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15 The Economics of Shipbuilding and Scrapping

Build me straight, O worthy Master!
Staunch and strong, a goodly vessel,
That shall laugh at all disaster,
And with wave and whirlwind wrestle!

Day by day the vessel grew,
With timbers fashioned strong and true,
Stemson and keelson and sternson-knee,
Till, framed with perfect symmetry,
A skeleton ship arose to view!

And around the bows and along the side
The heavy hammers and mallets plied,
Till after many a week, at length,
Wonderful for form and strength,
Sublime in its enormous bulk,
Loomed aloft the shadowy hulk!

('The Building of the Ship', Henry Wadsworth Longfellow,
The Poetical Works of Longfellow, Frederick Warne & Co.,
London 1899, p. 143)

15.1 THE ROLE OF THE MERCHANT SHIPBUILDING AND SCRAPPING INDUSTRIES

The shipbuilding industry supplies new ships, while shipbreakers ('recyclers') are the last-resort buyers of old ships which cannot be operated profitably in the shipping market. In terms of their economic structure, the two industries are very different. Shipbuilding is a heavy engineering business, selling a large and sophisticated product built mainly in facilities located in the industrialized countries of Japan, Europe, South Korea and now China. It requires substantial capital investment and a high level of technical and management expertise to design and produce a merchant ship. The ship scrapping industry, in contrast, is located mainly in the low-cost countries, particularly the Indian subcontinent, and is one of the world's most labour-intensive industries – in some countries ship scrapping takes place on the beach, with labour equipped with only the most primitive of hand tools and cutting equipment.

In the first part of this chapter we will examine the regional distribution of shipbuilding capacity and the relationship between the level of shipping and shipbuilding activity. We then consider shipbuilding market economics, looking in particular at the shipbuilding market cycle, the price mechanism and the influences on the supply of and demand for shipbuilding output. The section on shipbuilding ends with a discussion of competitiveness and the related issues of capacity measurement, the production process and international comparisons of productivity. The final section discusses how ships are scrapped, the market for scrap products and the international structure of the ship scrapping industry. Finally, in this chapter we introduce a new unit of measurement, the compensated gross ton (cgt). The compensated gross tonnage of a ship is derived from its gross tonnage (gt), but weighted to take account of the work content of that particular ship type – detailed definitions can be found in Appendix B.

15.2 THE REGIONAL STRUCTURE OF WORLD SHIPBUILDING

Who builds the world's merchant ships?

About 30 countries have a significant merchant shipbuilding industry (see Table 15.1), and it has a changeable history. Ship production trebled from 8.4 million gt in 1960 to 27.5 million gt in 1977, then halved to 13 million gt in 1980, edged up to 16 million gt by 1990 and more than doubled to 44.44 million gt in 2005. This volatility was accompanied by a realignment of regional shipbuilding capacity. Europe's market share fell from 66% to 10% while Asia's grew from 22% to 84%. Japan and South Korea now dominate the industry, between them producing over two-thirds of the world's ships, with China coming up very fast and trebling its production between 2000 and 2005, aiming to be the biggest shipbuilder. The remaining production is spread over many countries, mainly in eastern and western Europe. The shipbuilding output of most European countries declined during the 1980s, and several, including Sweden, stopped building merchant ships. Meanwhile Asia's dominant role increased as South Korea and China grew rapidly despite the general market problems in the shipbuilding industry. Finally, the market upturn in the early 2000s, during which newbuilding berths were in short supply, brought a surge of new Asian shipyards in emerging countries such as Vietnam, the Philippines and India.

Shipbuilding is a long-cycle business. Ships take several years to deliver, and once built they remain in service for 25–30 years. Since ships trickle in and out of the merchant fleet at only a few per cent a year, the pace of change in shipbuilding demand is slow. Trends develop over decades rather than years, and we need to step well back

Table 15.1 Merchant ships completed during years, 1960–2005 ('000 GT)

	1960	1977	1980	1985	1990	1995	2000	2005
Asia								
Japan	1,839	11,708	6,094	9,503	6,663	9,263	12,020	16,100
South Korea	—	562	522	2,620	3,441	6,264	12,228	15,400
Chinese PR	—	110	—	166	404	784	1,647	5,700
Taiwan	—	196	240	278	685	488	603	500
Singapore	—				49	99	17	
Total Far East	1,839	12,576	6,856	12,567	11,242	16,898	26,515	37,700
% world	22%	46%	52%	69%	70%	75%	84%	85%
Europe								
Belgium	123	132	138	133	60	11	0	0
Denmark	214	709	208	458	408	1,003	373	500
France	429	1,107	283	200	64	254	202	0
Germany FR	1,124	1,595	376	562	874	1,120	974	1200
German DR	—	378	346	358 in German FR				
Greece	—	81	25	37	19	0	0	0
Irish Republic	—	40	1	0	0	0	0	0
Italy	447	778	248	88	392	395	569	300
Netherlands	682	240	122	180	190	205	300	200
Portugal	—	98	11	41	74	18	47	
Spain	173	1,813	395	551	366	250	462	100
UK	1,298	1,020	427	172	126	126	105	0
Finland	111	361	200	213	256	317	223	0
Norway	254	567	208	122	91	147	114	100
Sweden	710	2,311	348	201	27	29	33	0
Total Europe	5,565	11,230	3,336	3,316	2,945	3,875	3,402	4,400
% world	66%	41%	25%	18%	18%	17%	11%	10%
Eastern Europe								
Bulgaria	—	144	206	173	92	92	21	0
Poland	220	478	362	361	141	524	630	700
Romania		296	170	204	175	229	139	0
USSR/Russia		421	460	229	430			
Yugoslavia	173	421	149	259	462			
Russia						83	17	—
Ukraine						185	5	0
Croatia						179	342	600
Total	393	1,760	1,347	1,226	1,300	1,291	1,154	1,300
% world	5%	6%	10%	7%	8%	6%	4%	3%
Others								
Brazil		380	729	581	255	172	10	0
USA	379	1,012	555	180	23	7	92	300
Other countries	586	573	278	286	288	225	523	744
Total	965	1,965	1,562	1,047	566	404	626	1,044
% world	12%	7%	12%	6%	4%	2%	2%	2%
World total	8,382	27,531	13,101	18,156	16,053	22,468	31,696	44,444

Source: Lloyd's Register of Shipping, Clarkson *World Shipyard Monitor*

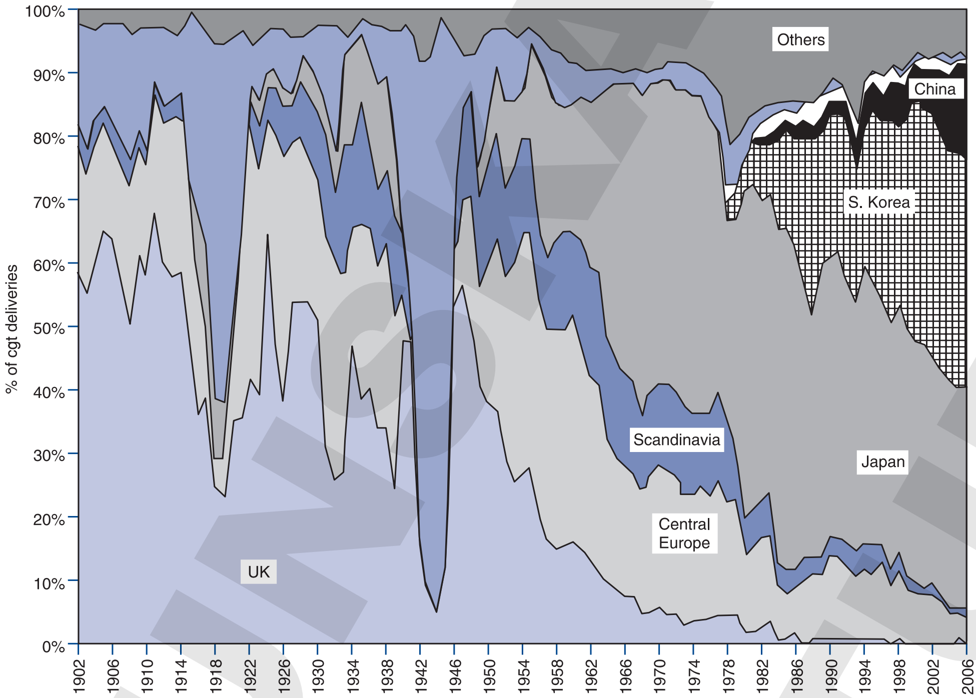

Figure 15.1
Shipbuilding market shares, 1902–2006
Source: Lloyd's Register of Shipping, Clarkson Research

to see them. Nowhere is this more apparent than in the changing regional location of shipbuilding activity, shown vividly in Figure 15.1. A century ago, shipbuilding was dominated by Great Britain. Gradually Continental Europe and Scandinavia squeezed Britain's share down to 40%. Then in the 1950s Japan overtook Europe, achieving a market share of 50% in 1969.

In the 1980s South Korean shipbuilding output grew rapidly, challenging Japan's dominant position and finally establishing the Far East as the centre of world shipbuilding. Then in the 1990s China started to increase in importance, achieving a 14% market share in 2006. Following this sequence of events we might ask what it is about shipbuilding that allows a single country to obtain the commanding position achieved by Britain, Japan, South Korea and China; and why has the balance changed so much over the years? To answer these questions it is instructive to take a brief look at the recent history of the shipbuilding industry, and in particular the relationship between the shipping and shipbuilding industries.[1]

The decline of British shipbuilding

In the early 1890s Britain dominated the maritime industry, producing over 80% of the world's ships and owning half the world fleet. In 1918 the Board of Trade Departmental

Committee on Shipping and Shipbuilding commented: ‘there are few important industries where the predominance of British manufacture has been more marked than shipbuilding and marine engineering’.[2] Britain held this dominant position until 1950 when it started to lose market share. The downward trend is apparent in Figure 15.2, as is the close correlation with the decline of the UK merchant fleet. At the beginning of the twentieth century, the UK merchant fleet had a 45% market share and shipbuilding about 55%, but by the end of the century the share had dwindled to virtually nothing.

It is not difficult to explain how British shipping achieved this dominant position. In the 1890s the Empire was at its height and Britain controlled massive trade flows, giving its shipping companies effective control of many liner routes in the Atlantic and Pacific, particularly between the colonies. In the tramp shipping market, Britain – an island nation – was the major importer of raw materials and foodstuffs such as grain, while the export trade in manufactures and coal was equally prominent. As the control of trade slipped away, so did shipping. With each world war the British Empire diminished in size, the merchant marine was weakened by wartime losses and its trading partners became better able to carry their own trade.[3] By 1960 the UK fleet had slipped to only 20% of world tonnage and British shipbuilding accounted for about the same proportion of world shipbuilding output, and by 2005 its market share of shipping had fallen below 2% and merchant shipbuilding was limited to very small ships.

One reason put forward for the decline of British shipbuilding was the industry’s failure to graduate from a production process based on manual skills to the more closely integrated production technology that was developed in Sweden and Japan during the twentieth century.[4] But there was also a link between the fortunes of shipping and shipbuilding. Discussing the rise of the British shipbuilding industry during the nineteenth century, Hobsbawm argues strongly for the existence of this link in the following terms:

> During the age of the traditional wooden sailing ship Britain had been a great, but by no means unchallenged producer. Indeed her weight as a shipbuilder had been due not to her technological superiority, for the French designed better ships and the USA built better ones … British shipbuilders benefited rather because of the vast weight of Britain as a shipping and trading power and the preference of British shippers (even after the abrogation of the Navigation Acts, which protected the industry heavily) for native ships.[5]

This link between trade, shipping and shipbuilding is too common to be a coincidence. In Britain relationships existed between shipowners and shipbuilders that went beyond normal competitive ties. Many British shipping lines had a long association with particular shipyards, which reinforced the tradition of building at home. Even in the 1970s there were shipyards in Britain that relied heavily on one or two domestic owners. As we shall see when we look at other regions, this was not a uniquely British state of affairs and shipbuilders are very dependent upon the fortunes of their home fleet.

