.

In conclusion, the minor bulk trades form an important source of bulk carrier employment, particularly for smaller sizes of vessels. Because of the physical characteristics of some cargoes and the low volume, they offer many more opportunities for innovative shipping operations than the major bulk cargoes, but are subject to many constraints that limit them to small ships.

## 11.11 SUMMARY

The sophisticated transport system for bulk commodities is one of the great innovations in world trade over the last 50 years. As a result of investment in integrated systems, the size of parcel in many commodities has increased very substantially and, as we noted in Chapter 2, transport costs have grown much more slowly than other costs in the world economy. In this chapter we discussed in more detail the economics underlying these developments.

We started off by dividing the bulk fleets into tankers and bulk carriers, whilst noting that some commodities are also carried by specialist vessels discussed in Chapter 12 and the MPP and container ship fleets discussed in Chapter 13. We also discussed the distinction between a bulk cargo and a bulk commodity: a bulk commodity is a material which can be handled in bulk, and bulk cargo is a parcel actually transported in a single ship. If the trade flow is large enough almost anything can be shipped in bulk to reduce costs. The trades in motor vehicles and sheep, both shipped in specially built vessels, illustrate the point.

We discussed four characteristics which determine the suitability of a cargo for bulk transport: the volume of cargo; its physical handling and stowage characteristics (granularity, lumpiness, delicacy); the value of the cargo; and the regularity of the material flow. The balance of these four characteristics determines the stage at which it is worth making the step from liner transport to a bulk shipping operation. In addition, we reviewed four principles which guide the development of a bulk transport system: using the biggest ship possible; minimizing cargo handling; integrating transport modes; and keeping stocks as low as possible. Some of these principles conflict, so transport systems involve trade-offs.

There are three classes of bulk cargo: liquid bulk, major dry bulk and the minor bulks. Because each commodity needs a different bulk handling system to deal with its physical and economic characteristics it is very difficult to generalize about bulk transport. Our discussion of the cargoes started with liquid bulk transport. We reviewed the global model of the seaborne energy trade and the geographical pattern of trade in crude oil, as well as the transport system. Crude oil uses very large vessels and is a well-defined trade with relatively few loading and discharge zones. In contrast, the oil products trade is a semi-manufactured commodity and more complex, depending on refinery locations, balancing trades and deficit traits. Cargo parcels of oil products are much smaller than for crude oil, occupying the fleet below 60,000 dwt, though a few big ships are used.

The major dry bulk trades reviewed included iron ore, coal and grain. These are the building-blocks of the world economy, and each has a very different economic model and different transport systems. Finally, there are a large number of minor dry bulk trades, each with its own different economic model, and many straddle the liner and bulk systems. The minor dry bulk trades also offer opportunities for innovation and ingenuity on the part of the shipowner, and trades such as forest products, chemicals, vehicles and refrigerated cargo provide specialized shipping services. We discuss these trades in greater detail in the next chapter.

In conclusion, each shipper must select the system which gives the best commercial result for the particular industrial operation. These systems were broadly reviewed in this chapter, and the transport of the more specialized commodities is discussed more fully in Chapter 12.

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# 12 The Transport of Specialized Cargoes

*It is difficult though not impossible to be both lower cost and differentiated with respect to competitors. Achieving both is difficult because providing unique performance, quality, or service is inherently more costly, in most instances, than seeking only to be comparable to competitors in such attributes.*

(Michael Porter, *The Competitive Advantage of Nations*, 1990, p.38)

## 12.1 INTRODUCTION TO SPECIALIZED SHIPPING

### What is specialized shipping?

Companies transporting the bulk cargoes discussed in Chapter 11 trade in perfectly competitive markets where hundreds of similar ships compete for homogeneous cargoes on an equal basis. There is little shipowners can do to differentiate their service, so they rely on the entrepreneurial skills needed to charter and trade the bulk cargoes. But some cargoes such as chemicals, gas, refrigerated cargo, forest products, vehicles, heavy lift and people are more demanding to transport, offering transport providers an opportunity to improve their service by investing in specialized ships and services.

This chapter discusses five groups of commodity trades which fall into this category: chemicals, liquefied gas, refrigerated cargo, unit load cargoes and passenger shipping. Table 12.1 summarizes the fleets of ships used to transport them: chemical tankers; gas tankers; refrigerated ships and containers; the unit load fleet which includes open hatch bulk carriers, ro-ros, pure car carriers (PCCs), MPP vessels and heavy lift; and the passenger fleet of ferries and cruise vessels. In total we are dealing with about 10,000 cargo and passenger vessels, accounting for about 25% of the deep sea fleet. These are some of the most expensive ships to build and they tie up a significant portion of the shipping industry's capital, so it is an important business. Our aim is to discuss the services they provide and to explain how their various markets work.

Each specialized trade has its own distinctive features arising from the character of the cargo and the way transport providers have adapted to improve their performance in carrying it. Chemical parcel tankers transport specialized liquid cargoes including chemicals,

**Table 12.1** Specialised Shipping Fleet 1 Jan 2006

| Design | Number | Capacity | Units |
|---|---|---|---|
| *1. Chemical tankers (see Table 12.3)* | | | |
| Chemical Parcel >1k dwt | 1,015 | 15,274 | M dwt |
| Chemical Bulk | 179 | 2,395 | M dwt |
| Chemical products | 682 | 19,942 | M dwt |
| Unknown type | 699 | 5,703 | M dwt |
| Total | 2,575 | 43,314 | |
| *2. Gas Tankers* | | | |
| LPG (see Table 12.5) | 993 | 14,612 | 000 $m^3$ |
| LNG | 193 | 22,871 | 000 $m^3$ |
| Total | 1,186 | 37,483 | |
| *3. Refrigerated ships* | | | |
| Refrigerated >10k cuft | 1,242 | 333 | M Cu ft |
| Container | | 899 | M Cu ft |
| *4. Unit load vessels* | | | |
| Open hatch bulk | 486 | 16,508 | M dwt |
| Ro-Ro | 1,040 | 9,183 | M dwt |
| PCC | 560 | 7,848 | M dwt |
| Multipurpose (>10k dwt) | 741 | 13,151 | M dwt |
| Heavy Lift | 193 | 3,113 | M dwt |
| Total | 3,020 | 49,803 | |
| *5. Passenger vessels* | | | |
| Ferry | 2,300 | | Lane length |
| Cruise | 235 | | Berths |
| Total | 2,535 | | |
| Total | 10,558 | | |

Source: Clarkson Research Services Ltd
Note: ship numbers differ from Table 2.5 due to differences in the lower size limits and date

vegetable oils and oil products which must be transported separately, often to rigorous safety standards. Most have multiple tanks with segregated cargo handling and safety features to meet the regulatory codes for hazardous cargoes. The gas tankers transport liquefied gases at very low temperatures, particularly LNG, LPG, and chemical gases such as ammonia and ethylene which must be liquefied for transport. Refrigerated ships (reefers) transport perishable commodities including frozen meat, fruit, vegetables and dairy products, and are the subject of fierce competition between container services. Unit load vessels ship the large general cargo units which cannot travel by container, including forest products, cars and heavy lift items. Finally, the passenger vessels carry people either for transport or pleasure.

The economics of these specialized trades is quite subtle, so before delving into detail we will briefly examine the economic framework within which specialized shipping companies operate. Specialized ships come in all shapes and sizes and we will discuss their design features in Chapter 14, but there are three areas where investors can tailor the ship design for a specific cargo. The first is improved cargo handling. For example, chemical tankers allow small chemical parcels to be handled separately, without risk of contamination, or corrosive damage to the vessel. Or wheeled cargoes, which are an important specialist shipping sector, can be handled more efficiently with ro-ro access. Other examples are wide hatches with advanced crane systems and specialized handling systems. In each case the shipping company invests to improve cargo-handling economics and boost the productivity of the ship. Second, improved cargo stowage minimizes 'deadfreight' and reduces damage. Fitting refrigeration systems for perishable cargoes and or protective coating to prevent the cargo from corroding the hull are related possibilities. Third, the system can be adapted to integrate with the customer's inland transport operation. For example, a shipping company transporting cars is a vital link in the manufacturer's distribution chain and this has resulted in some specialist shipping companies entering the terminal and storage business. Providing these services requires an appropriate management structure and proven sector-specific expertise which acts as a barrier to entry, often leading to a higher concentration of ownership. As a result pools and cooperative arrangements are more common in the transport of specialized cargo, for example cars, chemicals and gas.

## The specialized shipping model

The starting point is not, however, the ships or the transport system, but the market. No matter how clever the hull design or cargo-handling systems are, if the company cannot make a profit the venture will fail. These specialized cargoes can usually be shipped in several different ways, so there are nearly always competitors. For example, chilled cargo can be shipped in refrigerated ships, container-ships, or air freight. All three compete and market economics determine who gets the cargo. Some chilled cargoes such as raspberries are delicate and favour air freight, whilst others such deciduous fruits, which are less demanding and more price sensitive, gravitate towards the reefer ships. Specialist shipping companies search out and exploit these differences. If the economics works and the venture thrives, a new specialist segment emerges, and most of the trades reviewed in this chapter developed like this. But sometimes the economics does not work. The ships are sold to the highest bidder and work out their physical lives in services for which they were not really designed. This complicates things for analysts because commodity flows cannot be neatly matched against the fleet of specialist ships, but it is a reality of the business which we must accept from the outset

The forest products trade provides a good example of how the economics of specialization works in practice. Like most of the specialized commodities in this chapter, forest products are semi-manufactures, and the trade mainly travels in units such as packaged lumber, pulp bales, rolls of paper, packaged plywood and particle board. This is high-value cargo, worth up to $1,000 a tonne, and vulnerable to damage. Conventional bulk carriers are not very efficient at handling and stowing unit load cargoes and forest products carriers (FPCs) target this weakness. To improve stowage they have box- shaped holds and hatches which extend to their full width, allowing the FPC to load about 20% more cargo than a conventional bulk carrier of the same deadweight. Cargo handling is also improved by the open holds, which allow packages to be dropped directly into place. As a result cargo-handling rates in excess of 450 tonnes per hour can be achieved, compared with 250 tonnes per hour for a conventional bulk carrier.[1] However these improvements increase the capital cost by 25–50% above a conventional bulk carrier of the same deadweight capacity. Is it worth the money?

Figure 12.1 compares the cost per tonne of transporting packaged forest products in a conventional 47,000 deadweight bulk carrier (the dashed line) and a 47,000 deadweight FPC (the solid line), assuming the performance levels listed at the bottom of

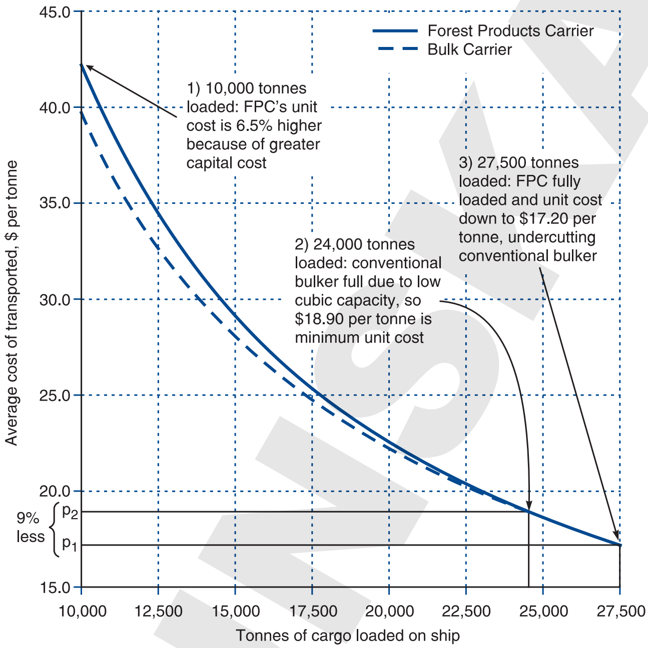


**Figure 12.1**
Specialized shipping competition model

the figure. The average cost per tonne is shown on the vertical axis, and the tonnes of cargo loaded into the ship on the horizontal axis. With a 10,000 tonne load the FPC has a higher cost per tonne ($42.30/tonne compared with $39.70/tonne), but as the cargo size increases the gap narrows due to the FPC's faster cargo handling. With both ships loading 24,000 tonnes of cargo the conventional bulk carrier is full, but thanks to its open holds the FPC keeps going and loads 27,500 tonnes of cargo, at which point its unit cost has fallen to $17.20 per tonne, undercutting the bulk carrier costs of $18.90 per tonne by 9%. Although this calculation will vary with the precise assumptions, it makes the important point that investing in a tailored ship does not necessarily produce decisively cheaper transport. A better way to look at the investment is as a way of providing a better service for the same cost. In this example the FPC's open holds and sophisticated cargo-handling gear offer a faster service with less risk of damage for 9% less than the conventional bulk carrier. When dealing with high-value semi-processed products such as chipboard, plywood and newsprint this can be decisive.

