Understanding Commercial Shipbuilding

A market perspective

Dr Paul Stott

Strategic Maritime

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ABOUT THIS BOOK

Commercial shipbuilding is a much-misunderstood industry, and that lack of understanding makes strategy difficult.

Significant volatility and the length of the cycle (around 30 years) are troublesome. Each time the cycle has repeated it has tended to be viewed as the first time and major swings in price and demand have generally come as a shock. A second issue is that **the** shipbuilding market does not exist – it is a set of inter-related sectors. A strategy must be predicated on as close a definition of the relevant sectors as can be achieved. There is no single strategy for all shipyards, and the appropriate strategies will change over time – as will investment and governmental priorities for support.

Understanding Commercial Shipbuilding has been written at a time of great change in trade, global economics and geopolitics. It should be anticipated that shipbuilding will also change. Only by understanding the past and the underlying market mechanisms can we hope to try to understand what might happen in the future.

This book takes the long view and elucidates principles on which the markets and the industry work, including sections on: demand, supply, price and competitiveness.

Understanding Commercial Shipbuilding is published free of charge. The motivation for this is to move the sector forwards in terms of understanding. Strategic Maritime (strategicmaritime.co.uk) has been created to provide free resources to promote the understanding of shipbuilding and its teaching at University level: a subject that is increasingly scarce in engineering curricula.

PREFACE AND ABOUT THE AUTHOR

Paul Stott has retired after 50 years working in ships and shipyards. His career started at sea as a Cadet, followed by a degree in Naval Architecture and Shipbuidling at Newcastle University in the United Kingdom, graduating in 1984. On graduation he joined British Shipbuilders, initially researching problems of accuracy control and distortion and subsequently as a project manager. From 1988 to 2010 he worked as a shipyard consultant specialising in market research and strategic planning, working for clients in over 40 countries. Employers in this work included the British shipyard consultancies A&P Appledore and First Marine International, as well as periods of self-employment. In 2010 he became Senior Lecturer in shipping market analysis and ship production at Newcastle University, and obtained a PhD in 2017, the results of which, inter alia, form the basis of his book.

The motivation to join academia stemmed in part from Dr Stott's work as Technical Expert supporting the European Commission in a World Trade Organization Dispute[1]. The EC won on some limited aspects of the dispute but essentially lost the argument by failure, in the opinion of the panel, to demonstrate an actionable subsidy. Part of the reason for this deemed failure was an inability to define precisely what the shipbuilding market is and, in particular, to demonstrate cross-price elasticity: tankers and container ships, for example, are clearly not like products in the context of shipping – how is it that they are alike in shipbuilding? This book aims to provide that definition. Rather than doing this with a view to future disputes in WTO, however, the work is published in the hope that it may be of use in improving market research in shipbuilding, in particular for forecasting, market monitoring and strategic planning. It is also hoped that this may be useful as a reference text for the teaching of commercial shipbuilding.

For further details on the technical aspects of the work, readers are referred to Dr Stott's PhD thesis[2], which is available from Newcastle University or from the author: paul@strategicmaritime.co.uk..

1. World Trade Organization (2005) 'KOREA – MEASURES AFFECTING TRADE IN COMMERCIAL VESSELS: Report of the panel' World Trade Organization WT/DS273. 7 March 2005. Geneva.

2. Stott, P., 2017 'Competition and subsidy in commercial shipbuilding'. PhD thesis. Newcastle University.

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- Dr Ian Buxton, who inspired me with shipping when I was a student and who has freely given access to his encyclopaedic knowledge of the industry and to his excellent Marine Technology Special Collection at Newcastle University.
- Professor Richard Birmingham, formerly leader of the Marine Science and Technology Research Group at Newcastle University, for employing me as an academic and giving me the opportunity to undertake a PhD alongside my lecturing commitments.
- Andrew Mayfield, my boss in A&P Appledore International when I started consulting, who showed me that market research could be even more interesting than technical consulting.

Dedicated to my wife Jane and daughter Florence – who has no interest in ships whatsoever.

NOTES ON DATA AND SOURCES

A wide range of data sources have been used in developing the analysis presented herein. The bibliography relating to my PhD may be helpful to those seeking to extend the research and can be found at https://strategicmaritime.co.uk.

Information and analysis are credited to the author, unless otherwise specified in the figure title. Acknowledgement is due to:

- Clarkson Research Services Limited, for permission to present some of the more recent time series – specific references are given in the text.
- The Marine Technology Special Collection at Newcastle University and Dr Ian Buxton, the founder of that collection, for guided access to important sources. The collection has been instrumental in obtaining long time series and sourcing important historical documents.

PART I
INTRODUCTION

1.

OVERVIEW

The shipyard industries in total represent a complex set of business sectors that vary by size and type of ship and by the focus of operation of the shipyard: newbuilding, repair or recycling[1]. This book concentrates on the first of these sectors, newbuilding, and within that on the commercial side of that business, or, in other words, non-military. This distinction is necessary because a market-based approach is used to define the industry and the military and commercial markets are distinct: the two sectors no longer tend to share capacity. The separation of commercial and warship building has not always been the case and until the 1980s the two were routinely built in the same shipyards. The mixing of commercial and military work in the modern era is problematic for many reasons.

A market is a mechanism that matches supply with demand leading to the formation of price. Using this definition the subjects are considered in the following chapters are:

- Part 2: Demand
- Part 3: Supply
- Part 4: Price
- Part 5: Competitiveness

Before addressing these subjects, however, it is necessary to define precisely what a shipyard is. Whilst this may seem obvious, misunderstanding of this is a cause of confusion, particularly for those trying to wrestle with the administration of what is often a troublesome industry.

1. Offshore fabrication could conceivably be added to this list but is excluded because the market context is not coherent with the subject of this book.

2.

WHAT IS A SHIPYARD?

Those without firsthand experience may conceive that a shipyard is a single ubiquitous entity that can operate in any capacity to build, repair or recycle a ship, limited only by its size. Technically, it is often the case that a shipyard **could** operate in any sector but to understand why this is rare we need to consider what a shipyard is for – again a statement that may appear unnecessary, but which lies at the core of competitiveness.

A shipyard is normally an industrial business. One of the fundamental features that differentiates it from other industrial businesses, such as an automobile manufacturer, is that the shipyard requires a means of getting often very large objects into or out of the water and this feature defines them as shipyards. Mostly this requires that the shipyard is located next to water and has a launching/retrieval method[1]. Beyond this, fundamentally, shipyards exist for the same reason as any other industrial business: to make a profit and to provide a return on investment. They do this by building, repairing or recycling ships, which, to make a profit, they have to do in a focused way. Just because a shipbuilding yard could repair a ship, it does not mean that it can do so because, beyond the obvious fact that both types of shipyard focus on ships, the two businesses are operationally and economically very different. In the context of the goal of making money the two sectors are rarely compatible within the same investment.

For some reason it is much easier to see this distinction using an analogy from the automobile sector. It is intuitively easy to see that a car owner would not return to the manufacturing plant to have the tyres changed. Consider that the Nissan plant at Sunderland, UK, in 2024 produced 325,000 vehicles with revenue of £7.35 billion (around US$10 billion). A servicing contract of a few hundred pounds, which would make no contribution to the capital investment, makes absolutely no sense in the context of this business. Nissan's manufacturing plant in Sunderland technically could replace the tyres on a car, but it makes no business sense at all to even consider doing this.

Similarly, it is intuitively easy to see that a prospective purchaser of a new car would not visit an auto-repair shop and ask the proprietor to build them a new vehicle. Technically, the repair shop probably could build a new vehicle, using spare parts purchased from the manufacturer, but for many reasons it is unlikely to do so. Just because the repair shop could do this, it does not mean that it makes any sort of business sense that they would do it. As well as the likely time and cost of the one-off vehicle based on spare parts, issues of buyer's risk, warranty and finance would just not work in this scenario.

It would also seem nonsensical to group together the manufacturer of armoured vehicles, such as tanks, with the manufacturer of family saloon cars. At the highest level they both produce motor vehicles and

1. Small yachts or other small craft are an exception and may not even require to be built next to the water.

are therefore alike. In most technical and business senses, however, they are fundamentally not alike at all and cannot be considered together. For some reason we find it difficult to apply the same distinction to the builders of warships and the builders of tugs. The two are fundamentally not alike, even though we can designate both as shipbuilding yards.

So, what are the distinctions between the different types of shipyard business: newbuild, repair and recycle? [2] Appendix 1 describes some of the significant features of investment that mean that, whilst a newbuilding yard could technically repair a ship and a repair yard could technically build a ship, the two operations rarely happen together. There are significant differences in steelwork capacity, skills balance, the type and capacity of cranes, the type and layout of workshops and the form of docks. There are additionally significant commercial differences, not least in terms of revenue. A shiprepair yard may measure its revenue in tens of millions whilst for a newbuilding yard it may be hundreds of millions. Marketing and commercial management are additionally very different for the two businesses. Whilst repairing in a newbuild yard or building in a repair yard are technically possible, these scenarios would carry significant inefficiencies and do not normally represent business propositions. I say 'not normally' because, whilst these statements are generally true, you can never say never and combined yards do exist. Additionally, a large shiprepair yard may well, for example, build its own tugs and barges.

For the contrast of ship recycling with repair or newbuild a slightly different approach is needed to explain the incompatibility. The business of ship recycling involves the purchase of a ship at the end of its economic life, which is then broken up and the businesses' revenue comes from the re-sale of the recycled products, the largest value being in steel and other metals. The gross margin available in doing this is small and, because of this, investment in facilities for undertaking the work is difficult to justify. This is one reason why so much recycling happens on the gently shelving beaches of the Indian Subcontinent where a section of beach is rented for the duration of the recycling: no capital investment is required to get the ship sufficiently out of the water to be dis-assembled. Traditionally the recycler would remove a generator and winch from the ship first to install at the head of the beach to haul the products up the beach and this would constitute the investment. This has largely improved to the point that mobile cranes may be used to help. These are often depreciated and may be rented, to minimise any investment needed. A shiprepair yard, of course, could dis-assemble a ship in a better way and in a more controlled environment, but could not make money in the context of competition that use beaches, zero investment and unskilled low-cost labour.

It is also significant that shipbreaking takes place close to the markets for the products of recycling, which as well as the metals, include machinery, lifeboats, furniture, sanitary ware, and so on, which tends to get re-used only in less wealthy societies.

The issue of recycling for builders and repairers, therefore, is that the work would make virtually zero contribution to return on investment or utilisation of human capital, and the value of the work is low compared to building or repairing ships. This may change in future only in the case that the economic con-

2. In considering this it should be kept in mind that routine shiprepair is not about fixing broken ships: repair is a misnomer. The work of a commercial shiprepairer is predominantly about routine service of machinery and equipment and re-painting – effectively the ship equivalent of an auto-repair shop.

ditions relating to the ship recycling change. For example, if regulations change to require recycling to be undertaken in the controlled environment of a drydock. But note, in this case the business model for recycling would no longer work. It is likely that the recycler undertaking the work in a more controlled manner would have to charge for their services, rather than paying for the ship.

In summary, a shipyard should be regarded as an economic unit that exists to be a commercial venture, and it is the commercial activity that drives the investment and the utilisation of that investment. The distinctions between shipyards does not stop there, however. Within each sector there are demarcations that lead to specialisation, which is required for competitiveness. In the chapter below on supply, we will learn that the era where a shipbuilder could build any type of ship required by a customer, from a submarine to a cruise ship, are long gone. Extreme examples help to clarify this: it is self-evident that a 3m plastic sailing yacht will not be built in the same newbuilding facility as a 320,000 dwt steel oil tanker. Similarly, a nuclear submarine will not be built in the same newbuilding facility as a harbour tug. The demarcations between newbuilding yards result from differences in customer type (particularly military and commercial), hull material (Steel/Aluminium/Composite/Wood), volume of business, commonality between orders, vessel size and vessel characteristics.

At the highest level, specialisation broadly divides the newbuilding industry into military and commercial. In military it then splits into surface ship or submarine and then by nuclear/non-nuclear and further splits may be predicated on ship size. In the commercial sector the industry broadly demarcates by size, and by ship type. Figure 1 presents a possible taxonomy for the newbuilding sector, specifying around 12 specific newbuilding shipyard types, which are not easily interchangeable.

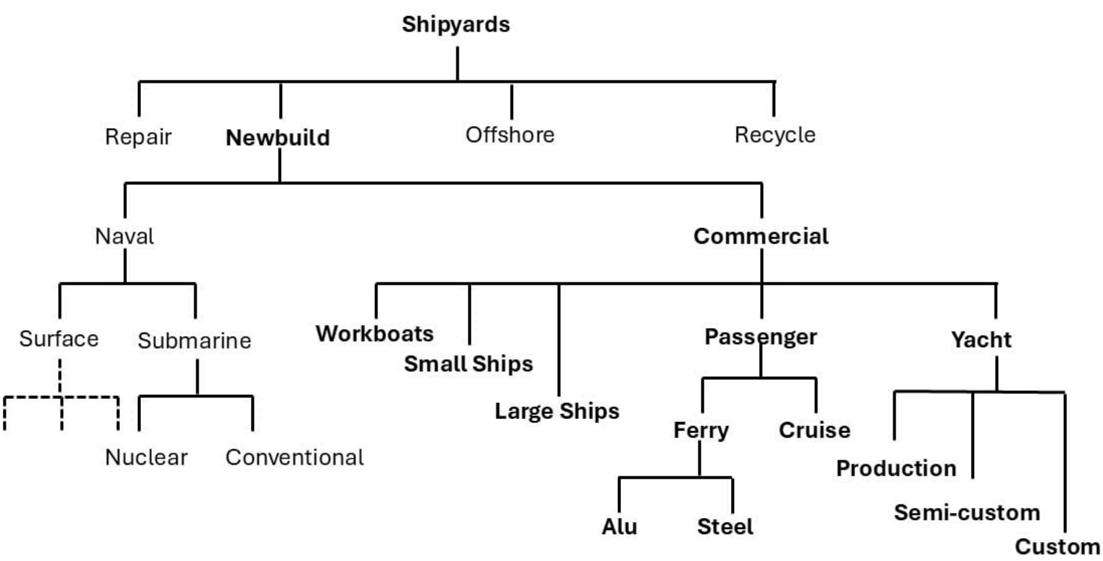

Figure 1: A possible taxonomy for shipbuilding markets and yard types

The elements of this taxonomy, because they define discrete sectors within which specific shipyards will compete for orders, define discrete market sectors. A shipyard competing for nuclear submarine orders will not be competing for aluminium ferries and is therefore not involved in price formation for aluminium ferries and vice versa. They do not, therefore, operate in the same markets. This is discussed further in the section on price. It follows from this that the ‘shipbuilding market’ cannot be a single entity. It is comprised of a set of (more or less) discrete sectors, as outlined in Figure 1.

PART II
DEMAND

3.

THE CHARACTERISTIC OF COMMERCIAL NEWBUILDING DEMAND

Commercial newbuilding yards exist to create new ships, which become part of the commercial shipping economic system, transporting cargo or passengers or providing a maritime service. The aggregate demand for these ships when viewed over the long term shows some very odd characteristics. Long term production is shown in Figure 2, which tracks total output in Gross Tons of ships delivered over roughly 130 years from 1892 to 2023[1].

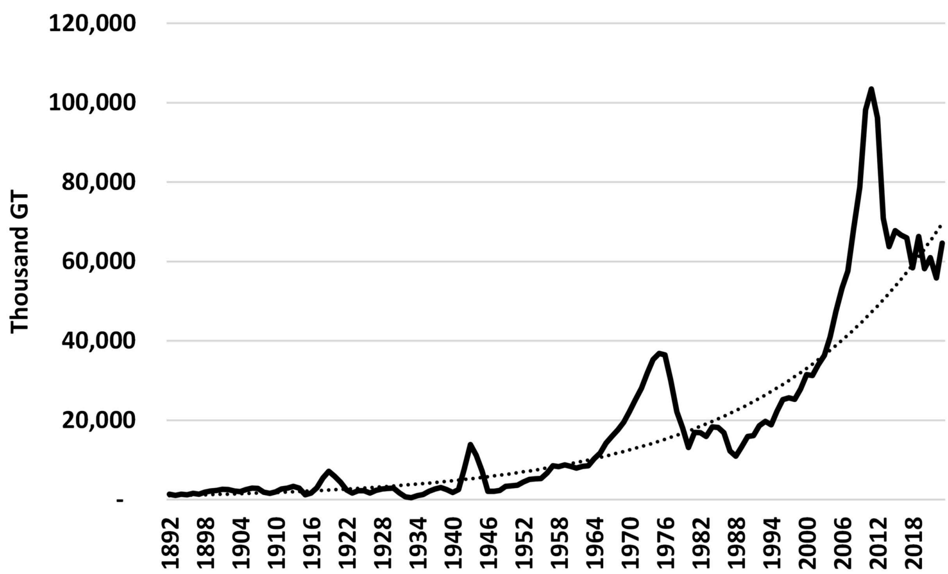

Figure 2: Long term annual Gross Tonnage delivered by global shipbuilding

What is particularly noticeable in this chart is the four significant peaks at, roughly, 30-year intervals. The two earlier peaks look relatively trivial now but when benchmarked against the total size of the fleet at the time they were similarly as exaggerated as the two more recent peaks: peak volume being consistently around 12% of total fleet size[2]. Underlying the long-term characteristic is a smooth growth of 3.1% per annum, on which the peaks are superimposed. The underlying trend corresponds well to the growth in seaborne trade, which might be intuitively expected, given that shipping is a derived demand based on that

1. Compiled by the author from numerous sources, with acknowledgement to the Marine Technology Special Collection at Newcastle University (UK).

2. With an uplift for war losses in the 1945 peak.

trade. But what is causing the exaggerated wave-like behaviour that is superimposed on this rational underlying trend?

This question will be considered below but, before that, some more analysis of the trend itself.

- The average length of the cycle over the past 130 years has been 31 years but has been increasing: 24 years between peaks 1 and 2, 32 years between peaks 2 and 3 and 36 years between peaks 3 and 4.
- The average peak length[3] has been 5.7 years and the average trough length[4] has been 25 years. This tells us that the sector, at the aggregate level, spends five times longer in trough than it does in peak and this is reflected in price and business conditions for shipbuilders.

Put bluntly: shipbuilders experience 5 subdued years for every one highly profitable year. For this reason alone, shipbuilding might be characterised as high risk and low return. This then inevitably begs the question: why on earth would anyone bother? The most significant answer to that question is that whilst the business is difficult, it is also unparallelled in its power to generate industrial economy. Japan used shipbuilding in this way as part of the US-backed strategy to resurrect the country's decimated economy following WWII. South Korea repeated this strategy to move the country from an agrarian to an industrial economy in the 1970s and China similarly used the power of the industry in the industrial and trading boom that started around the millennium[5].

A second answer to the question 'why bother?' reflects the fact that whilst the aggregate sector behaves in this difficult way, opportunities to generate return on investment can be found at different times and in different sub-sectors of the market and there may also be other issues at play beyond the economic. Certain commercial sectors may be buoyant even if the totality of the market is not. For example, at the time of writing this book the markets for cruise ships, yachts and LNG tankers are all buoyant even though the totality of the shipbuilding industry is not. Finally, it should be noted that small and specialised ship types, such as small cargo vessels, inland waterway, tugs, research vessels, dredgers and so on, are less influenced by the features of speculative ship investment that contribute to the cyclic behaviour of the market and are, therefore, less volatile. Figure 3 presents the number of commercial ships delivered per annum in three separate sectors of the newbuilding market: large commercial ships (> 5,000 GT), small ships (500 to 5,000 GT) and workboats (< 500 GT). The two smaller sectors do not present the same exaggerated peaked characteristic that is seen in the total market, which is dominated by the 90% of output that is large commercial ships. These two smaller sectors, therefore, whilst comparatively restricted in business volume, present a more rational market in which to seek work. This characteristic is further helped by the fact that the smaller

3. Defined as the period from the point that demand exceeds the previous peak level up to the point where it collapses.

4. Defined as the period from the bottom of the initial collapse up to the point where the previous peak level is re-achieved.

5. Stott, P.W. (2017) 'Shipbuilding innovation: enabling technologies and economic imperatives', Journal of ship design and production, 33(3), pp. 1-11; Paul Stott (2023) Shipbuilding Policy in the UK: The Legacy of a Century of Decline and its Influence on Naval Procurement, The RUSI Journal, 168:5, 54-67, DOI:10.1080/03071847.2023.2250389

the ship, the more likely it is to be ordered regionally or domestically, rather than being sourced from across the globe.

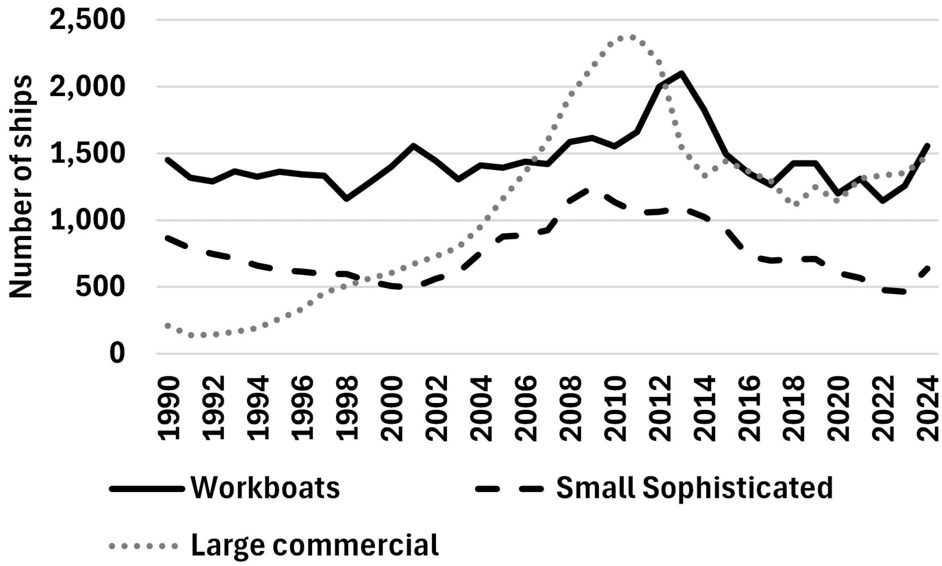

Figure 3 – Number of ships built over the most recent peak period, separated by newbuilding market sector (compiled from various sources)

Finally, there is another way of looking at the cycles that manifest in the long-term demand characteristic. Underlying structural changes and significant events contributed to the peaks. In the case of peaks one and two, they corresponded to two world wars, which required significant tonnage to be built to replace war losses. The third peak, culminating in 1975, corresponded to the first wave of globalisation and an energy boom that generated the demand for very large crude oil tankers: this was when the VLCC fleet was first established. The fourth peak corresponded to China's economic emergence after the millennium, which required a significant import of raw materials and energy and a significant export of finished and semi-finished goods. It also corresponded to the expansion of the LNG tanker fleet as energy mix shifted away from oil and coal, the expansion of the cruise industry, and the development of container shipping. All these events underpin the shape of the demand characteristic.