But the commercial performance of the shipyards is also important and Britain was slow in adapting to the new highly competitive shipbuilding market after the

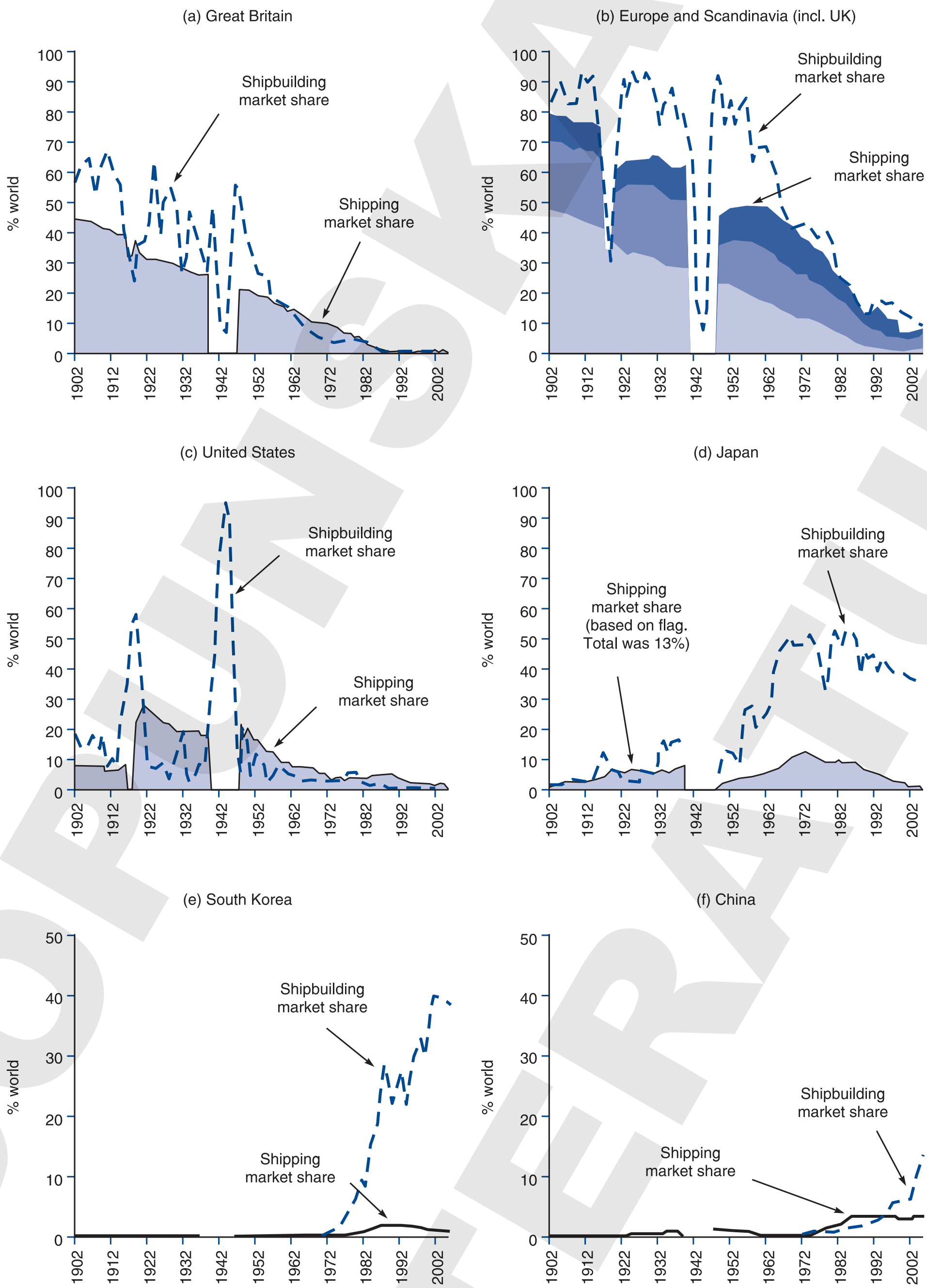

Figure 15.2
The link between shipping and shipbuilding market shares by region
Source: Lloyd's Register of Shipping
Note: This figure shows, for each region, the merchant fleet as a percentage of the world fleet and shipyard output as a percentage of world output.

Second World War. The battle was probably lost in the 1960s when British manufacturing industry as a whole was struggling with entrenched management practices and confrontational labour relations. Despite considerable capital investment, the British yards never achieved the high productivity levels of the German or Scandinavian yards. Typically it took twice as many man-hours to build a ship in the United Kingdom as in Scandinavia or Japan. A major strategic loss was the first container-ship which was started in the UK, but had to be towed to Germany to be completed. German shipyards continued to dominate the container business in Europe for the next 30 years.

The final blow was the UK's strong exchange rate when North Sea oil came on stream during the 1980s, at the trough of the 1980s recession. In 1988 the sterling price of a 30,000 dwt bulk carrier, £8 million, was only sufficient to buy the materials and left no margin for labour and overheads, an impossible position.[6] Slowly the industry slipped away.

European shipbuilding, 1902–2006

In Europe as a whole shipbuilding went through much the same cycle of growth and decline as in the UK. No individual country achieved prominence in the shipbuilding market on a scale comparable with Japan or the UK, but in the early 1900s European shipyards, including the UK, accounted for over 80% of world production, similar to the market share the Asian shipyards achieved a century later. This is shown in Figure 15.1 along with the market share of their shipping fleets. Until 1945 the shipbuilding market share was 20–30% higher than the shipping market share, and Europe was a net exporter of ships. But by the late 1950s this export dominance had been lost and the decline of the European shipping fleet in the 1960s and 1970s was accompanied by a decline in the market share of shipbuilding. By 2005 the market share of the fleet had fallen to 14% of the gross tonnage delivered, whilst the shipbuilding share was reduced to 6%. Of course these statistics have limitations, since during this period much of the fleet 'flagged out' (see Chapter 16) and gross tonnage does not fully reflect the high value-added of European shipbuilding, but there is no doubt that over the period Europe switched from being a net exporter to an importer of ships.

The experience of the Scandinavian shipbuilding industry was similar. Although none of the Scandinavian countries has sufficient population or heavy industry to make it a major participant in seaborne trade, they all have a strong maritime tradition. In this sense, the Scandinavian fleets may be regarded as part of the international shipping industry, in much the same way as Greece. In 1902 the Scandinavian shipyards had only a 3% market share, well below the 10% share of the Scandinavian merchant fleet. Shipbuilding capacity lagged behind the merchant fleet during this period because the Scandinavian shipyards had difficulty switching from wooden ships to the more capital-intensive process of building steel ships. Petersen comments:

> In the 1870s Norway had a large number of small shipyards employing expert master carpenters and experienced workers. These men were able to build all the sailing ships Norway needed, using only simple tools and home grown timber.

> The building of steam ships, on the other hand, demanded the import of raw materials and the erection of large shipyards with expensive, heavy machinery, and cranes. Steamship building did not gain momentum until the 1890s.[7]

Shipbuilding output in Scandinavia remained nominal until the First World War, when the industry started a rapid growth that eventually reached a peak market share of 21% in 1933. This position was maintained until the early 1970s when Scandinavian shipyards led the world in terms of productivity and production technology. For example Kockums shipyard in Sweden, which specialized in VLCCs, was generally regarded as the most productive yard in the world. But this success could not offset the high labour costs, and a decline in the market share of the Scandinavian fleet coincided with a fall in the market share of Scandinavian shipbuilding.

The fall in the European fleet, due partly to the transfer of registration to flags of convenience, was accompanied by a decline in Europe's market share, especially in the high-volume bulk markets. This undoubtedly reflects the growing competitive strength of the Japanese industry, and demonstrates that high productivity alone is not enough to maintain market share. But although many yards closed, some were successful in diversifying into high value-added ships for niche markets in which the Far East yards did not compete. These markets included container-ships, cruise ships, gas tankers, chemical tankers and many small vessels such as dredgers. All of these vessels are equipment-intensive, and this allowed the European equipment industry to maintain a leading role in design and development, for example in engines, cranes and engine room equipment.

Merchant shipbuilding in the United States

Historically the USA has had an unusual role in world shipbuilding. Apart from a spell in the early nineteenth century as the leading shipbuilder, which was brought to an end by the Civil War (1861–5), in peacetime the USA was not internationally prominent as a merchant shipbuilder or shipowner. With the exception of the two wars and the inter-war period, Figure 15.2(c) shows that its market share was only a few per cent. Of course, the USA had major shipping interests but, as we will see in Chapter 16, US shipowners were at the forefront of developing international registries. Despite this, much of the world's shipping and shipbuilding technology originated in the USA and during the two world wars the USA demonstrated its ability to mount a massive, if rather expensive, shipbuilding programme.

During the First World War, US shipbuilding output increased from 200,000 grt in 1914 to 4 million grt in 1919 – the USA alone produced 30% more ships in that year than the whole of world shipbuilding output before the beginning of the First World War. Production on this scale was achieved by using standard ships and standard production methods at the Hog Island complex which consisted of 50 building berths in five groups of ten along the Delaware River. The complex built a standard merchant ship in three sizes constructed as far as possible from flat plate. The building time was approximately 275 days. This was the first step towards standardized shipbuilding practices, though the yards did not achieve the degree of prefabrication introduced later.

The Second World War saw an even more extensive shipbuilding programme for the American Liberty ship, which was a standard dry cargo vessel of 10,902 dwt, and the T2 tanker of 16,543 dwt. These ships were mass-produced, with major sub-assemblies constructed off the berths – a development made possible by introducing welding in place of riveting. Production commenced in 1941 and reached a peak in 1944 when a total of 19.3 million grt of new ships were launched in the US – almost ten times the total world shipbuilding output in 1939. A total of 2,600 Liberty ships and 563 T2 tankers were built. After the war some of the Liberty ships were sold to private operators, others were traded, and the remainder, about 1,400, were laid up as part of the US strategic reserve fleet. By the 1960s their slow speed of 11 knots and full-bodied design made them unattractive in commercial operation and a series of Liberty replacement designs such as the SD14 and the Freedom took their place.

The activities of the US merchant shipbuilding industry during the twentieth century demonstrate two important points. The first is the speed with which, given the right circumstances, a major shipbuilding programme can be set up and dismantled. On these two occasions the USA developed a massive shipbuilding capacity and dismantled it again within an equally short period. The second is that, despite the obvious efficiency of the US shipbuilding industry, it could not compete commercially in the world shipbuilding market. In the 1930s, and again during the post-war era, the US government provided construction subsidies to US merchant shipbuilders to offset the difference between the construction in American and foreign yards. At different times the levels of subsidy varied from 30% to 50% of the cost of construction.[8] Like Scandinavian shipyards, high productivity was not enough, though the isolation of the industry from international market forces and the focus on the very different craft of warship building make it very difficult to judge what the underlying competitiveness of the industry really was.

The Japanese shipbuilding industry

The rise of Japan as the dominant force in the world shipbuilding market provides yet another example of the shipbuilding growth model. Like Britain, Japan is an island nation and the growth of the economy after the Second World War made intense demands on seaborne transport. Initially the development of the Japanese shipbuilding industry drew strength from a coordinated shipping and shipbuilding programme. For example, Trezise and Suzuki comment:

> In the early post war period … the industries selected for intensive governmental attention included the merchant shipping industry. A planned shipbuilding programme for the merchant fleet was instituted during the occupation, in 1947, and is still being pursued essentially along the lines laid down at this time. Each year the government – that is to say the Ministry of Transport – in consultation with its industry advisors in [the] Shipping and Shipbuilding Rationalisation

> Council – decides on the tonnage of ships to be built, by type (tankers, ore carriers, liners, and so on) and allocates production contracts and the ships among the applicant domestic shipbuilders and shipowners. The selected shipping lines receive preferential financing and in turn are subject to close government supervision.[9]

During the period 1951–72, 31.5% of the total loans made by the Japan Development Bank were for marine transportation. This domestic shipbuilding programme undoubtedly contributed to the success of the Japanese shipbuilding industry, but the Japanese merchant marine never achieved the degree of market domination that the British merchant fleet had established in the nineteenth and early twentieth centuries. One reason was that by the 1960s the growth of flags of convenience and high Japanese costs meant that much of the fleet was chartered in from independent shipowners, especially in Hong Kong, under *shikumisen* contracts. Figure 15.2(d) shows that, although the market share of the Japanese fleet increased from 1% in 1948 to 10% in 1984, this fell well short of the 50% market share achieved by Japanese shipbuilders in the 1980s.

There are two explanations for this. One is that the Japanese flag was uncompetitive and many of the ships commissioned for the carriage of Japanese trade were purchased by international owners in Hong Kong or Greece and registered under flags of convenience. In 2005, 89% of the Japanese-owned fleet was operating under foreign flags, so the low shipping market share in Figure 15.2(d) is misleading. The second is that the Japanese shipbuilding industry became highly competitive and built for the emerging export market, particularly the market for large tankers and bulk carriers bought by independent European, US and Hong Kong shipowners. Their strategy was similar to their approach in other major industries. They built large modern shipyards and used the domestic market as the volume baseload for selling highly competitive ships into the export market. The new facilities had building docks capable of mass producing VLCCs and large bulk carriers at a rate of 5–6 vessels per annum. Production engineering, strict quality control, sophisticated material control systems and pre-outfitting were all used effectively to reduce costs and maintain delivery schedules. Some shipyards were built in the main industrial centres (e.g. the Mitsui Shipyard at Chiba, the IHI Shipyard at Yokohama and the Kawasaki Shipyard at Sakaide), while others were in remote areas (e.g. the Mitsubishi Shipyard at Koyagi).

During the 1990s Japan was challenged by South Korea, and its shipyards faced high labour costs and a strengthening currency. However, the Japanese shipyards were remarkably successful in maintaining their competitive position despite these disadvantages. Unlike the European yards which focused on high value-added ships, such as cruise liners, the medium-sized Japanese yards developed a very successful business building bulk carriers, generally regarded as the simplest of vessels. By employing production planning, production engineering and subcontracting they increased productivity and in 2005 Japan was still the market leader, producing 16.1 million gross tons of ships, compared with South Korea’s 15.4 million gross tons (see Table 15.1).

The rise of South Korean shipbuilding

The entry of South Korea into the world shipbuilding market was, like that of its near-neighbour Japan, the result of a carefully planned industrial programme. In the early 1970s a major investment programme was planned, starting with the construction of the world's largest shipbuilding facility by Hyundai at Ulsan, designed in the UK, with a 380 metre dry dock capable of taking vessels up to 400,000 dwt. Later in the decade a second major facility was built by Daewoo, with a 530 metre dry dock capable of taking vessels up to 1 m.dwt. This started production in the early 1980s. Two other South Korean industrial groups, Samsung and Halla Engineering, built new shipbuilding facilities and by the mid-1990s South Korea had a 25% market share and four out of the world's five largest shipyards.[10] By 2005 South Korea had matched Japanese output in gross tons and overtaken Japan in cgt terms.