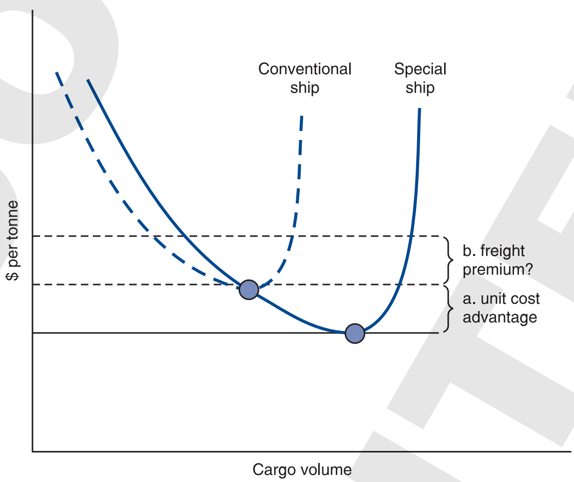


**Figure 12.2**
Specialized shipping model

In summary, specialized shipping companies operate on the two fronts: first, by undercutting the conventional operator on unit transport cost if they can; and second, by obtaining a premium over the freight rate offered by the conventional operator by offering a differentiated service, as illustrated in Figure 12.2. Neither is easy. In our example, to match the conventional bulk carrier's cost the FPC operator must run a tight voyage schedule, with only six days allowed for cargo handling. But success also depends on the customer's willingness to pay for the service offered, which is where the high value and delicacy of the cargo come into play. With cargo worth $1,000 per tonne, exporters may be willing to pay a freight premium for a fast service with good-quality ships and minimal damage risk. Arguably, specialized shipping sectors are the ones where shippers are prepared to pay this freight premium. This is the perspective from which we will approach the specialist segments in the following sections.

## 12.2 THE SEA TRANSPORT OF CHEMICALS

### The demand for chemical transport

The major chemical trades are between the USA, Europe and Asia, India, the Middle East and South America. Most specialist chemicals are used locally, but some are exported in response to local stock imbalances, or to areas where there is no local production of a particular chemical. Each year chemical tankers transport about 60 million tonnes of organic and inorganic chemicals and another 40–45 million tonnes of vegetable oils, alcohols, molasses and lubricating oils[2]. Clean petroleum products and lube oils also provide an important source of employment for the less sophisticated vessels in the chemical carrier fleet and a large proportion of the fleet can switch between these trades and chemicals or edible oils. Since there are so many products involved, a good starting point is an explanation of how they are produced and used (see also Figure 11.6 which describes the energy transport model).

*Organic chemicals* (also known as 'petrochemicals') contain carbon and are made from crude oil, natural gas or coal. The two main product groups are the olefins which include ethylene, propylene and butadiene; and the aromatics, named for their peculiar odour, which include benzene, toluene, xylene (known collectively as 'BTX') and styrene. These are used to manufacture virtually all products made with plastics and artificial fibres.

*Inorganic chemicals* do not contain carbon and are made by combining chemical elements. Phosphoric acid, sulphuric acid and caustic soda are three of the most common. Phosphoric acid and sulphuric acid are used in the fertilizer industry, whilst caustic soda is used in the aluminium industry. They present several transport problems. One is that they are very dense: phosphoric acid has a specific gravity of 1.8; caustic soda liquor 1.5; sulphuric acid 1.7–1.8 and nitric acid 1.5. Second, they are corrosive to metals such as iron, zinc and aluminium and must be carried in tanks coated with stainless steel, rubber or acid-proof paints. The others are less demanding in normal concentrations. The chemical tankers which carry these cargoes generally load and discharge through stainless steel pipes with typical handling rates of 600 tons per hour. In port the acids are stored in steel cisterns with a rubber lining standing in concrete tanks that can hold the contents in case of leakage.

*Vegetable oils* are derived from seeds of plants and used extensively both for edible and industrial purposes. Animal fats and oils are also transported. They include palm oil and soya bean oil.



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*Molasses*, a by-product of the sugar refining operations, is a thick brown syrup which is fermented into alcohols such as rum but is traded mainly as an animal feed or in the production of organic chemicals.

These chemicals, especially the organics, often move in small parcels which must be handled separately and transported in segregated tanks which are meticulously cleaned between cargoes. An idea of what this means in practice is provided by Table 12.2 which shows a sample of 3,000 chemical 'parcels' (a parcel is an individual consignment). The average parcel was 1,475 tonnes but for different products the average ranges from 3,000 tonnes for caustic products to 279 tonnes for acetate. Over half the parcels are less than 500 tons and there are over a hundred different chemical and oil commodities in the sample (not all shown separately), some recognisable products like brake fluid, or liquid paraffin but many others that the average layman would not recognise. Chemical parcels of this sort are generally transported in small tankers under 10,000 dwt or in large 'parcel' tankers with many separate tanks. Tank containers are also sometimes used for parcels under 200 tonnes. The range of vessel sizes is illustrated in Table 12.2 which shows that, for example, the average 2925 tonne parcel of Caustic Products was carried in a 5736 dwt ship, occupying 51% of the cargo capacity. But some other commodities such as Paraffin wax, Toluene and Acetate travelled in parcel tankers of 35,000 dwt or more, occupying only 1–2% of the cargo space. This trade is also geographically complex with cargoes loading in the Middle East,

**Table 12.2** Sample of chemical parcels by size

Cargo parcel size analysis

| Cargo product group | Average parcel size, tonnes | Cargo % Ship |
|---|---|---|
| Caustic products | 2925 | 51% |
| Styrene products | 2195 | 35% |
| Formaldehyde | 1852 | 54% |
| MEG | 1836 | 12% |
| Ethylene products | 1485 | 40% |
| Paraffin wax | 1298 | 3% |
| Polypropylene | 1239 | 3% |
| Paraffin | 1217 | 12% |
| Resins | 955 | 26% |
| Polyol | 684 | 15% |
| Lube additive | 594 | 7% |
| Isopropyl alcohol | 579 | 6% |
| MEK | 578 | 3% |
| Toluene | 544 | 1% |
| Chlorinated organics | 514 | 15% |
| Xylene | 486 | 1% |
| Solvent naphtha | 429 | 1% |
| Additive | 367 | 2% |
| Brake fluid | 338 | 11% |
| Solvent | 336 | 1% |
| White spirit | 328 | 3% |
| Methyl isobutyl | 324 | 1% |
| Hexane | 314 | 4% |
| Alcohol | 313 | 2% |
| Acetone | 295 | 9% |
| Acetate | 279 | 1% |
| Grand Total | 1,475 | 24% |

Source: 1) Based on a sample of parcels transported on many routes over several years 2) The cargo type indicates the broad product category and in some cases covers a range of related products 3) The cargo % ship was calculated by dividing each cargo parcel by the dwt of the ship which carried it and averaging the resulting percentage over the cargo group.

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Singapore, US Gulf, West coast North America, NW Europe and Asia and distributed to a large number of importers around the world. The cargo flow on individual routes is often small, which adds to the complexity of the transport operation. Finally, chemicals may explode, corrode, pollute, taint, and be toxic to the crew or marine life, so the transport of products with these characteristics is regulated under the IMO Code on the Carriage of Hazardous Cargoes. All these features of the trade make chemical transport by sea a complex business.

## Development of chemical transport

Chemical tankers were pioneered in the USA. During the 1920s and 1930s the US chemical industry grew rapidly, especially along the Gulf coast around the oil and gas fields of Texas and Louisiana. Since most plants had good water access, it was natural to transport the chemicals by sea, and by the early 1950s over 25 varieties of liquid chemicals were being shipped in purpose-built tankers.

These vessels differed from products tankers in several ways. Dense chemicals were carried only in the centre tanks, and to allow parcels of different chemicals to be carried in the same ship, longitudinal coffer dams (i.e. double skins) separated the centre tanks from the wings, and transverse coffer dams separated the centre line tanks. Double bottoms were also fitted. One of the earliest vessels, the 16,000 dwt *Marine Chemist*, was built in 1942.[3] These early chemical tankers often had special coatings, for example zinc silicate. In the 1950s an international trade in chemicals started to develop and the evolution of the first vessels for this trade are described by Jacob Stolt-Nielsen as follows:

> Before 1955 the international chemical trade was very small. The cargoes were tallow, grease, vegoils and 'solvents.' Chemicals or BTX were collectively known as 'solvents.' The trade was trans-Atlantic and was served by small 2/4000 dwt tankers. The ships had ring-lines from one or two pumprooms. The cast iron lines had expansion boxes and flanges, none of which could hold solvents. They leaked like sieves. As a consequence, the ships could only segregate one grade fore and one grade aft of the pumprooms. Since the cargo lots seldom were larger than 1,000 tons per parcel that determined the size of the ships.
>
> But the trade was growing fast. The owner who could find a way to use a 10/15,000 dwt ship, with a break-even rate half of that of a 4000 dwt ship, would make a fortune! … I got the idea how to solve the problem from an article in Life magazine, about pumping water up from the depths under the desert: Deep-well-pumps. I persuaded Charles P. Steuber and Russel J. Chianelli (my partner) that with deep-well pumps we could carry as many grades as the ship had tanks. We time-chartered the 'M/T Freddy,' 13,000 dwt, from Erling Naess. The ship came to Todd's shipyard in Galveston, Texas, and I was waiting on the pier along with 18 brand new Byron Jackson deep-well pumps. I had no drawings, no marine architects, and no price from the yard. I had given them a verbal description of the



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> work to be done. Soon the big cranes were hovering overhead and ripping out the large cast iron pipelines. I cannot deny that I had butterflies in my stomach. This was in May 1955 and I was 24 years old.[4]

That was the beginning of the parcel tanker business. Stolt-Neilsen and Odfjell, two of the biggest companies today, both started operation in the 1950s and over the next two decades they developed and refined the chemical parcel tanker, a vessel with many tanks and segregations capable of carrying a mix of small parcels within the complex regulations laid down by the IMO.

## The chemical transport system

Today chemical transport has developed into a sophisticated and flexible transport operation capable of moving the wide range of different parcel sizes around the world. The diagram in Figure 12.3 shows how it works. On the right in column 5 are the chemical companies and a few of the hundreds of chemical commodities which they ship in a wide range of parcel sizes from a few hundred tons of MEK to 30,000 tons of MTBE. In column 2 is the fleet of ships used to transport them, consisting of a fleet of large ‘parcel tankers’ with many segregations; the bulk chemical tankers with a high proportion of segregated tanks, but bigger tanks of over 2700 cubic metres; and the chemical/product tankers which have big tanks, 50–75% of which are segregated.

The shipping companies involved in the chemicals trade are shown in column 3. This is a hybrid business, falling between the tanker market, with its aggressive focus on the spot market, and the liner business, with its tightly planned schedules. Transport is provided by three groups of shipping companies, each of which approaches the task in a different way. The first group, shown at the top of the figure, are the parcel tanker

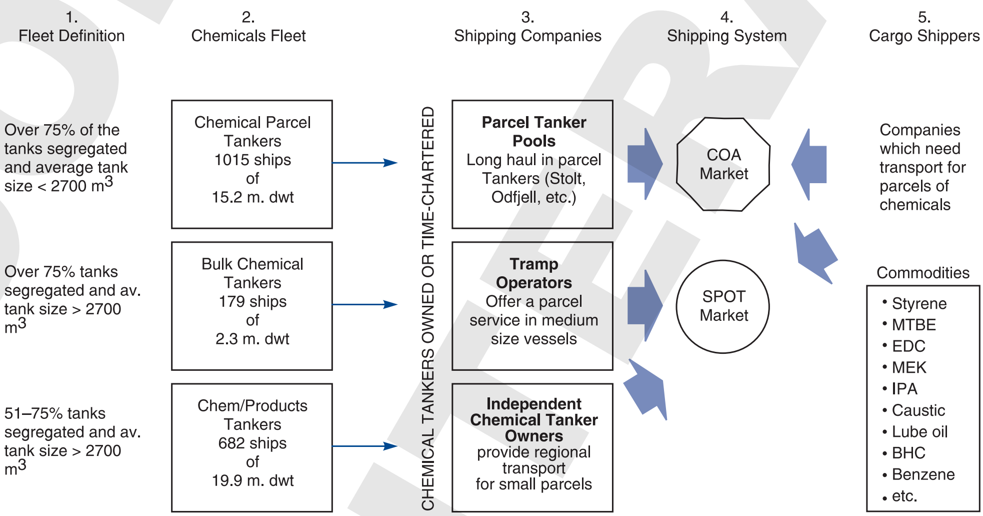


**Figure 12.3**
Chemical tanker sea transport system model, 2006

pools, operated by companies like Stolt and Odfjell. They offer liner services for small parcels, using fleets of parcel tankers. Transport is often arranged on a COA basis, with regular port itineraries worked out to meet the needs of the trade. However, they also take cargoes from the spot market where these are available at an acceptable rate and when the destination fits in with available capacity and the vessel operating pattern. The second group are tramp operators using medium-sized bulk chemical tankers, often of 10,000–20,000 dwt, which trade spot, grouping together several spot parcels on a voyage by voyage basis. Finally, there are the independent owners of small tankers which generally operate on the spot market, picking up whatever parcels are available, but may be engaged on a time charter or a consecutive voyage basis. These small vessels tend to operate within the regions, particularly Europe and Asia.

## Chemical fleet and supply

The fleet of about 2600 chemical tankers used to transport chemical cargoes, sometimes in shiploads using small tankers, but more often consolidating many small parcels of 100–5,000 tons in a single ship, is shown in Table 12.3. Although the transport of chemicals is different from the crude oil and product trades, there is some overlap, with ‘swing tonnage’ operating in either sector. This means we cannot define the chemical tanker fleet precisely, though many of the ships used in the chemical trade are built for the business and generally belong in a different investment category from crude oil and products tankers. Ships built specifically for the chemical business must satisfy the IMO regulations for the carriage of hazardous cargoes which are discussed in Chapter 14.