Caution must therefore be exercised in drawing conclusions from the characteristics of the cycles and any contingent conclusions for forecasting. The shipbuilding industry changed radically with the onset of globalisation and the end of empires following the Breton Woods conference at the end of WWII. This is shown in Figure 4, which charts the ratio of actual output in GT to the level predicted by the underlying 3.1% trend. Contemporary market analysis from near the time[6] confirmed that the first peak corresponds to a freight rate boom, so causation is consistent with the following peaks. For this and the second peak, however, demand includes significant up-lift to replace war losses, so they are higher than might have been expected in peacetime circumstances. The characteristics of demand in the pre-WWII period are clearly

6. Isserlis, L. (1938) 'Tramp Shipping Cargoes and Freights', Journal of the Royal Statistical Society, 101(1), pp. 53-146

very different to those that followed, not least that volatility of output reduced significantly in the later period, which I have called the 'modern shipbuilding era'. Future analysis of cyclical behaviour should concentrate on that era predominantly, rather than the full period shown, although further research is needed to confirm this.

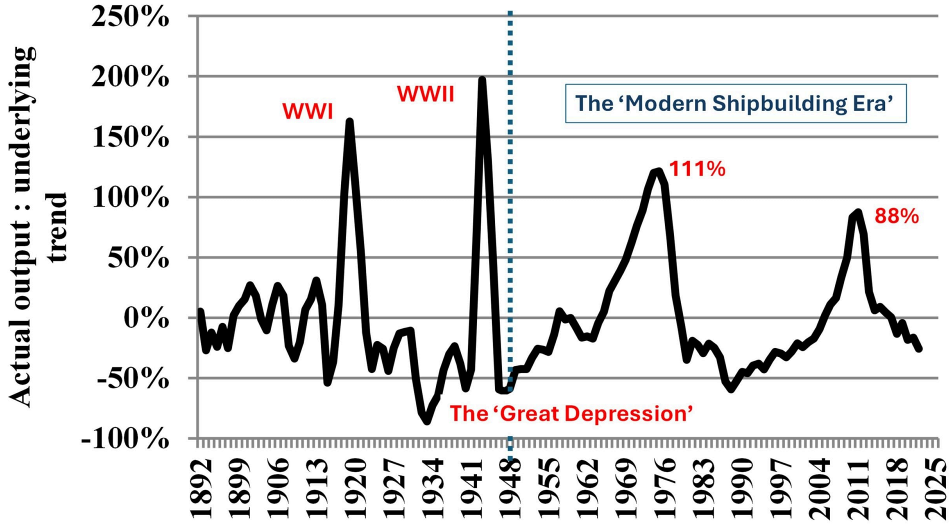

Figure 4 – Ratio of actual output to that predicted by the underlying 3.1% trend

4.

DEMAND DRIVERS AND THE 'STANDARD MODEL' FOR NEWBUILDING FORECASTS

The Standard Model

Commercial shipbuilding operates within the context of maritime economics. Maritime economics has some unique characteristics, which impinge on shipbuilding demand[1]. The particular features that make maritime economics 'different' include:

- High volatility;
- High cyclicality: the demand cycle for new ships is a good example, but there are other cycles that can be found underlying most sectors of maritime economics.
- Volatility of asset values: the means of production, that is the ships, is a tradeable asset and prices rise and fall. This means that buyers of ships can speculate to make profits by advantageous timing of purchase and sale. This introduces an element of speculation into the decision to purchase a ship, which in turn has a profound effect on shipbuilding demand.
- There is a lag between the decision to purchase a new ship and that ship entering into service: typically, between 2 and 6 years. This adds a level of risk for both the buyer and builder and means that the economic system is slow and cumbersome. As we will see, it also means that the shipping market is inevitably periodically over-supplied with tonnage, leading to prolonged recessions in freight rates and, correspondingly, newbuilding demand and prices.

Maritime economists refer to commercial shipping as a 'derived demand'. It is a subtle distinction but essentially it means that the economic demand is not for a ship but for movement of a cargo or a person and a ship provides one possible solution for that transport demand. Other possible solutions include aircraft, rail, road, pipeline and conveyor belt. Having said this, because of the size of parcels in many areas of seaborne trade, sea transport is the only feasible solution. For example, to get millions of tonnes of iron ore from Brazil to China, or millions of tonnes of crude oil from the Arabian Gulf to South Korea, large ships are the only viable solution to the transport demand. For transporting a high value car from Italy to Saudi

1. For an excellent essay on the peculiarities of the shipping industry, see: Thanopoulu, H. (2002) 'Investing in ships: an essay on constraints, risk and attitudes', in Grammenos, C. (ed.) The Handbook of Maritime Economics and Business. London: Informa, p. 623 to 641.

Arabia, on the other hand, there are many possible solutions, including road, rail, shipping container and air freight.

For long distance transport of passengers, there are several potential transport solutions, but air transport has become dominant. For example, to travel from The Netherlands to Japan it would technically be possible to travel by road or rail as far as Vladivostok and then to take a ferry to Japan. In reality, geo-political tensions as well as the time that this would take mean that the only practical way to make the journey is by air.

Because the demand for shipping is a derived demand, optimistically the demand for new ships should be reasonably predictable based on forecasts of the trades that it serves. This is one of two theoretical underlying demand drivers for newbuilding: demand is generated by the need to build new ships to satisfy expanding trade. The second element of demand is generated by the need to build new ships to replace capacity that has reached the end of its economic life and which will be recycled out of the system. These two demand generators constitute the 'rational demand' for new tonnage. This rational demand is to some degree predicable given that world seaborne trade grows (or at least has grown up to the point of writing this book) at between 2% and 3% per annum and the end of a merchant ship's economic life is typically between the 4th and 5th classification special surveys[2], that is between 20 and 25 years old. These assumptions form the basis of what might be termed the '**standard model**' for predicting shipbuilding demand: the model predicts how many ships will be required to carry expanding trade and how many ships are expected to reach the economic age limit and require replacement. The sum of the two is assumed to equal demand for new ships, but even this simple model is anything but simple in its application. Whilst globalisation has supported almost continuous expansion of trade since WWII there is no absolute reason to assume that this will continue, and different trade sectors (wet bulk, dry bulk, gas, general cargo) expand at different rates. The ultimate economic age of a ship is also a variable depending on economic and trade conditions and, in the author's experience, it has ranged from a life expectancy of below 5 years to over 100 years, with high value ships and ships that operate in fresh water often achieving much longer than 25 years. Even this simple model, therefore, requires complex assumptions and small changes in those assumptions can lead to large changes in predicted demand: the 'standard model' is very sensitive.

The greatest difficulty with the 'standard model', however, is that whilst it appears rationally (and thereby to some degree predictably) based, it does not return the correct answer to the question: what will future shipbuilding demand be. In the recent past, in fact, it has returned spectacularly incorrect answers. Table 1 compares three published predictions made using this methodology by three credible forecasters (one international and two national shipbuilding associations) for demand for new ships in the period 1997 to 2010, encompassing a significant upturn in the global market, and compares the forecasts to the actual market outturn.

2. The special survey cycle is a five-year inspection and maintenance cycle that is imperative for all commercial ships: because it is imperative for maintenance of classification, without which a ship could find neither insurance nor customers.

Forecaster	Prediction (m. CGT)	Reality (m. CGT)
International association	**223**	**375**
National association 1	**221**	
National association 2	**245**	

Table 1: Comparison of forecasts for shipbuilding demand in the period 1997 to 2010 and actual out-turn for the period

It can be seen from these statistics that even the best forecasts, based on the 'standard model' were out by a factor of almost two. We need to understand why that was to try to achieve a better forecast and to understand how the markets actually work.

Firstly, a look at the underlying factors for this period provides a revealing perspective. Taking demand generated by expanding trade first, Figure 5 presents graphs of shipbuilding output and seaborne trade development in the thirty years between 1990 and 2020, representing roughly a full commercial shipbuilding cycle.

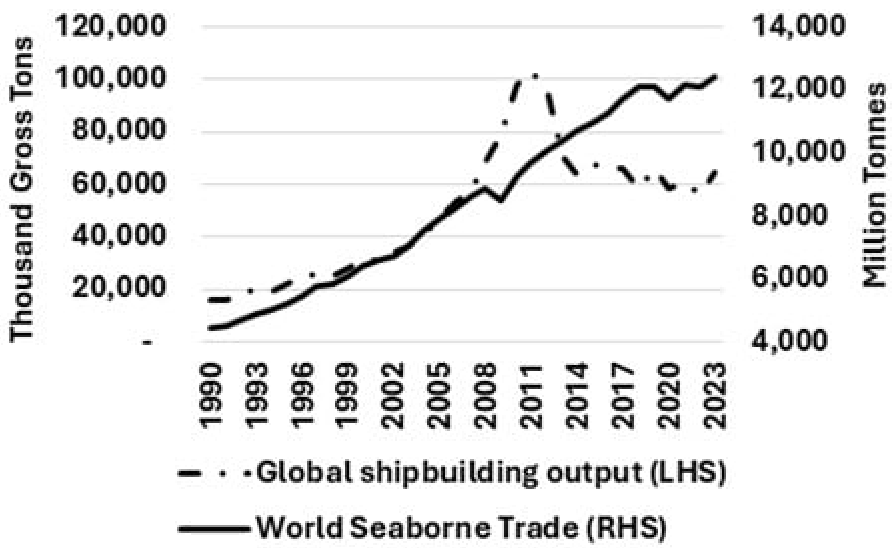

Figure 5 – Output of new ships 1990 to 2020 (chain dotted line and RHS(Clarkson data)) and growth in world seaborne trade (solid line and LHS (UNCTAD data)) over the same period

Except for a period of about 8 years between 1998 and 2006, It is very difficult to see any correlation between these two lines, even if we tried to apply a lag to represent the timing of placing the order rather than using the timing of delivery of the ship – demand for ships appears to be poorly related to demand for seaborne trade. Statistical analysis, however, gives a correlation of 78% at the two-star significance level for these two variables – meaning that there is a better than 99% chance that the correlation is not random. This confirms that the demand for seaborne trade is a generator of shipbuilding demand, but we clearly cannot reliably use this relationship in any simple way as a predictor even in the short term. The relationship between trade and newbuilding demand actually predicts the underlying trend shown in Figure 1 very well, so it works well over the long term. A mathematical model built on the relationship between seaborne trade and shipbuilding demand alone could not predict the downturn after 2011, however, or the very significant growth rate between 2005 and 2012. The 'standard model' clearly needs to be more complex than it at first appears. Something more is going on to generate the highly cyclical behaviour, and this would have to be factored into the model.

Could that second factor be the second of the demand generators: the need to replace obsolete tonnage? Certainly, this is a seductive idea; that the peaks are simply a propagation of previous peaks with the interval being equal to the mean scrapping age. In effect this would manifest as a 'wave' triggered by some original event. Norwegian economist Johan Einarsen set out in the late 1930s to find what he called an 'echo phenomenon' in the Norwegian fleet, where he postulated that a 'wave' would have been initiated by a significant peak of output of ships in 1920 and 1921, to replace heavy loss of tonnage in the first world war[3]. He was using this to investigate what Karl Marx had termed the 'reinvestment cycle', which postulates that investment in a capital system will typically be replaced after ten years, but Einarsen found no evidence for the 'echo phenomenon'. This is significant in the context of the 'standard model'. We have established that the first predictor, growth in trade, does not work easily and now, apparently, nor does the second predictor. The situation has not changed since Einarsen's time. Projecting the 1975 peak forwards by 20 to 25 years shows no observable contribution in the development of the 2008 peak, which occurred 33 years later and which was very significantly higher than might have been anticipated, based on replacement demand or, more poetically, by Einarsen's 'echo phenomenon'.

Just as with the relationship between newbuilding demand and trade growth, however; just because it is not immediately visible does not mean that the 'echo phenomenon' is not a generator of demand. It is just that it is not represented in a simple relationship. Part of the reason for this is that the notion that a buyer of a ship will use that ship for 20 to 25 years and then replace it, creating the demand, is flawed. Only about 1 in 5 ships remain with the first buyer for the full ship life. For the other 4 in 5 the most likely point of replacement by the first owner is after the second special survey at 10 years old, after which point maintenance costs and retention of a class certificate becomes more expensive and the ship will be replaced[4]. The first owner may replace it with another new ship, whilst their previous ship is likely then to descend through a succession of owners for the remaining 10 to 15 years of its life until it eventually leaves the fleet and is recycled. There may be a very slight 'echo' of the 1975 peak, manifested as a relatively small upturn in demand around 1985 (Figure 6), but even this is unlikely to be particularly significant. The scrapping of ships acts indirectly on the generation of newbuilding demand through the effect that it has on the supply and demand balance in the trading fleet and, thereby, on freight rates. This will become clearer in the next section that looks at how shipping and shipbuilding interact and in the discussion of price formation.

3. Einarsen, J. (1938) Reinvestment cycles and their manifestation in the Norwegian shipping industry. Oslo: Oslo University institute of economics.

4. Stott, P. (2014) 'A retrospective review of the average period of ship ownership with implications for the potential payback period for retrofitted equipment', Proceedings of the Institution of Mechanical Engineers Part M: Journal of Engineering for the Maritime Environment, 228(3), pp. 249-261.

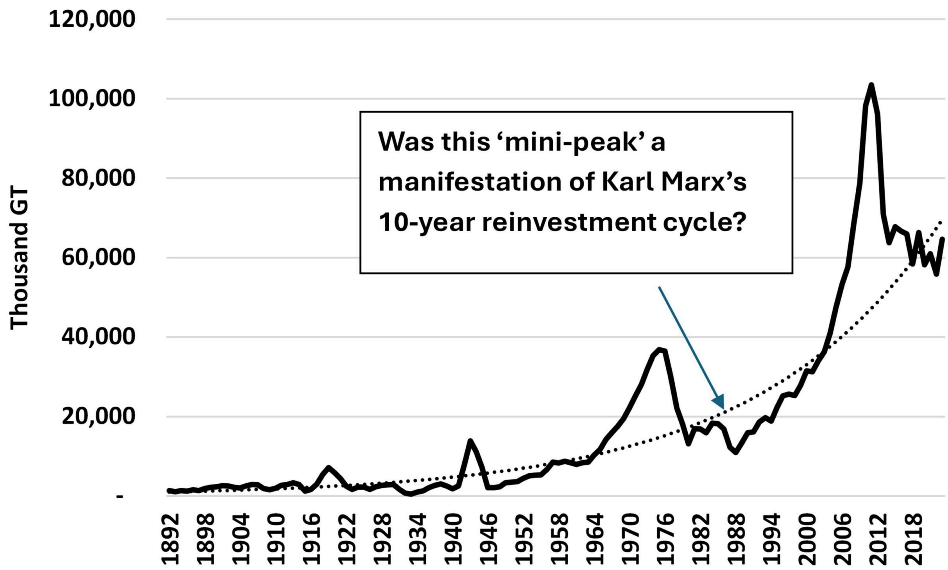

Figure 6 – The possible manifestation of a 10-year reinvestment cycle following the 1975 peak?

So, what is going on? The rational demand drivers do not appear to adequately predict the demand for new ships, even though statistically they can be shown to be significant. The answer is in two parts. Firstly, the 'standard model' is too simplistic to reflect real world behaviour, and a range of other variables and proxies would be needed to improve it. This increase in complexity would be fruitless, however, because the second issue is that the 'standard model' predicts the wrong thing. It attempts to predict the demand for ships needed to move world trade. What we should be predicting is the demand for investment in new ships and this is not the same thing. In making the investment decision the buyer and their finance will be focused on current market conditions and prospects for the ship and the purchase will be made in anticipation of making profit and not per se on an analysis of future transport demand. It also requires that the finance industry is positively disposed towards shipping, and this is only intermittently true. This is made even more complicated by the idiosyncrasies of the shipping industry and the way that shipowners make money, which will be the subject of a later section.

Before looking at that, however, it is worth finally remembering that looking at the industry on an aggregate level, as done here, ignores differences between fleet sectors, some of which may, individually, be predicted very well by the standard model, particularly in sectors away from the main large transport fleet of tankers, dry bulk, container and gas carriers, which form the bulk of the tonnage built. There is an element of speculation in the purchase of these ships, which may not be present in, for example, the purchase of a tug or a windfarm service vessel. Different sectors of the market, therefore, will be subject to different demand forces and no one model for demand prediction will work in all cases.

The influence of fleet development cycles

Superimposed on the demand drivers described in the previous section is the influence of fleet development in terms of ship types. New ship types and new classes of ship are developed from time to time, and this may in some cases force predecessor types and classes to be phased out. Examples help to clarify this concept. In reviewing these it may be noticed that the development of fleet sectors follows a pattern that is general in product life cycles, i.e.: introduction, growth, maturity, saturation and decline. As with product life cycles, understanding where a fleet sector is positioned on the cycle is important as a basis for strategic decisions. The typical parameters of this cycle may be generalised, very approximately, as follows:

Cycle stage	Market response
Introduction	Early adopters take up the ship type. Demand is low and fleet growth is slow.
Growth	The ship type starts to become established and the operating fleet is developed. Fleet growth rates are high, typically around 8% per annum.
Maturity	The fleet is now well established and growth declines to meet the underlying growth in trade, typically 2% to 3% per annum.
Saturation	Over-capacity develops and fleet growth, and consequently newbuilding demand, stalls.
Decline	Either the trade or the ship type becomes obsolete, and the fleet exits the market. Examples in recent decades include tween-deck general cargo ships, phased out to be replaced by container ships, or refrigerated cargo ships, phased out to be replaced by refrigerated containers. There is no typical decline rate and this stage can take several decades to play out.

It should be noted that in moving from growth to maturity the demand for new ships may be anticipated to fall by 75% and forecasting this change is therefore a key factor in newbuilding demand forecasting.

Two examples are given below. The first is the development of the container fleet, which superseded transport of goods in tween-deck general cargo ships. The development of the fleet in terms of number of ships is presented in Figure 7.

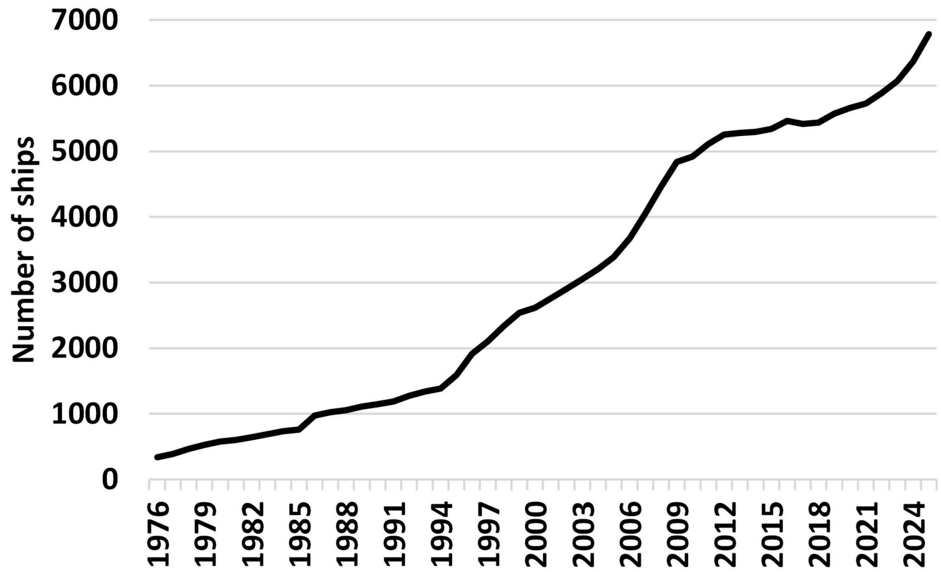

Figure 7 – Development of the fully cellular container ship fleet 1976 to 2025

The characteristics of the fleet development cycle shown in this chart are as follows:

Fleet development cycle stage	**Characteristics of the container fleet development cycle**
Introduction	Introduced in 1956 with *Ideal X* but tween-deckers remained the norm for moving general cargo up to around 1980.
Growth	The growth phase can be clearly seen in Figure 7, finishing around 2010. The average rate of growth of the fleet was 8% per annum in that period.
Maturity	Maturity commenced around 2010 when the average rate of growth fell to around 1% per annum, significantly reducing the demand for new ships. This kicked up again after 2020, averaging 4% per annum in the following 5 years, as over-capacity in the fleet reduced and as the ultra-large and new panamax sectors were introduced.
Decline	Decline is not yet anticipated for container shipping, although some decline could be anticipated with future changes in global trade, or phasing out of smaller less efficient ship classes.

This feature of demand development may be further complicated by the fact that within discrete subsets of any particular sector of the fleet different forces may apply. Figure 8, for example, shows the development of Ultra-Large Container Ships (>18,000 TEU) since the first one was delivered in 2013.

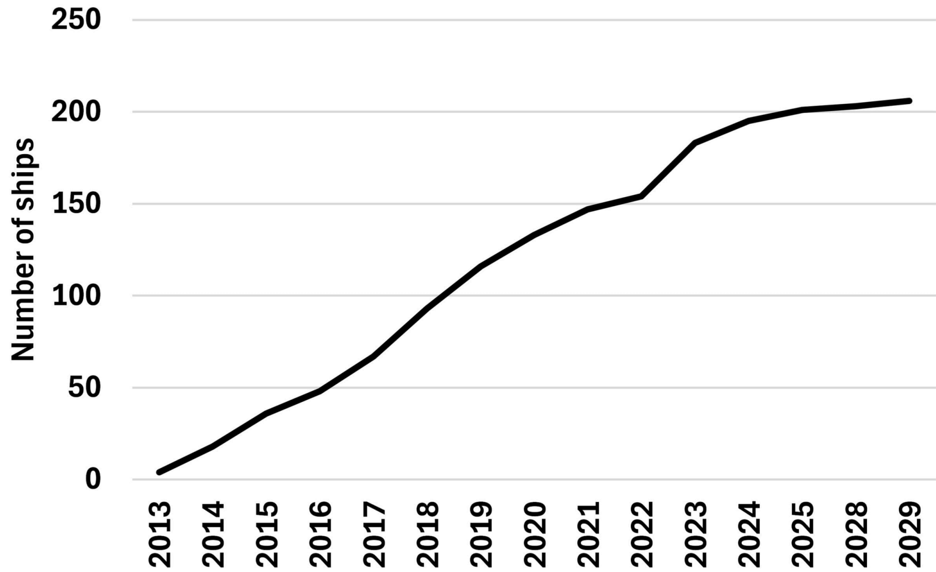

Figure 8 – Development of the Ultra-Large Container Fleet (>18,000 TEU)

The ULCC sector clearly matured from about 2023 and the rate of generation of demand for new ships turned down significantly.