Perhaps the most interesting aspect of the South Korean shipbuilding development model is that from the outset it focused on the export market. This is clearly visible in Figure 15.2(e). Unlike Britain or Japan, which had, to different degrees, built up their shipbuilding capacity to service domestic customers, from the beginning Korea targeted the export market. Whilst South Korea has a rapidly growing economy, this remains very much smaller than the Japanese or European in terms of trade volume. The success of Korean shipbuilding almost certainly reflects the growing internationalization of the bulk shipping industry where, with the development of international registries and multinational companies, the link between ship, shipowner and national interest is increasingly tenuous. The industry was also much more focused, with a small number of very large yards focusing on large vessels for the international market. In 2005 Hyundai, Samsung and Daewoo were the world's three largest shipbuilders and accounted for two-thirds of South Korea's production.

The Chinese shipbuilding industry

In the shipbuilding market there is always a new entrant preparing to challenge the market leaders and in the 1990s China emerged as the next challenger. However China's approach was very different from that of South Korea. It has a long history of shipbuilding, stretching back to the fifteenth century and the construction of Admiral Zheng He's famous treasure ships, some of which were reportedly up to 540 feet long, with a capacity of 1,500 tons, though the size of these ships is controversial.[11] During the 1980s and early 1990s China had an active shipbuilding industry, with many domestic yards and a full infrastructure, including research institutes. Some ships were built for export, at very competitive prices, but the volume of business was limited and Chinese-built ships generally sold at a discount in the second-hand market.

The major expansion of China's shipbuilding capacity gathered speed in the late 1990s, as part of the Chinese industrial expansion. Initially the expansion came from existing shipbuilding facilities, with just one major new shipyard built, the Dalian New yard. However expansion of the existing Chinese shipyards allowed shipbuilding production to increase from 784,000 gt in 1995 to 5.7 million gt in 2005 and 11 million gt in 2007. At that stage over 90 established shipyards in China were building a wide range of vessel sizes and types and about 30 major new shipyards were under construction, or at an advanced stage of planning. Shipbuilding is in three areas spread around the Bohai Rim in the North, Shanghai, and with a few shipyards in the Pearl River in the South. It is widely anticipated in the shipbuilding market that the Chinese industry will take a leading share of the world market within the coming decade.

Other countries

Eastern Europe is a long established participant in the world shipbuilding market, with a development pattern closer to western Europe than Asia. In fact Table 15.1 shows that between 1980 and 2005 eastern Europe's production was steady at about 1.3 million gt per annum. Poland increased its output, but others such as Ukraine declined under pressure from rising wage rates and exchange rates. However, in 2008 a number of new shipbuilding countries were emerging in Asia, including Vietnam, the Philippines and India, whilst Russia and Pakistan are developing plans to enter the shipbuilding market.

Conclusions from a century of shipbuilding development

This short overview of the evolution of shipbuilding suggests that the business lends itself to a few dominant producers, with a succession of new challengers creating a highly competitive market environment which drives technical change. It also suggests that the market focus on domestic customers in the first half of the twentieth century gave way in the second half to the broader role of the export market which exists today. However, the individual regions dealt with this complex commercial environment in very different ways.

Britain built its supremacy early in the century on its large home market which allowed it to develop craft-based skills, but then failed to evolve technically, leaving the industry vulnerable to recessions and adverse currency movements. The European and Scandinavian yards were more effective in improving their production technology, but ultimately this could not overcome their high labour costs and aggressive competition from efficient Asian yards using the same techniques. Many European yards closed, but others developed successful niche markets and survived, leaving Europe with a substantial market share in the high value-added ships. Japanese yards were very successful in developing sophisticated production systems, but also drew commercial strength from their strong home market which acted as a base for winning export orders. As South Korean competition and Japanese labour costs increased, the Japanese yards adopted a very different defensive strategy from the Europeans, concentrating on mass-producing highly engineered bulk vessels, especially dry bulk carriers. Starting with low labour costs and large, efficient facilities, South Korea was the first to build its business primarily around the export market, with a product range focused on large vessels. China followed on with many more yards but much the same formula.

So there are many permutations, but the common theme is that newcomers combine low labour costs and decent capital investment with the capacity to work hard and move with the market. Whatever the technology, shipbuilding remains a business where someone has to get their hands dirty.

15.3 SHIPBUILDING MARKET CYCLES

From a commercial viewpoint, these changes in the regional structure were accompanied by long periods of intense competition as each new entrant, Continental Europe, Scandinavia, Japan and then South Korea, fought for market share. This harsh commercial climate was intensified by the cyclical nature of shipbuilding demand. Over the last century there have been 12 separate cycles which are charted in Figure 15.3 and summarized in Table 15.2. The left-hand half of Table 15.2 shows the peak of each cycle, the number of years to the next trough, and the percentage fall in world shipbuilding output at the trough, whilst the right-hand half shows the same information for each trough and upswing. The length of each cycle from peak to peak is shown in the last column.

The average cycle lasted 9.6 years from peak to peak, but the spread was very wide, ranging from 5 years to over 25 years. The average reduction in output from peak to trough was 52%, and the maximum peacetime reduction was 83% during the recession of the early 1930s. As with the shipping cycles we discussed in Chapter 4, these cycles were not just random fluctuations designed to make life difficult for the shipyards, but are part of the mechanism for adjusting shipbuilding capacity to the changing needs of world trade. During the period since 1886 there were four periods of change which drove this process.

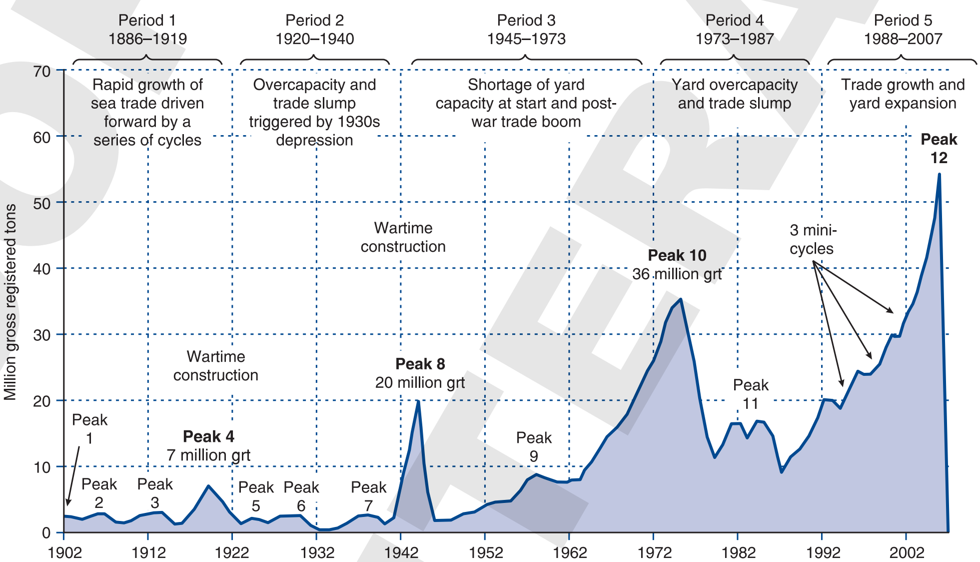

Figure 15.3
World shipbuilding launches, 1902–2007
Source: Lloyd's Register of Shipping

Table 15.2 Shipbuilding cycles, 1902–2007

Cycle no	Cyclical peak and downswing				Cyclical trough and upswing				Full cycle years
	Year	Peak '000 grt	Peak to next trough years	%	Year	Trough '000 grt	Trough to next peak years	%	
1	1901	2,617	3	–24%	1904	1,987	2	47%	5
2	1906	2,919	3	–45%	1909	1,602	4	108%	7
3	1913	3,332	2	–59%	1915	1,358	4	426%	6
4	1919	7,144	4	–77%	1923	1,643	1	37%	5
5	1924	2,247	2	–26%	1926	1,674	4	73%	6
6	1930	2,889	3	–83%	1933	489	5	520%	8
7	1938	3,033	2	–42%	1940	1,754	4	1057%	6
8	1944	20,300	3	–90%	1947	2,092	11	343%	14
9	1958	9,269	3	–14%	1961	7,940	14	352%	17
10	1975	35,897	4	–67%	1979	11,787	3	47%	7
11	1982	17,289	5	–43%	1987	9,770	20	534%	25
12	2007	61,900	Based on the orderbook output likely to double by 2010						
Analysis of cycles									
Average length			3.1	–52%			6.5	322%	9.6
Standard deviation			0.9	25%			5.9	313%	6.4

Source: Compiled by Martin Stopford from Lloyd's Register and other sources

The first period, which is only partly shown in Figure 15.3, lasted from 1886 to 1919 and was a period of 'cyclical growth', with output increasing with each peak, interspersed by periods of recession. As we saw in Chapter 1, this was a period of very rapid technical change as steel-hulled steamships of rapidly increasing size and efficiency replaced sail. The shipbuilding cycles seem to have followed the world trade cycles and the level of output responded sharply to each change in the market. During this period the cycles drove investment by drawing in a flood of new ships with the latest technology during the market peaks and then driving out the old and technically obsolete vessels during the lengthy troughs – a crude but effective way of adopting new technology, while deriving the maximum economic value from the existing stock of ships.

During the second period, from 1920 to 1940 the industry faced persistent market problems dominated by the 1931 depression. The period started with overcapacity because Europe had expanded its shipyards to replace wartime shipping losses and in 1919 the industry was capable of producing 7 million grt of ships a year, three times the underlying level of peacetime demand. In addition, the war had convinced some European governments that it was important to have a domestic maritime capability, and they devoted public funds to building up their industries. When combined with volatile trade, this capacity pressure contributed to two decades of almost continuous problems in the shipping market, with slumps interspersed by periods of moderate market improvement. Contemporary press statements illustrate the mood of the period. For example:

> In the early part of 1924 it was generally believed that depression in the shipbuilding industry had touched its lowest point. It could not be imagined that the

> signs of revival would be so short lived … the immediate outlook is now exceedingly grave.[12]
>
> The year 1926 was one of great depression in shipbuilding.[13]
>
> As far as shipbuilding is concerned 1930 has been a most trying time … only one berth in four occupied.[14]
>
> The year 1935 in the shipbuilding industry may be regarded as a year of marking time with only one-third of the greatly reduced capacity being utilised.[15]

In Britain, which dominated the shipbuilding market at that time, shipbuilding employment fell steadily from 300,000 in 1920 to 60,000 in 1931.[16] Unlike the pre-war period, this was not simply cyclical unemployment that was soon absorbed by the next boom; it was a steady downward trend. Broadly speaking, the 1920s were dominated by removing the surplus shipyard capacity. There was intense international competition, indicated by 'incidents' such as a Furness Withy order placed in Germany in 1926 at a price 24% below the lowest British price with marginal overhead recovery. Then in the 1930s the Great Depression undermined demand and resulted in an 83% fall in shipbuilding output between 1930 and 1933, the biggest of any of the 12 cycles shown in Table 15.2.

The third period, covering the period from 1945 to 1973, was one of exceptional growth. Although the industry started with output of 7 million grt (more than six times the pre-war level of demand – Figure 15.3), three-quarters was built under the US wartime construction programme, and at the end of the war the US effectively withdrew from the world shipbuilding market. Since war damage had reduced the output of the German and Japanese industries, there was an acute shortage of shipbuilding capacity. This persisted into the late 1950s and, for a few years it was a seller's market. It was not until 1958 that a major economic recession in the US, and over-ordering of tankers following the Suez closure in 1956, precipitated the first post-war shipbuilding depression, which lasted into the early 1960s. World shipbuilding output fell from a peak of 9 million grt in 1958 to a trough of 8 million grt in 1961 (Figure 15.3). By 1963, however, trade grew rapidly as Europe and Japan modernized their economies, bringing a steady upward trend in orders that resulted in an unprecedented expansion of shipbuilding capacity to 36 million grt in 1975 – in a single year the industry produced more shipping tonnage than was built in the whole period between the two wars.

The fourth period, which started after the 1973 oil crisis and continued until 1987, was grim for the shipyards. Trade growth was sluggish, volatile and unpredictable. The pace of technical obsolescence slowed, with few major advances in ship technology and a more stable size structure, especially in the tanker fleet. Shipyard overcapacity was increased by the entry of South Korea as a major shipbuilder. In these circumstances the shipbuilding industry swung sharply from rapid growth to deep recession.

At the start of this period in 1975, world shipbuilding output peaked at 36 m.grt, representing 50–100% overcapacity. After two decades of continuous growth, seaborne trade first stagnated and then abruptly declined, particularly in the oil sector, and the demand for new ships fell sharply from the pre-1975 level. This already difficult situation in the shipbuilding market was further aggravated by the entry of South Korea with a bid for a major share of the world market. As a result there was a three-way battle between Japan, Korea and western Europe for a share of the diminishing volume of orders.

During the late 1970s the restructuring of shipbuilding capacity started. Many shipyards were closed and output fell by 60% to 14 million grt in 1979. The time taken for this decline to occur reflects the large orderbook held by the world shipbuilding industry in 1974. A recovery in the world economy during the late 1970s brought renewed trade growth which, combined with the sizeable reduction in world shipbuilding capacity, was sufficient to produce a brief recovery in the world shipbuilding market. Laid-up tonnage fell to a minimal level, and during 1980–1 the world shipbuilding industry enjoyed a brief revival. However, following the brief market peak in 1980–1, demand again declined, fuelled by the collapse of world seaborne trade which fell from 3.8 bt in 1979 to 3.3 bt in 1983, a reduction of 13%. Severe downward pressure on shipbuilding prices and new ordering drove shipyard output in 1987 to a trough of 9.8 million gross tons, the lowest since 1962 and a decline of 73% from the 1975 peak. Employment in the world shipbuilding industry halved[17] and many of the marginal shipyards were closed. In 1986 new ships could be bought for prices not far above the cost of materials, and even the highly competitive South Korean shipyards announced major losses.