The fleet of 1015 chemical parcel tankers have average size of 15,000 dwt and are distinguished by having more than three-quarters of their tanks segregated with separate cargo-handling facilities; an average tank size of less than 2700 cubic metres; and some stainless steel tanks. The second is a group of 179 slightly smaller chemical bulk tankers averaging 13,380 dwt with segregated tanks, but all have tanks over 2700 cubic metres, enabling them to carry the bigger parcels. Finally, there are the

**Table 12.3** The chemical tanker fleet by vessel type, 2006

| *Size* | *Chemical Parcel* | | *Chemical Bulk* | | *Chem. Products* | | *Unknown* | | *Total* | |
|---|---|---|---|---|---|---|---|---|---|---|
| *(000 dwt)* | *No.* | *'000 dwt* | *No.* | *'000 dwt* | *No.* | *'000 dwt* | *No.* | *'000 dwt* | *No.* | *'000 dwt* |
| 1–4.9 | 192 | 639.9 | 62 | 200.7 | 56 | 187.1 | 393 | 880.0 | **703** | **1,907.7** |
| 5–9.9 | 304 | 2,278.1 | 39 | 289.3 | 89 | 616.9 | 176 | 1,258.3 | **608** | **4,442.6** |
| 10–19.9 | 279 | 4,232.2 | 36 | 489.5 | 102 | 1,489.3 | 53 | 758.5 | **470** | **6,969.5** |
| 20–29.9 | 70 | 1,761.2 | 23 | 589.0 | 32 | 841.7 | 16 | 425.0 | **141** | **3,616.9** |
| 30–39.9 | 130 | 4,619.1 | 4 | 141.5 | 163 | 5,910.1 | 35 | 1,266.5 | **332** | **11,937.2** |
| 40–49.9 | 40 | 1,743.6 | 14 | 633.5 | 224 | 10,037.1 | 26 | 1,114.7 | **304** | **13,528.9** |
| 50+ | – | – | 1 | 51.7 | 16 | 859.4 | – | – | **17** | **911.1** |
| Total | 1,015 | 15,274.1 | 179 | 2,395.3 | 682 | 19,941.6 | 699 | 5,703.1 | 2,575 | 43,314.0 |

Source: *Clarkson Research Services July 2006*

682 chemical/products tankers with fewer segregations (only 50–75% of their tanks are segregated) which can carry chemical parcels, or switch into the products tanker business. The distinction between these segments is fuzzy, but each group caters for a slightly different mix of cargoes. The design of these ships is discussed further in Chapter 14 (see Figure 14.7) which describes an 11,340 dwt chemical tanker of sophisticated design. The regulatory regime for carrying hazardous cargoes is discussed in Chapter 16.

## 12.3 THE LIQUEFIED PETROLEUM GAS TRADE

### The transport of LPG by sea

The LPG business has many similarities with the chemical trades discussed in the previous section. It supplies feed stock gases to the chemical industry and transports the intermediate gases produced by chemical plants and also gas for domestic and commercial use. On land these gases are generally transported by pipeline, but for sea transport they must be liquefied to reduce their volume by 99.8%. A bird's-eye view of the sea transport system is provided by Figure 12.4. The main cargoes – petroleum gases, ammonia and olefins – are listed in the right-hand column, which also notes that they may be transported by a COA, time charter or consecutive voyage charter. There is also

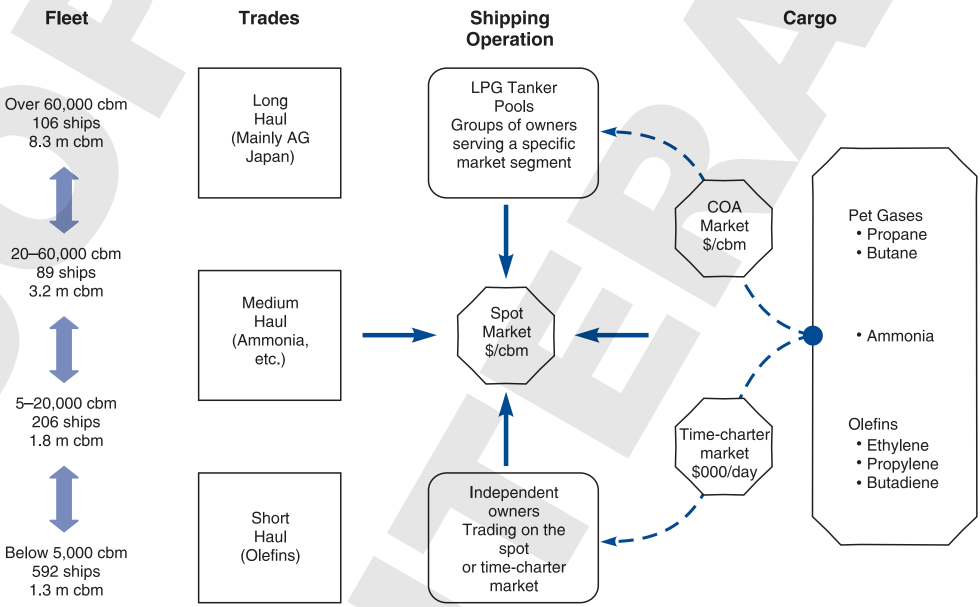


**Figure 12.4**
The LPG sea transport system model

**Table 12.4** Some major traded liquified gas commodities

| | Boiling point °C | Specific Gravity | Ship Type | Primary Markets |
|---|---|---|---|---|
| 1. Liquified petroleum gas | | | | |
| Propane | –42.3 | 0.58 | LPG tanker | Feedstock & heating |
| Ethane | –88.6 | 0.55 | LPG tanker | Feedstock & heating |
| Butane | –0.5 | 0.60 | LPG tanker | Feedstock & heating |
| 2. Chemical gases | | | | |
| Ammonia | –33.4 | 0.68 | LPG tanker | Fertilizer manufacture |
| 3. Olefines | | | | |
| Ethylene | –103.9 | 0.57 | LPG tanker | Chemical feedstock |
| Propylene | –47 | 0.61 | LPG tanker | Feedstock |
| Butadiene | –5 | 0.65 | LPG tanker | Feedstock |
| Vinyl chloride monomer | –13.8 | 0.97 | LPG tanker | Feedstock |
| *Memo* | | | | |
| Methane | –161.5 | 0.48 | LNG tanker | Electricity generation |

some spot market business. The fleet of about 1,000 LPG tankers built to carry the liquid gases at the very low temperatures (listed in Table 12.4) is shown in the left-hand column. The ships fall into four segments: the big LPG tankers over 60,000 cubic metres which are used on long-haul trades, especially to Japan; the mid-size vessels of 20,000–60,000 cubic metres, used in medium-haul trades, particularly for ammonia; and the smaller sized vessels of 5,000–20,000 cubic metres which are used in the short-haul trades, especially for the transport of olefins. There is also a sizeable fleet of very small vessels which are used mainly in the coastal and short-sea trades. LPG tanker pools play a significant part in the supply of LPG transport, but there are also independent operators who play the spot market or time charters. Finally, in the centre of the Figure 12.4 are the shipping operations, focusing around the spot market, but also including COA and time-charter markets.

## The demand for LPG gas transport

Not only LPG but also many other gases are shipped in LPG tankers. The gases fall into the three groups shown in Table 12.4. Firstly, the three main *petroleum gases* are propane, ethane and butane whose main markets are in transportation, residential and commercial heating, and as a feedstock for the production of petrochemicals. Secondly, ammonia is a *chemical gas* which is produced in large quantities and used in the manufacture of fertilizers. Finally, the *olefins*, such as butadiene, ethylene oxide, vinyl chloride and acetaldehyde, are used to manufacture everything from plastics to rubber tyres. These tend to be shipped in the smaller LPG tankers. At the bottom of the table, for reference purposes, is methane which is not shipped in LPG tankers because it travels at lower temperatures. This trade is discussed in Section 12.4

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*Propane and butane*, two major cargoes for LPG tankers, are mainly produced from crude oil, natural gas fields and oil refining. Because of the difficulty of transport they were often flared off, but nowadays most of the gas is either used in local chemical plants in oil-producing areas such as Saudi Arabia, or exported by pipeline or liquefied and shipped by LPG tanker. In 2006, 50% of the market was domestic, 12% in industry, 8% in transport and 27% as a feedstock. In the domestic and commercial energy markets the gas is used in restaurants, hotels and industry for cooking, heating and generally as an alternative to natural gas where that facility is not available. The demand for LPG as a chemical feedstock originated with the plastics revolution in the second half of the twentieth century, and this remains the main driving force behind demand. Petrochemical plants (ethylene crackers) produce the ‘primary petrochemicals’, especially ethylene, from which plastics, synthetic fibres and synthetic rubber are manufactured. The structure of the production process is briefly summarized in Table 12.5, which shows that the product mix of ethylene, propylene and butadiene varies depending on the proportions of ethane, propane, butane and naphtha used as feedstock. The early US plants used ethane which was plentifully available from natural gas fields, but modern plants are generally capable of adjusting their feedstock mix in response to price and availability. When LPG is used as a feedstock for chemical manufacture, price is important because supply and demand imbalances in the petrochemical industry lead to price differences between regions and, of course, LPG is in competition with other feedstocks such as naphtha. In the transport market LPG is used as a fuel for cars, trucks, taxis and industrial equipment such as fork-lift trucks. It has the advantage of cleanliness and low maintenance, and currently in some countries LPG users receive tax concessions.

North East Asia (Japan, China, and South Korea) is the world’s largest importing region of LPG, followed by western Europe and the United States. The biggest market is Japan, which imported over 14 million tonnes in 2,000, accounting for over 72% of demand. Japan has a well developed market for LPG, which is imported in large LPG tankers to coastal cities and towns and distributed by a fleet of coastal tankers, mainly under 1,000 dwt, to the local wholesale and retail network. The commercial markets include fuel for motor vehicles, industrial fuel and chemical feedstock. It is also used in

**Table 12.5** Typical ethylene plant yield pattern weight % yield

| | Feedstock | | | | |
|---|---|---|---|---|---|
| Product | Ethane | Propane | *n*-Butane | Light Naptha | Typical end products produced from the primary chemical products shown on the left hand axis |
| Ethylene | 78 | 42 | 37 | 32 | Plastic bags, antifreeze, plastic packaging, etc. |
| Propylene | 2 | 16 | 17 | 16 | Polyurethane foam, plastic coatings, moulded plastics |
| Butadiene, etc.[a] | 3 | 11 | 19 | 30 | Tyres, nylon, detergents, fibreglass, pesticides |
| Fuel oil | 15 | 29 | 25 | 20 | heating, etc |
| Loss | 2 | 2 | 2 | 2 | |
| Total | 100 | 100 | 100 | 100 | |

[a] Includes Butylene, benzene, toluene, raffinate

power stations. In Europe the principal market is as a chemical feedstock, though there is a significant secondary market for butane and propane gas in domestic heating. In the absence of a pipeline distribution system, the LPG moves from import terminals in small coastal tankers of around 3,000 dwt, barges and railcars which use 100 cubic metre tank cars, or 50 cubic metre trucks which load 20 tonnes of LPG. In northern Europe LPG is frequently moved by barges along the Rhine. In the USA the main distribution system is by long-distance pipeline, although barges and rail trucks are used. LPG is produced primarily in the North Sea, as a result of natural gas production, and in the Middle East, as a refining by-product.

*Ammonia* is used to manufacture fertilizers, explosives, and in several chemical processes. It boils at –33°C and is usually shipped in medium-sized semi-refrigerated chemical tankers. Between 1987 and 2002 the world ammonia trade increased from 8.2 to 13.4 million tonnes. The biggest exporters of anhydrous ammonia were Russia, Canada, Trinidad and Tobago, and Indonesia, and the largest importer was the USA (5.5 mt in 2002), followed by India, South Korea, and Malaysia.

*Ethylene* is derived from the cracking of petroleum feedstocks (see Table 12.5). It has a very low boiling point of –103°C, the lowest in this group (see Table 12.4) and it is generally shipped by sea in small pressurized vessels which can handle the small parcels and very low temperatures. It is the key raw material for manufacturing many day-to-day items – two-thirds of global production is used to manufacture plastics and automobile parts and the remainder is used to produce antifreeze and various artificial fibres. The principal ethylene exporters are the Middle East, Europe and Latin America.

*Propylene* is a by-product of ethylene and gasoline manufacture and is used to manufacture polyurethane foam, fibres and moulded plastics for use in manufacturing such items as car parts, plastic pipes and household articles. Polypropylene is used as a feedstock for plastics and is imported by the Far East from the United States and Europe.

*Vinyl chloride monomer*, produced by the cracking of ethylene dichloride, is used to manufacture PVC which is widely used in the construction industry, for example for window frames. It is exported by the USA to South East Asia and Latin America.

*Butadiene* is mainly used to manufacture rubber for use in tyres, but it is also used in detergents and pesticides.

## The LPG fleet and ownership

The LPG fleet consists of a mix of large vessels for deep-sea shipments and medium and small tankers for short-sea and coastal shipments. The range of low temperatures required to transport liquid gases by sea also affects the composition of the fleet. As already noted in Table 12.4, the LPG gases boil at temperatures ranging from –103°C for ethylene to –0.5°C for butane. These low temperatures can be achieved by pressure, refrigeration or a combination of both. Until 1959 LPG ships were fitted with spherical pressure tanks which relied on compression to liquefy gases. These tanks protruded above the deck, making the tankers immediately recognizable.



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**Table 12.6** LPG gas tankers – type and capacity analysis

| *Capacity Range* | *Pressurized* | | *Semi-refrigerated* | | *Fully-refrigerated* | | *Total* | |
|---|---|---|---|---|---|---|---|---|
| *m³* | *No.* | *m³* | *No.* | *m³* | *No.* | *m³* | *No.* | *m³* |
| 0–5,000 | 466 | 917 | 114 | 344 | 12 | 20 | 592 | 1,281 |
| 5–20,000 | 50 | 336 | 150 | 1,356 | 6 | 92 | 206 | 1,783 |
| 20–60,000 | — | — | 16 | 353 | 73 | 2,914 | 89 | 3,266 |
| 60,000 plus | — | — | — | — | 106 | 8,283 | 106 | 8,283 |
| Total | 516 | 1,252 | 280 | 2,052 | 197 | 11,308 | 993 | 14,612 |

Source: Clarkson *Liquid Gas Carrier Register 2006*

Although cheap to run, the size and weight of fully pressurized vessels makes them uneconomic over 5,000 cubic metres. In 1959 the first semi-refrigerated LPG ship was built, and three years later the first fully refrigerated LPG ship came into service. The fully refrigerated ships carry the cargo at ambient pressure under refrigeration, whilst the semi-refrigerated ships can carry gases at different temperature and pressure combinations. For example, a 140 metre semi-refrigerated tanker can carry 6,000 tonnes of propane at –48°C or 7200 tonnes of ammonia at –33°C. Structural steel is brittle at these temperatures and the tanks are installed as separate insulated units.