The second example of fleet development cycle is the LNG tanker sector. The first ship to carry LNG was a converted dry cargo ship, the *Methane Pioneer*, in 1959. As a dedicated ship type the fleet commenced in 1964, but it remained a niche ship type up to the millennium. After that point demand for ships increased dramatically, stimulated by increasing energy demand and by moves away from coal and oil for environmental reasons. The development of the fleet to 2025 is presented in Figure 9.

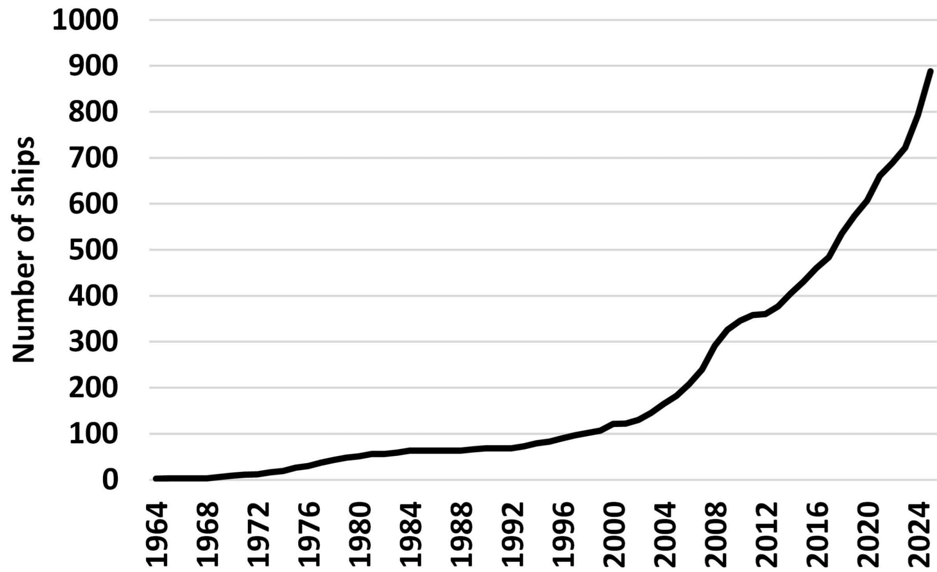

Figure 9 – Development of LNG tanker fleet 1964 to 2025

The characteristics of the fleet development cycle can be summarised as follows:

Fleet development cycle stage	Characteristics of the LNG fleet development cycle
Introduction	Introduced in 1964 but remained niche up to around 2000. The average annual rate of growth between 1980 and 2000 was around 4%.
Growth	Since 2000 the fleet has grown strongly at around 8% per annum and, at the time of writing this book, remains in the growth stage.
Maturity	Maturity has not yet been reached in the LNG sector.
Decline	Decline is not yet anticipated for LNG shipping.

The onset of maturity will be accompanied by a significant reduction in demand for new ships, when it happens.

The appropriate growth rates, reflecting both trade growth and fleet development, would clearly have to be incorporated into any demand forecast model.

The economic relationships between shipping and shipbuilding

To understand the generation of the highly peaked demand characteristic, it is necessary to understand the principle of the formation of freight rates in shipping[5] and the factors that lead to investment decisions. This requires that we consider four things:

1. investment decisions in commercial shipbuilding;
2. the attitude of finance to that decision;
3. the nature of the supply and demand functions in shipping;
4. the effect of the backlog.

Investment decisions in commercial shipping

This is a major study in its own right and the essential elements only, as they relate to newbuilding demand decisions, can be considered here[6]. The essential feature of the investment to grasp is that shipowners make

5. There are many good textbooks on the economics of shipping. Perhaps one of the more accessible for a non-economist is: Stopford, M. (2009) Maritime economics. third edn. London: Routledge.

6. Suggested reading (there are many other sources): **Grammenos, C.T. (2010)** The handbook of maritime economics and business. 2nd edn. London: Lloyd's List. **LaRocco, L.A. (2012)** Dynasties of the sea : the shipowners and financiers who expanded the era of free trade. Stamford, Connecticut: Marine Money. **Stott, P.W. (2021)** 'The shipbuilding industry and its interaction with shipping', The International Encyclopedia of Transportation. Elsevier, pp. 617-624. **Talley, W.K. (2012)** The Blackwell companion to maritime economics: Wiley-Blackwell.

money in two ways. Firstly, through the carriage of freight, earning a rate per tonne of cargo moved. Secondly, shipowners can generate revenue through the trading of their asset, the ship, the value of which is volatile. Put simplistically, the aim is to buy for a low price and sell for a high price. The trade of the ship itself is referred to as '*trading in steel*'.

The profits to be made in trading in steel can be very high. To illustrate the potential, Figure 10 shows how the newbuilding price of a VLCC varied between 1999 and 2025.

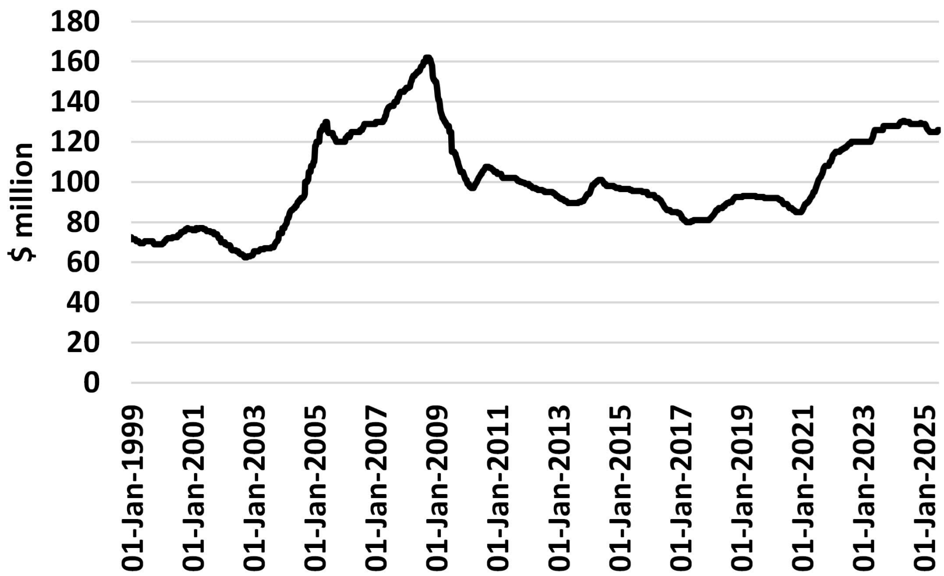

Figure 10 – Newbuilding price for a VLCC ($ million: Clarkson data)

Perhaps the ultimate opportunity for trading in steel in recent years was the period between about 2003 and 2008. A VLCC ordered in January 2003 for the market price of $60 million, at a time when backlog was around 2 years, could have been sold for at least $110 million on delivery, the newbuild price at January 2005 when it would have been completed.

This reveals a further feature of the newbuilding market normally termed '*trading in paper*', where a newbuilding contract can be placed and that contract subsequently traded, for a ship that does not yet exist. The ultimate opportunity for trading in paper in recent years occurred in the four years following 2004, in the build-up to the 2008 peak in demand. A VLCC ordered in July 2004 would have been contracted for around $60 million with 4 years backlog. On delivery in July 2008 the newbuild price had rocketed to $155 million – a profit of at least $95 million on a ship that had never yet existed. I use the term 'at least' referring to the sale price, because the contract re-sale value can be higher than the newbuilding price at the time of sale, because the ship is available immediately and will not have to wait for the construction period.

But, before you go out and bet your pension on a newbuild speculation, consider the fate of those unwise enough to play brinkmanship with the cycle. A VLCC ordered for $120 million in January 2006 would have left the shipyard in 2010 at the point that newbuilding prices had fallen to $81 million and were set to fall further, but at which point it would have been virtually impossible to sell the ship: nobody wanted new VLCCs at that point of the market.

As referenced earlier, we also need to factor in the possible premium on second hand ship prices that takes into account the availability of tonnage, given the backlog in newbuilding. Figure 11 shows the development of the ratio of 5-year-old to newbuilding price for a VLCC and for a capesize dry bulk carrier. The VLCC is included to show how low the ratio can go and the capesize to show how high it can go. The graphs include a chain-dotted line at 75% to represent an accounting value of a 5-year-old ship: assuming an economic life of 20 years, at 5 years old it would be assumed, through simple straight-line depreciation, and ignoring the residual scrap value at the end of the ship's life, that 75% of the value of the asset would remain.

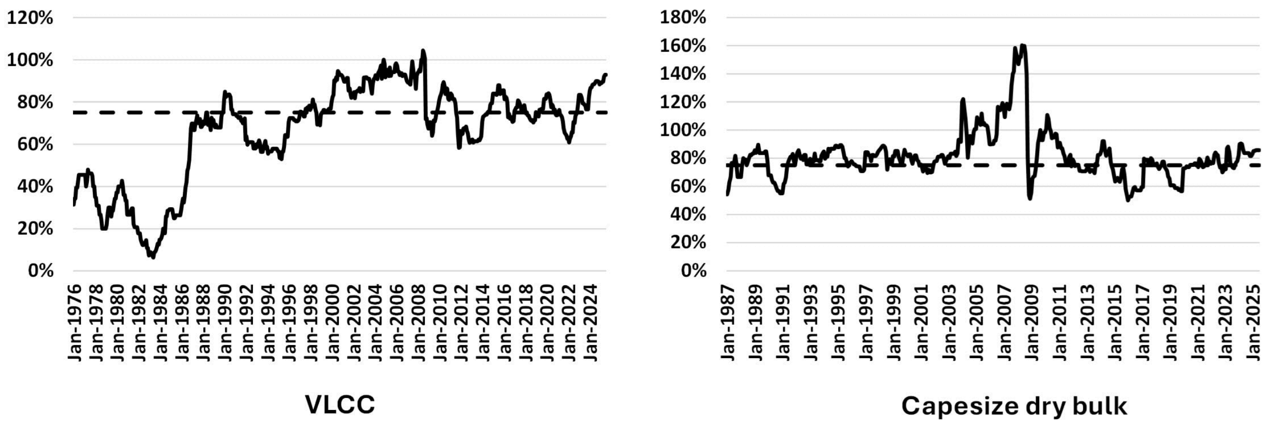

Figure 11 – Ratio of 5-year-old to newbuild prices for VLCC and Capesize dry bulk, including the accounting value at 75%

In the case of the VLCC it can be seen that in the period following the 1975 demand peak, the value of second hand ships plummeted to almost zero. This happened because:

1. the supply of VLCCs built during the peak far exceeded demand for that ship type;
2. the 1973 oil crisis led to a reduction in demand for long-haul transport of crude oil, exacerbating the over-supply of tonnage;
3. the 1973 oil crisis also saw a significant increase in bunker costs, which rendered the steam turbine machinery that characterised the first generation of VLCCs as uneconomic when compared to motor ships, which consume only about as 1/3 as much fuel.

During this period, many ships were scrapped early and there were reputedly cases of VLCCs proceeding directly from newbuild yard to scrap yard, although the author is unable to name any specifically. The earliest scrapping record found was the VLCC *Amoco Chicago*, 238,518 dwt, built at Astilleros Espanoles in Puerto Real in 1979 and recycled in Kaoshiung only 4 years later. Of the 398 first generation VLCCs built in that era, 14% were scrapped at 10 years or younger and only ½ were still operating beyond the third special survey at 15 years old.

Looking at the capesize graph, it can be seen that the value of a 5-year-old ship reached a peak of 60% higher than the newbuild price in 2008: $97 million to place a newbuild contract with 6 years backlog or $155 million for a five-year-old ship immediately available, if you could find one. This happened because the demand for shipping iron ore and coking coal, the two cargoes transported by capesize, into the superheated Chinese economy led to astronomically high freight rates and this stimulated the demand for excessive ordering, which eventually contributed to the market's collapse in 2008.

The opportunities for trading in steel tend to be less spectacular than the examples given here, but significant profits can be made where judicious decisions are made. In essence, a good time to buy is when the 5-y-o to newbuild ratio is below 75% and a good time to sell is when it is above that value – see Figure 11. These decisions are most successfully made by investors with long experience in shipping.

As with other factors discussed in this book, the preceding paragraph represents a generalisation that does not extend to all markets. In large transport sectors, particularly the bulk sectors, speculation may be a strong influence. In smaller and specialised sectors, however, this does not feature. Purchase of a yacht, for example, is normally not a speculation on the value of the ship. As another example, the buyer of a harbour tug is unlikely to be speculating: a harbour tug is normally ordered because its services are needed in a port.

The investment decision is therefore made on the basis of a combination of transport or service need coupled, in some sectors, to perceived opportunities to realise value through transporting cargoes and through trading in steel. The success or failure of the decision depends on how well the investor has read the future market, plus the structure of finance used to make the purchase[7].

The attitude of finance to shipping

The use of finance for purchasing a new ship could be regarded as the norm: ships are often not purchased for outright cash[8]. To raise the capital needed, therefore, the lending banks have to be convinced of the prospects of the purchase for which they are lending. The enthusiasm with which the finance sector views shipbuilding is itself a volatile thing: it waxes and wanes. To understand this, we need to look at specific sections of the demand profile that was shown in Figure 2. Figure 12 shows how shipbuilding presented as an opportunity to investors in the thirty years following the end of WWII.

7. The structure of finance is of almost over-riding importance in the investment, but this is beyond the scope of this book. For more information, see: Stopford, M. (2009) Maritime economics. third edn. London: Routledge: chapter 7.

8. Although this does, of course, happen, particularly in strong periods where trading conditions allow ship owners to accumulate significant cash reserves. There are, additionally, other ways sometimes used to finance ship purchase, in particular lease-purchase. IPO is occasionally also sometimes used to raise capital for new ship purchases.

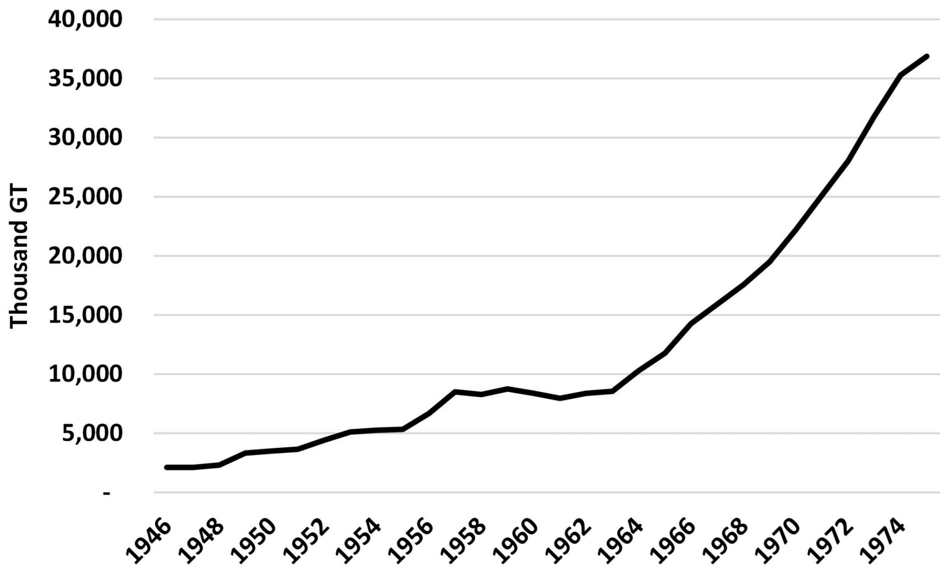

Figure 12 – Output from global shipbuilding, 1946 to 1975

This period presented thirty years of almost un-broken market growth and, between about 1964 and 1975, a boom market. During this period, banks opened specialist shipping divisions and finance became readily available not only for ship purchase, but also for shipyard development. It was during this period that the industry in Europe modernised, Japan expanded and South Korea entered shipbuilding. To put it crudely, you might have heard a financier during this period wondering why they had never noticed before that shipping was such spectacularly good business.

It didn't last, of course, and the steep crash following 1976 led to banks divesting from shipping and closing the specialist shipping divisions. Many loans were far from sound in the following period and bankers got their fingers well and truly burned.

Step forward now fifteen years, as shown in Figure 13. This time we see around 35 years of almost unbroken market growth and, following 2001, another boom market.

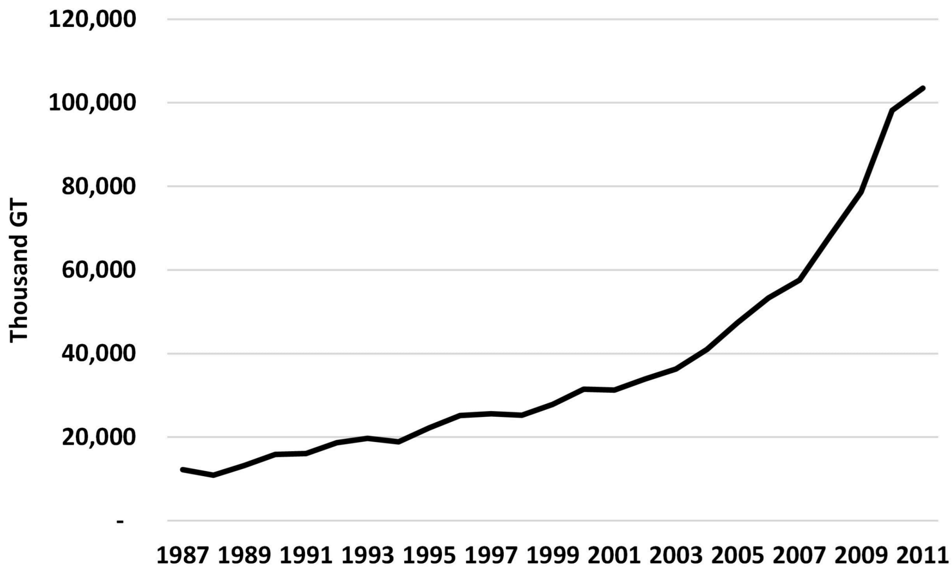

Figure 13 – Output from global shipbuilding, 1987 to 2011

It is significant that the commencement of the boom period occurred almost 40 years after the commencement of the previous boom in 1964: order of magnitude the length of a career and many of those that got their fingers burned in the previous boom and bust had retired. Memory had been lost in the system. We might have heard the comment yet again: why had we never noticed that shipping was such spectacularly good business? Finance became very motivated towards shipping again and finance availability became, arguably, too easy.

The reason for the comment that finance availability became too easy, is that availability of capital contributes to over-ordering, of which more later. More judicious lending, which will require better memory in the system and better forecasting, is unlikely to eliminate the trend for over-ordering but may possibly damp the extremes of the cycle. Whether this would be a good thing or a bad thing is an interesting debate.

As with most things discussed in this book, other conditions may at times apply. In particular, nationally owned banks may at times be positively disposed to lending money to finance ship purchases for national strategic reasons, even where trade prospects may be below thresholds that normal commercial finance would entertain as viable.

Shipping supply, demand and freight rate determination

The highly cyclical behaviour of demand is, in essence, generated by the cyclical nature of freight rates coupled to investors' response to those cycles. Data for cycle analysis is now relatively easy to obtain, and the cycles are well analysed. Early researchers faced a significant barrier, however, in that data was scarce. They were also faced with a bewildering complexity of routes and commodities, in the era prior to the development of dedicated bulk trades following WWII and before consolidation of liner and tramp cargoes into containers since the 1970s. Prior to the era of globalisation, each commodity and each route had a separate freight rate, making analysis extremely complex. A step forward was achieved in 1938 by British economist Leon Isserlis. Isserlis's paper "*Tramp Shipping, Cargoes and Freights*"[9] includes 38 pages of tables that define the cargoes and routes of the day, including rates for cargoes such as: "*deals; rice and or paddy; hemp; cottonseed; jute; teas; wool; jaggery; esparto…*". This disparate array of goods was consolidated into a series of freight rate indices. Isserlis points out that he was not the first to achieve this, noting the first use of such indices being in 1904, but his contribution was to develop the indices into a coherent and extensive set of time series. Essentially this was the first time that freight rate cycles had been seen clearly in statistics, as shown in Figure 14.