Following this appalling episode, the fifth period, from 1987 to 2007, saw an equally dramatic revival of world shipbuilding capacity as the expansion of Asia and China generated a recovery in trade, and this coincided with more capacity being needed to replace the ageing fleet built during the 1970s construction boom. By 1993 the volume of output had doubled to 20 million gt and by 2007 it had reached 62 million gt, five times the 1987 trough. In the process South Korea had consolidated its position as the leading shipbuilder, with China positioning itself in a bid for market leadership, opening the way for the next phase of competition.

Which leaves the question of how this fifth period will develop. Readers may know the answer to this, but in 2007 investors were still not sure. Some saw the cycle ending with a lengthy period of overcapacity, but others believed it was a new situation and still had a long way to go. Such uncertainty is the main reason why shipbuilding, like shipping, is a risky business. In a century of shipbuilding it is difficult to find many 'normal' years. The 12 cycles may have averaged 9.5 years in length, but they came in all shapes and sizes, driven by long-term swings in trade growth, combined with capacity imbalances caused by shipping market cycles. Add a constantly changing competitive structure and we can only conclude that shipbuilding is not a business for the faint hearted.

15.4 THE ECONOMIC PRINCIPLES

Causes of the shipbuilding cycle

It is easy to understand why the shipbuilding market is so volatile. The market mechanism uses the volatility to balance the supply and demand for ships, whilst at the same time drawing in new low-cost shipbuilders and driving out high-cost capacity. This mechanism is basically unstable, as can be illustrated with a simple example. If the merchant fleet is 1,000 m.dwt and sea trade grows by 5%, an extra 50 m.dwt of ships are needed. If, in addition, 20 m.dwt of ships are scrapped, the total shipbuilding demand is 70 m.dwt. But if sea trade does not grow, no extra ships are needed and shipbuilding demand falls to 20 m.dwt. So a 5% change in trade produces a 70% change in shipbuilding demand. Five per cent changes in seaborne trade are common, and sometimes much larger swings occur (see Figure 4.2).

This basic instability is reinforced by two other characteristics of the shipbuilding market. Because new ships are not delivered until several years after they are ordered, investors really have no way of knowing whether they will be needed or not, and, in the absence of believable forecasts, market sentiment often takes over. As a result, ordering often peaks at the top of a cycle, but by the time the ships are delivered the business cycle is already driving demand down and the flood of new ships increases the surplus and prolongs the downturn. This process is reinforced by the inflexibility of modern shipyard capacity. Because it is difficult for the shipyards to adjust output, they often drop their prices to encourage speculative 'counter-cyclical' orders and liquid investors often take advantage of the bargains. This combination of demand-side opportunism and supply-side inflexibility tends to slow the market adjustment process, leading to some very long shipbuilding cycles.

Shipbuilding cycles are, of course, close relatives of the shipping cycles discussed at length in Chapter 3, but with special features due to the industry's different economic structure. Volk, in a lengthy study of shipbuilding cycles, takes much the same view, concluding that: 'Shipbuilding is characterised by heavy fluctuations of demand over the short-term and by high inertia of supply. This fact leads to brief phases of prosperity and long phases of depression.'[18] In one sense, this is all there is to be said. Until the demand for ships becomes regular or shipyards find a way of adjusting their capacity when it is not needed, the shipbuilding industry must live with long cycles. From an economic perspective, however, this is just the beginning of our study. In the previous section we saw that over the course of the last century this simple mechanism has produced radically different commercial environments. Applied economists in shipping or shipbuilding who understand the underlying relationships can recognize the way a particular market is likely to develop. This is what we will focus on in the remainder of this chapter, starting with the general economic relationships and then going on to a discussion of the microeconomic aspects of shipyard production.

Shipbuilding prices

Shipbuilding cycles are controlled by the price mechanism, and this is where we must start. Shipbuilding is one of the world's most open and competitive markets. Shipowners invariably take several quotations before ordering a ship, and there are not the usual trade barriers in the form of distance, transport costs and tariffs to provide shipbuilders with a protected home market. Prices swing violently upwards or downwards depending upon the number of shipyards competing for a given volume of orders.

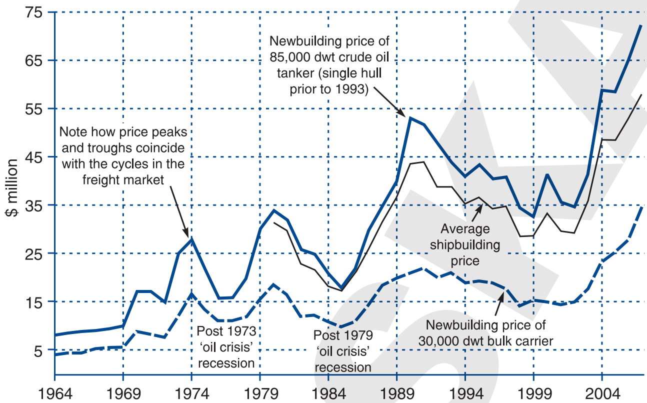

Figure 15.4
World shipbuilding prices, 1964–2007
Source: compiled from several sources including Fearnleys, CRSL

This point can be illustrated by following the development of the contract price for a 30,000 dwt bulk carrier and an 85,000 dwt tanker during the period 1964–2007 (Figure 15.4). Between 1969, when a 85,000 dwt tanker cost $10 million, and 2007, when it cost $72 million, we see price fluctuations on a scale which few capital goods industries can match. The price of the ship almost trebled to $28 million in 1974, fell to $16 million in 1976, increased to $40 million in 1981, fell to $20 million in 1985, increased to $43 million in 1990 and then edged down to $33 million in 1999, before more than doubling to $72 million in 2007. Faced with such volatile prices, it is hardly surprising that shipbuilders and their customers have difficulty in planning for the future. Because price movements for different types of ships are closely correlated – when the price of tankers goes up, so does the price of bulk carriers and ro-ros – there is no real refuge in finding market 'niches'. Most shipbuilders can compete for a wide range of ship types and, if their orderbook is short, will bid for ships they would not normally consider building.

These price fluctuations, and the large sums involved, make the shipbuilding market a tricky place to do business, and shipyards have to be very clever in their price strategy. In rising markets shipyards run the risk of filling their orderbook with ships contracted at low prices, only to find that by the time they deliver the ships, prices have doubled and costs have also increased. This happened to some shipyards in 2003 when they sold VLCCs for $70 million, only to find when they delivered them in 2006 that their value had escalated to $125 million and rising steel prices meant they had made a loss. Investors face the opposite problem – investors who ordered new tankers at the top of the cycle often found that by the time their tankers were delivered their value has slumped. But, of course, they can never be sure.

Shipbuilding demand, supply and the price model

In this highly competitive market, the price at which a new ship is sold depends on the trade-off between the demand for new ships (i.e. the orders placed in a year) and the available supply of newbuilding berths for that particular ship type. If there are more potential orders than berths, the price rises until some investors drop out, and if there are more berths than orders, prices fall until new buyers are tempted into the market.

So explaining price movements depends on understanding what determines the demand for building slots and the supply of berths.

Because shipbuilding is a capital goods industry selling to an international market, its price model is more complex than the freight rate model we discussed in Chapter 4. However, the experience of the last two decades tells us that, for a given price, shipbuilding demand is influenced by shipping freight rates, second-hand prices, market expectations and sentiment, and liquidity and credit availability, while shipbuilding supply is influenced by available shipbuilding berths, shipyard unit costs, exchange rates, and production subsidies.

The way *freight rates* influence the demand for new ships is easy to understand – as earnings increase, ships become more profitable and shipowners want to increase the size of their fleets. The longer high freight rates persist, the more cash they have to do this. Historically there has been a close relationship between peaks in the freight market and peaks in ordering new ships. However, the time-lag between ordering and delivery and the long service life of ships mean that current freight rates are only a partial influence on new prices. The second major influence is *second-hand prices*. Potential investors want ships immediately, so initially when freight rates rise they try to buy second-hand ships, bidding up prices. Only when second-hand prices increase do newbuildings start to look a better deal and the rise in second-hand prices works through into newbuilding prices (note also that at high freight rates old ships which would otherwise have been scrapped continue trading, maintaining the supply). Because the new ships do not arrive immediately, they are not a precise substitute, which means that how keen investors are to order new ships depends on *market expectations*, the third major influence on newbuilding demand. A convincing 'story' about why the future will be prosperous can be very important and explains bouts of heavy ordering when freight rates are low, as happened in the early 1980s, or for bulk carriers in 1999. Finally, the *availability of credit* allows owners to leverage up their internally generated revenue, and broadens the market to include many entrepreneurial shipowners without large sums of capital.

Turning to shipbuilding supply, there are also four influences to consider. Firstly there is available *shipyard capacity*. In the short term, supply depends on how many shipyards are operational, their forward orderbook and how many berths they are willing to sell at prevailing prices. In physical terms, production facilities place an upper limit on output, whilst productivity determines the number of ships built. But the available capacity at a point in time also has an economic dimension. Shipyard *unit costs* depend on labour costs, labour productivity, material costs, exchange rates, and subsidies (which determine whether the shipyard is able to sell at prices which result in an acceptable return on capital). It does not matter how many facilities a shipyard has, or how high its productivity is – if the price on offer does not cover its costs, it will not bid. So capacity is not an absolute, it is a function of price. *Exchange rates* are enormously important because they determine the cash the shipyard receives in local currency. A 5% weakening of the domestic currency is equivalent to a 5% increase in the dollar price. The exception is if the shipyard is prepared to make a loss, for example to avoid cutting the workforce. This is an expensive strategy, but may be the cheapest option if the yard wants to keep its skilled workforce intact until the market recovers. Finally, local or state governments may decide to offer *production subsidies* to support their shipyards through a difficult patch, artificially flattening the supply curve.

The whole process is dynamic. Across the market shipowners ponder possible future earnings and whether it is better to buy a prompt second-hand ship, order a new ship which will not arrive for several years, or sell a second-hand ship, or do nothing. Depending on all these factors, they make their bid and if market sentiment is strong many others will be thinking along the same lines. Since owners are competing for limited second-hand ships or newbuilding berths, prices start to rise and vice versa. The speed with which this can happen is illustrated by price movements during the dry bulk boom in 2007. In January a five-year-old Panamax bulk carrier cost \$37 million and a newbuilding for delivery in 2010 was \$40 million. But freight rates surged during the year and by December the price of the second-hand ship had almost doubled to \$72 million, whilst the new price had increased by 37% to \$55 million. Clearly the market had made a judgement that the value of a prompt second-hand ship had increased considerably more than the value of a ship which would not arrive for three years.

On the other side of the negotiation, the shipyards are anxiously weighing up how many berths to offer for sale. Again price is the focus. If their orderbook is very short they may be under pressure to sell berths immediately, which puts them in a weak negotiating position and they may have to drop their price to attract a buyer. But if they have a long orderbook they must decide whether to sell the berths now or wait in the hope that prices will rise. For example, if they are confident about the future they may decide not to offer any berths, in the hope that the price will rise. That means investors are competing for fewer berths, pushing up the price. For this reason expectations are just as important in determining the supply of berths for sale.

Finally, we can define the time-scale for adjusting supply. In the *short term*, either the shipyard berths are full and supply is inelastic or some shipyards have empty berths and are desperate to fill them, leading to price cutting. In the *medium term* (two or three years' time) the yards have berth spaces and the price depends on the level of demand relative to the available berths. If there is a shortage, raising prices brings in the high-cost yards, expanding supply. In the *long term*, shipbuilders which are profitable at current prices can expand their capacity and unprofitable builders can close uneconomic yards. These are the general factors involved in the shipbuilding price model and in the rest of this section we will look more rigorously at how it works.

The shipbuilding supply function

The first question is how many ships will be supplied or, in other words, how much capacity is available. The answer is provided by the *shipbuilding supply function*.[19] A typical short-term supply function (S1) is shown in Figure 15.5, which illustrates the relationship between the capacity available at a point in time, shown on the horizontal axis in million cgt of ships supplied, and the price. The bars show the capacity available in each of the shipbuilding areas, China, South Korea, Japan and Europe. They all have different cost levels. In China the average ship costs \$34 million, compared with

$36 million in South Korea, $38 million in the small Japanese yards, and $43 million in the big Japanese yards. The European yards have costs of $52 million, but they mainly build specialized ships so that is what bulk ships would cost if they switched capacity into the bulk market. Assuming yards only bid when they can at least break even, the available capacity increases from 5 million cgt at a price of $33 million for a standard ship to 22.5 million cgt at $52 million. The supply curve (S1) links these points. Note that when demand hits 25 million cgt and all the yards are bidding, there is an auction for any remaining berths that the yards have held back in the hope of such a situation arising. At this point the supply function is nearly vertical.