In 2006 there were 993 LPG tankers, and Table 12.6 shows that the split between the three liquefaction systems – pressurized, semi-refrigerated and fully refrigerated – is correlated with size. Broadly speaking, the small tankers are pressurized, the medium-sized are semi-pressurised, and the largest are fully refrigerated. The way these vessels are used is summarized below.

- 0–5,000 cubic metres. The smallest class of vessels is the most numerous, but contributes less than 10% of the fleet in capacity terms. Of the 592 tankers in this segment two-thirds are fully pressurized and carry petrochemical gases such as vinyl chloride monomer and LPG. Another 20% are semi-refrigerated, including several 4,000 cubic metres ethylene-capable carriers. They trade mainly in the short-haul cross-trades in the Far East, the Mediterranean, north-western Europe and the Caribbean.
- 5,000–20,000 cubic metres. About 70% of the tankers in this segment are semi-refrigerated, but there are some fully refrigerated vessels which carry LPG and ammonia mostly on long-haul routes. The semi-refrigerated vessels carry petrochemical gases, including ethylene on short- and medium-haul routes. A few of these smaller semi-refrigerated vessels can carry ethylene at –104°C, and ethane at –82°C. To a lesser extent, these smaller vessels are also used to transport LPG and ammonia over short-haul routes.
- 20,000–60,000 cubic metres. Mid-size gas tankers form 22% of the fleet by capacity. Most of this fleet is fully refrigerated but there are a few semi-refrigerated vessels.

They transport LPG on long-haul trades between the Arabian Gulf and the Mediterranean and cross-trades in the North Sea and Europe, and ammonia in various typically shorter cross-trades.

- Very large petroleum gas carriers (VLGCs) over 60,000 cubic metres. The 106 biggest LPG tankers account for 56% of the LPG fleet by capacity. All are fully refrigerated and mainly carry LPG on the long-haul routes such as from the Middle East to Japan, and from Trinidad and Tobago to Europe.

The ownership structure of the VLGC fleet is highly concentrated, and there are several pools. For example, Bergesen, one of the largest owners of LPG tonnage, operated the VLGC pool which in 2003 included ships owned by Exmar, Mitsubishi, Yuyo Ship Management, Neste Sverige and Dynergy.

## 12.4 THE LIQUEFIED NATURAL GAS TRADE

Natural gas (methane) is the third major energy source transported by sea, after oil and coal which we discussed in Chapter 11. In 2005 the world consumed 2.5 billion tons of natural gas (oil equivalent), compared with 3.8 billion tons of oil and 3 billion tons of coal; since it burns cleanly, gas is the preferred energy source for power generation. Between 1990 and 2005 demand increased at 2.2% per annum which was faster than both coal (1.8% per annum) and oil (1.3% per annum) as shown in Figure 12.5. However, gas delivered to markets that cannot be reached by pipeline must be processed into LNG. Although this technology is well established and very reliable, it is expensive and inflexible. For example, over the last 20 years shipping oil from the Middle East to Europe cost on average \$7–10 per tonne, whereas LNG cost \$25–100 per tonne, depending on the distance.[5]

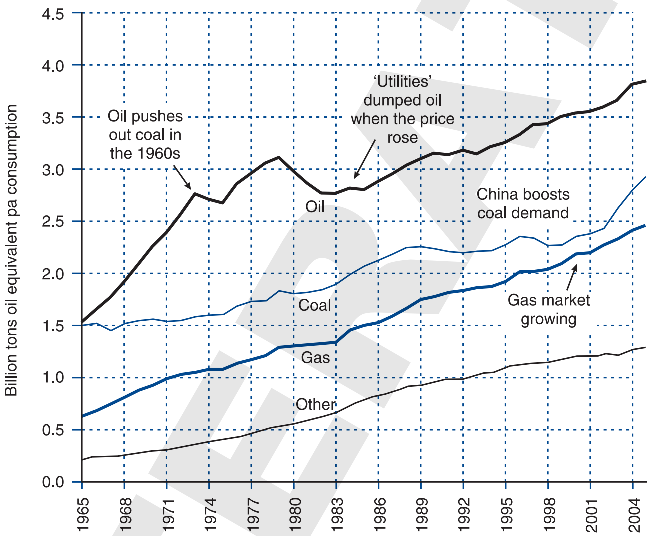


**Figure 12.5**
World energy consumption by commodity
Source: *BP Annual Review of the World Oil industry*

**Table 12.7** World natural gas reserves, demand and LNG trade 2006

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|
| | Gas reserves | | Gas demand | | | LNG imports | |
| | Billion m³ | % | Billion m³ | Mtoe[a] | R/D years[b] | billion m³ | Mtoe[a] |
| USA | 5,925 | 3 | 630 | 566.9 | 9 | 16.6 | 14.9 |
| Russian Federation | 47,650 | 27 | 432 | 388.9 | 110 | 0.0 | 0.0 |
| Middle East | 73,471 | 41 | 289 | 260.3 | 254 | 0.0 | 0.0 |
| Japan | — | 0 | 85 | 76.1 | 0 | 81.9 | 73.7 |
| South Korea | — | 0 | 34 | 30.8 | 0 | 34.1 | 30.7 |
| European Union | 2,426 | 1.3 | 467 | 420.6 | 5 | 57.4 | 51.7 |
| China | 2,449 | 1 | 56 | 50.0 | 44 | 1.0 | 0.9 |
| Other Asia | 12,371 | 7 | 264 | 237.7 | 47 | 18.2 | 16.4 |
| Other | 37,300 | 21 | 604 | 543.6 | 62 | 1.9 | 1.7 |
| Total | 181,458 | 101 | 2861 | 2574.9 | 63.4 | 211.1 | 190.0 |

[a]Million tonnes of oil equivalent.
[b]R/D is the reserves to demand ratio in years.
Source BP *Annual Review* 2007

## Natural gas supply and demand

Natural gas has been used as an energy source since 1825 when small amounts were found in Fredonia, New York. Larger gas fields were discovered in Pennsylvania in the 1860s, and the first distribution system, a six-inch cast iron pipeline 17 miles long, was built in 1874 to ship gas from Butler County, Pennsylvania, to an iron mill at Etna near Pittsburgh.[6] It is now widely used in the USA, the EU Russia, the Middle East, Japan, South Korea and various other Asian countries (Table 12.7, col. 5). However, two-thirds of the gas reserves are in the Middle East (41%) and the Russian Federation (27%), with smaller quantities in Africa (8%); Asia (8%); North America (4.9%); South America (3.9%) and the EU (1.3%). Within the Middle East, Iran and Qatar each had 14% of world reserves in 2005. This pattern of demand and geographically dispersed supply creates the basic conditions for trade, especially since the USA and EU have limited reserves, whilst Japan, South Korea and China have almost none. However, despite this regional imbalance, in 2006 the LNG trade of 190 million tons was only 7.4% of world gas demand, well short of oil, whose trade was 63% of demand.[7]

## Development of LNG trade

To explain why the gas trade is so small, we need to look at the basic economics. Successful gas trade requires three conditions to be met. Firstly, a plentiful source of gas is needed at a price competitive with other energy sources such as coal. Secondly, there must be a market with a pipeline network capable of distributing the gas to domestic and commercial customers. Thirdly, it must be possible to raise funds for the required liquefaction and transport system. These conditions have been difficult to meet in the gas trade. Although there are plenty of reserves, they are in the wrong place and



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multi-billion dollar investment projects are needed to ship the gas to market. This locks investors into a very inflexible long-term commitment, so political stability and future pricing worries weigh heavily on their minds, often leading to delays. But price is the central issue and for many years Europe and the USA had access to cheap natural gas from domestic gas fields, so high-cost imported LNG struggled to be competitive in these important markets, especially from long-haul sources such as the Middle East.

The first LNG cargo was shipped in 1959 when the *Methane Pioneer*, a converted dry cargo ship, carried about 5,000 cubic metres of LNG from Louisiana to Canvey Island. The ship was a technical success, but was too small and too slow to be economically viable, and the operation was terminated after the first year and the ship switched to the LPG trade, though it later carried transatlantic LNG cargoes when freight rates were high. Five years later in 1964 the first large-scale liquefaction plant was built at Arzew in Algeria. It had a capacity of 1.1 million tonnes per annum divided over three trains (an independent unit for liquefying gas) and the gas was shipped between Algeria and Canvey Island in the UK using two purpose-built ships, the *Methane Princess* and the *Methane Progress*. This was followed by a scheme to export LNG from Brunei to Japan, which came on stream in 1969. Following these successes, plans were developed for exports from North Africa to the USA and Europe and from South East Asia for Japan, and forecasters were predicting that the LNG trade would reach 100 million tons by 1980. However, the 1973 oil crisis intervened and the uncertainty this created, especially over future gas export prices, resulted in projects being deferred or abandoned altogether, and by 2004 the trade was still only 50 billion cubic metres.

By 1983 a third of the LNG tanker fleet's 71 ships were laid up (Figure 12.6) and pricing disputes, breach of contract cases and the closure of two US reliquefaction terminals brought investment to a halt, especially in the Atlantic. Only two export projects were completed in the 1980s, one in Malaysia and the other in Australia, both for the Asian market. It was 20 years before any further development projects occurred in the Atlantic. However in the 1990s investor confidence revived and the LNG business got a new lease of life. Trade quadrupled

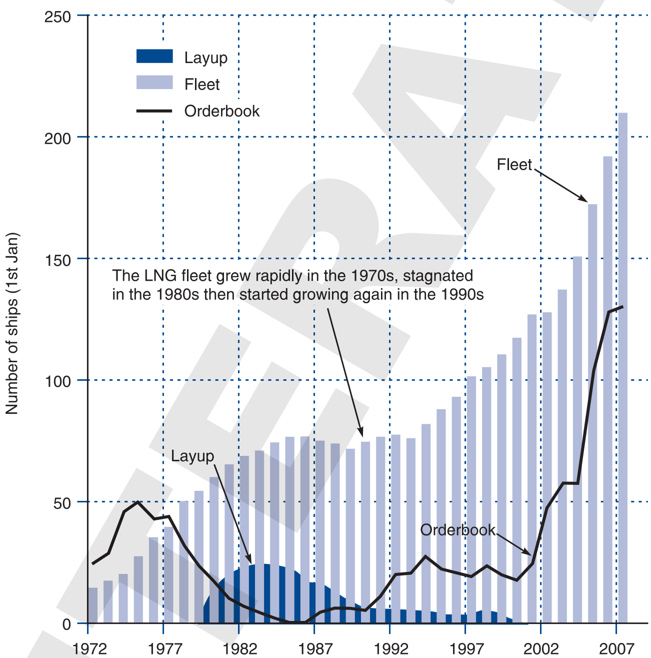


**Figure 12.6**
LNG fleet, 1972–2007
Source: Clarkson Research Gas Tanker Register

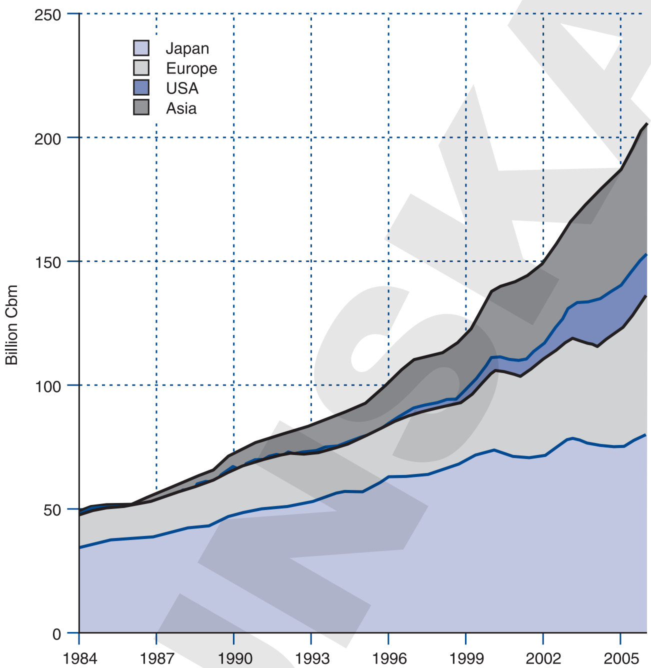


**Figure 12.7**
LNG trade, 1984–2006
Source: BP Annual Review of the World Oil Industry/Cedex

from 48 billion cubic metres in 1984 to 211 billion cubic metres in 2006 (Figure 12.7), finally reaching the forecast 100 million tons in 2000, twenty years behind schedule, with the long-awaited growth of the Atlantic market finally occurring in the mid-1990s. By 2006 the trade split roughly one-third in the Atlantic and two-thirds in the Pacific, as shown in the trade matrix in Table 12.8. Malaysia and Indonesia were the biggest exporters, with the Middle East accounting for less than a quarter of the trade. Japan remained by far the biggest importer, mainly from short-haul Asian sources, followed by Europe, and South Korea. The 13 countries shown in the matrix exported LNG to 48 import terminals, located in Japan (24 terminals), South Korea (4), Taiwan (1), India (1), Europe (13), and the United States (5). So this is a well-defined trade.