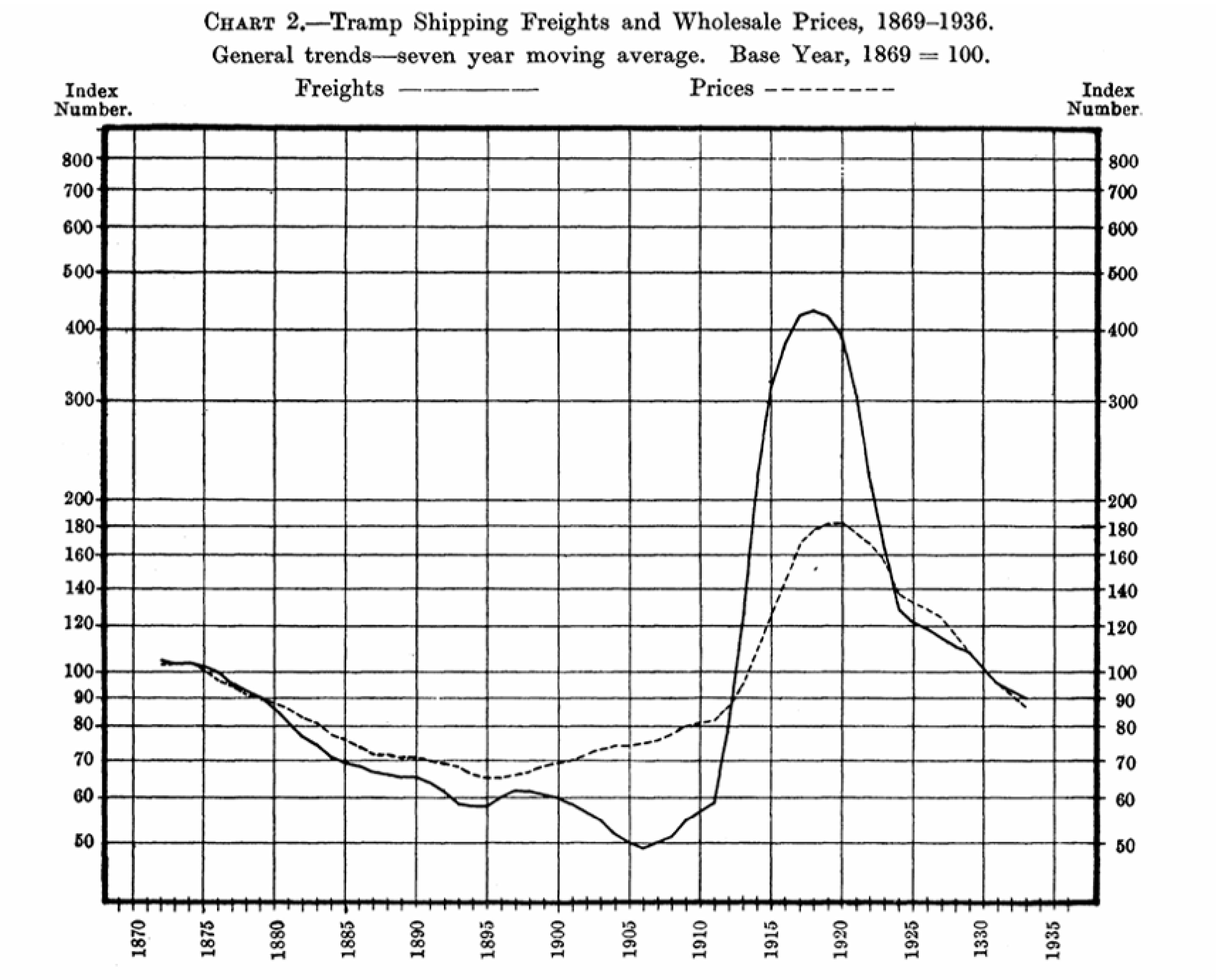

Figure 14 – Freight rate indices for tramp shipping from Isserlis's 1938 paper, with the cycle clearly visible in the time series

A freight rate spike can be clearly seen in Figure 14, probably the first time that this phenomenon had been shown in maritime economics, although ship owners would undoubtedly have had knowledge of spiked opportunities and experience would have helped in advance of statistics in predicting opportunities that stem from those spikes. In the context of this book the significance of the spike is that it leads to high prof-

9. Isserlis, L. (1938) 'Tramp Shipping Cargoes, and Freights', Journal of the Royal Statistical Society, 101(1), pp. 53-146.

itability in shipping and, following this, intense interest in investment in ships by both ship owners and finance. Note that the peak shown corresponds with the first cycle peak shown in Figure 2. A more recent spike, which contributed to the demand peak around 2011, is presented in Figure 15 which shows one-year time charter rates for capsize bulk carriers.

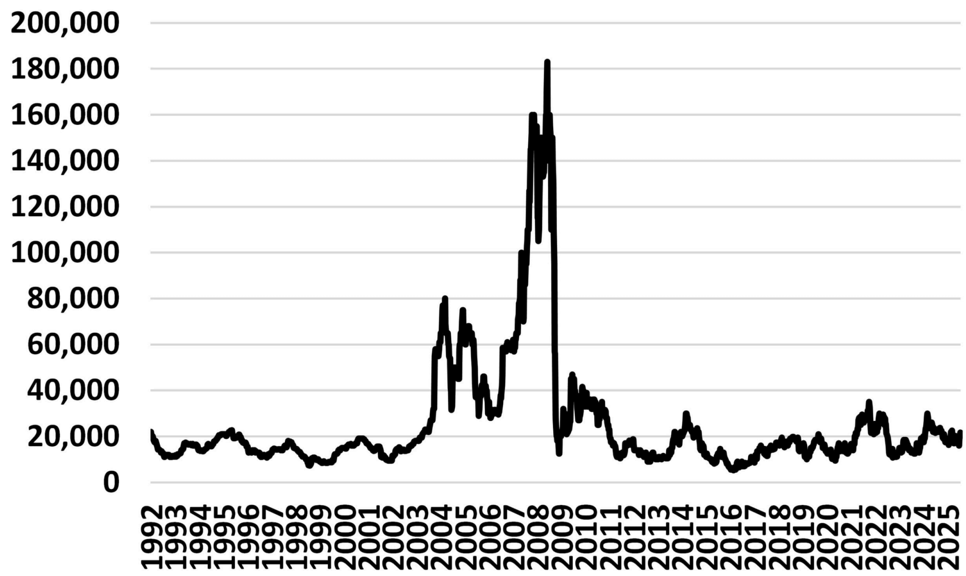

Figure 15 – One-year timecharter rates ($ per diem: Clarkson data) for capesize

A market for which the 'usual' rate was somewhere between about $15,000 and $20,000 per diem peaked at over $180,000 per diem in 2008. At that rate bulk shipping became spectacularly profitable and investors and finance became very interested in the sector. The inevitable crash can also be seen in Figure 15, where the market returned to a more typical level. What was happening to cause this extreme behaviour?

To understand this, we need to look at the supply and demand functions for bulk shipping[10]. Supply and demand functions most often describe how quantity responds to changes in price. For example, if a supplier lowers their price they might expect quantity demanded to increase: a common sales tactic. In shipping the functions are normally represented as inverse functions, describing how freight rates (price) respond to changes in quantity of cargo shipped. Notional shapes of bulk shipping's supply and demand functions are presented in Figure 16.

10. For more details on this subject see Stopford, pp. 160 – 172.

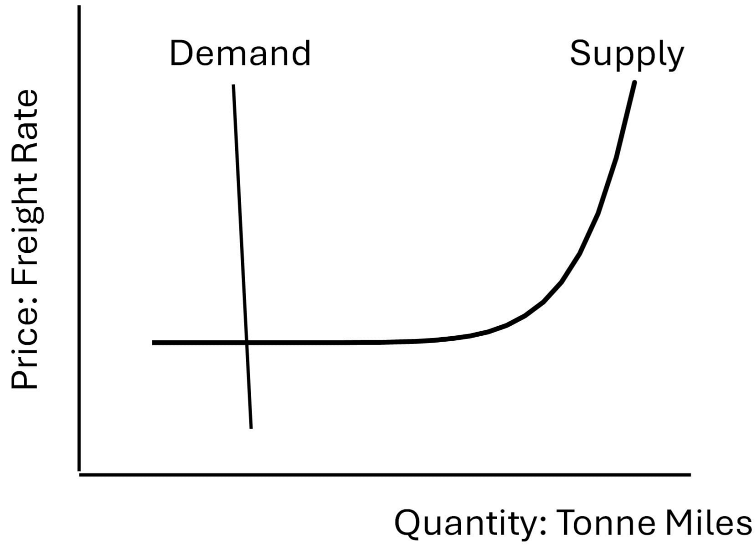

Figure 16 – Notional supply and demand functions in bulk shipping

The quantity of shipping is measured in Tonne-miles and not Tonnes. This is important because speed is an important regulator in quantity of shipping supplied. One Tonne of cargo moved for one mile represents the same transport demand as two Tonnes of cargo moved for ½ mile. Both represent a demand of 1 Tonne-mile. One tonne moved for 10 miles represents ten times this demand, despite the weight being the same. If a ship slows down then it reduces the transport capacity offered to the market or, conversely, if it speeds up it increases the quantity offered, because it affects the 'miles' element of demand, even if tonnes shipped remains unaltered.

Elasticity, in this context measures the sensitivity of price to variations in quantity: how much would freight rate increase or decrease for a unit change in transport supply/demand?

Taking the demand curve first: in shipping demand is highly inelastic – it varies little in response to changes in freight rate. The crude oil and iron ore still needs to be shipped, even if freight costs increase. Underlying this is the fact that, in the context of total landed costs, freight tends to be cheap, particularly in bulk shipping. If freight rates become very high then a small reduction in quantity shipped may result, but as discussed earlier, for many trades there is no alternative to ships and the global economy still needs the energy and raw materials, and to deliver the finished and semi-finished products.

Looking secondly at the supply function, the quantity of shipping supplied, unlike the demand, is, for much of the time, highly elastic. It can be varied using productivity factors in the ship's operation: lay-up, part loading, waiting at anchor, port and repair times and choice of speed. There comes a point, however, when the fleet is travelling as fast as it can and productivity is as high as it can be, at which point the supply curve shifts to become inelastic. In the 'J'-shaped supply curve, this represents the transition from the horizontal to the vertical.

The effects of the 'bimodal' nature of elasticity of the supply function, when set against the inelastic demand function, can be seen in Figure 17.

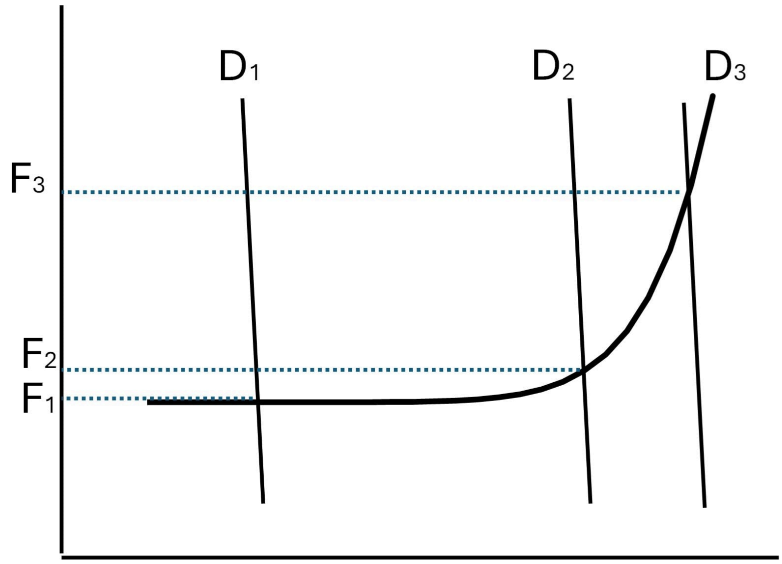

Figure 17 – The effect on freight rates of changing demand in shipping

For most of the time the fleet is in the elastic supply phase, and changes in demand (D1 to D2) lead to only small changes in freight rate (F1 to F2) – the normally prevailing low levels of rate that can be seen in Figure 15. When the inelastic phase is reached, however, freight rates rise dramatically because of a shortage of tonnage to move the world's cargo: the peak section of Figure 15. At this point even small changes in demand (D2 to D3) lead to extreme changes in freight rates (F2 to F3) and return on investment in shipping becomes spectacularly high. This in turn stimulates investment, both in ship owning and in finance, and ordering of new tonnage picks up strongly. Orderbooks become full and investment in new shipbuilding capacity follows, shipbuilding becoming highly profitable for the period that the peak lasts.

The effect of shipbuilding backlog on the cycle

What is needed when freight rates spike, of course, is more ships to satisfy demand (no more productivity or speed is available from existing tonnage) but this cannot happen instantaneously because of the backlog in shipyards. This lag in supply reinforces the capacity shortage in the fleet and, at the end of the boom, ensures that over-supply of tonnage is inevitable.

Backlog is calculated by dividing the total quantity of the orderbook by the prevailing annual rate of delivery and is expressed in years. It manifests as a lag between ordering new tonnage and that tonnage being delivered into the shipping system. An estimate of backlog between 1996 and 2025 is presented in Figure 18[11].

11. Calculated on the basis of Compensated Gross Tonnage (CGT) on order and delivered. CGT is a non-dimensional measure of work content in shipbuilding and gives a more accurate representation in this context than GT alone would.

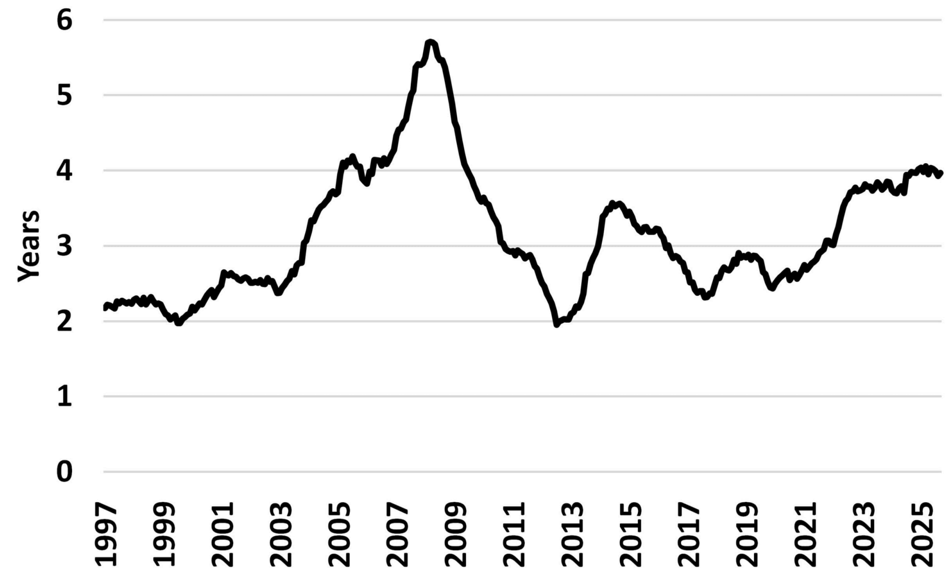

Figure 18 – Estimate of shipyard backlog development (years of work represented by the prevailing orderbook)

Backlog has significance for both the buyer (shipowner) and builder (shipyard) and is in one sense a measure of risk. For the builder it signifies how close the shipyard may be to running out of work or, in other words, how in need of new orders the shipyard is. With longer backlog the yard will not be in desperate need of further orders and prices will remain high. When backlog falls the shipyard will become more in need of new contracts to support the future of the business and prices will fall. For the owner the length of backlog varies the risk they are taking in relation to future earning potential: what will freight rates be in several years' time? This in turn will affect how resistant shipowners may be to further price increases.

Backlog never normally dips below two years, with capacity adjustment and discounting being used by shipbuilders to maintain forward order books. The typical build cycle for a large ship in a Far East shipyard may be around 9 months, and two years backlog thus represents about 2½ ships in hand for each slot[12]. If the backlog were to fall to 9 months the shipyard would be working on its last orders and this is a special case for shipbuilders, commonly referred to as "*last ship syndrome*". At this stage the workforce tends, where it can, to leave to find more secure work elsewhere and completing ships becomes difficult. In extremis the final contracts may eventually be towed elsewhere for completion and the shipyard closes at that point. More commonly, final orders are simply not started.

It can also be seen that at the most recent peak, backlog had increased to almost 6 years. That is 6 years of new tonnage at peak output that is almost inevitably destined to enter service, even if it is not needed. Shipbuilding contracts are watertight and can be cancelled only in exceptional circumstances, although a proportion of the backlog is likely to be subject to default, either by buyer or builder. In the 6 years following peak ordering in 2008, 9% of orders defaulted (default by either buyer or builder), totalling about 17%

12. A slot is a designated space in the forward build programme of the shipyard, which can be assigned to a specific order. This is discussed in more detail in the next part (supply).

of the tonnage on order at the peak. The majority, therefore, 91% of ships and 83% of tonnage, entered the fleet, where it was not immediately needed.

The lag, therefore, acts to exaggerate the cycle. When new ships are needed to correct the shortage of capacity that occurs when shipping's supply function switches to the inelastic phase, it is a minimum of two years before that can be achieved and shipyards take time to build up new capacity. This exacerbates the shortage of capacity because seaborne trade may continue to increase whilst fleet capacity cannot do so easily. At the other end of the cycle a large overhang of tonnage that is not needed is delivered into the fleet: overbuilding is inevitable in this economic system. The system then operates on overcapacity of ships until such time that expansion of seaborne trade absorbs the excess tonnage, committing the shipping industry to a period of suppressed freight rates.

5.

DEMAND SUMMARY

The anatomy of a cycle

Putting this all together, Figure 19 presents a diagram that combines the development of world seaborne trade and fleet capacity, expressed in deadweight. The scales have been manipulated to superimpose the two factors together and it should be kept in mind that this is an illustration, rather than a rigorous analysis, but it illustrates the story well.

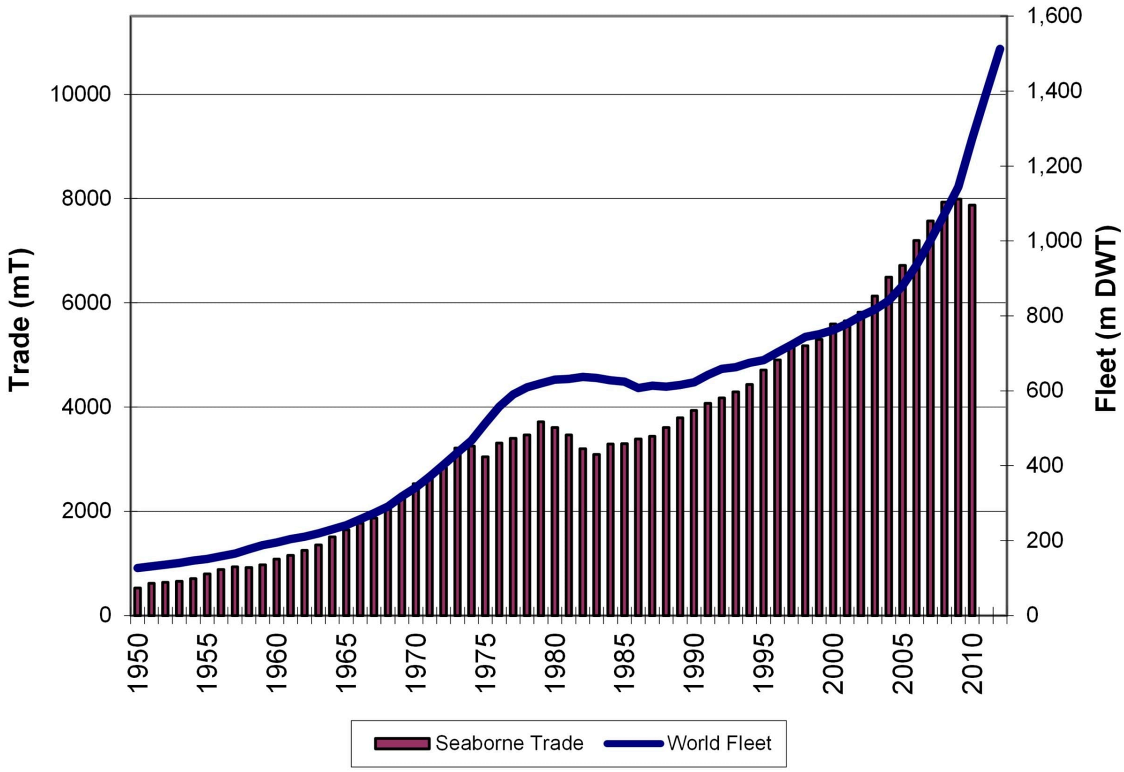

Figure 19 – Diagram showing the relationship between supply (fleet dwt) and demand (seaborne trade in mT) in shipping

- Between 1950 and 1965 excess tonnage prevailed and freight rates were subdued.
- In about 1966 the fleet moved to scarcity (the inelastic region of the supply curve) and shipping became highly profitable, stimulating investment in both new ships and new shipyards. It was during this period that the modern shipbuilding industry in Europe was established, Japan expanded and South Korea started planning to enter shipbuilding.
- In 1973 an oil crisis saw a downturn in seaborne trade but the backlog of orders that had built up led

to overcapacity in shipping that persisted for the next 20 years. Finance became averse to shipping, and the ordering of new ships became suppressed.

- By about 1998, expansion of trade had absorbed the excess capacity and eventually capacity became scarce again, leading to exceptional earning in shipping. Scarcity prevailed for about 10 years, up to 2008 and, again, investment in shipping and shipyards proliferated (in this period South Korea expanded and China entered shipbuilding). Finance became positively disposed towards shipping during this period.
- By 2008 scarcity in shipping was resolved and freight rates returned to lower levels, but the 'over-hang' of surplus tonnage due to be delivered into the fleet had reached almost 6 years of peak output from the expanded industry. Fleet overcapacity was inevitable and will prevail until world trade expands to absorb it.

Analysis could possibly predict where, towards the end of the trough phase, not enough ships are being constructed to serve world trade and scarcity is looming. This will not be seen in freight rates, however, which will remain suppressed, and therefore the cycle of boom and bust appears inevitable. This pattern appears destined to repeat, unless something fundamental changes in the system: which, of course, is entirely possible. What is important is that we understand the market principles so that good decisions can be made for the future of the sector.

It may also be perceived that the 'standard model' for forecasting shipbuilding demand cannot return a valid prediction in this context. Better forecasting could possibly damp the extremes of the cycle to some extent, making shipbuilding a more rational economic proposition for investors, although this would also, of course, eliminate some of the extreme value that some investors can realise by 'playing' the cycle.

Summary of demand and cycle drivers

Based on the preceding discussion, it is possible to summarise the pattern of shipbuilding demand as being caused by three elements:

1. **Demand drivers**, of which there are three: i) growth in seaborne trade leading to increased fleet capacity; ii) the reinvestment cycle, where obsolete tonnage is re-built; iii) fleet development cycles where new ship types are established, and obsolete types are phased out.
2. **Cycle drivers**, of which there are two: i) freight rate volatility and cycles, particularly spikes caused by the idiosyncratic nature of shipping's supply and demand functions; ii) perpetuation of previous cycles, in particular the effects of over-ordering that is inevitable at the peak, followed eventually by under-ordering when the supply and demand balance in shipping has recovered.
3. **Cyle exaggerators**, of which there are two: i) backlog, which exaggerates freight rates when ship-ping capacity is tight and which leads to inevitable over-ordering; ii) sentiment and lack of memory, particularly in the finance industry, which so far has inadequately learned the lessons of the past.

PART III
SUPPLY

6.