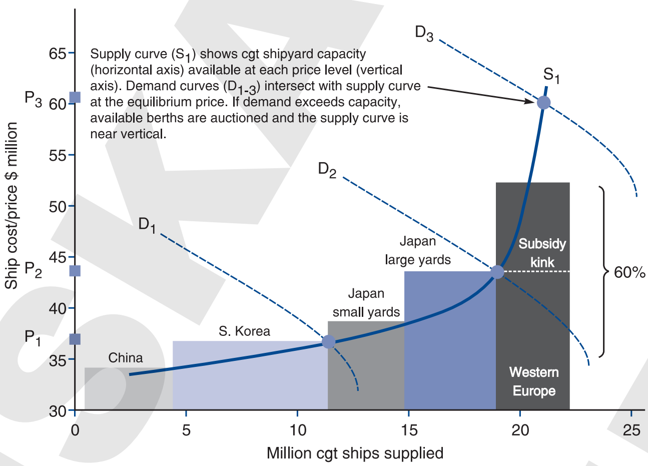

Figure 15.5
Short-run bulk shipbuilding demand and supply functions
Source: Martin Stopford 2007

The short-term shipbuilding demand function

The *shipbuilding demand function* shows how many ships investors will want to buy. Three examples of demand functions are shown in Figure 15.5, labelled D1, D2 and D3. For example, the demand curve D2 shows that if the ship price is $50 million investors will only order 14 million cgt, but if the price drops to $35 million orders will increase to 24 million cgt. This demand curve implies that price does have an effect on ordering activity, and economists analyse this degree of responsiveness by calculating the demand curve's *price elasticity* which is defined as the percentage change in demand divided by the percentage change in price:

$$e_{sbp} = \frac{\%\ \text{change orders}}{\%\ \text{change price}} \qquad (15.1)$$

If the price elasticity is greater than 1 demand is price elastic, and if it is less than 1 it is price inelastic. In this example demand is relatively price elastic, but it is very difficult to be sure because so much depends on expectations. If shipping investors have plenty of funds and positive expectations they may order the same amount of ships regardless of price, in which case the demand curve would be vertical. But the usual assumption is that as prices rise the financial case for investment weakens and only those investors with a very profitable market opportunitiy or an urgent need for new ships are willing to pay. Others prefer to take their chances and wait until prices fall, by perhaps extending the life of their existing ships, especially since rising prices are generally associated with a long delivery date. Conversely, as the price falls the financial case for new orders improves and the demand for new ships increases until, at some point, constraints on finance or market expectations limit the number of new orders placed and no further ships are ordered however low the price falls.

Shipbuilding market short-term equilibrium

Putting the supply and demand curves together, we have a sort of battlefield in which yards with different cost levels compete for business at the best price they can negotiate with their customers, the shipowners. There always seems to be a spectrum of yards with different cost levels and market cycles forming the backdrop to a running battle between low-cost new entrants and the established builders. Five hundred years ago it was the Dutch newcomers versus the Venetians. Later it was the Japanese newcomers versus the Europeans, then the South Koreans versus the Japanese. Over long periods shipbuilding cycles work like a pump, sucking the low-cost capacity in and pumping the high-cost capacity out. When demand is strong enough at D3 in Figure 15.5 even the high-cost yards can fill their berths and survive, limping from one peak to another. But they are vulnerable to recessions, and if demand falls to D2 the highest-cost yards will lose money and eventually give up, making way for the low-cost newcomers which enter the market because at D2 demand levels they can make a very decent profit.

As the low-cost yards make more profits they start to expand, moving the supply curve to the right and undermining the position of the high-cost yards even more. Meanwhile, the newcomers which entered the market during the boom when prices were at D2 have their own obstacles to overcome. Some will be small established yards moving into the international market place, and they will have to establish a reputation for quality and delivery that will carry them through recessions when orders are hard to get. Others will be 'greenfield' yards established to develop a country's industrial base. In the latter case the new shipyards carry high capital costs and may need to import specialized materials and marine equipment during the startup-up phase. Governmental financial aid is sometimes available to assist the development of upcoming yards. But all must find a way to compete. No wonder the shipbuilding market feels like a battlefield.

In the short run, equilibrium is achieved at the price where the demand for new ships equals the supply offered by shipbuilders. This is illustrated in Figure 15.6. At a price of $1,000 per cgt the 32 million cgt offered by the shipyards exactly matches the 32 million cgt the owners are willing to buy. If the shipyards try to increase prices to $1,500 per cgt, demand falls to only 20 million cgt, leaving shipyards with 10 million cgt of unutilized capacity. Conversely, at $750 per cgt the owners would want to order 37 million cgt, but the shipyards would offer only 30 million cgt of ships. There would be a shortage of berths and the price would be bid up. In this way the price mechanism matches existing capacity to demand on a day-to-day basis.

In the longer term, the shipyards respond to the market cycles by adjusting capacity. The low-cost shipyards which are profitable even in weak markets build new facilities, or expand existing ones, moving the supply curve to the right. For example, in Figure 15.7(a) we see an initial supply function (S1) with the equilibrium price of P1. At this price the low-cost shipyards make excess profits, but as they add new capacity, the supply curve moves to the right and at this increased level of output the equilibrium price falls from P1 to P2. As supply expands and prices fall, the high-cost yards start to make losses and eventually some of them will close or diversify – the market has replaced high-cost yards with low-cost yards, which is exactly what the market process is all about. Through this ratchet process capacity expands and the competitive yards gradually drive out the inefficient ones, making better use of economic resources.

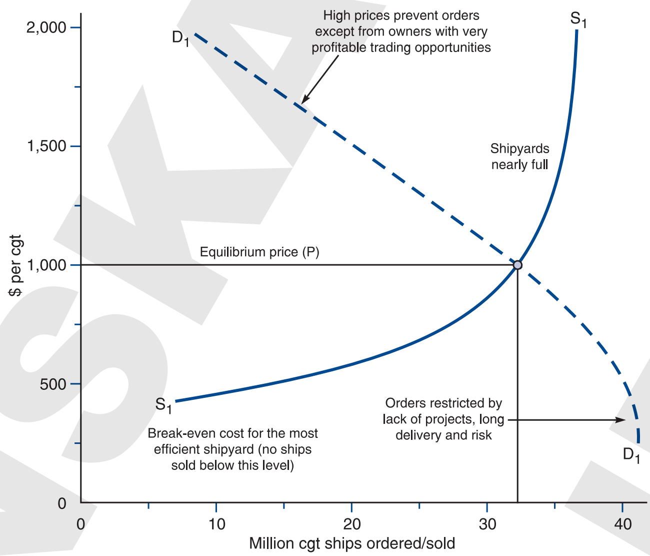

Figure 15.6
Shipbuilding supply and demand functions
Source: Martin Stopford 2007

But demand also plays a part in this market adjustment process. For example, the demand curve D1 in Figure 15.7(b) represents a situation where ship demand is growing at 3% per annum, requiring Q1 cgt of new ships (about 33 million CGT) at an equilibrium price of P1. But if total ship demand growth slips to a new trend of 2.8% per annum, only 30 million cgt of deliveries are needed each year and the demand curve

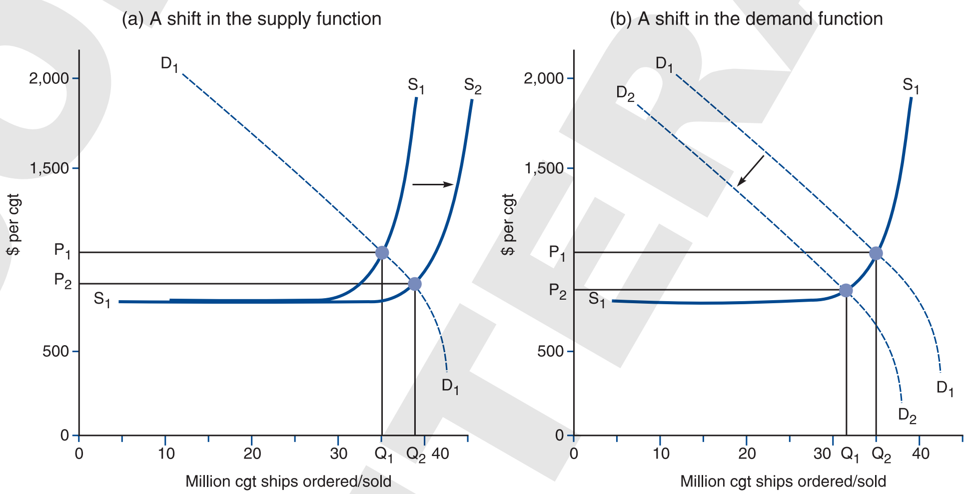

Figure 15.7
The effect on price of movements in shipbuilding supply and demand
Source: Martin Stopford 2007

moves left to D2. As a result the equilibrium price falls to P2. At this lower price the high-cost shipyards cannot cover their costs and eventually they close.

Putting the supply and demand dynamics shown in Figure 15.7 together, we have the basic model which drives the shipbuilding cycles we reviewed in Figure 15.3. During periods of expansion such as the long upswing from 1963 to 1977, or from 1988 to 2007, the demand curve is constantly moving to the right, with the shipyard capacity unable to keep up. As demand surges ahead so do prices, but when supply surges ahead, prices slump. The shape of the curves makes volatility normal.

The long-term shipbuilding demand

The volatility of shipbuilding demand means that planning ahead is a priority for the shipbuilding and the marine engineering industries, and that calls for long-term forecasts of demand for new ships. The long-term demand forecasting model splits shipbuilding demand into two parts: *expansion demand* (X) which is the tonnage of new ships needed to carry trade growth in a given period, and *replacement demand* (R), which is the tonnage of new ships required to replace ships scrapped or removed from the fleet in the same period. Both are important. For example, between 1963 and 2005 expansion demand accounted for 57% of demand for new merchant ships and replacement demand for 43%. Using this model, which is discussed further in Appendix A, shipbuilding demand forecasts are made by estimating future values of X and R.

This long-term shipbuilding demand forecasting model is given by

$$SBD_t = X_t + R_t \tag{15.2}$$

where

$$X_t = \frac{\partial DD_t}{P_t} = \frac{DD_t - DD_{t-1}}{P_t} \tag{15.3}$$

$$R_t \approx F_{t-\sigma} \tag{15.4}$$

Here, for forecast year t, SBD is the requirement for new ships (in deadweight or compensated gross tonnage terms, for example) X the expansion demand, R the replacement demand, DD is the tonnage of cargo transported, P is ship productivity (measured by dividing weight of cargo delivered by ship deadweight), F is the fleet of ships by year of delivery, and σ is the economic life of ship in years (e.g. 25 years).

Shipbuilders often use this basic model to forecast shipbuilding requirements for their own strategic planning and as a basis for international discussion of capacity levels. Expansion demand is estimated from trade growth and the incremental shipping capacity needed to carry it is calculated by applying the productivity factor P_t. So if trade is projected to grow by 70 million tonnes and the productivity is 7 tonnes per deadweight per annum, the expansion demand forecast for year t would be 10 million deadweight. Forecasting replacement demand involves two steps. First, the economic life of the fleet is determined and its age profile is used to estimate the tonnage of ships likely to be replaced in the forecast period. For example, if tankers have an expected economic life of 25 years and the fleet has 10 m.dwt of tankers 25 years old, the expected replacement demand would be 10 m.dwt. Put the two together as shown in equation (15.2) and the forecast shipbuilding demand in year *t* is 20 m.dwt.

Like so many aspects of shipping economics, the long-term shipbuilding model is simple in principle, but complex in practice. The model is illustrated in Table 15.3 which calculates shipbuilding demand from expansion demand and the replacement demand. We start in column 1 with a memo item, the actual growth of the world fleet between 1990 and 2006. The total at the bottom of this table shows that the fleet increased by 308 m.dwt during this period. This gives us a base in reality with which to compare our shipbuilding demand calculations. Next, in columns 2–4, we calculate the expansion demand. Column 2 shows total world trade, whilst column 3 estimates ship demand, by assuming the average ship carries 7 tonnes of cargo per deadweight per year. Analysts often employ complex commodity-based models to make this calculation, but we will keep it simple. Shipbuilding expansion demand is shown in column 4. It is quite volatile from year to year, but the trend

Table 15.3 Shipbuilding demand model, 1990–2006, showing expansion and replacement demand in million deadweight (except where otherwise stated)

	1	2	3	4	5	6	7	8	9
	memo:	Expansion demand			Replacement demand			Total	memo:
	Fleet (1st jan)	World trade (Mt)	Total ship demand	Expansion demand X_t	Ships scrapped	Other removals	Total replacement R_t	ship-building demand SDM_t	ship-building deliveries
1990	587.2	4,126	589	10.6	4.6	1.4	6.1	16.6	20.7
1991	603.2	4,313	616	26.7	3.8	4.5	8.2	34.9	20.6
1992	617.7	4,479	640	23.8	15.8	0.9	16.7	40.5	24.2
1993	626.2	4,623	660	20.6	16.8	1.2	18.0	38.5	27.5
1994	636.6	4,690	670	9.6	18.9	2.3	21.2	30.8	27.6
1995	639.4	5,083	726	56.1	15.5	1.2	16.7	72.9	33.0
1996	663.6	5,218	745	19.2	17.9	3.5	21.4	40.6	37.4
1997	679.7	5,506	787	41.2	15.7	4.0	19.7	60.9	36.5
1998	696.4	5,666	809	22.8	24.9	1.5	26.4	49.2	34.8
1999	704.5	5,860	837	27.7	30.4	1.1	31.5	59.2	39.8
2000	712.7	6,273	896	59.0	22.2	1.4	23.6	82.6	44.4
2001	733.8	6,167	881	-15.2	28.1	4.2	32.3	17.1	44.6
2002	746.4	6,276	897	15.6	28.2	2.6	30.8	46.4	48.4
2003	764.1	6,598	943	45.9	26.9	2.4	29.4	75.3	55.6
2004	787.6	6,893	985	42.3	9.8	3.8	13.6	55.9	61.8
2005	834.0	7,122	1,017	32.7	5.7	3.2	8.9	41.6	70.2
2006	895.4	7,407	1,058	40.7	6.5	2.7	9.2	49.9	75.3
Total increase	308.2			479.3	291.6	42.1	333.8	813.1	702.4

Notes

Col. 1	Clarkson fleet at year end from SRO	Col. 6	Other removals in year
Col. 2	World Trade UNCTAD	Col. 7	Sum col. 5 and col. 6
Col. 3	Ship demand based on 7 tons per dwt pa	Col. 8	col. 4 + col. 7
Col. 4	Increase in col. 3 since previous year	Col. 9	Memo: deliveries in year
Col. 5	Demolition in year		

moves from around 20 m.dwt in the early 1990s to around 40 m.dwt per annum in 2006. Then, in columns 5–7 we calculate the replacement demand. Since we are dealing with history, scrapping and removals are used as the indicator of replacement demand. However, forecasters would use a model based on the life expectancy of ships.