## The LNG transportation system

LNG transport involves four operations. Firstly, the natural gas is transported by pipeline from the gasfield to the plant. Secondly, the LPG and condensates are separated out and the methane gas is liquefied and stored ready for sea transport. Thirdly, the liquid gas is loaded onto ships for transport to its destination. Finally, the receiving terminal unloads the cargo, stores it and regasifies it. The costs are around 15% for production and transport to the export terminal, 40% for liquefaction, 25% for sea transport, and 20% for regasification.[8]

A liquefaction plant has one or more ‘trains’ which liquefy the gas. A train is a compressor, usually driven by a gas turbine, which compresses a coolant until it reaches −163°C, at which temperature the gas is reduced to $\frac{1}{630}$ th of its original volume, and feeds it into cooling coils which liquefy the gas passing over them. A train might produce 4 million tons of LNG a year and a large facility will have several trains. The liquid gas is stored in refrigerated tanks until a ship arrives and carries it rapidly to its destination. LNG tankers rely on insulation to prevent the gas from reliquefying and the boil-off gas is burned in the engines of the vessel or reliquefied. Typical modern LNG tankers are

**Table 12.8** LNG trade movements, 2006 (billion cubic metres)

| | LNG Exports from | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Americas | | Middle East | | | North & West Africa | | | | SE Asia & Oceania | | | | |
| to | USA | Trinidad | Oman | Qatar | UAE | Algeria | Egypt | Libya | Nigeria | Australia | Brunei | Indonesia | Malaysia | Total |
| *Atlantic* | | | | | | | | | | | | | | |
| USA | | 10.9 | | | | 0.5 | 3.6 | | 1.6 | | | | | 16.6 |
| Dom. Rep | | 0.3 | | | | | | | | | | | | 0.3 |
| Puerto Rico | | 0.7 | | | | | | | | | | | | 0.7 |
| Mexico | | 0.2 | | 0.1 | | | 0.2 | | 0.5 | | | | | 0.9 |
| Belgium | | 0.2 | | 0.4 | | 3.4 | 0.3 | | 0.2 | | | | | 4.3 |
| France | | | | | | 7.4 | 2.3 | | 4.2 | | | | | 13.9 |
| Greece | | | | | | 0.5 | 0.0 | | | | | | | 0.5 |
| Italy | | | | | | 3.0 | 0.1 | | | | | | | 3.1 |
| Portugal | | | | | | | | | 2.0 | | | | | 2.0 |
| Spain | | 3.0 | 1.0 | 5.0 | | 2.8 | 4.8 | 0.7 | 7.1 | | | | | 24.4 |
| Turkey | | | | | | 4.6 | | | 1.1 | | | | | 5.7 |
| UK | | 0.6 | | | | 2.0 | 1.0 | | | | | | | 3.6 |
| *Asia Pacific* | | | | | | | | | | | | | | |
| China | | | | | | | | | | 1.0 | | | | 1.0 |
| India | | | 0.2 | 6.8 | 0.1 | 0.1 | 0.6 | | 0.1 | 0.1 | | | 0.1 | 8.0 |
| Japan | 1.7 | 0.4 | 3.0 | 9.9 | 7.0 | 0.2 | 0.8 | | 0.2 | 15.7 | 8.7 | 18.6 | 15.6 | 81.9 |
| South Korea | | 0.1 | 7.1 | 9.0 | | 0.3 | 1.3 | | 0.2 | 0.9 | 1.2 | 6.7 | 7.5 | 34.1 |
| Taiwan | | | 0.2 | | | | 0.2 | | 0.4 | 0.4 | | 4.3 | 4.9 | 10.2 |
| TOTAL | 1.7 | 16.3 | 11.5 | 31.1 | 7.1 | 24.7 | 15.0 | 0.7 | 17.6 | 18.0 | 9.8 | 29.6 | 28.0 | 211.1 |

Source: BP and Cedigaz (provisional)

around 160,000 cubic metres, travelling at 19 knots and with a steam turbine engine or diesel and carrying about 115,000 tonnes of liquefied gas (1 million tonnes of LNG is equivalent to 1.38 billion cubic metres of natural gas) though in 2006 vessels twice this size were being built for the long-haul Middle East export trades. At the other end of the voyage the regasification plant turns the liquid back into gas, and feeds it to the power utility or the local pipeline system. All this equipment makes the LNG trade very capital-intensive relative to coal and inflexible at today's trade levels.

During the 1990s the cost of gasification plants fell by more than 30% for a 5 million tonnes per year plant, whilst the cost of LNG tankers varied from $250 million to $160 million. These developments, combined with the diminishing domestic reserves in Europe and the USA, resulted in a renaissance in the LNG trade during the early years of the twenty-first century. This was accompanied by changes in the LNG transportation market. Originally the LNG business was conducted with long-term contracts, usually 20 years, with fixed prices and rigid commitment to the contracted quantities. In these circumstances negotiating the price caused great difficulties, due mainly to the lack of any established 'norm'. Later as oil prices became market-driven, the price of the gas was indexed to oil in some way, for example a basket of oil prices, and the growth of forward markets in gas allowed pricing to be hedged. All of this, combined with the growing number of terminals, created a more flexible investment climate.

### LNG transport supply

In 2006 the LNG fleet consisted of 193 ships with another 140 on order. Because the LNG business is still built around major projects which can take as much as a decade to develop, it is relatively easy to see where the next tranches of business will come from. Since large sums of money are involved, the progress of these schemes is fraught with difficulty. The design of LNG tankers is discussed in Section 14.6.

## 12.5 THE TRANSPORT OF REFRIGERATED CARGO

### Demand for refrigerated transport

Refrigerated transport is another example of a trade created by transport technology. Perishable commodities could only be shipped between regions when it was possible to preserve them during transit, and when this technology became available new trades rapidly emerged. The trade developed for several different reasons. One is that some parts of the world could produce perishable foodstuffs much more cheaply than others. For example, New Zealand is a major international supplier of meat and dairy products to economies in the North Atlantic because it can produce these products much more cheaply. A second element in the trade is the movement of seasonal crops between the hemispheres, smoothing out the imbalances caused by the harvest cycles. This is particularly prominent in the citrus and deciduous fruit trades, where countries like South Africa produce their new crop during the Northern Hemisphere winter. Thirdly, there are climatic differences. For example, bananas, which can only be grown in tropical areas, are exported to the temperate zones. There is fierce competition for these cargoes between conventional reefer ships and refrigerated containers, and in many trades containers pushed the reefer ships into second place. Air freight has also become important for the high-value exotic fruits. As a result fast, cheap transport has opened up an enormous global market for seasonal vegetables at all times of the year, greatly widening the range of fresh foodstuffs available in most countries. In this section we will examine how the trade fits into this model in practice.

### Development of refrigerated transport

Refrigerated sea transport started in the meat trade in the nineteenth century. As Europe's urban population increased, local meat and dairy farmers could not feed the cities and the railways were opening up vast new food-producing areas of North America, South America, New Zealand, Australia and South Africa. With unsatisfied demand in Europe and meat supplies available overseas, all that was needed was a transport system. As in so many other specialist trades, it was the shippers who made the running. To begin with the meat was canned and shipped by liner. The first Australian canning company started in 1847, and in 1863 the Liebig beef extract process was established at Fray Bentos in Uruguay. Between 1868 and 1876 there were various



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experiments in shipping frozen meat, but the refrigeration equipment was unreliable and, even when it worked, the quality of the meat was poor.

By the end of the 1870s refrigeration technology was improving and the *Paraguay*, fitted with a Carre ammonia machine, carried a frozen cargo from France to Buenos Aires, returning to Le Havre with 80 tons of mutton which arrived in excellent condition. This marked the beginning of the seaborne reefer business. Two years later in 1880 Australia shipped its first cargoes in the *Strathleven* which loaded 40 tons of beef and mutton which was frozen on board and delivered to London in perfect condition. Later that year the *Protos* sailed for London with 4600 carcasses of mutton and lamb, stored in holds insulated with wool.[9] When the vessel arrived in London the cargo was discharged in excellent condition and the wool insulation was removed from the vessel and also sold – those old-time shipping entrepreneurs certainly knew how to squeeze an extra buck out of the business! The first New Zealand frozen cargo in 1882 sold in London for twice the market price in New Zealand, which gives an idea of the financial incentive driving the trade. This convinced the meat producers of South America, Australia and New Zealand that refrigerated transport was viable and within a few years a transport system had evolved. Freezing plants were established in the meat-exporting areas to supply wholesale markets with refrigerated storage and distribution facilities at the importing end. For example, Smithfield Market in London acted as the main centre for meat in the UK. In the 1970s palletization was introduced and ships, storage and cargo-handling facilities were all designed around the standard pallet sizes of 800 × 1200mm and 1000 × 1200mm agreed by the OECD.[10] This opened the way for greater mechanization of cargo handling, for example using fork-lift trucks and banana conveyors.

However, in the 1940s the land-based transport industry developed the portable refrigeration unit, initially in the form of an insulated trailer with an integral refrigeration unit, and this technology was to have a major impact on reefer trade. These refrigerated trailers, which kept produce fresh by saturating the air with moisture from the integral refrigeration unit, were introduced in 1942 for US troops stationed overseas and subsequently were adopted by the railways in the USA. In the 1950s the trucking business started to use them, and when diesel engines replaced gas-powered refrigeration in the late 1950s the technology became more reliable and cheaper to run, especially on long trips with high run hours.[11] This coincided with the start of containerization by sea, and from the outset the new seaborne container business carried refrigerated containers, competing with the conventional reefer ships.

## The reefer commodity trades

In 2005, 130 million tons of perishable cargoes were traded world-wide (Table 12.9), though these statistics are not precise because they include land trade and some cargoes that are not refrigerated. Broadly speaking, the refrigerated cargo trade falls into three groups: deciduous fruit, which accounts for about a third; meat and dairy produce, which account for another third; and fish, which accounts for the remainder. In addition, Table 12.9 shows 'other fruit and vegetables' as a memo item. This is a very large trade

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**Table 12.9** World trade in perishable foodstuffs (mt)

| Year | Commodity | | | | | | | | Total growth Yr on Yr | Memo: Other Fruit & Veg. |
|---|---|---|---|---|---|---|---|---|---|---|
| | Bananas | Citrus fruits | Deciduous fruits | Total fruit | Dairy products | Meat | Fish | Total trade | | |
| 1983 | 6 | 7 | 5 | 19 | 10 | 9 | 20 | 58 | | 59 |
| 1984 | 7 | 8 | 5 | 20 | 11 | 9 | 22 | 61 | 5.9% | 63 |
| 1985 | 7 | 7 | 5 | 19 | 12 | 9 | 25 | 64 | 5.1% | 66 |
| 1986 | 7 | 9 | 5 | 21 | 12 | 10 | 27 | 69 | 7.7% | 70 |
| 1987 | 8 | 8 | 6 | 21 | 12 | 10 | 28 | 71 | 2.8% | 73 |
| 1988 | 8 | 8 | 6 | 21 | 13 | 11 | 29 | 74 | 3.5% | 77 |
| 1989 | 8 | 8 | 6 | 22 | 13 | 11 | 31 | 77 | 4.5% | 81 |
| 1990 | 9 | 8 | 6 | 24 | 12 | 12 | 29 | 77 | –0.5% | 84 |
| 1991 | 10 | 8 | 7 | 25 | 13 | 13 | 29 | 81 | 5.1% | 88 |
| 1992 | 11 | 9 | 7 | 26 | 15 | 14 | 31 | 85 | 5.4% | 91 |
| 1993 | 12 | 9 | 8 | 29 | 15 | 14 | 34 | 92 | 7.8% | 96 |
| 1994 | 13 | 10 | 8 | 31 | 16 | 16 | 41 | 103 | 12.5% | 102 |
| 1995 | 13 | 10 | 8 | 32 | 16 | 17 | 38 | 103 | 0.0% | 101 |
| 1996 | 14 | 10 | 9 | 33 | 17 | 18 | 38 | 105 | 1.7% | 104 |
| 1997 | 15 | 10 | 9 | 34 | 18 | 19 | 39 | 110 | 4.5% | 107 |
| 1998 | 14 | 11 | 9 | 33 | 18 | 19 | 32 | 104 | –5.4% | 109 |
| 1999 | 14 | 10 | 9 | 34 | 19 | 21 | 36 | 110 | 6.1% | 115 |
| 2000 | 14 | 11 | 9 | 34 | 20 | 22 | 41 | 117 | 6.7% | 117 |
| 2001 | 15 | 11 | 10 | 35 | 20 | 22 | 41 | 118 | 0.9% | 123 |
| 2002 | 14 | 12 | 10 | 36 | 20 | 23 | 41 | 120 | 1.8% | 126 |
| 2003 | 15 | 12 | 11 | 38 | 21 | 24 | 41 | 124 | 3.0% | 129 |
| 2004 | 16 | 13 | 11 | 40 | 21 | 26 | 41 | 128 | 3.0% | 131 |
| 2005 | 16 | 14 | 11 | 41 | 21 | 27 | 41 | 130 | 1.4% | 133 |

Source: FAO Trade Yearbook and FAO Yearbook of Fishery Statistics.
Note: data includes land and seaborne trade.

which includes commodities such as manioc which are shipped in bulk. Between 1990 and 2005 the trade grew by an average of 3.6% per annum, making it one of the more rapidly growing segments of the business, driven by the high income elasticity of fruit and vegetables in the developed countries of the Northern Hemisphere.

Bananas provide a stable base load from exporters in the West Indies, South America and, to a lesser extent, Africa. Western Europe and the USA account for about two-thirds of the imports. Exports from the seasonal producing areas in the Southern Hemisphere such as South Africa are volatile. There is a major trade in oranges from the Mediterranean (especially Israel) and South Africa to Western Europe. Recently the trade in exotic fruits such as strawberries, raspberries and kiwi has grown rapidly as exporters have searched for value added. The ‘other vegetable’ trade includes a sizeable trade in manioc from South East Asia to western Europe where it is used as an animal feed – this is not refrigerated cargo. A wide range of other fruit and vegetables are also traded by sea, including potatoes. The fresh meat trade is principally from Australia, New Zealand and Argentina into the developed areas of western Europe, the USA and Japan. The trade accounts for only a very small proportion of meat consumption and growth has been more rapid into Japan and West Coast North America than elsewhere, benefiting particularly from the growth of the ‘fast food’ business. Fresh milk is hardly traded internationally (though there is a trade in powdered milk of over 2 mt per annum) and the main dairy trades are in butter and cheese. The traditional trade was from New Zealand or Australia into the UK, though this started to change when the UK joined the EEC.