OVERVIEW

Shipbuilders come and go, as does market leadership and as do entire national industries. Current snapshots of the profile of suppliers provides useful information for strategic planning but it dates very quickly. The following sections consider how the industry has developed over the long term and draws out principles on which supply development is based. This is inevitably focussed on the 90% of shipbuilding production that is large commercial ships, but analysis of the global industry is followed by comments on other commercial market sectors.

Before looking at these matters it is important to understand why a precise specification of supply in shipbuilding is not achievable.

7.

THE UNMEASURABLE NATURE OF SHIPBUILDING SUPPLY

The capacity of a shipyard is consequent on two things: fixed capital and human capital. One form of capital is of no use without the other. Even the largest shipyard with extensive steel workshops, cranes and drydocks, has a capacity of zero if it has no workers. Similarly, the most productive labour force has zero capacity if it has no access to steel fabrication, assembly and launching facilities.

For both fixed and human capital, capacity is further determined by the effectiveness and efficiency of the two types of capital in relation to the product mix. The relationship between capacity and the product mix is important. To give an extreme example, a shipyard that is invested to build large bulk carriers and which carries a workforce that is skilled and experienced in building that type of ship will possess a very different capacity to that of the same investment and workforce if it were to re-focus its product mix to, say, cruise ships. Efficiency and productivity would change and, thereby, the capacity would also change.

Capacity of any shipbuilding yard will have a theoretical limit, determined by the rate at which steel can be fabricated and the rate at which ships can be assembled and launched. The rate of steel fabrication is limited by the area of fabrication facilities, the arrangement of cranes, the level of technology used, the number of persons employed and the productivity and utilisation of those persons. The rate of ship assembly and launching is limited by the type of launching arrangement (slipway or drydocks), the capacity of those arrangements, for example the number of slots available in the dock, the capacity of the final assembly crane and the number, productivity and utilisation of persons employed in ship assembly, testing and commissioning.

Other limitations may stem from the supply chain, for example relating to the availability of main engines or the availability of steel, and access to finance can also limit capacity. Finance limitations could stem from both contract finance (a shipyard cannot take orders if it cannot provide repayment guarantees) and working capital finance.

A permanent increase in supply would stem from investment in new shipyards or expansion of existing shipyards, and in the recruitment and training of human capital to put those investments to work. In the short-term capacity can also temporarily be modified through hiring/firing of the labour force or by subcontracting, either bringing additional labour into the shipyards on a temporary basis or subcontracting work outside the shipyard where this is an option. This would normally involve subcontracting of whole steel blocks to a third party, a tactic that was used extensively by South Korean shipyards around the peak of 2011, with entire blocks subcontracted to steel fabricators, including in China. Temporary increase of launching arrangements is more difficult but not impossible: Daewoo, for example, used a load-out quay and a floating dock to launch ships at the most recent peak and Samsung used a large floating crane to assemble ships offshore in a floating dock. Such arrangements will inevitably be accompanied by a reduction in efficiency and thereby higher costs, but this will be offset by peak prices that will justify such expedients. After the peak dissipates, the temporary docks can be sold for other uses.

The problem in quantifying capacity, therefore, is that there are so many variables it is practically impossible to achieve an estimate even in the short term. It might be postulated that this could be solved by saying that the capacity of a shipyard is de-facto equal to its current output. To some extent this is true, but this would inevitably under-estimate actual capacity because of the factor of utilisation of both labour and capital investment. More is always possible so as a measure of capacity per se this is limited. The flexibility of the facilities and labour in terms of quantity, and the limitations of flexibility in terms of product mix, would also have to be factored in.

In economic analysis, therefore, we have a problem: supply is un-quantifiable in practical terms. Happily, there is a derived factor, backlog, that provides a way around this problem by providing a proxy for capacity in economic modelling. This is discussed below in Part IV: price.

8.

MARKET LEADERS

Shipbuilding supply has been described as an 'hegemony', which is to say being dominated by a leading supplier. Certainly, in the past this has been the case and at the time of writing this book China is in the ascendancy.

To examine this, Figure 20 presents a time series of around 130 years, showing the development of share of commercial shipbuilding's market dominators[1].

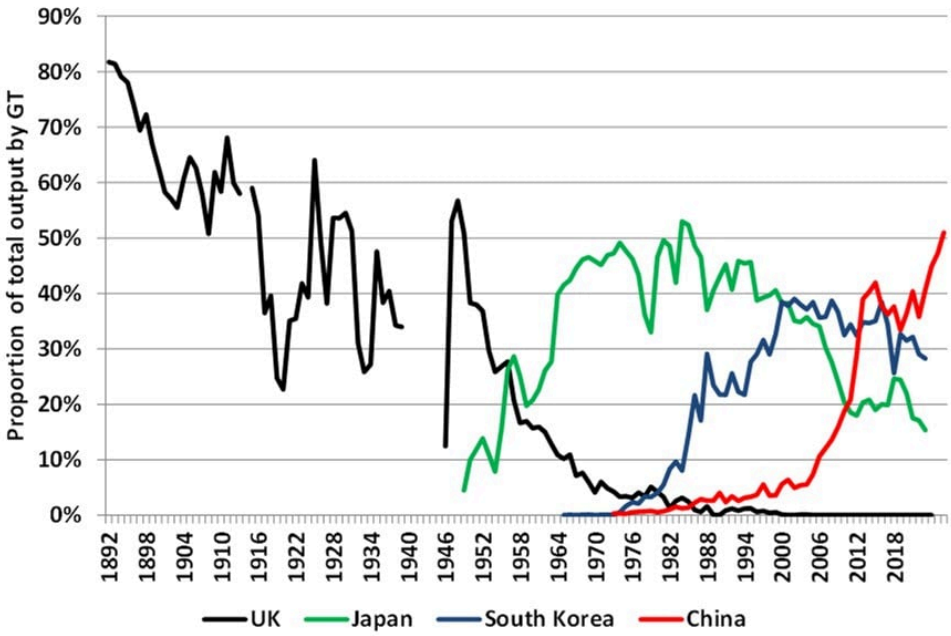

Figure 20 – Market share achieved by the market leader, 1892 to 2023 (Source: the author based on multiple sources)

The progression of market lead since 1892 has been as follows:

- UK led from 1892 to 1957. UK's success had its roots in technical supremacy in iron and steel in the 19th Century, coupled to a very strong home demand for commercial and warships for the British Empire. UK had lost its technical lead by the 1920s, however, with Germany in particular rising as a potential successor. This progression was curtailed by WWII.

1. Prior to the start-point of this chart, UK had been market leader since the onset of iron and steel construction but prior to that the United States was market leader, particularly due to the plentiful and cheap supply of soft wood. See: Slaven, A. (2013) British shipbuilding 1500-2010 : a history.

- Japan assumed the lead in the era of globalisation that developed following WWII. Shipbuilding was selected as one of the industries promoted to resurrect the decimated Japanese economy, benefitting from US expertise and capital. Japan also had, and continues to have, a significant home market.
- South Korea developed shipbuilding in the 1970s, as part of the goal to move the economy from an agrarian to an industrial basis. The industry was developed with tight government control, particularly in the era of the military government in power until 1988. Korea built on technologies and techniques developed in Japan but focussed heavily on economy of scale to achieve competitiveness.
- China repeated Japan and South Korea's achievements in using shipbuilding to develop the industrial base of the country, commencing around 2000 and is market leader at the time of writing this book.

Looking more closely at the characteristics of the curves presented in Figure 20, the period for which the market lead has been held has reduced progressively: 60 years + for UK, 42 years for Japan and 13 years for South Korea. It can also be seen that no subsequent dominator has achieved the level of share as the UK at its zenith, although having said that the UK was dominator of an industry that effectively ceased to exist in the age of globalisation and UK's typical output of around 1 million Tons per year was very small in the context of the modern era[2]. Figure 21 repeats Figure 20 but this time in tonnage of ships delivered rather than market share.

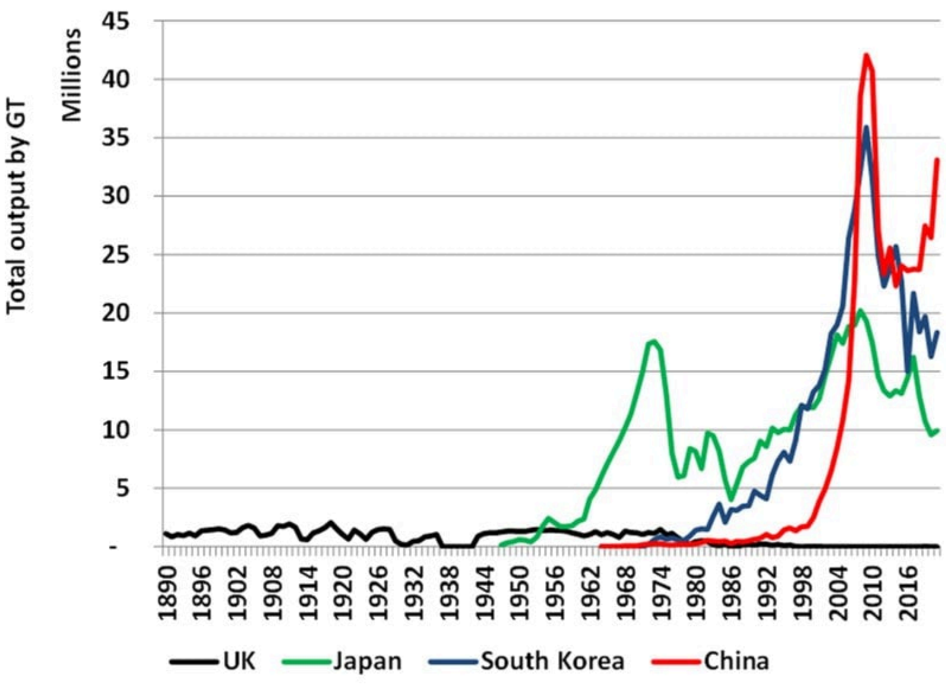

Figure 21 – Tonnage delivered by the market leader, 1892 to 2023 (Source: the author based on multiple sources)

2. Stott, P.W. (2017) 'Shipbuilding innovation: enabling technologies and economic imperatives', Journal of ship design and production, 33(3), pp. 1-11; Paul Stott (2023) Shipbuilding Policy in the UK: The Legacy of a Century of Decline and its Influence on Naval Procurement, The RUSI Journal, 168:5, 54-67, DOI:10.1080/03071847.2023.2250389.

The most obvious question that arises from this analysis is: where will the hegemony proceed next? Analysts speculate on this and Vietnam and India are commonly put in the frame as the next market dominators. Both countries have developed shipbuilding industries and India has tried hard to become a significant competitor, but both countries have, so far, failed to achieve significant market shares. Part of the problem is that establishing a large shipbuilding industry is very expensive and is not possible without significant government help: in other words, it is unlikely to be possible to establish a major industry using private capital alone[3]. The high cost is not only due to the capital investment in the shipyards themselves. To be competitive at scale the supply chain also needs to be established, including steel, main engine and marine equipment manufacturers. India's attempt at market penetration in the first decade of the 21st Century, for example, was based on a perceived competitive advantage from low labour cost, but with a requirement to import all steel and equipment from manufacturers across the Indian Ocean, incurring a cost that competitors did not have[4]. There is additionally a further significant invisible cost that requires support: losses during the period of build-up of competitiveness. This is further discussed below in the section on competitiveness. At this point it is important to point out that this period can be ten years or more and the cost of support for loss-making contracts in that period can be, order of magnitude, similar to the cost of capital investment.

To develop a market dominating position, therefore, a specific set of circumstances must be in place to stimulate government interest, and that interest has to extend to goals beyond shipbuilding itself. To elucidate this, it is helpful to repeat the underlying conditions that led to the four market dominators shown in the charts above.

1. United Kingdom: UK's dominance was based on economic necessity, building the large number of ships needed to serve a large global empire. Without this, trade and defence of the empire would have been vulnerable, and UK's economic potential would have been limited: ships were essential to the country's economic development.
2. Japan's dominance also stemmed from economic necessity, relating to the resurrection of the country's decimated economy following WWII. The industry developed alongside supplier industries, including steel, which were part of Japan's post-war "*economic miracle*".
3. South Korea's dominance also stemmed from economic necessity, based on the military government's aim to move the economy from an agrarian to an industrial basis. The country in effect emulated the success of Japan, but using scale to achieve competitiveness rather than shipbuilding technology per se. Steel and other marine equipment industries were developed alongside shipbuilding, harnessing shipbuilding's power as an economic generator.
4. China similarly used shipbuilding to stimulate the country's industrial economic development.

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3. Bruno, L. and Tenold, S. (2011) 'The basis for South Korea's ascent in the shipbuilding industry, 1970-1990', Mariners Mirror, 97(3), pp. 201-217.

4. India is a major steel producer but at the time produced no Grade A shipbuilding plate, the basic requirement for building ships, and there was no significant marine equipment supply sector in the country at the time. India's industry also lacked the scale needed to compete with South Korea and China, discussed below in the chapter on competitiveness.

It follows from this that if there is to be another dominator in future, the economic conditions and national ambition need to be present, as well as the financial strength to achieve dominance. At the time of writing this book there are no clear candidates for this position. This raises the question as to whether an hegemony in shipbuilding is inevitable: just because it has been the case in the past does not mean it will propagate into the future. This is worthy of further research, given that a change in this pattern could mean a sharing of opportunity between countries in future.

9.

THE DEVELOPMENT OF PRODUCT MIX

Prior to about 1960 shipbuilding was a highly skilled craft-based business and this was reflected in typical product mixes of shipyards. The highly skilled workforce would turn its hand to anything, and the variety of products was very high. It was often possible to identify the shipbuilder from design features that could be seen on the vessels themselves and ship owners demanded unique designs to their own detailed requirements and specifications.

Under the influence of the industry in Japan and as a product of globalisation, ships after about 1960 started to become much larger and standardisation became the norm, not only for specific ship types but between shipyards. This is not to say that ships became identical, but principal dimensions, arrangement, powering and equipment became pretty-much uniform, with details varying primarily in terms of makers of the equipment fitted. The level of skill also gradually reduced as mechanisation was introduced as far as possible into shipyards: starting with the steel preparation processes (shotblasting and priming of plates), with automated steel cutting and panel fabrication following. By the peak of 1975 the market leader, Mitsubishi Nagasaki of Japan, had become a 'ship factory' rather than a shipyard, and the factory mass-produced a single product-type: VLCCs at a rate of more than one per month.

Following the 1973 oil crisis the demand for VLCCs evaporated and it became clear that volatilities in demand meant that it is not viable, at least in the long term, for a shipyard to focus all its efforts on a single product. Flexibility to build a range of similar products is needed to stay in business. Production techniques based around common interim product families[1], commonly referred to as "*group technology*", were developed and computer-aided design and production became established to facilitate this.

The development of product mix in shipbuilding has mirrored closely the progression of that in automobile manufacture, as described in the book *The Machine that Changed the World* [2] by Harvard professor JP Womack and colleagues. At the start of the twentieth century motor cars were one-off, coach-built and extremely expensive, being affordable only by the very wealthy. Henry Ford changed that with his mass-production of the Model T following its introduction in 1908. Customers demanded variety however, and by the 1920s General Motors was developing production techniques to deliver product variety from the

1. Interim products are the individual sub-products fabricated in the shipyard from which the ship is assembled. The most numerous is the 'stiffened flat panel', being the basic steel unit from which ships are constructed. See: Lamb, T., Society of Naval, A. and Marine, E. (2003) Ship design and construction. Jersey City, N.J: Society of Naval Architects and Marine Engineers.

2. Womack, J.P., Jones, D.T., Roos, D. and Massachusetts Institute of Technology. (1990) The machine that changed the world : based on the Massachusetts Institute of Technology 5-million dollar 5-year study on the future of the automobile. New York: Rawson Associates.

production lines. The situation was developed further through lean manufacturing by Toyota in the post-WWII period.

Womack developed a framework to show this progression, which can be adapted to show the progression of product mix development in shipbuilding. It provides a useful strategic framework. Figure 22 shows a development of this framework for commercial shipbuilding.

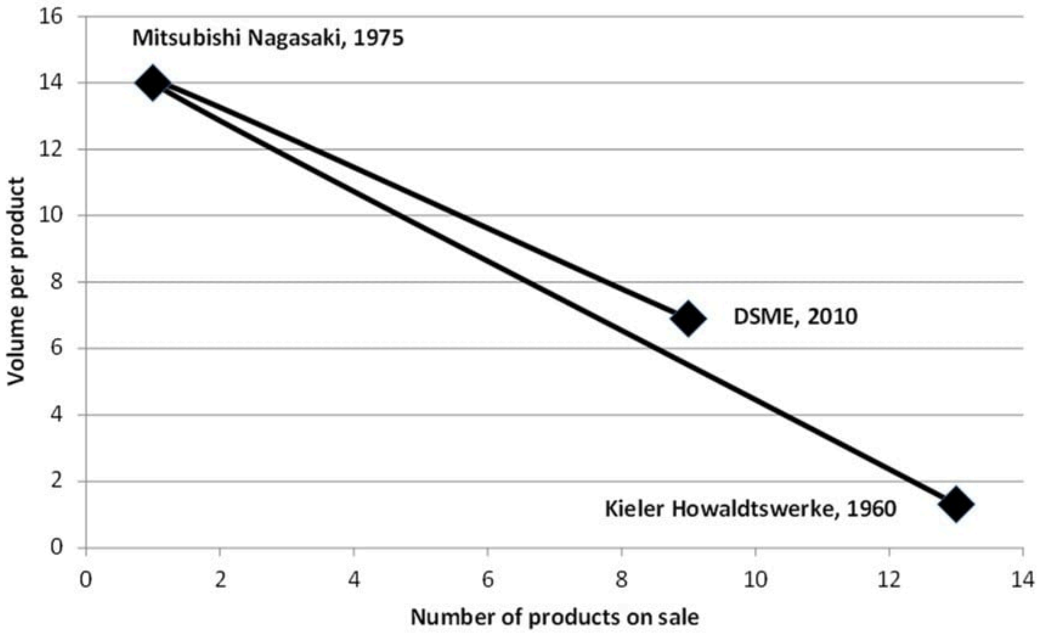

Figure 22 – Development of product mix in commercial shipbuilding market leaders, using the framework developed by Womack for automotive (source: authors research)

The horizontal axis shows the number of products on sale in the years chosen and the vertical axis shows the average number of each product sold in the year. Multiplying the two coordinates together gives the total number of ships delivered in the year. In this analysis a product may relate to a specific ship type, for example an LNG tanker, or sub-types within a ship sector: for example, VLCC, Suezmax and Aframax for tankers or panamax and capesize for dry bulk. The market leaders at three points in time are shown: in 1960 and then subsequently around the two market peaks in 1975 and 2010.

- In 1960, Kieler Howaldswerke of Germany delivered 13 unique products, the vertical ordinate being 1. The analogy is the coach-built automotive sector prior to Henry Ford.
- In 1975 the situation had reversed with the horizontal ordinate being 1 and the vertical 14: Mitsubishi delivered 14 identical VLCCs in that year. The analogy is mass production of the Model T.
- In 2010 flexibility has been introduced, with DSME delivering 63 ships of 9 different types. The analogy is flexibility in product mix developed by GM and Toyota. In shipbuilding this level of flexibility is a fundamental requirement for high volume of production.

Where this track proceeds next in shipbuilding is not currently clear but it might be noted that there are flaws in the volume competitive strategy represented by Daewoo's position on this chart, discussed further in the section on competitiveness. Greater flexibility whilst benefitting from the advantages of digital technologies may be the way forward.

In summary, the suppliers (shipbuilders) utilise group technologies to provide a product mix that is, to some degree, proof against the volatilities of the market and shifts in demand between products. There remain, however, niche sectors where more specialised builders exist. These are discussed at the end of this section.

10.

THE DEVELOPMENT OF SCALE

In line with the development of product mix, the size of market leading shipyards has increased exponentially since 1960. The pursuit of volume has been a strategy for competitiveness and has been substantially, although not exclusively, a feature of the industry in South Korea. It has been a highly successful strategy, as evidenced by Korea's progression in the hegemony shown earlier, but the approach may not be invulnerable.

Figure 23 shows how the volume of output of the market leading shipyard at the start of each decade has progressed between 1960 and 2020.

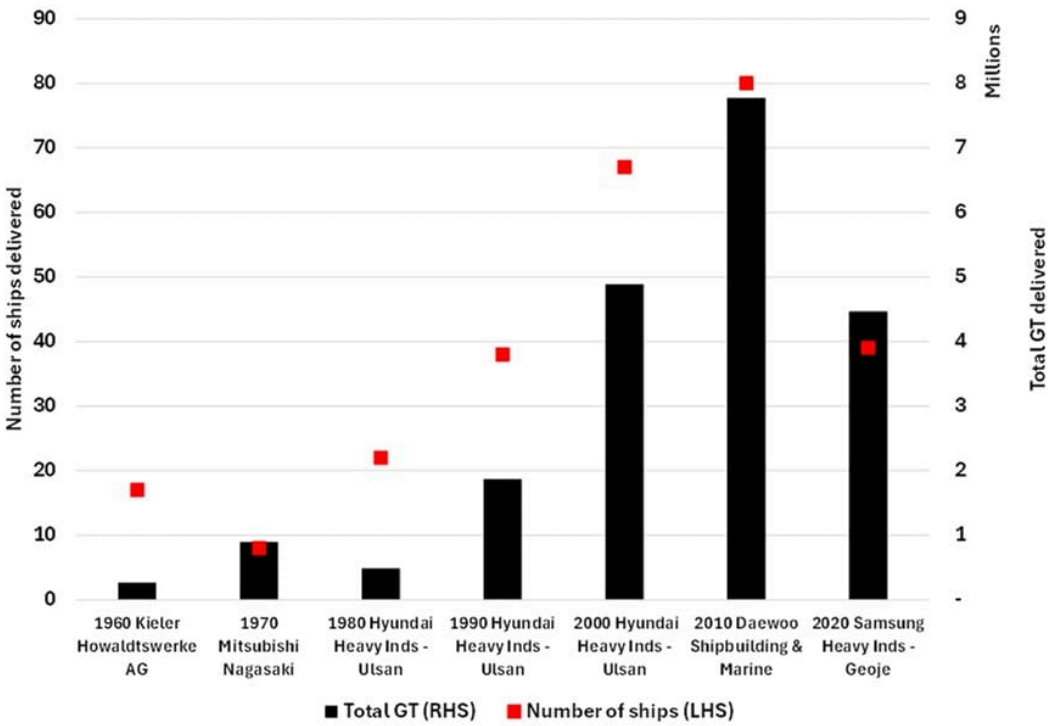

Figure 23 – Output from market leading shipyards (number of ships and tons delivered) at the start of each decade since 1960

The pursuit of volume became a feature in the development of the South Korean industry following 1990 and in 2010 the world's leading shipyard produced five times as many ships and thirty times the gross tonnage compared to the leader in 1960. To give a more direct comparator by which to judge scale, this would involve fabricating around 3 million tonnes of steel in a single year and installing more than 60 main engines. 2010 usefully corresponded with a demand peak, so the graph shows what is possible from a single yard when the market provides enough work. The downturn in 2020, however, points to one of the flaws in the pursuit of competitiveness through volume: it is only 100% effective when demand justifies it, which is to say at the peaks. For most of the time the capacity developed is destined to be under-utilised.