Total shipbuilding demand is shown in column 8, and this model can be used to project scenarios of future shipbuilding requirements by forecasting the components in columns 2–7 at whatever level of detail is appropriate (many of the considerations about the shipping supply and demand model discussed in Chapter 4 are relevant to such an analysis).

This analysis raises two problems with this sort of long-term forecasting. Firstly, we must be very careful to define where supply and demand were at the start of the forecasting period. Estimated expansion demand between 1990 and 2006 shown at the bottom of column 4 is 479.3 m.dwt, but during this period the fleet only grew by 308.2 m.dwt. The explanation is that in 1990 there was surplus shipping capacity, which during the decade was gradually removed. Such factors need to be taken into account, which is not easy. Secondly, scrapping is not a precise indicator of replacement demand, since it includes a market component. As the markets tightened towards the end of the period, scrapping fell, possibly creating a backlog of 'over-age' tonnage. For both reasons what happens in practice can differ from the theoretical shipbuilding demand calculation, and these dynamic issues need to be taken into account. Finally, actual shipbuilding deliveries in column 9 provide a 'reality check' to see how the estimated demand compares with actual deliveries. It looks as though deliveries were below demand for the first half of the period, but drawing ahead towards the end.

15.5 THE SHIPBUILDING PRODUCTION PROCESS

For a better understanding of the shipbuilding supply model, we must now turn to the production process. In 2006 there were over 250 major merchant shipyards world-wide. The number of docks/berths and the layout and equipment of the shipyard place an upper limit on the number of vessels which can be built over any given period. There is great diversity. Some yards are fully operational, while others are uncompetitive and underutilizing their facilities.

Categories of shipyard

Although modern shipyards are highly flexible in the type of ship they build, physical and commercial factors tend to subdivide the shipbuilding market into a number of sectors. The world's shipyards today fall broadly into three categories – small, medium and large.

Small shipyards specialize in vessels below about 10,000 dwt. These facilities generally have a workforce of below 1,000 employees, sometimes as few as 100–200. Some specialize in particular ship types, such as dredgers or offshore supply craft, but the product range is very wide, comprising small cargo ships, mini-bulkers, chemical tankers and a whole range of service craft such as tugs and dredgers. Consequently, most small shipyards tend to be very versatile in their product range. This sector is comparatively self-contained and it is unusual to find large shipyards competing for orders in the small ship market.

Medium-sized shipyards build vessels in the size range 10,000–40,000 dwt, although some may take vessels up to Panamax size. The constraint is usually the size of berth/dock and the facilities to process large quantities of steel. Typically, medium-sized shipyards have a workforce of about 500–1,500, though this varies greatly. In product terms the mainstay of these yards are container-ships, bulk carriers and small tankers. More sophisticated yards handle vessels such as short-sea ro-ros, ferries and gas tankers.

Finally, some very large shipyards have docks capable of accommodating tankers of up to 1 m.dwt and in a few cases a workforce of 10,000 or more, though some have fewer than 1,000. These facilities generally have highly automated equipment for steel preparation and assembly.

The ship and the shipyard

The merchant ship is the world's largest factory-produced product. A 30,000 dwt bulk carrier might typically contain 5,000 tons of steel and 2500 tons of other components, ranging from the main engine to many thousands of minor items of cabling, pipes, furniture and fittings – and, by modern standards, this is a small vessel. Over half of the cost of the ship is materials. Figure 15.8 shows a rough breakdown of the main items. Steel represents about 13% of the cost, the main engine 16% and other materials 25–35%. The remainder of the cost is direct labour and overheads. The material content is higher for high-outfit ships such as cruise liners and lower for simple cargo ships such as large bulk carriers. Because of their size and value, virtually all merchant ships are built to order and the construction period is a long one, falling anywhere in the range 12 months to 3 years, depending on the ship size and the length of orderbook held by the shipbuilder.

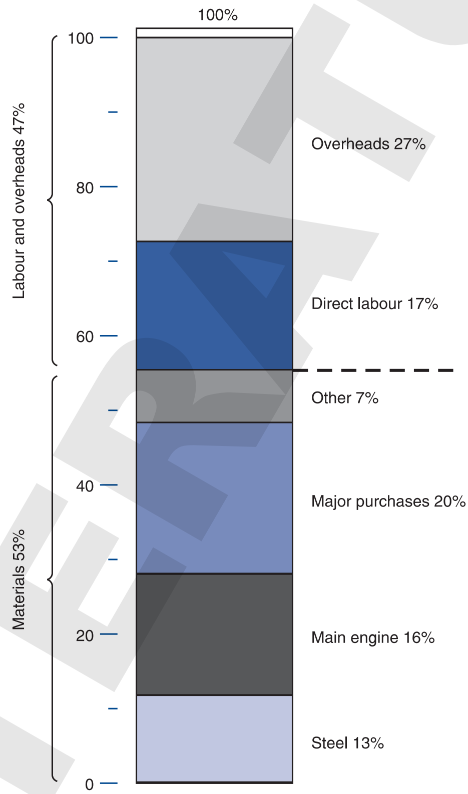

Figure 15.8
Cost structure of merchant ship
Source: Complied by Martin Stopford from various sources

The hull of a merchant ship is basically a box built from thin steel plate, reinforced by internal bulkheads and sections to give strength. Within the hull are various items of equipment required to propel and control the ship, handle cargo, accommodate the crew and monitor performance. The complexity in shipbuilding lies in minimizing the materials

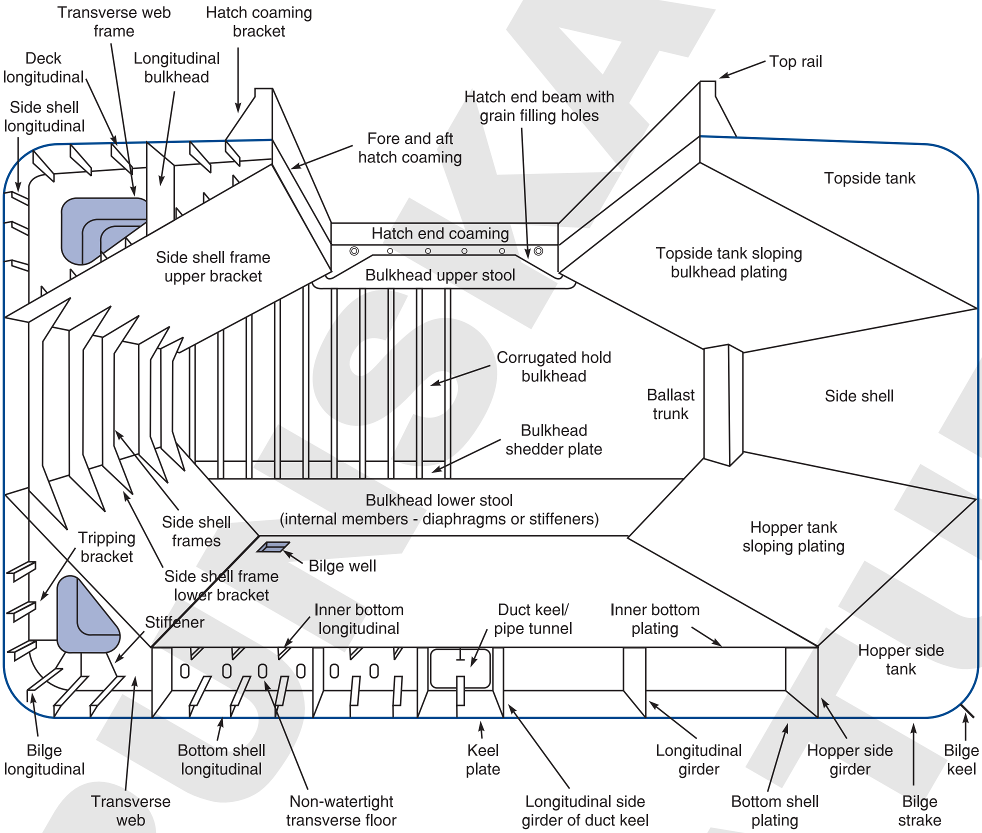

Figure 15.9
Cross-section of bulk carrier hull
Source: Lloyd's Register of Shipping

and labour required to construct a ship to the structural standards ('scantlings') laid down by the classification societies. The way naval architects resolve this problem depends on the ship. The bulk carrier hull shown in Figure 15.9 uses steel plate to construct the sides, double bottom, sloping plates, bulkheads and shaped components such as the transverse web. Sections are welded to the flat plate, for example as side or bottom shell longitudinals, to give rigidity. Although this structure looks simple, its structure is complex. The main deck is broken up by hatch openings and the hull derives its strength from the double bottom, the hopper tanks, the hatch coamings and the frames which run along the hull. Into the hull are fitted the many components, main engine, auxiliaries, pipe work, control systems, wiring and pumps. The entire structure must be coated with an efficient paint system, offering a long working life with minimum maintenance.

The shipbuilding production process

To build ships the shipyard must accomplish three main tasks – the design and planning of the ship, the construction of the steel hull, and the outfitting of the hull with machinery, equipment, services and furnishings. These operations are not necessarily sequential and there is much overlap. An example of a shipyard layout is shown in Figure 15.10, with arrows indicating how work flows from the delivery of materials to the steel stockyard through to the assembly of the ship in the dock. This shipyard layout illustrates the different stages unusually well, though not all shipyards are designed in such a logical way. It is common to find these facilities spread around the yard, with units moved from one location to another on low loaders. The ten manufacturing stages are itemized in Box 15.1 and the numbers in brackets following the stage titles refer to the location in the shipyard diagram in Figure 15.10 where that stage takes place.

The production process is essentially one of assembly, and few of the individual tasks require sophisticated technical skills, though some automation of cutting, welding and repetitive assembly is possible. The skill comes in planning and implementing the tens of thousands of operations that contribute to the production of a merchant ship – materials must be ordered and arrive on time; steel parts, fabrication and pipe work must fit accurately without the need for rework and must be delivered to the work

BOX 15.1 TEN STAGES IN THE SHIPBUILDING PRODUCTION PROCESS

The notes below are designed to be read in conjunction with the shipyard layout plan in Figure 15.10.

Stage 1: *Design and estimating (1)*

The design, cost estimates and vessel building strategy and production plans are produced by shipyard staff, initially in outline and then, if the ship is sold, gradually developed in greater detail to produce detailed working drawings and parts lists. Computer graphic equipment allows digital information developed during the design and estimating process to be used to plan and control the production of the vessel. Materials are ordered. Developing comprehensive and accurate information at an early stage in the design programme is one of the most crucial areas for improving productivity and product quality in modern shipbuilding.

Stage 2: *Materials reception (2, 15)*

Materials account for about 50–60% of the cost and labour and overheads for the remainder (see Figure 15.8), and a large merchant ship may involve several thousand separate purchase orders. A cost estimate must be prepared, often before the full design has been finalized, and materials, particularly long lead items such as the main engine, must be ordered. Items of equipment are delivered to the shipyard's material reception facility (2) where they are stored until needed. Pipes and other subcontracted components are delivered to the outfit storage area (15). The prompt delivery of materials is essential, as is quality control. Material supply problems can disrupt production programmes.

Stage 3: *The steel stockyard (3, 4)*

The steel is one of the first items to be ordered, and when it arrives it is stored in the steel stockyard. The two principal steel components used in ship manufacture are

BOX 15.1—cont'd

plates and rolled sections, which are used primarily to stiffen the plates. They are delivered to the yard by sea or road. The stockyard is laid out in an orderly manner and materials are retrieved using an overhead gantry crane.

Stage 4: *Surface preparation (5)*

Steel plates and sections are retrieved from the steel stockyard and processed through a surface preparation plant to ensure they meet the precise standards required for construction. This involves rolling plates and straightening sections to ensure that they are true, followed by shot blasting to remove rust and priming to protect the plate from further rusting and provide a foundation for paint. The edges of plate to be welded are chamfered ready for the welding machines.

Stage 5: *Plate and stiffener preparation (6)*

The primed steel plates are cut to the precise required size using numerically controlled profile burning machines. Any plates that do not need cutting are transferred to the flame planer to have their rough edges removed, and create the proper edge profile for welding. If required, they are bent to shape using a press or rolls. Framing members (e.g. as shown on the left-hand side of Figure 15.9) are prepared from steel sections, cut to size and then bent to shape using a frame-bending machine. By this process the many thousands of steel components for constructing the ship's hull are prepared, cut to size and numbered in accordance with the drawings. In practice, this is a flow process with a steady stream of components moving through the steel preparation bays.