Perhaps the most interesting aspect of the refrigerated cargo trade from the maritime economist's viewpoint is the competition between different transport modes for this type of cargo. Refrigerated cargo can be carried in reefer ships; refrigerated containers; refrigerated spaces in conventional liner and MPP vessels; and in refrigerated trucks on ro-ros. In recent years the container trade has become increasingly important, providing a fascinating example of the dynamics of competition in specialist shipping. For example, during the first half of the twentieth century there was intense competition between the liner services and the reefer fleet for the refrigerated cargo. The fleet of refrigerated vessels grew steadily and many cargo liners fitted refrigerated capacity if cargo was moving on their routes (see Chapter 13 and the discussion of the *Point Sans Souci* class of liners). In 1956 Sea-Land introduced the first refrigerated containers on its new container service, using 500 refrigerated trailer units with their own cooling system, adapted for sea transport. In the 1960s more reefer services were containerized, including the important Australia to Europe trade, and the reefer operators responded by palletizing the cargo and building ships designed to handle and stow pallets efficiently. Initially this defensive strategy was successful, but in 1999 container capacity finally overtook conventional reefer capacity, forcing a decline in the fleet of dedicated reefer ships (Figure 12.8).

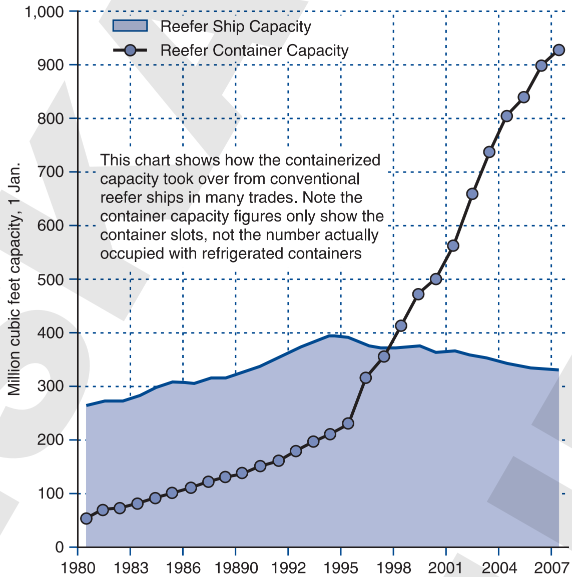


**Figure 12.8**
Reefer fleet and reefer container capacity, 1980–2007
Source: Clarkson Research Reefer and Container Registers

## Reefer transport technology

The cargoes shown in Table 12.9 all need to be transported at carefully regulated temperatures, but they have very different requirements. Broadly speaking the refrigerated cargoes can be divided into three groups:

- *Frozen cargo*. Certain products such as meat and fish need to be fully frozen, and transported at temperatures of up to –26°C.
- *Chilled cargo*. Dairy products and other perishables are transported at low temperatures, though above freezing point, in order to prevent decomposition.

- *Controlled temperatures*. Fruit transported by sea is generally picked in a semi-ripe state, and allowed to finish ripening at sea at a carefully controlled temperature. For example, bananas require precisely 13°C.

Refrigerated ships remain the core source of transport for the high-volume trades. Temperatures must be maintained consistently throughout the ship to prevent deterioration of the cargoes, and even small temperature deviations can be disastrous, especially for tropical fruit. To achieve this, air passes over a bank of refrigerated pipes and is distributed through ducts to the cargo space, allowing both the temperature and the rate of air change to be controlled. The circulating air can also be adjusted for carbon dioxide content, which is important in the carriage of chilled meat and the controlled ripening of certain fruit. The cargo holds are generally lined with plywood and layers of polystyrene insulation (not wool!).

Two types of containers are used in the refrigerated container trade. 'Integral units' are fitted with their own refrigeration unit designed to meet ISO standards and to fit the container-ship cell guides. On board the ship, the refrigeration unit is plugged in to the ship's power supply, the size of which determines how many refrigerated containers the ship can carry. These units are expensive but flexible. 'Insulated containers' have no integral refrigeration unit, just insulation, and must be plugged into an air cooling system on the ship or terminal, or 'clip-on' refrigeration units can be used.

### Supply of refrigerated transport capacity

In 2006 the reefer fleet numbered 1,242 vessels with a capacity of 333 million cubic feet. However, as Figure 12.8 shows, the reefer fleet capacity had been declining since the mid-1990s and the container-ship fleet was expanding with capacity to carry 939 million cubic feet of containerized cargo, though how much of this is in use is not statistically recorded. It is, however, an excellent example of the continuous competition between different shipping services.

## 12.6 UNIT LOAD CARGO TRANSPORT

There are many large physical units such as package timber, bales of pulp, spools of paper, motor vehicles, heavy lift cargoes such as components for a petrol refinery, heavy units such as container cranes, earth-moving equipment, and the host of other large and awkward physical objects which need to move from one part of the world to another. Where volumes are sufficiently large it is often economic to build specialized vessels designed for the efficient transportation of the specific cargo, and over the years several specialized fleets totalling over 3,000 ships have developed to service these trades (see Table 12.1). The five we will cover are deep sea ro-ros used for a mix of cargoes including containers, forest products and wheeled cargo; open hatch bulk carriers, used principally in the forest products trades; PCCs and PCTCs; MPP vessels used for mixed cargoes and increasingly for heavy lift; and heavy lift vessels which focus on the transport of very large unit cargoes,



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sometimes weighing thousands of tons. All these vessel types are to some extent competing with each other, and the cargo flows are not clearly defined in statistical terms. So the following notes concentrate mainly on the development of the various fleets.

## Deep-sea ro-ros

Deep sea ro-ros were one of the first unit load cargo carriers to be developed. These vessels have multiple decks accessed by ramps in the stern, bow or side of the vessel and are very much in the cargo liner tradition, capable of transporting forest products, cars, containers, pallets and heavy lift cargoes. Forest products, containers and palletized cargo are loaded with fork-lift trucks, whilst cars, trucks and other wheeled cargo are driven on. Some also have hoistable decks to accommodate tall items of cargo. All this versatility comes at a price and they are expensive to build. Although in the early days some enthusiasts saw the ro-ro as the natural successor to the cargo liner, it was pushed into the sidelines by the less versatile but ruthlessly efficient container-ship. Table 12.10 shows that by 2006 the fleet had edged up to 1040 vessels, but it had a sluggish growth record. Between 1996 and 2006 the ro-ro fleet grew at an average of only 1.7% per annum, compared with the 10% growth of the container-ship fleet. In addition, the average ship size remained small, edging up to 8800 dwt in 2006.

**Table 12.10** The cargo ro-ro fleet, 1996–2006

| 1 Jan. | No. | Dwt | Growth % p.a. | Av. dwt |
|---|---|---|---|---|
| 1996 | 962 | 7,754 | | 8,061 |
| 1997 | 981 | 7,989 | 3% | 8,143 |
| 1998 | 996 | 7,984 | 0% | 8,016 |
| 1999 | 1,007 | 8,118 | 2% | 8,062 |
| 2000 | 1,036 | 8,401 | 3% | 8,109 |
| 2001 | 1,039 | 8,561 | 2% | 8,240 |
| 2002 | 1,034 | 8,716 | 2% | 8,429 |
| 2003 | 1,042 | 8,904 | 2% | 8,545 |
| 2004 | 1,039 | 9,016 | 1% | 8,678 |
| 2005 | 1,035 | 9,088 | 1% | 8,781 |
| 2006 | 1,040 | 9,183 | 1% | 8,830 |
| 2007 | 1,075 | 9,500 | 3% | 8,837 |

Source: CRSL Containership Register 2007, Table 5

The modern ro-ro type vessels were first built in volume by the US Army which in the 1940s used landing ship tanks (LSTs) to move tanks to beachheads and discharge them through wide bow doors.[12] An early commercial vessel to use this technology was the *Vacationland*, built in 1952 to trade on the Great Lakes. It had accommodation for 150 vehicles in eight lanes and 650 passengers. Cargo could be loaded and discharged via ramps at the bow and stern. By the end of the 1950s Scandinavian shipowners had started using small ro-ros to transport forest products, pulp and paper from Baltic ports to the Continent, with a backhaul of motor vehicles to Scandinavia. These vessels had large stern doors, 6–7 metres wide and 5 metres high, and could carry big trailers and heavy equipment of up to 70 or 80 tonnes on their ramps.

In the late 1960s the first large deep-sea ro-ro services were developed. Scandinavian owners Wallenius Line, along with Transatlantic AB and a group of European owners, set up Atlantic Container Line in 1967 using a fleet of ten large ro-ro vessels with stern ramps for stowing about two-thirds of the cargo below decks with containers on the deck.[13] The ships operated on the North Atlantic and their main aim was to speed up cargo handling and reduce stevedore costs, at a time when both of these factors were a major problem for the shipping industry. Shortly afterwards in 1969 Scanaustral set up a ro-ro service between Australia and Europe. The service was to handle cargoes of forest products, cars, and heavy lift southbound and return with wool, sheepskins, hides, canned and refrigerated foods and metal ingots or bars. After a careful study they concluded that although almost all of this cargo could in principle be containerized, the trade was imbalanced, and the ro-ro system offered better overall economics.[14] Although this logic seemed valid the critical mass built up by container services meant that this deep-sea ro-ro transport never developed as more than a niche.

However, this was not the end of the road for ro-ro transport. Whilst ro-ro vessels have a limited role on the deep-sea general cargo routes, the design has proved extremely effective in two other unit load areas: Firstly in the vehicle trades using PCCs and, more recently, PCTCs which are discussed below, and secondly, in the short-sea trades where ro-ro ferries carrying cargo and passengers now dominate sea transport over short distances.

## Pure car and truck carriers

With the opening of global markets in recent decades, the sea trade in cars and trucks has grown rapidly and has become one of the most important unit load cargoes. Vehicles are light, easily damaged and take a lot of space in a conventional cargo ship, typically stowing at 12 cubic metres to the ton. As a result the freight rates on conventional ships were very high and in the 1950s car exporters started to arrange their own transport, initially using bulk carriers with folding car decks which could be stowed when not in use and which could be prepared for cars in under an hour. In 1956 Wallenius built the first ocean-going vehicle carrier with a capacity for 260 vehicles, and in the following years their size and sophistication increased. By 1965 Japan's first car carrier, the *Opama Maru*, had a capacity of 1200 cars, with a stern ramps that allowed the cars to be driven on and off the ship and elevators to move them between decks where they were stowed. By 1970 car-carriers capable of carrying over 3,000 cars at 21 knots were being built and rapidly replaced the earlier lift-on, lift-off vessels. For example, *Lorita*, belonging to Uglands, carried 3200 motor cars on nine decks, each with deck headroom of 2.52 metres. Cars were loaded through side doors and internal ramps connected the decks, with final positioning by fork-lift truck. In January 2008 the fleet was 634 vessels of 9.1 million dwt (see Table 12.11), including both PCCs and PCTCs. During the previous decade it grew at over 6% per annum, and the largest ships could carry 7,000 vehicles. Most are owned by a small number of Japanese, European and Korean companies.

### DEMAND AND THE TRANSPORT SYSTEM

Car manufacturing is subject to scale economies, but consumers like variety and cars are traded in volume. The growth of international consumer markets in the 1970s and 1980s encouraged a rapidly growing interregional trade in vehicles. The trade is principally from Japan and South Korea to the USA and Europe, with a much smaller trade from Europe to North America. In 1996 the trade was 6.9 million vehicles, but in the next decade it grew rapidly, reaching 15 million units in 2005. The major import trades were 2.5 million units to Europe, 6.4 million units to USA and 2.9 million units to Far East countries. These deep-sea trades have all been growing rapidly. The main exporters in 2005 were Japan which exported 5.6 million units, South Korea which exported 2.6 million units and Western Europe which exported 1.9 million units. This trade pattern reflects the growing diversity of the market place, as discussed in Chapter 10, and the cost-effective transport system which makes manufacturing location less important than product differentiation.

**Table 12.11** The pure car carrier fleet, 1996–2006

| 1 Jan. | No. | Dwt | Growth % p.a. | Av. dwt |
|---|---|---|---|---|
| 1996 | 379 | 4,552 | | 12,011 |
| 1997 | 381 | 4,636 | 2% | 12,168 |
| 1998 | 395 | 4,831 | 4% | 12,230 |
| 1999 | 436 | 5,298 | 10% | 12,151 |
| 2000 | 452 | 5,840 | 10% | 12,920 |
| 2001 | 476 | 6,291 | 8% | 13,217 |
| 2002 | 483 | 6,461 | 3% | 13,377 |
| 2003 | 494 | 6,627 | 3% | 13,416 |
| 2004 | 524 | 6,847 | 3% | 13,067 |
| 2006 | 526 | 7,266 | 6% | 13,814 |
| 2006 | 560 | 7,848 | 8% | 14,015 |
| 2007 | 599 | 8,700 | 11% | 14,524 |
| 2008 | 634 | 9,100 | 5% | 14,353 |

This is a classic industrial shipping operation. As a cargo, cars are high-volume, low-density, and high-value. Vehicles move in large numbers out of western Europe and Japan, mainly shipped in purpose-built vehicle carriers. When operating at full capacity, a large-scale auto assembly plant can produce one car about every 40 seconds. This means that a full 24-hour production schedule results in a maximum daily production of 2160 cars. This level of production can be maintained for long periods despite differentiation in colour, style, accessories and trim. Materials handling to ensure that the right cars arrive at the right destination must be highly organized.