It is particularly the industry in South Korea that has pursued competitiveness through volume to the degree suggested here. In 2020, leading Chinese shipyards produced about ½ the tonnage compared to the leading South Korean shipyard. The proportion of deliveries against number of shipyards in the leading three shipbuilding nations in 2020 is examined in Figure 24.

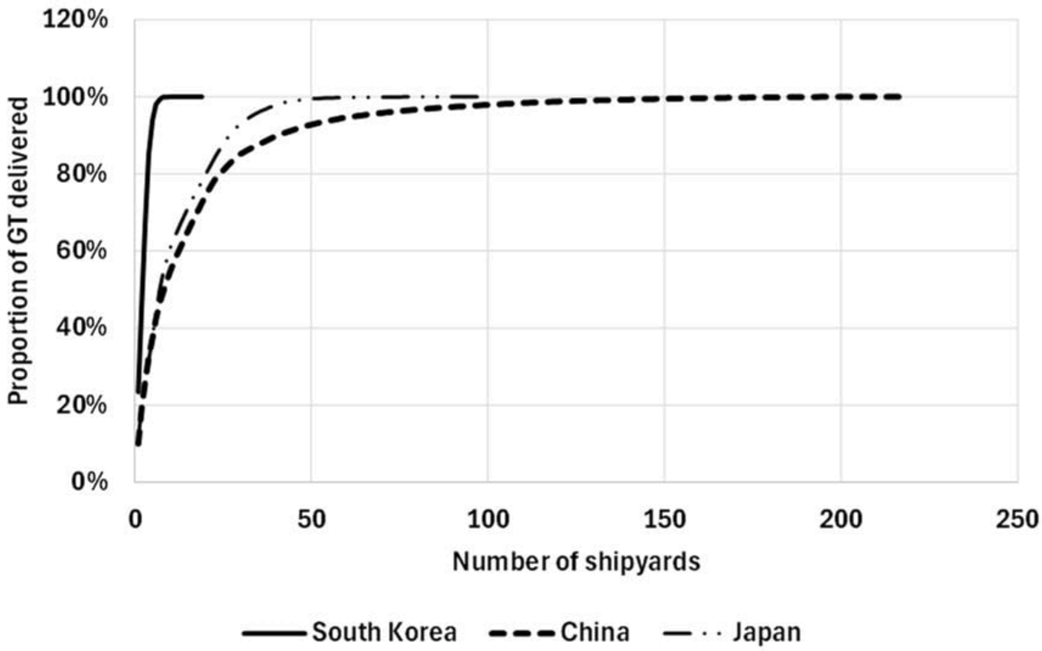

Figure 24 – GT delivered in 2020: proportion of deliveries against number of shipyards

The majority of output from South Korea was from 5 super-large shipyards, compared to around 50 in Japan and around 150 in China. The output from the leading shipyard in each country in 2020, in GT, is shown in Figure 25. In approximate terms, the leading South Korean yard was twice the size of the leading Chinese yard and three times the size of the leading Japanese yard.

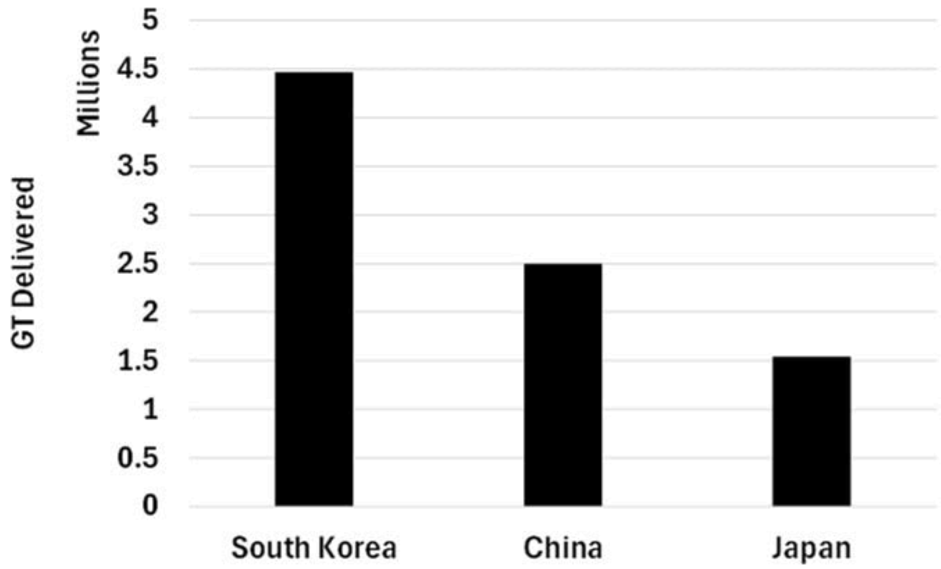

Figure 25 – Output from the largest shipyard by country in 2020

The advantages of scale relate to economic efficiency and control of the industry. With size comes vulnerability, however, as demonstrated by the downturn that can be seen between 2010 and 2020 in Figure 23. This is discussed further in the section on competitiveness.

11.

THE CHARACTERISTICS OF SUPPLY AWAY FROM THE VOLUME MARKET

As a general principle, as the size of ship becomes smaller the shipbuilding industry becomes more dispersed, with numerous small suppliers around the globe, often specialising in specific ship types, for example dredgers or fishing vessels or small ferries, and often focussed on local or regional contracts. The main exceptions to this are:

- In the small ship sectors, the global market leader, Damen, offers a globally dispersed building strategy that achieves a hybrid form of volume production for smaller ships. This is often based on standard products that are well proven, and which provide assurance for customers that may not be frequent buyers of new ships. What is being purchased is a known quantity and this reduces the risk for the buyer, who may be prepared to pay some premium for that assurance. The Damen strategy also includes elements of the separation of the design, sales, fabrication and assembly, which is not normally found with larger ships.
- Cruise ships are predominantly built in a limited number of large specialist yards located in Europe, with ready access to the specialist supply chain that is essential to the building of these ships. These products are highly complex in design and construction and experience and track record contribute to competitiveness. Complexity and specialisation, along with the essential specialist supply chain, present a barrier to entry for those aspiring to the sector. Non-specialist shipyards in Japan and China have attempted to diversify into cruise building, but with limited success so far. Cruise ship building keys into none of the factors of competitiveness that lead to success in general volume shipbuilding: the high-volume steel capacity is not needed; the thin plate typical in cruise ships is poorly compatible with the production lines needed for volume ships; and the high-volume supply chain is substantially not relevant to cruise building. The specialisation needed to compete in this sector does not come without risk for the builder, however: this is a single product sector and without access to a product mix the shipyards may be vulnerable to shifts in demand.
- Yacht building is also concentrated in Europe in a relatively small number of highly specialist shipyards. The yards have a brand reputation that is important to the buyer and therefore attracts a premium. Having said that, lower cost builders can at times gain work on a price basis.

PART IV
PRICE

12.

INTRODUCTION

Newbuilding price, as might be expected, is cyclical. Figure 26 presents Clarksons Newbuilding Price Index for the period 1996 to 2025. As with other sections of this book, we now need to try to objectively answer the question: why does the market behave in this highly cyclical way?

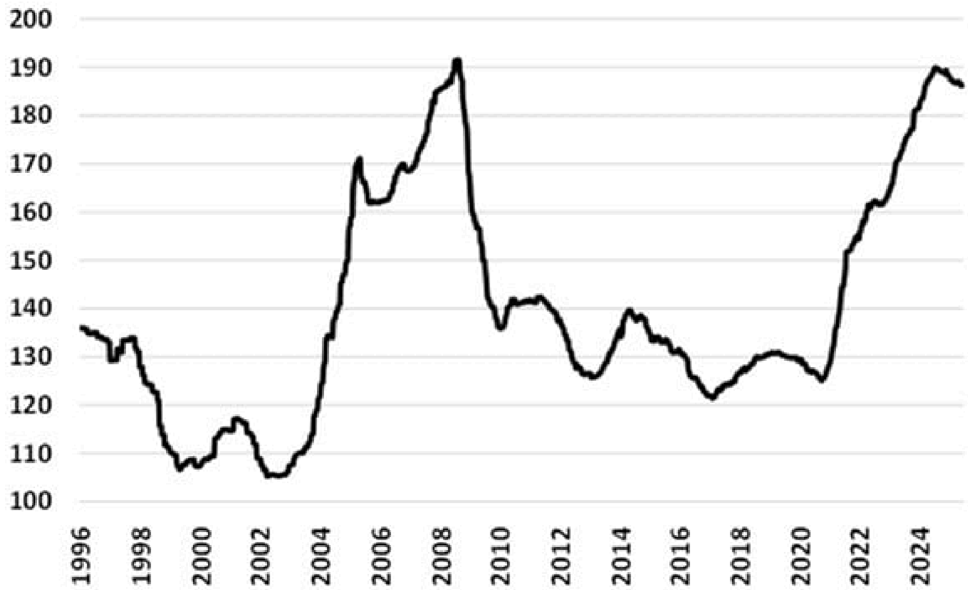

Figure 26: Clarkson Newbuilding Price Index

In 1921, shipbuilder Maxwell Ballard published a paper in the transactions of the (then) prestigious North-east Coast Institution of Engineers and Shipbuilders[1] relating to the behaviour of shipbuilding prices. He reported two features of prices which surprised him. Firstly, he had expected prices of ships to correlate with price of steel and equipment, i.e. the cost of raw materials, but he found no such correlation. What he found instead was that prices of new ships correlated with freight rates. Secondly, he was surprised to find that the prices of different ship types moved together closely in parallel rather than being related to differentiated demand for those types. Ballard had stumbled across two important principles in the determination of ship prices. Firstly, that prices are set within a market that balances supply and demand, with increased freight rates leading to increased demand and, thereby, increased prices: cost inputs may (at times) be of secondary importance. Secondly, that different ship types are, for the shipbuilder, economic substitutes.

1. Ballard, M. (1921) 'The relation between shipbuilding production, prices, and the freight market', Transactions of the North East Coast Institution of Engineers and Shipbuilders.

The shipyard is just as happy building a tanker as a dry cargo ship, providing that the price is right. The function of the ship is, to the shipbuilder, largely immaterial.

The correlation that Ballard found with freight rates implies that ship prices reflect to some degree what the buyer is prepared to pay for the ship. This is far from the only influence determining the price of new ships, however, and the balance of influences changes over the cycle and depending on the conditions in the shipbuilding industry. Other influences include material costs, backlog and government support. In extremis, government support (subsidy) might lead to price being below the minimum rational value, that being the break-even cost for the shipbuilder.

The principle of substitutability is of central importance to shipbuilding prices and relates to the development of product mix. To understand this, we must establish two principles central to shipbuilding price determination.

1. When a shipbuilding contract is placed the ship does not exist and will not exist for between 2 and 6 years depending on backlog. What is traded at the point of contract, therefore, is not a ship but a promise by the shipyard to provide capacity (known in the industry as a 'slot') at a future time to design, fabricate, launch, commission, test and deliver the ship specified by the buyer. The shipbuilding market, therefore, trades in slots and not ships, and price relates to the value of the slot within which the ship will be built.
2. The slot is flexible within the product mix of the shipbuilder. Consider the case where a shipbuilder takes an order for a container ship but before construction starts that order is somehow cancelled. The shipbuilder will then seek to re-sell that slot but it is not necessary that the slot is re-sold to build a container ship similar to the original order. It will be sold to whatever ship type represents the best option for the slot at the time of the re-sale. For the shipbuilder, the ships that are within its product mix are economic substitutes and the value of the slot translates to the price level of all ship types within its product mix competing for that slot: which is why prices for different ship types move in parallel. It also explains why an irrationally high price could be attributed to a ship type for which there is zero demand and for which shipping prospects are poor. For the builder such an order would compete for a slot with other ship types where prospects may be better, and the price will reflect that.

13.

SUPPLY AND DEMAND FUNCTIONS IN SHIPBUILDING

General principles can be found in text books and progress has been made by economists in OECD[1] but the economics of shipbuilding is in general under-researched. The generalities of supply and demand are examined in the previous two chapters of this book, but what shape are the economic functions in shipbuilding that combine these factors to determine price?

In principle it may be stated that the demand curve is elastic and the supply curve is 'J' shaped. A notional shape is presented in Figure 27.

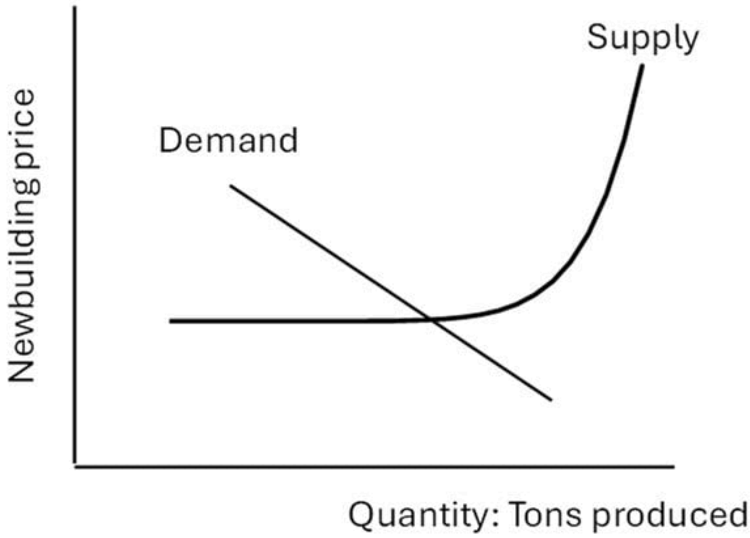

Figure 27 – Notional forms of supply and demand functions in the shipbuilding market

The inelastic portion of the supply function (i.e. the upright portion of the 'J' shaped curve) will lead to spikes in price, as it does in the shipping markets, and as can be seen in the newbuilding price index in Figure 26. The elasticity of the demand function, however, is different to that in shipping, where demand is quasi-inelastic (i.e. a near-vertical line). The higher elasticity of shipbuilding demand opens the potential that pricing strategy might be used to stimulate demand. In other words, when demand is low there may be potential to increase it by lowering price. This, in turn, leads to the subject of subsidy, which has been used

1. Gordon, K. (2019) An analysis of market-distorting factors in shipbuilding – the role of government interventions. Paris: OECD.

in the past to support uneconomic capacity. This is discussed further in the chapter on competitiveness. It should also be noted that when supply is short, the vertical part of the supply function, additional capacity cannot easily be developed. New shipbuilding capacity takes time.

14.

COSTS AND GROSS MARGIN

Cost of construction varies for different ship types and between suppliers, depending on the efficiency of the business and its workforce, volume of production, characteristics of the supply chain and the cost base of the building country. It is therefore not possible to produce a single indicative breakdown of costs for the industry. In general, however, it may be stated that shipbuilding is a low gross margin business: this manifests as supply chain costs predominating over labour and overhead costs, typically in the ratio of about 70:30. A notional breakdown is given in Figure 28.

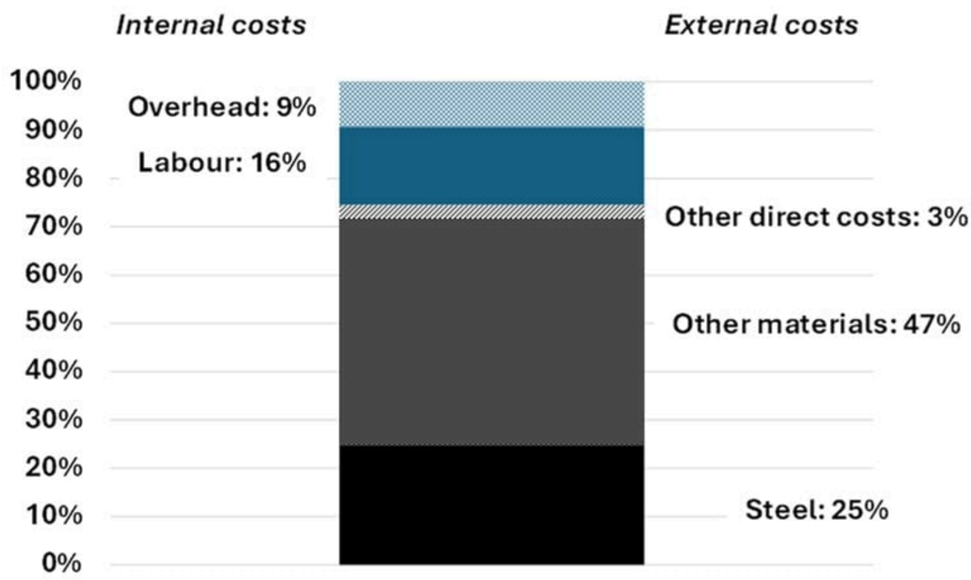

Figure 28 – Notional typical cost breakdown for commercial ships

In this chart:

- steel is the structural material from which the ship is built;
- other materials include all other materials such as the main engine and supporting equipment, propeller and shafting, pipes, pumps, valves, deck and cargo handling equipment, hatch covers, bridge equipment, electrical equipment and so on.
- Other direct costs include classification, builders risk insurance and any other cost that can be directly attributed to the contract, such as consultancy or licensing costs.
- Labour is production workers that charge their time against the contract, commonly referred to as 'direct' labour.
- Overhead, also called establishment costs, is a contribution to labour cost that cannot be charged

against specific contracts (i.e. 'indirect' labour), maintenance, management, plus office costs, marketing and so on. In some cases the cost of energy may be separated out to contracts, but in this example it is notionally charged as an overhead cost.

It should be noted that this breakdown includes no provision for depreciation or, in cash terms, for generation of revenue to cover finance costs for indebtedness (of the business itself, rather than for contract finance). These factors can add significantly to the cost of shipbuilding, particularly for heavily indebted shipyards.

Whilst the detail will vary between ship types and shipyards, the 70:30 split has been found to be robust in cost modelling. The heavy reliance on external suppliers demonstrates one of the advantages that stem from volume in the shipyard. It also demonstrates why location in a country with a strong steel and marine equipment supply sector is important for competitiveness. The worst case for competitiveness is having to import relatively low volumes of steel and materials for long distances, which will significantly increase costs.

For the labour and overhead costs, efficiency is extremely important, but the potential for cost reduction in those internal cost categories is about 60% weaker than the potential of each $ saved in the supply chain.

15.

THE CRITICAL ROLE OF BACKLOG IN SHIPBUILDING ECONOMICS

Backlog has several important significances in shipbuilding economics. Firstly, as previously discussed, it represents a measure of risk for both the buyer and builder in the shipbuilding transaction, and this influences both buyer and builder behaviour. Secondly, backlog is a measure of utilisation of capacity and, thereby, solves the problem that supply (capacity) itself is not quantifiable. The importance of backlog is such that it is the most consistently significant factor in modelling of shipbuilding prices – showing more consistent significance than the two other important predictors: material costs and freight rates[1]. The reason for this is that it effectively provides a proxy for the balance between supply and demand and therefore relates directly to the underlying economics of the system.

Taking, firstly, the effects of backlog on risk. The effect on pricing can be summarised (roughly) as follows:

- If backlog falls below about 2½ years, builders will be motivated to discount prices to try to increase throughput and avoid running out of work. In extremis this may mean pricing below cost, leading to losses and possibly dependency on subsidy.
- As backlog rises shipbuilders will increase prices and the basis of pricing will shift from cost covering to rational pricing, taking into account customers' earning opportunities and thereby what they may be willing to pay. Freight rate becomes more significant as a price determinant at this point. Prices will rise rapidly, once the backlog exceeds around 3 years.
- When backlog exceeds 4 years the risk for the buyer increases: what will conditions be in the shipping market in 4+ years' time? Further price increases will be resisted, resulting in a slower rate of increase, even where the underlying driver, freight rates, continues to spike.
- Following a peak of demand prices may be to some degree 'sticky' even where dramatic falls in demand occur. With a backlog of 6 years the shipbuilder is not in immediate need of new work and there is little benefit to reduction of prices. When backlog falls back to around 3 years, on the other hand, the shipbuilder will become motivated to reduce prices to attract orders.

Before leaving the subject of backlog it is important to analyse two further attributes: firstly, that backlog is not uniform across the market, secondly, it is not only demand that causes backlog to vary.

1. Stott, P. (2017) Competition and subsidy in commercial shipbuilding. PhD thesis. Newcastle University.

Figure 29 shows how backlog has developed since 2020 in the three market leading shipbuilding nations.

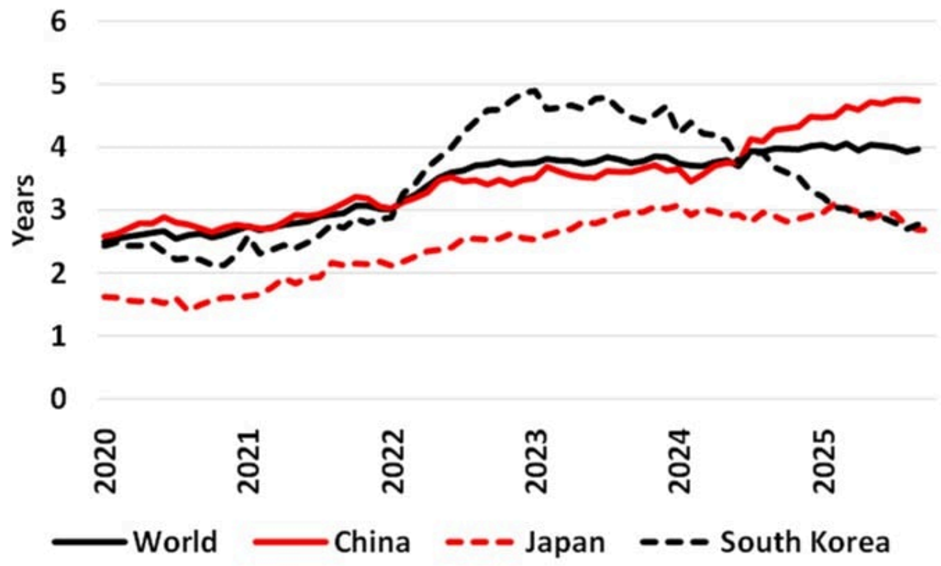

Figure 29 – Backlog globally and in the three market leading countries

Whilst the total backlog has increased to around 4 years, that in market leaders South Korea and China has approached 5 years. Japan, on the other hand, has not recently exceeded three years. This will have had a significant effect on price formation, increasing price higher than the average global 4-year backlog would suggest, because the market leaders are operating below capacity. Because of cross-price elasticity and because the market is based on slot value, increased prices will be available to all shipbuilders despite individual differences in backlog.