Stage 6: *Assembly into blocks (7, 8, 9)*

The next stage is to build the steel components into the 'sub-assemblies' and 'blocks' weighing up to 800 tons from which the ship is constructed in the dry dock. The larger flat plates that make up most of the hull are transferred to the panel assembly line (7) where they are welded together, and framing members are welded in place to form 'straight hull blocks'. Shaped steel used to build curved hull blocks (e.g. bow and stern sections, double bottoms) requires different processes such as line heating which are carried out in the curved hull assembly shop (9). Smaller sub-assemblies are constructed in the sub-assembly shop (8). As each block is finished it is taken to the storage area (10) where it waits until the next stage of processing.

Stage 7: *Coating (11, 12)*

Once the blocks have been assembled all surfaces must be treated with anti-corrosion coatings under carefully controlled conditions, ideally in a properly designed paint cell. From a production viewpoint, this is particularly challenging because coatings are easily damaged and can become a production bottleneck. The blocks and sub-assemblies are taken to the block surface preparation unit (11) where surfaces are prepared and coatings applied under controlled conditions. Depending on the coatings used they will then be taken to the accelerated

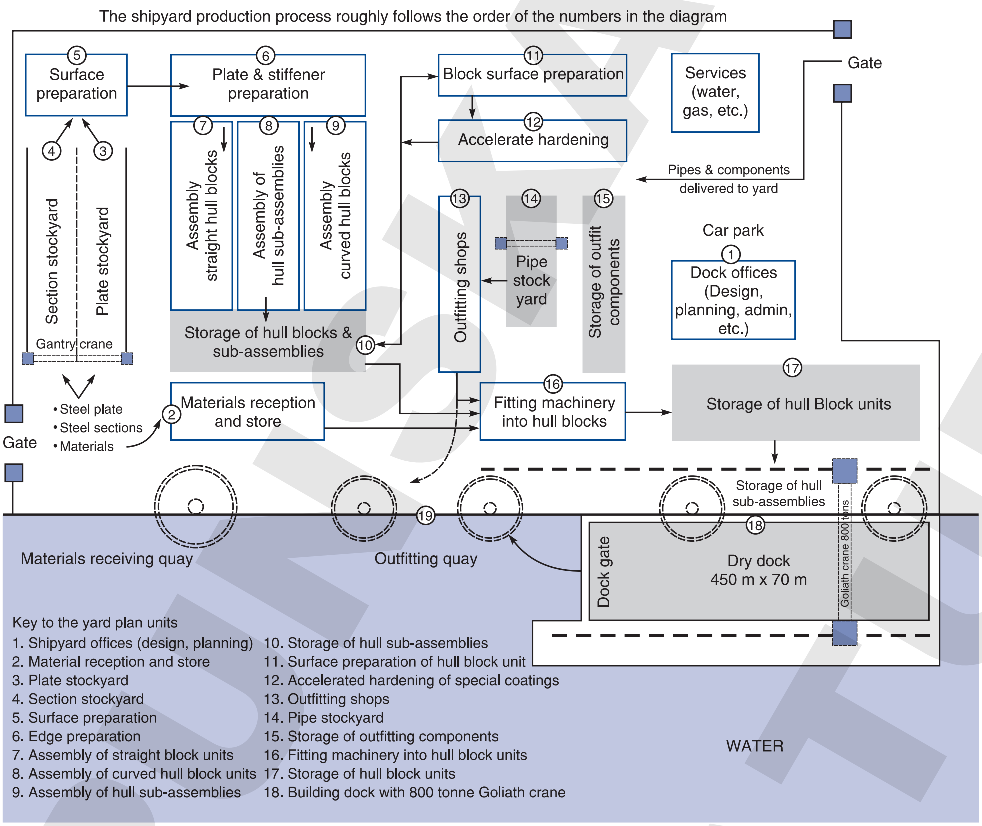

Figure 15.10
Shipyard layout plan
Source: loosely based on Odense Lindo shipyard, part of A.P. Møller

BOX 15.1—cont'd

hardening unit (12) to finish the process. When complete the blocks are taken back to the storage area (10) to await the next stage.

Stage 8: *Pre-outfitting (13, 16)*

The next step is to fit into the blocks and sub-assemblies as many as possible of the thousands of outfit items such as pipes, electrical cables, switchboards, furnishings and machinery. Most of this is done in the block outfitting hall (16). Blocks are brought there from the storage area and pipes and components from the pipe stockyard (14) and storage area (15) are fitted into them. This method allows better access and material scheduling control than is possible when working on the hull in the dock and is an important way of increasing shipyard productivity. Advance outfit requires sophisticated information management, accuracy control and tight organization. Plans must be made, and materials ordered and delivered to the work zone at precisely the right moment so that assembly can proceed smoothly. When materials

BOX 15.1—cont'd

arrive in the yard they must be precisely as specified and fit into the assembly without adjustment or rework. However, in the real world things inevitably go wrong and the greatest skill is the ability to adjust schedules when things do not go as planned. This sounds easy, but calls for great care in planning and accuracy control. After pre-outfitting the blocks are taken to the storage area (17).

Stage 9: *Assembly in the dock (18)*
Finally, prefabricated sections of the ship, together with those items of outfitting already installed, are lifted into the assembly dock and lowered in place, using the 800-tonne Goliath crane. They are carefully aligned, then welded into position. Outfit installations such as pipe runs are linked up.

Stage 10: *Outfit at outfit quay (19)*
When the hull is complete, the dock is flooded and the vessel is floated to the outfit quay where the outfitting of the ship is completed, systems are commissioned to ensure that on-board systems are operating correctly, and basin (or dock) trials of the main engines and auxiliary machinery are carried out.

station exactly when they are needed. Achieving this day after day is not as easy as it sounds, requiring considerable effort at the design and planning stage along with a production capability to manage material handling and production planning.

The major advances in shipbuilding techniques have been in planning and managing this process – for example, the introduction of pallets for material handling; the pre-outfitting and painting of assemblies before installation in the ship; and information systems to support these processes. The application of these techniques can yield dramatic results in terms of the man-hours required to build the ship.

15.6 SHIPBUILDING COSTS AND COMPETITIVENESS

In practice the level of efficiency and costs varies considerably from one yard to another. Although attention often focuses on the facilities as the main determinant of competitiveness, in reality there are many factors to consider. Broadly speaking, the price competitiveness of a shipyard depends on the key variables summarized in Figure 15.11 – material supply, facilities, availability of skilled labour, wage rates, labour productivity, cross exchange rates and, in some cases, subsidy all play a part in determining the cost and the revenue received by the shipbuilder.

Material costs

Materials account for 60% or more of costs. Countries with large numbers of shipyards such as Japan, South Korea and China can support a full range of material suppliers, including engine builders, equipment manufacturers, subcontractors and manu-facturers of specialist items such as stern frames. Long production runs give these suppliers a competitive advantage, as does the ability to deliver a wide range of components from stock. Equipment which requires high levels of research and development is often supplied by local manu-facturers operating under licence. For example, marine diesel engines are developed and marketed by B&W MAN and Wärtsilä which have a major market share, and production is undertaken locally to their specifications. Shipyards in areas with little ship-building activity have a more difficult time. Even if they can obtain supplies abroad, timing and delivery issues can make this a difficult strategy to implement.

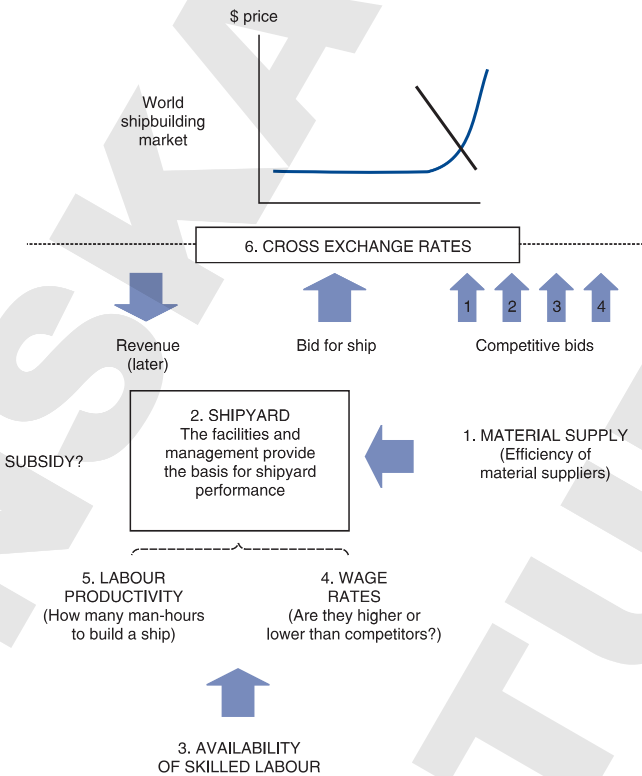

Figure 15.11
Influences of shipbuilding competitiveness
Source: Martin Stopford 2007

Shipbuilding productivity

There are enormous differences in the productivity of shipyards around the world. Facilities explain some of these differences, setting an upper limit on the size and volume of ships that can be built. However, the productivity of the shipyard is more important. Unlike a process industry where achieving maximum production merely involves switching on the machinery and feeding in the required volume of raw materials, building a merchant ship requires the managerial skills to organize and control the fabrication and assembly process. Ultimately the maximum throughput will depend not just upon the size of the facilities, but upon the efficiency with which they are used. Some shipyards take ten times as many man-hours as others to build the same ship.

This naturally raises the question of how productivity can be measured As a rule, labour productivity is measured in man-hours per unit of output. Unfortunately there are practical difficulties in applying this formula to measuring and comparing shipyard productivity on an international basis. There are four main problems:

- *Output measurements*. There is no standard unit of shipyard production, and this is even more problematic at an industry level where production consists of a variable mix of large ship types. Although there have been a few successful standard ship designs such as the SDI4, even where ships have an apparently similar specification, for example Panamax bulk carriers, there is considerable scope for varying the design, machinery and general quality of finish. The best measure currently available is compensated gross tons (cgt), but this has limited value when dealing with sophisticated or complex ships.
- *Differences in subcontracting*. Shipyards differ in the amount of work that is subcontracted and there are few consistent detailed statistics about the labour used. For example, a shipyard which subcontracts electrical and joinery work will spend fewer man-hours building the ship, but its material costs will increase. The accounting practice of most shipyards is to treat subcontract labour as 'outside goods and services' and to include it in material costs. As a result, a comparison of man-hour productivity between two ships will be distorted if such differences in subcontracting are not taken into account, and this is extremely difficult to do at an international level.
- *Delivery peaks and troughs*. Ship deliveries from a yard may not represent the underlying level of production owing to the size and mix of ships. It is possible for a shipyard to be productively employed all year but not actually deliver any ships because of the irregular distribution of delivery dates. For this reason, throughput needs to be calculated from several years' deliveries if an accurate figure is to be obtained.
- *Joint product manufacture*. There are practical difficulties in measuring employment engaged on merchant shipbuilding because many shipyards undertake other activities such as warship construction, offshore and ship repair.

For these reasons any calculation of shipbuilding productivity and cost competitiveness is unlikely to be very accurate. However, to illustrate the general method involved, Table 15.4 shows the calculation of average shipbuilding productivity for some of the major shipbuilding countries in 2005. The first column estimates employment on merchant shipbuilding, while the second shows the tonnage completed in each country. Finally, productivity measured in cgt/per man-year is calculated in column 3 by dividing completions by employment. The range of productivity is very wide. Japan is at the top of the list with productivity of 183 cgt per employee, followed by S. Korea at 145 cgt per employee and Denmark at 91 cgt per employee. At the bottom of the range is Poland with 42 cgt per employee. For the reasons mentioned above, the productivity figures should only be regarded as a rough guide to the differences between shipyards, but they do at least illustrate the diversity that exists within the industry.

Labour costs and competitiveness

Labour accounts for 40–50% of the cost of the ship, so wages have a major impact on competitiveness. The labour cost determines the total wage bill for producing the ship and depends upon the basic wage, to which must be added overtime payments and any bonuses paid to the workforce. In order to compare hourly wage costs it is necessary to convert them to a common currency; for present purposes, the US dollar has been used. There are significant differences in the wage rate in different countries, as can be seen in the right-hand half of Table 15.4. Applying the labour cost per man-year to the cgt productivity per man year gives an estimate of the labour cost per cgt, which is shown in column 5 of Table 15.4.

Shipyards facing competitive pressures due to rising wage rates, materials costs, or increasing price competition from other yards will, if they are to survive, have to reduce the man-hours required to build the ship. This can be done by improving facilities, systems and labour productivity. Automation is important, but improved organization, systems and product development may all play a part. For example, some Japanese shipyards tackled the challenge of rising labour costs by developing bulk carrier designs which were heavily engineered to assist the production process and thus reduce man-hours. In contrast, the Italian shipyards focused on the cruise market and mastering the skills needed to bring together the production of the hull with the very different task of outfitting the ship as a seagoing hotel and leisure centre. One way or

Table 15.4 Merchant shipbuilding productivity by country

	1	2	3	4	5
	PRODUCTIVITY			LABOUR COST	
	Numbers employed on merchant new work, 2005	Tonnage completed 2005	Productivity cgt per man-year	Hourly pay 2005	Labour cost $ per CGT
Country		('000 cgt)		US$[a]	
South Korea[b]	38,600	5,600	145.1	13.56	159
Poland	11,818	500	42.3	4.54	182
Japan[c]	14,605	2,668	182.7	21.76	202
Spain	2,222	200	90.0	17.78	336
Italy	8,689	500	57.5	21.05	622
Denmark	3,300	300	90.9	33.47	626
France	3,500	200	57.1	24.63	733
Germany	14,600	1,100	75.3	33.00	745
Netherlands	4,300	300	69.8	31.81	775
Finland	4,290	200	46.6	31.93	1,164
Total	65,153	11,568	177.6		

Source: CESA, KSA (all figures are approximate)

[a]Hourly pay is very sensitive to exchange rate of local currency against the US$

[b]Data for 2001 employment excludes 25,300 subcontractors source KSA

[c]Japanese data for 1998, Source KSA 'Proposal for the criteria of the derivation of productivity'

another these very different solutions increase the value added by the yard, but there is no simple formula for increasing productivity to offset high wage rates. Each shipyard must find its own solution.