Finished cars cannot be economically stored at the plant and are moved to distribution points as quickly as possible. This extends to the carriage of export cars by sea, and the shipping operation must 'fit' the overall system with storage facilities at the port, fast cargo handling, timely arrival of ships and security for the valuable product in transit. Thus the vehicle carrier fleet operates to carefully scheduled timetables by professional management teams. The largest vessels carry up to 7,000 vehicles, often with hoistable decks which can be adjusted to transport trucks and earth-moving equipment, especially on the backhaul when the vessels are generally empty. Because of the high value of the cargo and age restrictions on vessels imposed by car exporters, car carriers are generally subject to quite rapid depreciation.

### SUPPLY AND OWNERSHIP

In January 2008, the car-carrying fleets stood at 634 ships of 9.1 m.dwt, with a capacity of about 3.0 million vehicles (see Table 12.11). As with other segments of the fleet, the size is dispersed, with vessels varying in size from 1,000 vehicles up to 7,000 vehicles.

In recent years there have been mergers and the carrier market is dominated by eight operators who control about 90% of capacity. Two, Nissan and Hyundai are

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manufacturers; three are Japanese shipowners, NYK, Mitsui OSK, K-Line; one South Korean shipping company, Cido Shipping; and two Scandinavian operators who specialize in car transport, Walenius and Leif Hoegh.

## Open hatch bulk carriers

### THE OPEN HATCH BULK SHIPPING

In 2006 there was a fleet of 486 open hatch bulk carriers of 16.5 million dwt, with an average ship size of 34,000 dwt, most of which work in the forest products trade. Vessels of this type first appeared in the early 1960s to speed up the transport of newsprint which is shipped in large rolls weighing 730 kilograms each. At the time cargo was handled by lifting each roll on rope slings, dropping it into the hold, then laboriously manoeuvring it into place. The hatch overhang made this very labour-intensive, which tied up the ship in port for long periods and the cargo was easily damaged. The first open hatch bulk carrier, the *Bessegen*, built in 1962, had hatch openings the full width of the ship and gantry cranes with grabs capable of lifting eight spools of paper and dropping them vertically into the hold. This transformed a dangerous and labour-intensive process into a fast and highly automated one. There are several large operators which specialize in the transport of all types of forest products, but also carry other unit loads, including containers. Most of the fleet is owned or operated by specialist operators, including K.G. Jebsen Gearbulk (60 ships), Star Shipping (40 ships), Egon Oldendorff (18 ships) and NYK (21 ships).

This distinctive business focuses on the efficient handling and stowage of unit cargoes. Forest products form the base load of the business, but these vessels also carry steel products, containers and project cargoes. The vessels which range in size from 10,000 to 57,000 dwt are designed specifically for the efficient transport of these cargoes. They have open hatches and some can fit ’tweendecks into the holds, allowing several cargoes to be carried in a single hold, for example a bottom cargo of lumber, with wheeled cargo in the ’tween deck (the ’tween decks rest on fold-down supports and are dropped into place when needed). They also have a variety of different types of gear. About 40% are fitted with gantry cranes capable of lifting of up to 70 tons, and the remainder with conventional cranes. Special slings and ‘spreaders’ are used to speed the handling of specific cargoes such as rolls of paper and steel products. The impact this has on cargo-handling speeds is significant. A conventional bulk carrier with slewing cranes handles forest products at a rate of 250 tons per hour, taking 4 days to load a 25,000 ton cargo, whereas an open hatch bulk carrier with 40 ton gantry cranes can load at over 400 tons per hour, cutting the loading time to 2.4 days.[15] This reduction in ship time is mirrored by increased terminal throughput, which reduces the cost of the overall transport operation, and the economics of the operation has already been discussed in Section 12.1.

All of which makes it a specialized business, and the following brief review clarifies the different ways operators seek to differentiate their service:

> Star has more than 40 highly specialized Open Hatch vessels that are tailor made for the carriage of wood pulp, rolled paper and other forestry products.



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> In addition we carry a wide range of other unitized cargoes, project cargoes and containers. … Our vessels have box shaped holds, gantry cranes with rain protection, dehumidification systems and state-of-the-art cargo handling equipment. This enables us to load and discharge the cargo with minimum handling, ensuring safe stowage and minimum delays. Additionally our latest generation will also be equipped with 'tween decks in some of the holds, enabling a mix of various fragile types of cargo in the same hold. Our Open Hatch business is based on long term contracts and strong relationships where high quality, efficiency, punctuality and flexibility are necessary to ensure our customers' satisfaction in the long run.[16]

### PACKAGE BULK CARGO TRANSPORT SYSTEM

This type of operation often involves investment in terminal facilities, since handling and storing packaged cargoes provides terminal operators with a different type of problem. The broad aims are the same, but the operational aspects are very different.

The Squamish Terminals Ltd in British Columbia illustrates the terminal requirements in the forest products trade. The terminal handles exports of pulp from British Columbia. Pulp is shipped from the pulp mill by rail. The railway line runs into the terminal alongside the warehouses. Bales of pulp are discharged from train to storage and then to the ship with a fleet of 34 fork-lift trucks and 14 double-wide tractor trailer units of 34 tons capacity, plus four extension trailers. Three warehouses provide covered storage for 85,000 tons of pulp, about two shiploads, since the vessels servicing the terminal are 40,000–45,000 dwt. However, the terminal operators found that, because the pulp mills have little storage, any stock-building on their part ends up at the terminal. A third warehouse was built as a buffer for this purpose.

Cargo is loaded from two berths, Berth 1 of 11.6 metres draft and Berth 2 of 12.2 metres draft. Because the terminal is serviced by a fleet of geared bulk carriers there is no need for cranes on the quayside. Ships come alongside the apron and cargo is loaded with the ship's gantry cranes. Berth 1 can handle ships up to 195 metres, with an apron 135 metres long, which is sufficient to give access to the cargo holds. Berth 2 handles ships up to 212 metres, with an apron of 153 metres.[17]

## Heavy lift

One of the most difficult segments for the shipping industry to deal with are the large structures which need to be moved around the world. We will define a heavy lift cargo as any unit too large to fit in a container because it exceeds $40 \times 8 \times 8.5$ feet in dimensions or 26 tons in weight. This includes three categories of cargo. Firstly, there are industrial cargoes, for example a 230 tonne reactor for a power plant, a refining column or a container crane. Secondly, there are offshore structures – jack-up rigs, semi-submersible rigs and other pieces of offshore equipment, for example single point moorings or a 56 metre steel jacket, that need to be moved around the world. Thirdly, there are small ships or dredgers, ferries, or yachts and small cargo ships where it is cheaper and safer to move the vessel on a heavy lift ship than take it under its own steam.

Heavy lift ships are concerned with the transport of all these cargoes. Broadly speaking, they fall into three categories: first, powerful tug barge systems which tow large structures around the world on barges; second, semi-submersible heavy lift ships which can be ballasted down, allowing the heavy cargo to be floated onto the deck on a pontoon, after which the vessel de-ballasts to its normal freeboard; and third, many of the large fleet of cargo ships are equipped with heavy lift cranes and they pick up the many small to medium-sized heavy lift cargoes.

*Ocean-going tugs* are very different from the tugs used for manoeuvring ships in port. Essentially they are floating power units with engines of over 4,000 hp. The wheel-house must be positioned for maximum visibility and the afterdeck is kept clear of obstructions which might snag the tow wire. Reliability and the ability to sustain heavy workloads over long periods are vital, as is the ability to handle a very variable workload and large-capacity fuel tanks for undertaking long tows. Apart from the power unit, the tug will carry specialist equipment, depending upon the type of work it is intended to undertake. The flat-topped barges towed by tugs are fitted with ballast systems that allow them to submerge so that heavy equipment can be floated on. Simpler units submerge and rest on the bottom whilst the more sophisticated vessels can achieve float on without the aid of bottom support.

*Semi-submersible heavy lift ships* are also popular. These vessels do much the same job as a tug and barge system, but the power plant is integrated into the vessel, giving better sea-keeping capabilities. The ships are generally designed to be ballasted down, allowing the cargo to float on board. These vessels can be very powerful, with 8,000 to 23,000 bhp engines, and are capable of carrying very heavy loads.

*Heavy lift ships* are generally under 15,000 dwt and fitted with heavy cranes capable of working in tandem. The cargo holds have open hatches, allowing heavy units to be dropped into place, and the cranes will have a capacity of up to 1800 tonnes working together. Cranes are often mounted to the side of the vessel, allowing the cargo space to be unobstructed. To ensure stability during loading and discharging, the ships have anti-healing ballast tanks, and strengthened hatch covers to take heavy loads on deck. In addition to crane capacity, some heavy lift vessels have ro-ro access and strengthened ramps so that cargo can be rolled on. For example, vessels operated by BigLift group have ramps capable of carrying loads of up to 2500 tons weight, substantially more than can be achieved using cranes. The fleet numbers 193 vessels of 3.1 m. dwt. Because of the small size of the fleet and the global reach of the business, some owners increase efficiency and flexibility by operating in pools.

As always there is pressure to increase flexibility. Recently heavy lift ships have been built with container capacity, whilst some of the car carriers discussed earlier in this chapter have strengthened ramps and hoistable decks, allowing them to load heavy lift and project cargoes.

This is a convenient point to mention the *multi-purpose and tramp fleets* shown in Table 12.12 because these ships play an important part in servicing the smaller end of the heavy lift market. The vessels in this table are divided into three categories: the MPP fleet;

**Table 12.12** Multi-purpose and tramp fleet

| 1st | MPP fleet | | Tramp fleet | | Liner fleet | | Total fleet | | |
|---|---|---|---|---|---|---|---|---|---|
| Jan | No. | m dwt | No. | m dwt | No. | m dwt | No. | m dwt | % growth |
| 1996 | 1,955 | 19.8 | 678 | 7.5 | 1,111 | 15.9 | 3,744 | 43.2 | |
| 1997 | 2,025 | 25.3 | 632 | 6.8 | 1,044 | 15.0 | 3,701 | 42.0 | –3% |
| 1998 | 2,095 | 20.6 | 623 | 6.7 | 895 | 13.0 | 3,613 | 40.1 | –5% |
| 1999 | 2,170 | 21.1 | 618 | 6.3 | 786 | 11.4 | 3,574 | 38.8 | –3% |
| 2000 | 2,219 | 21.3 | 606 | 6.0 | 727 | 10.3 | 3,552 | 37.8 | –3% |
| 2001 | 2,296 | 21.6 | 598 | 5.7 | 624 | 9.1 | 3,518 | 36.5 | –4% |
| 2002 | 2,227 | 21.4 | 585 | 5.5 | 546 | 7.9 | 3,358 | 34.8 | –5% |
| 2003 | 2,346 | 21.5 | 571 | 5.3 | 492 | 9.0 | 3,409 | 33.7 | –3% |
| 2004 | 2,365 | 21.6 | 562 | 5.1 | 442 | 6.2 | 3,369 | 32.9 | –2% |
| 2005 | 2,424 | 22.1 | 575 | 5.2 | 425 | 5.9 | 3,424 | 33.3 | 1% |
| 2006 | 2,533 | 22.8 | 605 | 5.4 | 419 | 5.8 | 3,557 | 34.1 | 2% |

Source: CRSL Containership Register 2007, Table 5

the tramp fleet; and the multi-deck ‘liner’ fleet. These are flexible vessels generally with more than one deck and cargo-handling gear, often heavy cranes. It is a large fleet, with 3,521 vessels in 2006. The MPP fleet is now much the largest, with 2,533 vessels and a capacity of 22.8 m.dwt though many of these are below 10,000 dwt. Typically these ships carry a mix of unit load cargoes, including containers, heavy lift, motor vehicles, forest products and steel products. The size of cranes varies enormously: 30–60 ton cranes are common but some can lift 100 tons (see Figure 14.4). This MPP fleet is growing slowly, increasing from 19.8 m.dwt in 1996 to 22.8 m.dwt in 2006. In contrast, the tramp and liner fleets are declining, since during the last 20 years most new investment has focused on the MPP segment.

## 12.7 PASSENGER SHIPPING

### Development history

The passenger business has changed a good deal over the years. Until the 1950s passenger ships were the only way of crossing water, and in the early twentieth century passengers became the core business of many great shipping companies. The powerful liners built to transport passengers in luxury at 20 or even 30 knots made it one of the most evocative periods in shipping history. Many cargo vessels also had facilities to carry paying passengers. In 1950 ships still carried three times as many passengers as aircraft across the Atlantic. However, as intercontinental airlines developed in the 1950s, the economics moved decisively against passenger ships, which proved to be far too labour-intensive to survive in the post-war world (Section 1.6). By the 1960s ships carried few deep-sea passengers. Some companies left the business whilst others, such as P&O and Cunard, diversified into the cruise business. But although aircraft had a decisive economic long-haul advantage, for short-sea voyages sea transport remained competitive, especially for cars, lorries and wheeled cargo. As motor transport flourished in the 1950s

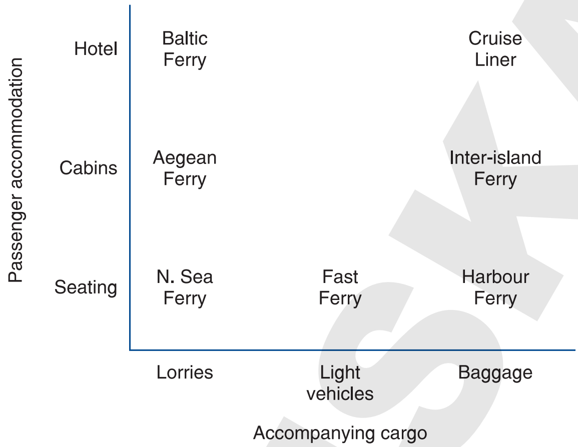


**Figure 12.9**
Passenger transport options

and 1960s, so did the ferry business. Today we have a whole spectrum of passenger vessels, ranging from commuter ferries to the luxurious 'resort' cruise liners dedicated to taking passengers on holiday.