Backlog in 2026 is, in general, higher than might be anticipated at this stage of the cycle (demand is still very much in recession). The reason for this is that supply has not kept pace with increasing demand or, in other words, the orderbook has been growing but output growth is lagging. The growth in orderbooks and output for the total market and for leading shipbuilding countries is presented in Table 2.

Sector	Growth in orderbook since 2020 (CGT)	Growth in output since 2020 (CGT delivered per annum)
World	92%	21%
China	213%	71%
South Korea	47%	30%
Japan	0%	-40%

Table 2 – Change in orderbook and annual delivery rate (CGT) 2020 to 2026

In Japan, orderbooks are relatively flat but output is falling. In South Korea output has picked up over the past year and this has reduced backlog. Only in China has output been increasing significantly but still lagging well behind the growth in orders.

This appears to be a new development in the shipbuilding market. In the past output has kept pace with orderbooks more closely. There are three possible explanations for this:

- output growth is simply lagging, given suppressed output over the past ten years, and will catch up in the future, or;
- supply is being restricted as a matter of business strategy, to increase prices, or;
- labour shortages are beginning to restrict supply as it becomes more difficult to attract new persons into the industry.

The situation must develop further to identify the extent to which these three factors are affecting the market.

16.

PAYMENT TERMS

As well as the price of the ship, in concluding a contract the payment terms will be a matter of negotiation. Payment terms are necessary to manage risks in a shipbuilding contract: the buyer is unlikely to want to pay for the ship, which will not exist for several years, at the time of contract placement. The risk would be too high. The builder, on the other hand, is unlikely to accept payment in full on delivery of the ship. The risk from default would be too high and the funding of working capital to facilitate this would be expensive.

In practice, therefore, payment is made partly at the point of contract, typically 10% of the contract value, and then according to a payment scheme that reflects the value created during the construction of the ship, with a final payment on completion. In an ideal world the payment scheme would be neutral, with advantage to neither party, with payment made to match expenditure by the shipyard. It would be possible to achieve such terms, based on verified inspections of work and bills of materials on, say, a monthly basis. In practice, however, this makes billing difficult and expensive, and the payment scheme is normally approximated according to key production milestones. Typical schemes might be:

- 10% on order and 10% on delivery, with 4 payments of 20% at equal periods between the two points. This scheme has the advantage that it is simple and easily verified but has the disadvantage that it is not necessarily related to value of work completed.
- 10% on order and 10% on delivery, with other payments triggered by key events, for example commencement of steel cutting, keel laying, 50% of steelwork completed and launch. The stages need to be verified by the owner's representative and there is some potential for manipulation by the builder: early laying of the keel or commencement of steel cutting, for example, could be used to accelerate payment earlier than value creation might objectively justify.

Whilst the achievement of a neutral scheme is the ideal situation, actual terms reflect the negotiating strengths of the two parties in concluding the contract. In a buyers' market, where demand is weak and the shipyard is keen to conclude the contract, the power is with the buyer and the payment terms may be skewed towards completion. If finance is available to support it, advantageous payment terms can be used along with low prices to stimulate work in a poor market. The most extreme example encountered by the author was 10% on contract and 90% on completion, for a developing shipyard that was keen to attract work in a poor market, and which was supported by a government bank to do so. On the other hand, in a sellers' market the payment terms may be skewed towards the contact, the power lying with the shipyard and the buyer keen to secure whatever slots may be available.

The payment scheme is therefore a variable. Cost of finance for working capital and down payments (the ship cannot earn revenue to re-pay debt until it is completed) can be significant, amounting to several million $US for a large ship. This amount modifies the price for the buyer and the cost for the builder.

17.

SUMMARY OF PRICE FACTORS

The newbuilding price of a ship is determined by the cost to build, by the value of the slot it is competing for and by the price the buyer may be willing to pay. Because the slot is flexible within the potential product mix, there is cross price elasticity between ship types competing for the same slot and between shipyards competing for the same opportunities.

More specifically, price is determined by:

- the cost of construction, which determines the minimum rational price for the seller, unless support is available, either from the shipyard's reserves or from an external organisation (e.g. a subsidy);
- freight rates, which, as discussed previously, are a key determinant of demand for new ships, and which determine the rational price for the buyer: in other words, how much is the buyer prepared to pay?
- backlog, which is a proxy for balance between supply and demand.

The balance of significance between costs and freight rates varies over the shipbuilding demand cycle but backlog remains a strong determinant at all stages and is the most significant single determinant of newbuilding price.

It is easiest to summarise the influences by mapping the latest cycle against the cost drivers, using steel plate price as the proxy for material costs. Figure 30 shows newbuilding prices mapped against steel place prices, shipowner earnings (Clarksea Index), ordering (CGT), total orderbook (CGT) and backlog (years)[1].

1. Information sourced from Clarkson Research SIN, except for backlog, which is the author's estimate

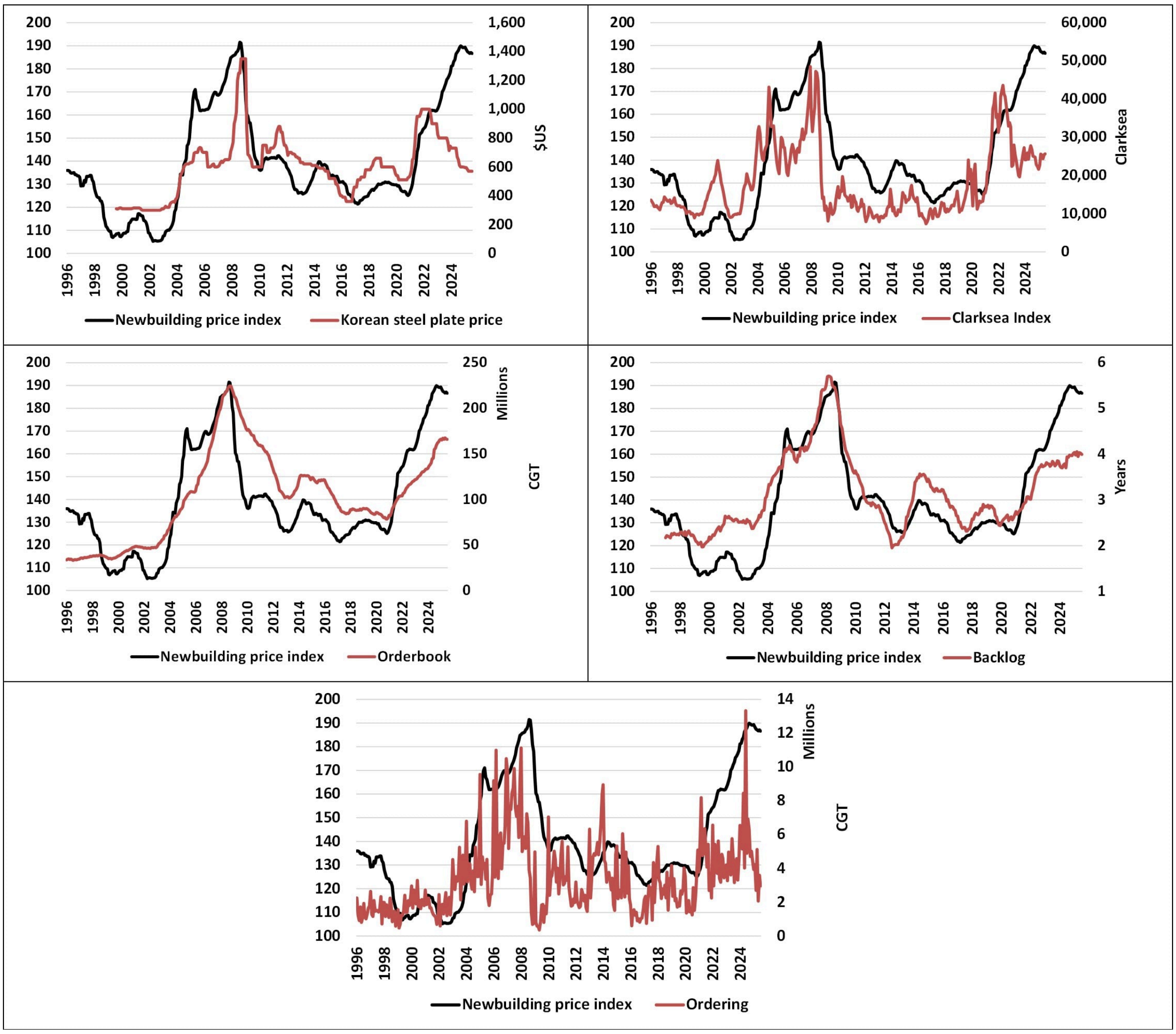

Figure 30 – Determinants of newbuilding prices (determinants RHS, price LHS: source, the author based on information from Clarkson SIN)

The development of price was as follows:

1. 1996 to 2003: backlog remained low at around 2 to 2 ½ years and owners' earnings remained subdued due to oversupply in the fleet. No significant increase in ordering was the result. A small increase in price in 2001 appears to have been triggered by small increases in earnings and backlog but what is hard to explain in this period is the significant fall in price after 1997. This was the period of the EU complaint against South Korea at the WTO where it was argued that this was price suppression in a period of capacity expansion in South Korea. The WTO did not find that this had been proven.
2. 2003 to 2005: owners' earnings began a significant rise at the start of 2003, as supply in the fleet became tight. This led to a sharp increase in ordering, with orderbook and backlog following. Shipbuilding costs also increased at this time, with steel plate price increasing from around $300 per tonne to $700 per tonne. Backlog increased to 4 years and newbuild prices rose quickly.
3. 2005 to 2006: Owners' earnings and ordering fell sharply in 2005, as new tonnage started to be deliv-

ered into the fleet, and backlog had risen to 4 years. Steel plate remained steady at around $600 to $700 per tonne. At this point the increase in newbuilding prices faltered, with buyer's risk increasing and the freight markets becoming more volatile.

4. 2006 to 2008: newbuilding price increased further to peak level as owner's earnings recovered and then increased further and backlog increased to a peak of almost 6 years. The rate of increase of price was slower than in the period up to 2006, however, because of greater uncertainty in the market. Steel prices did eventually increase, up to around $1,300 per tonne, but not until the end of this period and only for a short time.
5. 2008 to 2010: the Clarksea index plummeted as balance was restored to the fleet but the 6-year backlog meant that oversupply was inevitable. Ordering dried up and the orderbook and backlog plummeted. The price of steel plate halved almost overnight, back down to $600 per tonne. Newbuilding prices plummeted in response.
6. 2010 to 2021: shipowners' earnings and ordering retreated to trough levels and newbuilding prices returned to pre-1998 levels (i.e. pre the disputed period that led to EU's WTO action). Prices at this point correlated poorly with owners' earnings but well with steel plate price and backlog, which had fallen back to 2½ to 3 years, slightly higher than the level it was prior to the start of the boom period in 2003.
7. 2021 to 2025: in 2021 newbuilding prices rose sharply in response to an increase in owners' earnings, which resulted in a significant increase in the orderbook and backlog, which rose to around 4 years. The increase in earnings was triggered by a combination of covid effects, war and route disruptions, added to which was an upturn in the demand for new LNG tankers and large container ships. A spike of new orders in 2024 is particularly noticeable in the data. In addition, this was a period of high inflation, peaking in 2023, which increased shipbuilders' costs. Following 2022, however, the fundamentals fell but prices carried on rising. It is possible that slot value reflects the large number of LNG orders taken in South Korea and high backlog achieved in that country. This requires further research, however, to fully understand the dynamics. Fundamentally, both backlog and price are higher than might be expected at this stage of the shipbuilding cycle. How much of this is down to inflation and how much to other factors, such as shipbuilding supply restriction, has not been rigorously determined[2].

Finally, a caveat is required to this section. It must be acknowledged that the rigorous econometric analysis that would finally prove cross-price elasticity in shipbuilding has remained elusive, probably because of limitations of readily available data. The author's approach was to demonstrate using correlation and linear regression that prices for new ships were closely correlated with each other, and not necessarily with demand for the ship type itself or its economic prospects. Proof is so far, therefore, below the level of rigorous economic methods, but the results were nonetheless robust and conclusive. It was clearly demonstrated that cross-price elasticity can be seen in historic prices, but without arriving at a generalised theory. Given

2. A rough estimate by the author in 2025 suggests that inflation accounts for around 40% of the price increase, but this is very tentative.

the strength of the individual predictors and the variation in influence between them over time, it is possible that AI could provide an interesting route for price prediction in commercial shipbuilding, and this is recommended for further research.

PART V
COMPETITIVENESS

18.

OVERVIEW OF COMMERCIAL SHIPBUILDING COMPETITIVENESS

In commercial shipbuilding, except in certain sectors (for example, yachts and cruise ships), it is difficult for shipbuilders to differentiate themselves through branding, product design, technical features or product quality. Part of the reason for this is that the quality of ships is assured through classification and compliance with IMO regulations, and this leaves little room for such differentiation. For large commercial ships the purchasing decision, usually facilitated with the help of a sale and purchase broker, is made based on available slots and the track record of the shipbuilder, but above all is likely to be based on price. In seeking to gain new customers a shipbuilder may have to offer additional incentives, often based on advantageous payment terms or access to financing.

Competitiveness in commercial shipbuilding, therefore, can be defined fundamentally as the ability to meet a market-derived price.

The availability of a home market can additionally be advantageous and domestic ordering is important. Where a competitive supplier exists, a buyer would prefer to order from a domestic shipbuilder to reduce purchasing costs and transactional risk. This is particularly significant in the smaller ship sectors, where purchases are more likely to be made domestically or regionally.

It is also a feature of shipbuilding that suppliers seeking to enter a market face very few barriers apart from the high capital cost of building and establishing a new shipyard. The exceptions to this are LNG ships, where qualification to build is required, cruise ships, which have technical, reputational and supply chain barriers, and yachts where brand presence needs to be established along with design and product quality. The lack of barriers in most sectors however reinforces the over-riding nature of price as the chief determinant of competitiveness.

Factors that confer competitive advantage are wide ranging and can vary over time. They include, inter alia, access to a strong home market, a supportive government, ready access to finance and access to a competitive domestic marine equipment supply industry. To this might be added: investment in fixed and human capital, intelligent design and production engineering and investment in planning and logistics (material control), all of which contribute strongly to productivity of the workforce.

It should be noted that low wages do not figure in this list. Low wage alone confers no competitive advantage if not accompanied by appropriate levels of productivity – which is often not the case. For emerging industries, a wage cost advantage can be easily wiped out by poor performance. It can also be quickly eroded by increased supply chain costs, and by inflation as prosperity develops in a low-wage country. Low wage cost is, clearly, not a disadvantage but it is not alone a factor of competitiveness. Similarly, higher wage costs are not necessarily a deterrent to competitiveness. It is one factor in the mix that ultimately determines whether a shipbuilder can compete[1].

It is not possible to leave this summary without mentioning subsidies, which, along with low labour costs, are most often cited as the reasons for losing work to competitors by shipyards struggling to compete. Shipbuilding has at times been heavily subsidised. Subsidy is often not per se illegal and is generally permissible up to the point where it adversely affects a competitor's business, at which point it may become actionable. There are always suspicions that hidden subsidies are aiding competitors, but such suspicions are almost always without evidence and thereby remain only suspicion. To be actionable, a subsidy must be specific (i.e. applicable to shipbuilding only) and it must be demonstrated that material harm has been caused to the competitor's business. Such conditions are very hard to establish.

1. This conclusion echoes that of Maslow in his 1943 book: 'A theory of human motivation'. For the motivation of a worker, Maslow classed wages as a 'hygeine factor', rather than a motivating factor per se.

19.

THE VOLUME PARADIGM

Volume production is the dominating competitiveness model in building of large commercial ships at the time of writing this book. The elements of competitiveness of the volume strategy are:

- high fixed capital investment;
- high throughput;
- standard designs;
- location in the context of a competitive supply chain;
- control of the makers list in the contract to direct equipment purchases to the supply chain;
- volume purchasing from the supply chain, promoting economy in procurement and in many cases justification for setting up supplier businesses close to the shipyard, minimising transport and transaction costs.

When the market provides sufficient demand, this strategy appears unbeatable. The flaw is that the market is volatile and its predominant mode is the trough, during which periods the economic efficiency of the strategy is compromised. This effect can be seen clearly in the most recent data point in Figure 23, benchmarking the volume of market leaders. Competition is intense during trough periods and prices can be subdued. This has at times led to insolvency in very large shipyards, requiring government assistance to keep them in business.

At the time of writing the volume model for large shipbuilding appears unbeatable and the very high capital investment that would be required to compete on this basis presents a barrier to entry for any investor seeking to gain access. Due to high volatility of demand and price, however, the strategy remains vulnerable and is only really viable in the context of a country that will act to support companies that may get into trouble, arguing that these businesses become too large to be allowed to fail and support is in the national interest.

It should be noted that volume shipbuilding in this sense is only encountered in the large ship sector (> 5,000 GT). This mode of competitiveness is not (yet?) seen in the small ship and workboat sectors.

The volume paradigm is vulnerable to downturns and, potentially, to any restriction in the labour force. Given the high risk and low return nature of the business, it must also be questioned whether it represents the best route to competitiveness in the future. It is a corollary of this that a new shipbuilding strategy that shifts competitiveness away from labour and towards automation and a reduction in the reliance of capacity on human capital would be an advantage, if the higher capital cost implications could be accommodated.

20.

PRODUCTIVITY

Consider the example of a welder working on fabrication of ship's structure. That welder is only truly adding value when their arc is struck. Aspects of leadership and motivation in that context are the same as in any industry sector. What might typically stop the arc being struck in the shipbuilding context are a lack of technical information, materials, tools/facilities or the requisite skills to complete the task and in this context the role of lean principles in eliminating waste also apply the same as in any sector. The importance of planning, presentation of technical information and material control can be seen to be significant in this context. The welder should not be wasting time looking for or retrieving materials or interpreting technical information, both of which commonly lead to waste in shipbuilding. Rework due to distortion and poor accuracy, which require correction to achieve acceptable fit-up before welding can commence, is also a common cause of waste in fabrication of ships' structure and accuracy and distortion control are fundamental keys to good productivity.

Another common cause of reduced productivity in shipbuilding is the need for rework due to design changes. This in turn is caused by incomplete design when production commences and by the need for the shipyard to commence cutting steel at an inappropriately early stage. This in turn is a feature of:

- contractual conditions that link payment terms to physical progress and;
- the need to provide work to keep shop floor employees busy in an environment of volatile demand.

On the first point, most commercial shipbuilding contracts are derivatives of a small number of standard contracts that were established some decades ago and the pegging of payment to physical progress is the norm. Planning and preparatory work, which are keys to good productivity, are not adequately recognised as having value in this context. On the second point, subcontracting is commonly used to cope with shipbuilding's fluctuating demand, but maintenance of a core workforce is normally essential and that workforce needs to be kept busy. Continuity of work and automation are really the only means of avoiding under-utilised labour.

The conditions described in the previous two paragraphs mean that shipbuilding, unless standard products are involved, is limited in its ability to take advantage of one of the main tools now available to maximise productivity through the simplification of the assembly process and optimisation of planning and logistics: simulation of production using the digital twin before physical production commences. This might delay production for as much as 50% of the total contract time, whilst the design is finalised and simulation and production engineering take place, but contract terms and production imperatives tend to force production to start as early as possible. Simplification of the assembly process through production engineering has great potential to improve productivity but requires a contract that recognises the value inherent in the planning stages.

Beyond this, good productivity can be linked to the use of best practice at each stage of production, with attention to detail at every stage being important. Productivity improvement programmes in British Shipbuilders in the 1980s, led by IHI of Japan, produced the following useful chart illustrating the approximate relative cost of work as the ship's structure moves through the stages of sub-assembly to block fabrication and then to ship assembly.

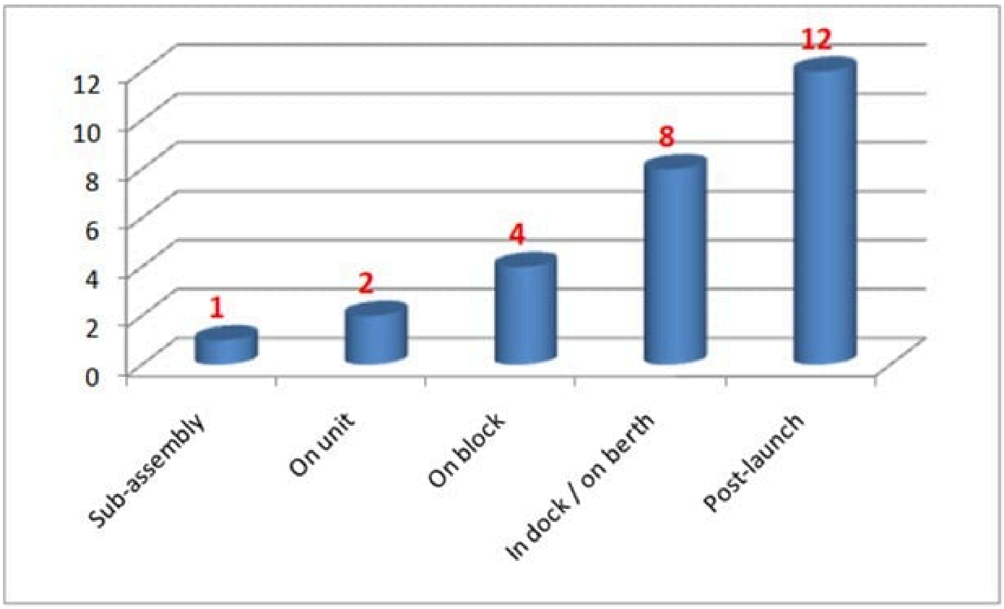

Figure 31 – Relative cost of work by stage of construction

Work is cheapest when undertaken downhand, without the need for staging or other access equipment, in an open environment and directly under the reach of a crane. Work is most expensive when overhead, at height, in a closed space and at a remote location (such as alongside a quay after launch). It follows from this that every single operation in the fabrication and assembly process should take place at the earliest stage possible and with the work in the most favourable orientation (for example with deck heads outfitted upside down). A corollary of this also is that the potential productivity of a shipyard is limited, inter alia, by the capacity of the final assembly crane (or any other factor that limits block size, such as door dimensions). The larger the crane, the larger the block that can be delivered to the final assembly site, minimising work at the most expensive stage of production and maximising the amount of outfit that can be achieved in optimum workshop conditions.