Currency movements and competitiveness

Although currency movements seem far removed from the shipyard, they are the single most important factor in determining shipbuilding cost competitiveness. Since the world economy moved to floating exchange rates after the breakdown of the Bretton Woods system in 1971, shipbuilders have faced a major problem with exchange rates. Unit costs vary proportionately with the exchange rate, and given the volatility of exchange rates during the 1980s and 1990s this is clearly a very major factor in determining shipbuilding cost competitiveness.

An example illustrates the point. A shipyard was negotiating the sale of a small bulk carrier. The yard's cost was £10 million and the $/£ exchange rate was 1.40, so the best price they could offer was $14 million. Unfortunately the owner would not pay more than $10 million, so to win the order the shipyard needed to cut its price by 30%. Since bought-in materials accounted for 60% of the shipyard cost, that was not possible, but while the negotiation dragged on over a period of six months the exchange rate fell to 1.06. At this exchange rate the shipyard could offer a price of $10 million and the contract was signed. Although such large currency movements are uncommon, it demonstrates just how vulnerable shipyards are to exchange rate fluctuations.

As we pull all of these factors together we build up a picture of how the competitive structure of the world shipbuilding industry really operates. At one extreme there are shipyards with low productivity but wages so low that man-hours hardly matter. They can undercut all comers. At the other end there are the high-productivity yards with even higher wage costs, which are slowly going out of business. This happened to the Swedish shipyards in the early 1980s, despite the fact that they had the highest productivity in the world. Between lie a whole range of shipyards with different combinations of wage costs and productivity. Washing over the whole industry are the waves of exchange rate movements that can sweep shipyards up and down the competitiveness league table in a matter of months. All of this combines to make shipbuilding a tough business that requires great management skill. Despite all these problems, or perhaps because of them, shipbuilders are some of the most tenacious businessmen in the maritime industry.

15.7 THE SHIP RECYCLING INDUSTRY

Compared with shipbuilding, shipbreaking (sometimes referred to as 'demolition' or 'recycling') is a rough business. The ships are sold at a negotiated price per lightweight ton (see Section 5.7 for a discussion of the commercial process). Shipbreakers mainly rely on manual labour to dismantle ships in whatever facilities are available, often a suitable beach. Although it is possible to increase productivity by using mechanized shipbreaking methods, these are capital-intensive and the investment has not generally been thought economic, given the volatility and small margins in the shipbreaking business.

The process of non-mechanized shipbreaking falls into three stages. At the preparatory stage, the owner of the vessel should undertake various operations including stopping up all intake apertures; pumping out all bilge water; blocking off intakes and valves; and removing all non-metal objects together with potentially explosive materials. If the vessel is a tanker it must be cleared of potentially dangerous gases. This work is often subcontracted.

The next stage is to beach the ship and remove large metal structures such as masts, pipes, superstructure, deck equipment, main engine, ancillary equipment of machinery room, decks, platforms, transverse bulkheads, propeller shafts, propeller shaft bearings, upper hull sections, bow and stern end sections. The remainder of the ship is then hauled by winches or lifted on to dry land by means of slipways, ramps or dry docks and cut into large sections. In some of the less sophisticated shipbreaking operations the vessel is simply winched on to the beach. Although this process can be undertaken satisfactorily on a beach or alongside a quay, the availability of a dry dock is a considerable advantage in terms of efficiency, safety and control of spillages.

Pumps, auxiliary engines and other equipment are removed and sold. Finally, the panels and sections obtained from the ship are cut into smaller pieces as required, using manually operated propane cutters. The scrap is then assembled for transport to its ultimate destination.

The market for scrap products

Ships provide very high-quality steel scrap, especially tankers which have large flat panels. Sometimes the scrap is simply heated and rerolled into reinforcing rods for sale to the construction industry. Rerolled steel is also ideal for sewage projects, metal roads and agricultural needs. Smaller pieces are melted down. Much of the shipbreaking industry is located in the Far East and Indian subcontinent where there is a sizeable market for reprocessed steel products of this type. In the advanced countries of Europe, scrap is generally completely melted down to make fresh steel.

Although the scrap steel provides most of the value of the ship, the most lucrative return comes from the equipment and the 2% of non-ferrous items. Diesel engines, generators, deck cranes, compasses, clocks and furniture can also be resold. Again, the market for such equipment is stronger in Asian countries than in the developed countries, where technical standards are more demanding, the costs of refurbishing are higher and there is less demand for the second-hand equipment reclaimed from the ship.

Who scraps ships?

For these reasons most shipbreaking occurs in low-wage countries in Asia where shipbreakers have a local market for their product and cheap labour to dismantle the ships.

Table 15.5 Shipbreaking, by country, (1985–2005)

	1986		1991		1995		2005	
	GT	%	GT	%	GT	%	GT	%
Taiwan	7,773	38	48	2	–	0	0	
China	4,567	23	172	7	754	9	200	3%
South Korea	2,658	13	8	0	3	0	0	
Pakistan	861	4	445	19	1,670	20	0	
Japan	770	4	81	3	146	2	0	
India	636	3	695	29	2,809	33	1000	16%
Spain	581	3	13	1	40	0	0	
Turkey	418	2	77	3	207	2	0	
Italy	311	2	8	0	1	0	0	
Bangladesh	268	1	512	22	2,539	30	4600	75%
Others	1,444	7	306	13	354	4	300	5%
Total	20,287	100	2,365	100	8,523	100	6,100	100%

Source: Lloyd's Register of Shipping

This is a relatively mobile industry. Table 15.5 shows that during the recession in the mid-1980s when scrapping was very high, almost three-quarters of the shipbreaking industry was located in Taiwan, China and South Korea. Ten years later Taiwan and South Korea had left the industry. China's market share had fallen to 9% and India, Bangladesh and Pakistan had taken over as market leaders. By 2005, when the shipping industry was booming and demolition had fallen to 6.1 million gt, Bangladesh dominated the industry.

The explanation is that this very basic industry gravitates towards countries with low labour costs. Taiwan's development as a shipbreaker illustrates the point. The shipbreaking business got started with the dismantling of ships damaged during the Second World War and expanded rapidly after import controls were lifted in 1965. Encouraged by the government to meet rising domestic scrap demand and benefiting from a purpose-built site and from plentiful cheap labour, the industry established itself as the world's leading shipbreaker, with highly efficient facilities. Demolition took place in two state-owned sites at the deep-water port of Kaohsiung, using specially built berths and dockside cranes. The ships to be demolished were moored two abreast along the quayside and systematically dismantled, with a breaking cycle of 30–40 days. With each decade the working conditions improved.[20] As the economy grew and labour costs increased, shipbreaking became less attractive and in the early 1990s Taiwan closed the demolition yards and replaced them with a container terminal. South Korea was a more recent entrant to the Far East scrapping business, but the story is much the same. In the 1980s South Korea was the third biggest shipbreaker with a 13% market share, mainly carried out in two demolition yards owned by Hyundai. As wages rose in the late 1980s and the shipbuilding industry expanded, the demolition yards were closed.

The People's Republic of China entered the ship demolition market in the early 1980s and rapidly became the world's second largest buyer of ships for scrap. There was a considerable domestic demand for steel products and, in fact, the China Steel Corporation was already importing a considerable amount of scrap steel from Taiwan. Although China continued to operate demolition yards in the 1990s, the scale of the business was restricted by government regulations controlling currency for the purchase of ships and strict environmental regulations, and China's market share fell from 23% in 1986 to 9% in 1995 and 3% in 2005.

In 2005 the main ship demolition sites were located in Pakistan, India and Bangladesh (Table 15.5), though the level of activity varies with the volume of ships available to scrap. Pakistan's main site is at Gadani Beach, with up to 100 scrapping plots, each plot covering 2500 square yards. Gadani Beach has no electricity supply or water mains and only a few plots have electric generators. Ship demolition takes place at the most basic level. Ships are driven on to the beach where an army of workers dismantle them. During busy periods, up to 15,000 labourers are employed breaking up the ships with the aid of very little mechanization. Much of the scrap material is moved manually, with the assistance of king-post trucks, blocks and pulleys, but the more profitable plots have now moved into mechanization and are using fork-lift trucks and mobile hydraulic cranes. Alang in India's Gujerat State was opened in 1983 and has 170 ship breakers along the 10 km of coastline on the west coast of the Gulf of Cambay. Strong tides and gently sloping beaches allow ships to be beached under their own motors or by tugs. The workers have access to them at low tide. There were 50,000 workers on this site in the 1990s but by 2006 that had shrunk to between 5,000 and 10,000. The Bangladeshi ship recycling yards are located near the port of Chittagong, and are the nation's main source of steel. Rerolling mills in Chittagong and Dhaka produce over 1 million tons of reinforcing rods for the construction industry.

Little shipbreaking is carried out in western Europe, owing to high labour costs and the lack of a ready market for recycled material. There are also various difficulties associated with health and safety legislation and environmental protection, both of which are more prominent than in the countries scrapping ships in Asia. The only European country of any significance in breaking activity in the recent past is Turkey. There are, however, a number of small shipbreaking companies scattered around the UK and continental Europe, mainly with 10–100 employees, specializing in breaking warships, fishing vessels and other high-value vessels.

Several features of the shipbreaking industry have recently raised concerns over the release of polluting materials such as heavy fuel oil and the effect of hazardous substances such as asbestos on workers. The IMO is currently developing a convention providing global ship recycling regulations for international shipping.

The regulation of shipbreaking

Much of the ship dismantling nowadays takes place on tidal beaches and under primitive conditions and this presents society and policy-makers with a dilemma. On the positive side, the industry provides thousands of jobs for migrant workers and recycles valuable materials, including steel, other scrap metal and equipment which can be refurbished. However, the conditions in which this is done mean that workers employed in the industry face high accident rates and health risks from the dismantling of ships containing many hazardous materials, including asbestos, polychlorinated biphenyls, tributyl, tin and large quantities of oils and oil sludge. Protection for the environment is also a problem, with the pollution of coastal areas.

Work is ongoing, involving inter-agency cooperation between the ILO, IMO and the Secretariat of the Basel Convention, to establish mandatory requirements at a global level to ensure an efficient and effective solution to the problem of ship recycling. The IMO has adopted Guidelines on Ship Recycling and a new IMO Convention on ship recycling will include regulations for the design, construction, operation and preparation of ships so as to facilitate safe and environmentally sound recycling, without compromising the safety and operational efficiency of ships; the operation of ship recycling facilities in a safe and environmentally sound manner; and the establishment of an appropriate enforcement mechanism for ship recycling.

15.8 SUMMARY

In this chapter we have discussed the international shipbuilding and scrapping industries. Although shipbuilders face the same market volatility as their customers, the shipowners, it is a very different business with large fixed overheads and many employees.

Our review of the regional structure of world shipbuilding showed a clear regional pattern. During the first half of the twentieth century the industry was dominated by Europe, then in the second half the focus moved to Asia, with Japan leading the way, followed by South Korea which took over the dominant position at the beginning of the twenty-first century, by which time China was making a bid for market leadership, with a number of smaller Asian countries also entering the market.

This process of regional change was driven by a succession of shipbuilding market cycles, first generating growth which allowed new entrants to win market share, and then recessions during which the less efficient shipyards were forced out of the business. There were 12 of these cycles during the period 1901–2007, with an average length of 9.5 years. The cycles are driven by the interaction of supply and demand and coordinated by price movements. The shipbuilding supply function reflects differences in international cost competitiveness and typically has a J shape, whilst the demand curve is more difficult to define but is generally thought to be relatively inelastic. Movements in the demand curve result in changes in ship prices, which in turn move the supply curve to the left (reducing supply when prices are low) or the right (increasing supply when prices are high).

Shipbuilding production is an assembly process involving 10 steps. However, the competitiveness of the shipyard does not just depend on how efficiently it assembles the ship. Wage rates, the cost and availability of good-quality materials, and, most importantly, the exchange rate all play a part. Labour costs and productivity vary enormously from one country to another.

Finally, we discussed the shipbreaking industry, a very different industry from shipbuilding. Although ideally demolition takes place in a dry dock, gently sloping sandy beaches are often used. The industry at the beginning of the twenty-first century was mainly located in areas with plentiful cheap labour and a market for the steel and equipment recovered from the ship. India, Pakistan and currently Bangladesh undertake most of the ship demolition. Regulation governing health and safety in the recycling yards and the construction of ships from recyclable materials is increasing.

In conclusion, shipbuilding and demolition are fascinating industries, in some ways very close to shipping, and in others very different. Their global location is constantly shifting and this, combined with fixed capacity and a volatile market, makes it a tough business. But the shipbuilders, who are tough people themselves, do not seem to mind that, and as long as there is seaborne trade and salt water, they will remain a distinctive and essential part of the maritime business.