To illustrate the diversity of passenger vessel types, Figure 12.9 concentrates on two key aspects of passenger ship design, the passenger accommodation, shown on the vertical axis of the diagram, and the accommodation for accompanying vehicles. There are three levels of accommodation. The most basic is seating with benches or overnight 'couchette' seats. At the second level cabins are provided, whilst the third level offers complete hotel accommodation with restaurants, shops and entertainment. It would be possible to extend the diagram one step further to the most modern development of 'resort' accommodation in which the ship is purpose-designed as a complete leisure resort, essentially a small town at sea. The other dimension identified is the accompanying cargo which ranges from hand baggage, through light vehicles such as motor cars, to lorries.

Using these broad criteria, the figure defines seven types of passenger vessel. On left-hand side of the diagram are the ferries designed primarily to carry cars and lorries. On the short routes such as the English Channel these will have seating accommodation, with associated restaurants, but no cabins, since the voyages are too short to include an overnight stay. At the second level of the 'Aegean Ferries' they have simple cabin accommodation, whilst at the third level the 'Baltic ferries' are designed to provide overnight accommodation with a full range of hotel-style services, entertainment, etc. These vessels are in effect cruise liners, but with roll-on roll-off accommodation for cars and lorries.

On the right hand side of the diagram are the vessels with no vehicle decks. At the lowest level is the harbour ferry, which has passenger seating accommodation and possibly some refreshment facilities. At the second level are Inter island ferries which have simple cabin accommodation, but no ro-ro facilities. Finally at the top are cruise liners with hotel accommodation and leisure activities.

The fundamental difference between these ship types is their role of transportation. Essentially, with the exception of the Cunard transatlantic service and the seasonal repositioning of vessels, the cruise liners are exclusively designed for leisure, with no transportation role, whilst all the others are primarily transport vessels which offer different degrees of leisure services to customers during their voyage. But they have many features in common.

## Passenger ferries

Ferries transport people, goods and vehicles over short distances by sea. They vary in size from small passenger ferries used to cross channels such as Hong Kong harbour, the Hudson River in New York, or the Bosphorus in Turkey, to very large ro-ro ferries which carry 3,000 passengers and 650 vehicles across the English Channel, the Baltic Sea or between the islands of Indonesia.

The vessels used in the ferry market share many common characteristics such as ro-ro access, vehicle decks, accommodation for passengers and entertainment facilities, but there are so many permutations of these basic characteristics that the ferry fleet is extremely diverse. As mentioned in the previous section, almost all ferries use ro-ro technology to allow motor vehicles and wheeled cargo to be loaded and discharged quickly and easily. Passengers arrive in motor transport which is stowed on vehicle decks designed with as few impediments as possible. Access is through a stern door which doubles as a loading ramp, possibly with a bow door arrangement which permits straight-through driving and parking. Accommodation is located above the car decks, and its design depends on the service for which the ferry is intended. This is where the ferry companies move into the entertainment business.

The opportunity to entertain passengers during their voyage and in so doing generate a profitable income stream is one of the prime considerations in the ferry business. Vessels used on short trips, for example across harbours or rivers, will have simple seating arrangements, but little entertainment. On short sea crossings taking a few hours, for example the English Channel, the accommodation typically focuses on restaurants, shopping facilities and seating areas for passengers. On longer voyages, for example across the Baltic, cabins are provided and the focus is on a offering customers a ‘mini-cruise’, with more exotic entertainment, discos, etc. Because of this distinction in commercial function, there are major differences between ferries used in these different markets, leading to a degree of market segmentation. In Europe the market splits into the Baltic market, which is relatively long distance and uses the most sophisticated overnight ferries; the North Sea which generally involves transit times of 3–8 hours, with less focus on passenger accommodation, and more on shopping and restaurants; and the Mediterranean, which has a mix of both.

The economics of the ferry business is complex. Because of the large amount of marketing required, and expense of the ships, ferry services are generally operated by large companies. There is generally intense competition with other ferry operators serving on the same routes or other routes to the same general destination. Speed, frequency of service and the levels of on-board accommodation are all key issues. Over the last 20 years the ferries built for these demanding markets have grown larger and more sophisticated. A typical example is the *Gotland*, a 196 metre vessel of 29,746 gross tonnes built in 2003 to operate between Visby on the Baltic island of Gotland and the Swedish mainland. It is capable of carrying 1500 passengers, 1600 metres of trailers or 500 cars at a speed of 28.5 knots and has 112 cabins with 300 berths. Ferries of this type have a variety of cabins, several restaurants and relaxation areas and luxurious public areas.

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## The cruise business

Although it may seem surprising to include cruise liners in a book on maritime economics, that should not be the case. Cruise lies at the most sophisticated end of the specialized shipping market, and its principal assets are ships operated by seamen and moving from port to port. Like cargo vessels, cruise ships must load, discharge and operate to a tight schedule in all weathers. Viewed in this way cruise vessels and ferries are merchant ships. The difference is that passenger shipping is the only segment that deals directly with consumers and its competitors are not other shipping companies, but other holiday providers. But this is no different from the passenger liners of the previous century.

Sea cruising dates back to the nineteenth century when liner companies with spare passenger ships would offer occasional cruises. The first purpose-built cruise liner was the *Prinzessin Viktoria Luise*, built by Hamburg Amerika Line in 1901, with accommodation for 200 passengers. In the 1930s the *Arandora Star*, with 400 berths, was very successful, completing 124 cruises to the West Indies, the Canaries, the Mediterranean and the Norwegian fjords.[18] However, this was a very narrow market for the rich, and the real growth started with the tourism boom in the 1960s, with the highly successful development and marketing of Caribbean cruises. By 1980 the North American market was 1.4 million cruises a year, and Figure 12.10 shows that since then the number of passengers has grown at 8.2% per annum to 12 million cruises in 2006. In total 51 million people in North America (17% of the population) have taken a cruise, usually lasting an average of 7 days.

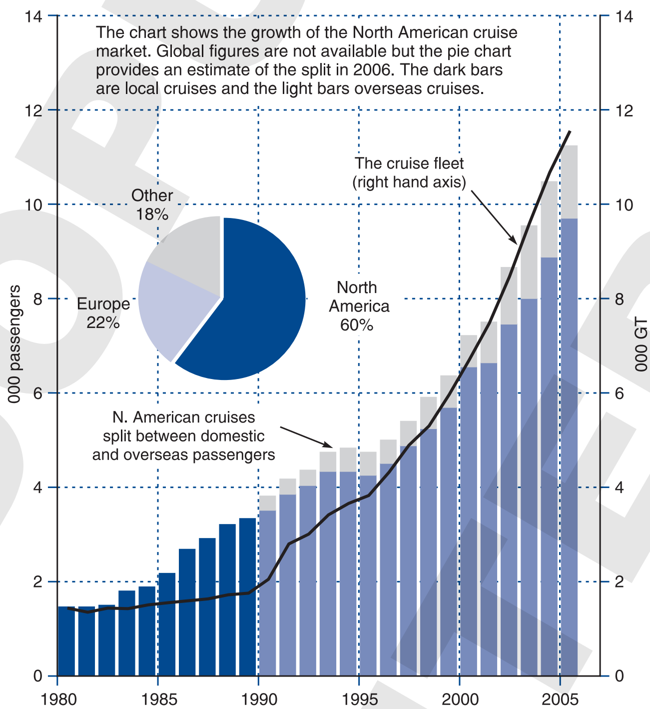


**Figure 12.10**
The North American cruise market
Source CLIA

In 2006, over 15 million people worldwide took a cruise, with North America accounting for about 60% of the world cruise market, and another 15% overseas visitors flying to the USA to take a cruise (Figure 12.10, left-hand axis). From a company viewpoint the business is relatively consolidated. Carnival Cruise, the biggest brand and owner of several other brands, has 22 ships and 51,000 lower berths, giving it a 15% market share. Its market capitalization in 2007 was



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$40 billion, making it the second biggest public shipping company after A.P. Møller-Maersk. The top five cruise companies owned 55% of the capacity and the top 10 have 74% of the capacity. This is a much higher concentration than is found elsewhere in the marine business and suggests that in the cruise business size brings a greater commercial advantage than in other segments of shipping. Concentration is even higher when considered on the basis of owning groups. The top three groups, Carnival, Royal Caribbean and Star, own 77% of the fleet capacity. Carnival alone owns 46%.

The cruise fleet capacity has also grown rapidly (see Figure 12.10, right-hand axis), averaging 8.7% per annum since 1980. In 2007 the 251 ships in the cruise fleet had 337,000 berths and a measurement of 12.8 million gross tonnes. The fleet is segmented by size, with 64 vessels over 2,000 berths, 76 with 1,000 to 2,000 berths, and 111 with under 1,000 berths. These are the most expensive merchant ships, costing around $280,000 per berth in 2007. On that basis a 3,000-berth vessel would cost close to $0.8 billion.

Traffic growth in the cruise business is driven by capacity. For all of the mass-marketed brands, where ticket prices are heavily discounted, it is imperative that the cruise lines fill their ships in order to take advantage of on-board spending in casinos, bars, spas, gift shops and for shore tours. High utilization rates in excess of 100% (possible because capacity is based on 2 per cabin, while third and fourth berths in a cabin are frequently used) ensure a steady stream of cash that can amount to as much as 25% of total revenue. High-end luxury brands tend to have lower utilization rates, which is viable because their higher *per diem* fares make them less dependent upon on-board spending.

Structurally, cruise liners must provide hotel accommodation and entertainment for the passengers whilst on board, and to achieve this the ships are arranged over multiple decks. A typical large cruise ship might have 10–12 decks available for passengers, though with the increasing size of ships and the popularity of balconies 12 or 13 decks are now the norm for new vessels and the largest have 15. The upper decks are devoted to sun decks, sports activities, observation decks and lounges, spa/fitness centres and a lido with swimming pools and casual buffet dining facilities. The next several decks would be devoted to passenger cabins, with balconies on most outside cabins. Two more decks are then typically devoted to public spaces, with casino, theatres, lounges and discos, cinema, library, shops and a range of restaurants. The remaining decks are devoted to passenger cabins, without balconies on the outside cabins. Passenger services (purser, shore excursions, forward bookings) are generally clustered on one of the lower decks around a central atrium that may extend up several decks and which often serves as the principal embarkation/debarkation area.

## 12.8 SUMMARY

Transport of specialized cargoes is one of the most challenging segments of the shipping market. Designing ships or whole transport systems to carry specific cargoes is not a recent development, but in the second half of the twentieth century the global economy developed in a way that has created many new opportunities for shipowners to offer specialized services which cut costs, improve quality and often make it economic

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to transport cargoes that otherwise could not be traded. The result is the fleet of over 10,000 specialized ships discussed in this chapter.

Specialist trades are often more difficult to analyse than bulk trades (see Chapter 11) because most are manufactures or semi-manufactures. In Chapter 10 we discussed why the economic model of the manufactures trade raises difficulties for the analyst. Competitive trades occur when cheaper supplies are available abroad, leading to trade flows which reflect these differences – for example, exports from chemical plants in the Middle East with low-cost raw materials such as gas available locally. Naturally these trades move when costs change. Deficit trade occurs when there is a temporary shortage of a product in one area and supplies are imported from another to fill the gap. This is very common in the oil products trades and forest products. Finally, differentiated trades develop because consumers like a choice. For example, many cars are shipped by sea because some consumers prefer the models that overseas manufacturers can offer. These are all issues which come up in discussing the trades carried in specialist vessels, so do not expect the trade analysis to be easy.

Most of these specialized trades segments face a degree of competition from other parts of the shipping market (LNG is the exception) and the main focus of the business model is to differentiate the service in a way which reduces costs per unit of transport and offers improved service in areas which are of importance to the customer. The chemical business invests in ships and terminals to handle small parcels of liquid cargo while complying with the various regulations for the transportation of hazardous substances by sea. It is very competitive, with parcel tankers competing with medium-sized tramp vessels and small tankers on short sea routes. Cargo handling and terminals play an important part in the business. Gas transport is also diversified. There is a large LPG trade from the Middle East mainly to Japan, whilst the mid-sized gas tankers focus on the ammonia trade and smaller vessels on ethylene and various industrial chemical gases. The gas tankers are pressurized; semi-pressurized or fully refrigerated. LNG is separate due to the low temperature of −162°C at which methane liquefies.

The refrigerated cargo trade consists of frozen meat, chilled fruit and vegetables and fish. Purpose-built reefer ships are used for all three trades, but containerization has taken a growing market share. Car carriers move vehicles around the world as part of a tightly integrated transport operation. Many vessels now have hoistable decks to carry trucks, project cargoes and large units. Another segment which focuses on the 'large and awkward' cargo is the heavy lift business which moves very large structures around the world, employing several different types of ships. The basic heavy lift vessels are open hatch MPP ships with heavy lift gear and possibly a stern ramp. Other more sophisticated vessels allow cargo to be floated on. Open hatch bulk carriers are also used in the forest products trade where they offer very high productivity for the transport of package lumber, paper and, where appropriate, containers, steel products and other small unit cargoes. Finally, the ferry and cruise business has been developed as an important part of the shipping market, and the only one which deals directly with consumers.

The message of specialized shipping markets is that there are few clear boundaries. Shipowners invest to meet a market need, and many of them work off very tight margins. But there can be little doubt that the businesses discussed in this section differ substantially from the rough and tumble of the bulk markets discussed in Chapter 11.



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