Further to this the use of standards is also a key to productivity. Standard products (including standardisation of the makers list of equipment) offer the greatest benefits but standardisation of detail design and methods is also important where the products vary. Standardisation of methods and detailed design, for example grouping pipe and cable runs and the fastenings for those systems and their installation and maximising straight runs of pipework, also produces great benefits.

Optimisation of productivity requires minimisation of choice for the customer, detailed production engineering to optimise the assembly process and minimise work content and the use of standard interim products and processes. Production engineering and detailed design are keys to removing work content and history suggests that the importation of expertise from other industries can provide an impetus to move shipbuilding technology forwards (for example from automotive and civil engineering in the USA in WWII and from aircraft construction in Japan post-WWII).

21.

THE PRODUCTIVITY JOURNEY

Data on shipyard productivity is difficult to find, firstly because it is difficult to define precisely in comparative terms and, secondly, because it would normally be confidential. The basic parameters on which an assessment could be made, and the likely progression of productivity, are set out in a useful paper published on this subject[1]. The analysis of Craggs et al proposes hours worked per unit of work produced (manhours per compensated gross ton) as the metric and shows that an organisation should see a reduction in this factor over time, referred to as 'shipyard learning', but that the progression can be disrupted by change: either change in the product or the processes used.

My own work as a consultant benchmarking productivity concluded that the annual rate of progress that could be achieved (the shipyard learning) amounts to around 7% to 8% per annum. The curve of progression is much steeper at the beginning of the shipyard's journey, however, and tends to an asymptote as the shipyard matures: there must be a limit to productivity in any shipyard: it can clearly never be 0 mh/CGT. The steeper journey at the start reflects the fact that significant gains can be made relatively easily at the early stages.

This leads to a notional shape of the productivity journey that is illustrated in Figure 32. The positioning of a shipyard on this curve dictates the nature of interventions that could be applied to speed up the journey and to improve productivity and thereby competitiveness.

1. Naval compensated gross tonnage coefficients and shipyard learning: J. Craggs, D. Bloor, B. Tanner and H. Bullen: Journal of Ship Production 2004 Vol. 20 Issue 2 Pages 107-113

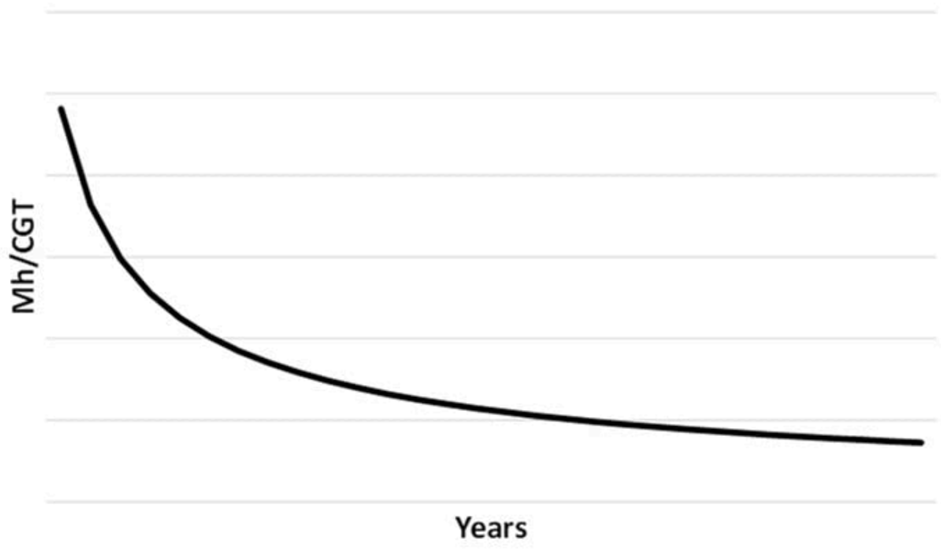

Figure 32 – The notional shape of the 'productivity journey'

To give the order of magnitude of the vertical parameters of this curve:

- The starting position in year 1 could be of the order or 100 to 150 mh per CGT, although worse than this is possible and better than this is also possible, given planning and help in start-up.
- Once the initial steep increase has flattened off, an annual increase of 7% to 8% may be possible.
- The final asymptote (very tentatively) may be around 10 mh/CGT or slightly lower.

There are therefore three distinct regions of this curve, which need separate strategies:

1. During the start-up phase, the shipyard is unlikely to be competitive, given that, as defined earlier, competitiveness implies an ability to meet a market-derived price. This reinforces the notion that Government assistance is needed to establish any significant new shipyard. Without such assistance a shipyard is likely to be at risk of failure during the initial phase. A shipyard that 'dips its toe into the shipbuilding water' only to retreat due to losses on ship 1, would be doomed to 'yo-yoing' at the start point each time it tries to build a ship. Continuity of work is needed to progress down this curve and financial or other assistance, for example protected contracts, may be required to achieve this.
2. Once the shipyard has progressed beyond the start-up period, benchmarking and productivity improvement programmes can be used to assist progression.
3. Once the curve levels off, i.e. the asymptote has been reached, no further progression will be possible: the shipyard has reached its limits and inputs to increase performance further will move into diminishing returns. To beat the asymptote a disruption would be needed: in other words, a change to the shipbuilding strategy or the processes used.

22.

GOVERNMENT ASSISTANCE AND PROTECTIONISM

Subsidy

General assistance to industry, for example to support apprenticeships or training schemes or for infrastructure developments, would not normally be counted as shipbuilding subsidies providing that they are generally available to other industries and are not shipbuilding-specific. There are also generally accepted subsidies in shipbuilding that seek to address idiosyncrasies of the industry that lead to disadvantages when compared to other industry sectors. Most important of these are:

- Special rules for support of product development, required because shipbuilding does not (cannot) develop prototype products for testing. First of class is always the prototype and, as such, the prototype is sold commercially and ordinarily may not be eligible to receive government assistance for R&D. Such support is commonly referred to as "*innovation aid*" and is essential for any shipyard seeking to develop new products.
- Special provisions for order finance, and particularly guarantees, needed because finance industries can be reluctant to lend to shipbuilding, except periodically during peak periods. Shipbuilding has a difficult reputation and the time needed to persuade lenders to back a sale can be prohibitive to that sale. This measure can be particularly important for a shipyard in the start-up phase. This does not mean to say that subsidised rates should be offered. It is the timely availability of commercial finance per se that is the problem, not the cost.

Any commercial shipbuilding industry seeking to compete in the international context must consider at least these basic provisions.

Beyond these specific provisions, subsidy has been a common feature of the shipbuilding industry for as long as the industry has existed and had a wide range of causes and forms, many of which have been indirect, which is to say the subsidy may be given to the shipping industry to indirectly support shipbuilders. The earliest reference to a shipbuilding subsidy found by the author is a British act of parliament passed in 1685 "*for the encouragement of shipbuilding greatly decayed in Newcastle, Hull, Yarmouth, Ipswich and other ports of England on the eastern coast, occasioned chiefly by so much employing of foreign-built ships in* *the coal trade"*. A duty of 5 shillings per tun[1] was imposed on foreign-built ships. Such a tax in the modern era would be construed as an indirect subsidy to the shipbuilding industry that it seeks to support.

Commercial shipbuilding has at times been openly supported by direct subsidies. For example, in 1986 the European Commission instituted a shipbuilding directive that limited permissible contract subsidies to 35% of the value of the contract. This was in the period where the industry in Europe was collapsing following the cyclical downturn after 1975. The support given to European shipyards was very expensive, averaging an estimated €840 million per annum in the period 2001 to 2003. In the long run this expenditure probably slowed the rate of attrition in the sector and possibly contributed to the retention of core sectors, but it saved very little capacity.

Cyclical downturns are one cause of shipbuilding subsidies, but they are far from the only cause. Past subsidies in the UK have included '*mail subsidies'* to encourage the construction of ships to support communications around the Empire between 1921 and 1932[2], and '*subventions*' to support construction of ships on the prestigious trans-Atlantic passenger routes between about 1840 and 1920. It was not only the UK that offered such subsidies. These trades were tantamount to critical infrastructure in that era and shipbuilding was seen as strategically vital in maintaining global empires.

As well as at the time of economic difficulties or to promote national interests, the role of state support in the start-up of shipbuilding companies can also be important. Bruno and Tenold conclude that the establishing of a modern large shipyard would be virtually impossible without state aid[3]. For example, in relation to the fledgling South Korean industry: "[the] *state supported HHI by giving access to domestic and foreign funds with preferential interest rates; helping in obtaining and providing financial guarantees; making complementary investments in facilities and complementary industries, such as steel; and providing support for technology acquisition"*. It is likely that a proportion of this help was effectively straightforward operating subsidies.

The need for assistance in the start-up phase is generated by two effects.

- The shipyard must gain orders in competition with established shipbuilders that are likely to be more productive and have lower cost. Even the best planned new shipyards are likely to have a build-up period where supply chains and productivity are developed, during which time the new yard is unlikely to be competitive.
- Throughput in early years is likely to be slow and the high cost of establishing the shipyard must be supported by this low level of business.

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1. This is the origin of the word 'ton', as in 'Gross Tonnage'. A 'tun' is an archaic term for a barrel and 'tunnage' was originally a measure of the earning capacity of a ship in terms of the number of barrels it could carry.

2. It is possible to date this specifically from an act of Parliament in 1921 that instituted the subsidies to another in 1932, which sought to correct the over-supply of tonnage that the subsidy created.

3. Bruno, L. and Tenold, S. (2011) 'The basis for South Korea's ascent in the shipbuilding industry, 1970-1990', Mariners Mirror, 97(3), pp. 201-217.

Protectionism

Protectionism refers to the directing of work to home shipyards, for strategic national reasons. Protectionism in warship building is common: the need to maintain a capability to develop, build and maintain a naval fleet has clear strategic significance. In the commercial shipbuilding sector, there are examples where this may be extended to encourage commercial ships that may be seen as significant in the national context to be constructed in home shipyards[4]. Examples have included commercial ships that may be used in military support, ships for offshore energy industries, to maximise the economic benefit to the state from the development of those industries, or ferries and other 'strategic' or critical infrastructure. The measures leading to protectionism can range from legal measures that openly force contracts to be placed in home shipyards, to domestic content requirements that can act de facto in the same way.

Protectionism may constitute an alternative form of subsidy in the case that the protected shipyards offer prices higher than could otherwise be obtained if they had to compete internationally, although in this case it is the customer that pays rather than the state per se. Protectionism is therefore not without an economic cost and as a long term strategy could be seen as counter-productive. As a short term expedient, with specific goals, for example in establishing a shipbuilding presence, it may provide an alternative approach to subsidy where the industry is seen as needing help in the early stages.

Other factors of competitiveness

Specific sectors of the fleet may be subject to local factors of competitiveness in addition to the preceding. For example, any sector that includes significant elements of thin plate structure may require specific investments and processes to enable thin plate panels to be fabricated without excessive distortion. Other factors may exist, for example the need for availability of specialist supply chains.

4. Probably the most debated protective measure is the so called 'Jones Act' in the United States, enacted after WWI to ensure that a merchant marine capability would be maintained for strategic resilience.

PART VI
LAST WORD

23.

CONCLUDING REMARKS

The aim of this work has been to improve understanding of the commercial shipbuilding markets and, thereby, to improve strategic decisions. Key to this will be improvement in market monitoring and forecasting, to which the following comments are addressed.

1. The shipbuilding market is constituted by a set of (more or less) discrete sectors. Market analysis must be based on as precise a definition of the market sector concerned as can be achieved. This does not mean to say that market monitoring at the global level is of no value, but it relates primarily to the 90% of the industry (by volume) that is constituted by larger ships and may not adequately represent conditions or prospects for other sectors, such as cruise, yachts, or smaller ship types.
2. Data is readily available for the larger sectors (including cruise) and analysis is readily achieved. For other sectors data can be more difficult to obtain, particularly for monitoring on anything more than an annual basis. Improvement in data availability for yachts and workboats would be particularly helpful for those seeking to analyse those sectors.
3. There is no single or simple model that can be used for demand forecasting. The key lies in, firstly, correctly defining the market and, secondly, in assessing the appropriate drivers that can be used for modelling of the future of that specific sector. The significant drivers can be summarised as: growth in demand, fleet development (for example the development of new ship types or technologies) and economic opportunity (for example periodic freight rate spikes or prosperity development). All three are important in forecasting demand for the main fleet above 5,000 GT (excluding cruise and ferry), but in other sectors the mix of determinants may be different. For example, a decision to purchase a harbour tug is likely to be related to obsolescence of a previous purchase or expansion of port capacity, and not directly to freight rate behaviour. For yachts the main driver is individual wealth. The specific drivers need to be defined first, before seeking data and proxies for analysis.
4. There are three main drivers of price: costs, freight rates and backlog. The relative significance of these varies over the market cycle and will vary between sectors. For example, in the main large ship sectors, freight rate spikes will be reflected in increased shipbuilding prices, because they will stimulate ordering and thereby increase the utilisation of capacity. This explains in part why backlog, which is a proxy for capacity utilisation, is consistently the best predictor of price. For a harbour tug or a yacht, on the other hand, where freight earnings have no direct relevance, costs are likely to be more significant in forecasting price. As with demand forecasting, the most important thing is to define the market correctly and then to rationalise the factors that will affect price, before seeking data and proxies for modelling.
5. In defining market sectors for price analysis, product mix must be considered, because cross price

elasticity will be a factor between ships that compete for the same capacity. For this reason, the market definition cannot be too narrow. For yachts or cruise ships the market may be defined by a single ship type: the yards that build these ships often specialise. For most other ship types, however, the mix of products that make up the market sector must be taken together to analyse both demand and price.

6. Shipyard capacity is inherent in both fixed and human capital. At the time of writing the availability of human capital is being brought into question. Backlog is higher than would be expected at the prevailing stage of the market cycle and this leads to prices that are higher than might be expected. The situation is still developing but if human capital has developed in a way that it may impose a restriction on capacity, this suggests that future ship prices will be relatively higher than has been experienced in the past. This will be exacerbated if capacity cannot expand to accommodate future demand upturns, bearing in mind that demand is highly cyclical and the industry is, at the time of writing, in the trough phase. Any labour shortage in shipbuilding may, therefore, have a significant effect on shipping and global trade. Conversely, a higher price base may be beneficial to shipbuilders and may open the potential for new suppliers to enter the market.
7. Competitiveness can be defined as the ability to build ships at a price that is set by market forces. Analysis of this is complex and competitiveness is contingent on several factors. Competitiveness, or more commonly lack of competitiveness, is often cited as being linked to low wage rates in competitor businesses, but this can be misleading. Factors of competitiveness include aspects of investment, the supply chain and productivity. Low wages per se confer limited advantage.
8. The predominant route to competitiveness in recent decades, at least in the large ship sector, has been through volume but it must be questioned as to whether in the long term this can be sustained. The reasons for this caution are, firstly, because the market is highly cyclical and the effectiveness of the strategy is reduced during the predominant trough phases and, secondly, because of the difficulty in sustaining the significant workforce needed over the longer term, as prosperity develops and young workers become resistant to joining heavy industry.
9. Because of the shape of performance improvement in shipbuilding, it is extremely difficult for a new shipyard to achieve competitiveness at the start of operations. The time needed for the build-up of competitiveness could be measured in terms of number of build cycles ('slot turnover') needed to achieve a competitive level of performance in both the workforce and the supply chain. This is likely to take several years, during which time the shipyard is likely to be performing below a competitive level and thereby, given the definition of competitiveness, unable to operate profitably. Development of new capacity is, therefore, problematic and likely to require support, either financial or using protectionism. For this reason, it would be beneficial if assistance to support the start-up of new investments were to join innovation aid as a generally accepted specific provision that is needed in ship building. This must, of course, be tightly controlled and time-bounded to avoid dependence in the shipyard.
10. Problems of labour shortage, should this be confirmed by future developments, could potentially be addressed through automation, shifting the balance of capacity from human to fixed capital. In shipbuilding this is difficult, however, because of the highly complex nature of the product and because

> of the way steel behaves when it is subjected to the intense heat of cutting and joining processes: it shrinks and distorts so that parts require manual adjustment during the assembly process. Further to this, the ability of shipyards to maximise the use of technologies for optimisation of the assembly process, that is to say AI and the use of the digital twin to optimise the design and avoid problems before production commences, are limited, inter alia because the standard form of contracts normally used in shipbuilding have not kept pace with technology: payment is normally linked to physical progress, which tends to force production to start too early. To make progress in this regard, therefore, two pre-requisites arise: firstly, a change to standard contracts to facilitate increased pre-production time and, secondly, processes that achieve perfect accuracy of steelwork with zero distortion. This requires a re-think of the shape and form of shipyards, including their processes, equipment, materials handling and raw materials, rather than an adaptation of current forms. It may also be perceived that there are finance and cash flow implications in this change, which will also require new thought. Such a change to the concept of a shipyard could provide a disruption that could take the sector forward.

These final conclusions close the circle: finance and capital will be required to make progress and, to address the risk inherent in this, improved monitoring and forecasting will have a key role to support strategic decisions at all levels.

The following sections consider some of the fundamental technical differences between newbuilding and repair yards, which tend to make them distinct from each other.

Steelwork capacity

- The largest newbuilding yards fabricate around 3 million tonnes of steel per year when busy and even a relatively small shipyard will fabricate several tens of thousands of tonnes per year. Steelwork capacity is therefore a significant factor of competitiveness for a shipbuilder. The largest ship repair yards, by contrast, are unlikely to fabricate more than a few hundred or at most a few thousand tonnes of steel per year and steel fabrication capacity is normally of secondary importance in a repair yard. A shiprepair yard lacks the investment required to compete for any significant level of newbuilding work and, conversely, repair work would make only a trivial contribution to the investment in steel capacity in a newbuilding yard.

Skills Balance

- Newbuilding's focus on steel manufacture is reflected in the skills profile of the workforce. The balance of skills in shipbuilding is skewed towards steelwork trades. For a shiprepair yard the balance of trades is skewed in the opposite direction, away from steelworking and towards mechanics, electricians, painters, etc. For this reason, a newbuilding yard taking on repair work would see the majority of the workforce idle for much of the time. Put another way, the investment in human capital in newbuilding is not supported by repair work and vice versa.

Cranes

- Final assembly cranes in shipbuilding yards (often a so-called 'Goliath' crane, that is a self-supporting gantry crane that straddles the building dock) are required to lift heavy blocks. For reasons that were outlined in the section on competitiveness, the larger the block lifted into the drydock, the more efficient the shipyard can be. Final block weights can be several thousand tonnes and the cranes that move such large loads are very slow. One lift can take a day. This is of very limited use in shiprepair, where every item that needs to be removed from the ship to take it to a workshop for service or repair will need to be lifted by a crane and the majority of lifts will be less than 5 tonnes. This results in hundreds of small lifts for a typical shiprepair contract, which would take months with a goliath crane. Shiprepair drydocks require to be surrounded by light and agile cranes to obtain the speed of lift needed to keep the work going. Such cranes, conversely, are of limited use in shipbuilding and would be a wasted investment. They would spend most of their time idle.

Workshops

- If you look at a photograph of a large shipbuilding yard you will notice hectares of integrated steel workshops, required to achieve the volume of steelwork needed to compete. By contrast, look at a photograph of a large shiprepair yard, where you will see a group of relatively small workshops clustered around the drydock, with those workshops focussed on engineering rather than steelwork. Proximity to the dock, the focus of work in shiprepair, is important for competitiveness in repair, avoiding time lost in transport to more remote workshops.

Drydocks

- There are two issues relating to the difference between shipbuilding and shiprepair drydocks (often referred to as a graving dock in shiprepair). Firstly, a graving dock fits the ship quite closely, because the requirement for work area around the ship is relatively low and ships tend to dock singly for repair. This also leads to the minimum volume of water to be pumped out to empty the dock – something that has to happen for each docking, bearing in mind that routine commercial shiprepair contracts last for only a few weeks. Drydock pumps are heavy users of electricity but, more than this, the pump-out has to be achieved within about a shift. Building docks, by contrast, tend to be large, with multiple ships under construction side by side and plenty of room around the ships to lay out work. They tend to be flooded and emptied only a few times per year and this operation can take days – not compatible with a successful shiprepair yard. Building docks also tend to be disappointingly shallow in the context of repair – the ship is at the lightest draft it will ever be at float-out and, when at operational light draft, the ship would not be able to re-gain access to the building dock for repair. The dock draft is likely to be insufficient.

Commercial shipbuilding is a much-misunderstood industry, and that lack of understanding makes strategy difficult.

Significant volatility and the length of the cycle (around 30 years) are troublesome. Each time the cycle has repeated it has tended to be viewed as the first time and major swings in price and demand have generally come as a shock. A second issue is that the shipbuilding market does not exist - it is a set of inter-related sectors. A strategy must be predicated on as close a definition of the relevant sectors as can be achieved. There is no single strategy for all shipyards, and the appropriate strategies will change over time – as will investment and governmental priorities for support.

Understanding Commercial Shipbuilding has been written at a time of great change in trade, global economics and geopolitics. It should be anticipated that shipbuilding will also change. Only by understanding the past and the underlying market mechanisms can we hope to try to understand what might happen in the future.

This book takes the long view and elucidates principles on which the markets and the industry work, including sections on: demand, supply, price and competitiveness.

Understanding Commercial Shipbuilding is published free of charge. The motivation for this is to move the sector forwards in terms of understanding. Strategic Maritime (strategicmaritime.co.uk) has been created to provide free resources to promote the understanding of shipbuilding and its teaching at University level: a subject that is increasingly scarce in engineering curricula.

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